MAHASAMVIT AGROTECH LIMITED

“There are no secrets to success. It is the result of preparation, hard work, dedication and learning from failure.”

“Opportunities don’t happen. You create them.”

“What we fear doing most is usually what we most need to do”

“All our dreams can come true, if we have the courage to pursue them.”

“The true test of leadership is how well you function in a crisis.”

“Never give up on a dream just because of the time it will take to accomplish it. The time will pass anyway.”

“Strive not to be a success, but rather to be of value.”

“Success is walking from failure to failure with no loss of enthusiasm.”

“Perfection is achieved, not when there is nothing more to add, but when there is nothing left to take away.”

“Self-belief and hard work will always earn your success.”

“An investment in knowledge pays the best interest”

OUR IDEOLOGY

Vision – to become an Indian Multinational Conglomerate who touches lives of millions through its high-quality products produced with advanced technologies and processes, serving customers globally.

Mission –

– To create a brand that is familiar and liked by every household within country.

– To become a true Indian MNC with Pan India presence and operations across the globe.

– To create best value proposition to investors, vendors & society.

– To uphold the principles of corporate governance.

From 2024 we are launching an AGRO BASED COMPANY with huge potential and with unique, innovative ideas and which is highly profitable and emerging business for all over the world and which leads huge employment generation.

The main projects will be prima facie for 30 innovative projects which will continue to grow up to 2030.

1) **VEGAN PRODUCTS AND FOODS – manufacturing of vegan products, and to open restaurant chain named DELICIOUS VEGAN (separate annexure) with all delicious vegan Recipes. - EXIHIBIT–1**
2) **POTATO POWDER AND ALL POTATO BASED PROJECTS. – EXIHIBIT-2**
3) **BANANA PRODUCTS AND WAFFERS AND POWDER-/ TAMARIND BASED ALL PRODUCTS – EXIHIBIT-3**
4) **GINGER OIL/ POWDER/PASTE - EXHIBIT-4**
5) **ONION POWDER/PASTE - EXIHIBIT-5**
6) **GARLIC POWDER/PASTE- EXIHIBIT-6**
7) **HERBAL BUTTER AND CHEESE – EXIHIBIT-7**
8) **COCONUT PRODUCTS- EXIHIBIT-8**
9) **MANGO PRODUCTS- (EOU)- EXHIBIT-9**
10) **DIABETIC FOOD – EXHIBIT-10**
11) **FOOD CONCENTRATE- EXIHIBIT- 11**
12) **HERBAL PLANTATIONS- EXHIBIT-12**
13) **ORGANIC AGRI FARMING /horticulture / tissue culture/ greenhouse projects – EXHIBIT-13**
14) **SOYA PRODUCTS MANUFACTURING – EXHIBIT-14**
15) **GLUCOSE PRODUCTION – EXHIBIT-15**
16) **ORGANIC HERBAL CHOCOLATES /CANDIES – EXHIBIT-16**
17) **BIO FERTILIZER AND BIO PESTICIDES - EXHIBIT-17**
18) **SPICE / PROCESSING/ TRADING/ MARKETING – EXHIBIT-18**
19) **COCA POWDER, COCA PRODUCTION/ PROCESSING--- EXHIBIT-19**
20) **YEAST MANUFACTURING AND CAKE GEL MANUFACTURING – EXHIBIT-20**
21) **VANILA CULTIVATION - EXHIBIT - 21**
22) **HORTICULTURE AND FLORICULTURE IN GREEN HOUSE PROJECTS - EXHIBIT-22**
23) **Edible oil projects and castor oil and by product – EXHIBIT-23**
24) **AGRICULTURAL WAREHOUSES AND LOGISTICS AND COLD STORAGES. – EXHIBIT-24**
25) **ANIMAL FEED – EXIHIBIT-25**
26) **Millets projects. – EXHIBIT-26**
27) **Ethanol projects – EXHIBIT-27**
28) **Rice products – EXHIBIT-28**
29) **OMEGA 3 PROCESSING PLANT BASED. - EXHIBIT-29**
30) **Artificial intelligence in agriculture projects. – EXHIBIT-30**

These all projects will be started during 2024 to 2026 and with the idea of new agricultural policy of govt. FPO (FARMER PRODUCER ORGNISATIONS).

With Full mobilization of this FPO concept we will progress further.

Farmer Producer Organization (FPO) FPO is a generic name, which means and includes farmer-producers' organization incorporated/ registered either under Part IXA of Companies Act or under Co-operative Societies Act of the concerned States and formed for the purpose of leveraging collectives through economies of scale in production and marketing of agricultural and allied sector. However, FPOs registered under Cooperative Societies Act of the State (including Mutually Aided or Self-reliant Cooperative Societies Act by whatever name it is called) for the purpose of this Scheme, is to be insulated from all kinds of interference including in election process and day today management through suitable provisioning in their Memorandum of Association and Bye-laws with a view to encourage healthy growth and development of FPO.

The formation of the AGRO COMPANY with potential professional project reports and with the funding from BANK/VENTURE CAPITALISTS / ANGEL INVESTORS / PRIVATE EQUITY.

Thereafter within 3 years, after utmost skills and professionalism and due diligence we will bring IPO for then required amount (INITIAL PUBLIC OFFER) and listed in stock exchanges.

First, we will work as

Agricultural research and aggrotech consultancy company

To launch our own Agricultural projects as stipulated

E commerce business for Agricultural and other products

engage with all agricultural processing /food processing

dealing with all agricultural processing machinery.

MAHASAMVIT AGROTECH LIMITED (MAL)

WILL PLAY A KEY ROLE AS Agricultural Research company and it will be apex research organization of the country with a high standing amongst international agricultural research institutions. We spearheading agricultural research, education and extension activities for productivity enhancement and diversification of Indian agriculture.

The world as a whole is undergoing several transformative changes. Growing population, changing lifestyles, expanding urbanization and accelerated climate changes are creating new challenges for the national agricultural research system. Whereas in the past, the challenge was to supply adequate food, but now it is to provide adequate nutrients to promote health; and in the future, the challenge would be to provide optimal nutrients based on individual's genetic profile. Fortunately, along with challenges, the developments in science are creating new avenues for tackling the challenges. We are determined to harness the advances of science for the welfare of society. The Council is committed to transform itself into an organization engaged fully with the farmers, industry, entrepreneurs and consumers at large.

To keep pace with the changing environment, the MAL has been updating its visions and strategies from time to time. The first systematic effort to envision the challenges and opportunities, and formulate its own strategy was undertake 'Perspective Plan' and the ''MAL Vision 2050', provides the strategic framework for innovation-led inclusive and sustainable agricultural growth in the country.

We will work alongside farmers, producers, manufacturers, retailers, governments, and other organizations to fulfil our purpose to nourish the world in a safe, responsible and sustainable way. Together, we create efficiencies, develop innovations, and help communities thrive.

MAL is committed to helping the world thrive.

MAL will create connections across the global food system to help the world thrive. We link farmers to markets, customers with sustainable nutrition solutions, and nourish the world.

Our ambition is to have the most sustainable food supply chains in the world.

MAL works every day to implement new sustainable practices to reduce our impact on the planet and protect people.

Through long history, we have seen agriculture be part of the solution to the world's most urgent challenges. We know that we must address climate change and conserve water and forests, while meeting the rising demand for food. These are complex challenges, but we have overcome many obstacles to keep our food system resilient and we will continue. We feel a deep responsibility to protect the planet and its people, to ensure a cleaner, safer future for generations to come.

Our Priorities

We've set priorities that account for the diverse environmental, social and economic impacts of our business. Still, we realize that no company can take on these challenges on its own. Through connection and collaboration with farmers, our customers, and global and local communities, we believe our food system will remain resilient.

MAL provides food, agriculture, financial and industrial products and services to the world. Together with farmers, customers, governments and communities.

Agriculture

We buy, process and distribute grain, oilseeds and other commodities to makers of food and animal nutrition products. We also provide crop and livestock producers with products and services.

Food

We provide food and beverage manufacturers, foodservice companies and retailers with high-quality ingredients, meat and poultry products, and health-promoting ingredients and ingredient systems.

Food Ingredients & Bio-Industrial

We will develop across the world serving food and beverage manufacturers, foodservice companies and retailers with food ingredients as well as food and non-food applications.

Animal Nutrition and Nutrition

we will help livestock and aquaculture farmers, feed manufacturers and distributors of all sizes deliver better animal nutrition through unparalleled research capabilities, innovative feed and premix products and services, and digital modelling and formulation solutions.

Agricultural Supply Chain

We connect producers and users of grains and oilseeds around the globe through origination, trading, processing, and distribution, as well as offering a range of farmer services and risk management solutions.

Ensuring continuous improvement, with a focus on the simplification and increasing operational efficiency.

Maintaining and improving compliance and controls.

Driving competitive advantage by delivering insights through planning and analytics.

Community Engagement

MAL will invest in local communities through economic development, partnerships and giving combined with the volunteer efforts of our employees. MAL provides corporate support to select national and global nonprofit and nongovernmental organizations (NGOs) that serve communities in which we have a business presence. We support partners working within our focus areas of food security, nutrition, and sustainability. And, our businesses and facilities sponsor employee-led groups, which support civic and non-profit organizations in their local communities.

MAL Councils seek to recognize issues important to our communities; build effective relationships with community leaders; and work to help improve living standards and promote vibrant, stable communities.

Rural Development Foundation:

Every child has the right to education and everyone has the duty to give back to the society. In this background Addressing basic needs and integrated community development initiatives in the country

Uplift the lives of women by imparting financial inclusion training to women to help them set up their own micro-enterprise.

Agriculture sector in India is a primary source of livelihood for a majority of the population. Low and stagnant income in the sector remains a focal point of policy debate in India. The most prominent pathways to enhance farmers' income is the adoption of improved agricultural technologies. This study documents the current state of agriculture technologies in India. The main objectives are:

(a) What are the adoption levels of improved technologies and their impact on farmers' income, agricultural production, natural resources and environment?

(b) What are the constraints in up-scaling improved technologies and the conditions for success of their adoption?

(c) What is the rate of return on agriculture research and extension system? And

(d) What can be learnt from the global perspective on agriculture research and extension services?

This includes the technologies related to:

(i) genetic enhancement,

(ii) natural resource management,

(iii) farm mechanisation,

(iv) conservation agriculture,

(v) climate smart agriculture,

(vi) biotechnology and genetic modification,

(vii) biofortification,

(viii) frontier technologies, and

(ix) digital technologies.

It shows that the adoption of improved technologies varied across technologies, commodities and geography. Adoption of improved technologies have shown an unambiguous positive impact on agricultural productivity and agricultural production. More specifically, these have had an impact on increasing farmers' income, income diversification, conserving natural resources, improving input use efficiencies, generating employment opportunities and promoting diversification. At the same time, defective policies and incentives have led to degradation of natural resources, especially a fall in water table and deterioration of soil health. Demand and supply side factors, such as extension, credit, human capital, technology traits, institutional barriers and enabling environment, play a crucial role in the adoption of improved technologies. Small and fragmented size of land holdings, the education level of the farmers, access to knowledge systems and availability of irrigation also determine adoption of improved technologies. Therefore, land consolidation through institutional reforms, connecting farmers with technology delivery systems and markets, and strengthening agricultural credit system are to be addressed for a faster and wider adoption of improved technologies.

Recent studies on agriculture extension highlight the salient role of targeting based approaches, including social networks, for the faster adoption of improved technologies. There is a need to connect farmers in a network mode with a targeted approach by taking farmers' aspirations and needs. It is suggested that the social networking should be a part of the strategy for promoting improved technologies. The study also notes that a perfect symphony is needed amongst technology traits, policies, institutions and infrastructure for the accelerated adoption of improved technologies.

The study highlights key conditions for the successful adoption and implementation of improved agricultural technologies, which includes an effective agriculture extension system, access to credit, human capital and direct benefit transfers. To enable small and marginal farmers for easy access to information and credit, the role of public sector programmes such as Krishi Vigyan Kendra's (KVKs) and the Kisan Credit Card (KCC) scheme are crucial. Education and skill development matter for all aspects of technological interventions starting from the choice of technology to its appropriate implementation. Social safety nets such as PM-KISAN can play an instrumental role in providing assistance to marginal and small farmers to improve the investment capacity of farmers to achieve the long-term goals of farmers' welfare.

Investment in agricultural research and extension significantly contribute to increasing productivity and agricultural growth in India. For instance, the recent studies on the returns of frontline extension system reveal a very high benefit-cost ratio of 8 to 12. But the agriculture spending in agricultural research and extension in India is much lower compared to the neighbouring and competing countries, especially China. This largely explains the slow agricultural growth in the country compared to China. The cross-country evidence highlights that the investment in the agriculture research and development have a huge potential in gaining the marginal returns. Therefore, there is a need to strategize the investment in

agriculture research and extension to generate and disseminate improved technologies to different agroclimatic regions.

Emerging challenges, such as climate change, degradation of natural resources and undernourishment, need a different approach and higher research resources. It appears that future agricultural research would be more capital intensive, which would require modern tools, infrastructure and upgraded skills. Next-generation technologies, such as climate smart agriculture, frontier technologies and digital agriculture require a different approach in technology generation and their dissemination. There is a need to reform the agricultural research and extension system by allocating more financial resources, improving capacity of human resources, creating an enabling management structure, promoting multi-disciplinary and multi-institutional research, strengthening public-private partnership, and developing appropriate research infrastructure.

India is home to 1.4 billion people, and globally ranks second in terms of the agricultural output. The agriculture, forestry and fishing sector accounted for 16.4% of the gross value added (GVA) in 2021. In contrast, the sector is serving as a primary source of livelihood for more than 50% of the country's population. Low and stagnant income across these sectors remains a focal point of policy debate in India. These sectors accounts for the majority of the poor of the country. Recent estimates show that about 220 million people are poor in India. One of the most prominent pathways to enhance farmers' income is the adoption of improved agricultural technologies.

Both demand and Supply side factor splay a crucial role for the adoption and diffusion of improved agricultural technologies. Demand side factors include awareness and knowledge about technology, access to credit and relevant inputs, risk implications and marginal returns et al. 2019a). Supply side fact- include policy support, investment in agricultural research and extension system, availability of infrastructure, and institutional arrangements for the delivery and benefit sharing of technologies. A perfect blending of demand and supply side factors accelerate the penetration rate of improved technologies for achieving desired outcomes. In India, the public sector agriculture research system is primarily responsible for the development and dissemination of improved technologies. With the passage of time, the private sector is gradually contributing to developing and marketing of improved technologies. Delivery of improved technologies through agricultural extension mechanisms play a key role in their up-scaling and out-scaling. In fact, agricultural extension system addresses demand side factors such as awareness creation, risk reduction and proficiency improvement. All these factors are significant in the widespread adoption and dissemination of improved technologies.

Genetic Enhancement

Genetic enhancement research in major agricultural commodities has received the highest priority in India. Over the years, the genetic enhancement research addressed different challenges in different phases:

(1) yield enhancement,

(2) resistance against biotic and abiotic stresses,

(3) product quality improvement,

(4) adapt and mitigate climate change,

(5) fortification of nutrients, and

(6) genetically modified commodities.

The research efforts yielded positive dividends in terms of ensuring food security, increasing incomes of farmers, reducing poverty, generating employment opportunities and enhancing export of agricultural commodities.

Adoption Patterns of Key Technologies

Evolution of genetically improved technologies started significantly with the Green Revolution through the introduction of dwarf and high yielding varieties (HYVs) of rice and wheat.

1 Their yield potential was much higher than the traditional varieties. Later, the technological progress has been to

(i) develop resistance against various biotic and abiotic stresses,

(ii) reduce length of growing season and crop duration,

(iii) improve quality traits for better tastes and prices, and

(iv) build resilience against climate change. During the early phase, rice variety IR-8 and the semi-dwarf HYV of wheat HYV (Kalyan Sona and Sonalika), were introduced for the large-scale adoption by the farmers.

2 Adoption of improved varieties,

The following messages can be summarised

(i) Improved varieties made a significant impact in transforming Indian agri-culture, increasing agricultural production and ensuring food security. This elevated India from a food deficit to food surplus nation on the global map.

(ii) Adoption patterns of improved cultivars varied by the commodity type and geography.

(iii) Adoption of improved cultivars show an unambiguous impact on the agri- cultural productivity, agricultural production and farmers' incomes.

(iv) Adoption of improved cultivars have implications on employment, equity and poverty.

(v) Negative externalities, especially the adverse impacts on the sustainability of natural resources and environment, are surfacing, and it needs to be better managed through appropriate technologies and effective policies.

(vi) Targeted approach holds the key for quicker and wider diffusion of improved cultivars.

Natural Resource Management

Promising technologies in natural resource management are related to improving water use efficiency, increasing input use, especially of fertilizer, and conserving soil and water resources.

(a) Water use

Water is an essential input for agriculture and allied activities. Adoption of water-efficient technologies is one of the most prominent pathways to address the sustainability of agriculture. This section provides a brief review of key technologies to better understand how these impacted the sustainability of agriculture and farmers' income. The assessment includes micro-irrigation technologies, land-levelling technology, agronomic practices and multiple water use systems to understand the adoption barriers and the potential impact.

Adoption of micro-irrigation technologies such as sprinkler and drip irrigation have a huge potential to improve water use efficiency and increase agricultural pro- ductility

The main reason for the slow rate of adoption of micro-irrigation systems is the high cost of establishing the system. There are suggestions that low-cost of micro irrigation systems is the precondition for their large-scale adoption. there are other constraints, as listed below:

(i) Unreliable access to ground water.

(ii) Less independence across farmers in extracting water.

(iii) Mismatch between micro-irrigation system and existing cropping patterns.

(iv) High opportunity costs of pumping ground water.

(v) Poor knowledge due to weak extension services.

(vi) Fragmented and small size of land holdings.

The better access to irrigation water through rainwater harvesting result in multiple benefits such as:

(i) Increasing agricultural production.

(ii) Enhancing cropping intensity and enable two to three crops in a year.

(iii) Improving groundwater availability.

(iv) Facilitating crop diversification towards high-value crops.

(v) Generating employment opportunity.

(vi) Raising farm incomes.

(vii) Improving sustainability of soil and water resources.

b) others

(i) Necessity of people's participation, and involvement of local stakeholders in planning, development and execution is crucial.

(ii) Need for demand-driven activities of watershed programme rather than supply driven.

(iii) Active participation of women and landless labour.

(iv) Develop processes for decentralisation of decision making.

(v) Involvement of elected leaders and village heads.

(vi) Visible tangible economic benefits.

(vii) Awareness about the benefits of the programmes and community participation.

(viii) Need to develop linkages with other institutions like credit sector and technology.

(ix) Implement agro-ecoregion specific technologies.

The key messages that emerge from the above review are summarised as follows:

(i) There are positive economic, social and sustainability impacts due to the adoption of technologies related to natural resource management.

(ii) There is a large variation across states or agro-ecoregions in the adoption of technologies related with natural resource management.

(iii) The main adoption barriers are poor access to water, lack of technical knowledge, poor extension services, and small and fragmented land holdings.

(iv) Main drivers of the adoption are the community participation, government subsidy, access to information, and effective coordination among farmers.

(v) Significant benefits of watershed programmes are increasing efficiency, improving equity and enhancing sustainability.

Farm Mechanisation

Labour-saving technologies, such as tractors, seed-drills, harvesters, combines, etc., are important not only to reduce costs and drudgery but also to increase labour efficiency and farmers'

To promote farm mechanisation, the following steps may be taken-up

1. Existing machines and implements are pro-large farmers. The smaller land size (about 1.08 ha) in India, compared to Europe (14 ha), limits the adoption of equipment suitable for the large land size. There is a need to develop and promote suitable farm machines, which suit the requirements of smallholders.

2. High fixed and variable costs of operation (economies of scale) for a smaller and fragmented piece of land limits the ownership of existing farm machines and equipment. Aggregation of farmers through Farmer Producer Organisations (FPOs) would enable them to use farm implements and machines.

3. Need for appropriate agriculture extension services for selection of farm equipment suitable across different farming systems.

4. Relax credit constraints for small and marginal farmers.

5. Hilly regions are way behind in use of available farm machinery and implements, as these are unsuitable to the existing terrain and topography. To promote farm mechanisation in hill regions, suitable implements are needed that suit the terrain and cropping systems.

6. Existing machines and implements are not women-friendly. As agriculture is getting more feminised, new machines and implements need to be more women-friendly.

Conservation Agriculture

The upper Indo-Gangetic plain is facing serious challenges in terms of depletion of natural resources, especially soil and water. These are related to rising production costs and declining profitability, mainly on account of

(a) declining organic matter content and carbon in the soil,

(b) extensive tillage and imbalance use of nutrients,

(c) growing menace of residue burning,

(d) steeply falling ground water table,

(e) increasing wages and labour scarcity, and

(f) rising fuel prices.

These factors are adversely affecting soil, water and air, and consequently affecting agricultural productivity, farm income and human health. To overcome these problems arising due to conventional agriculture, the concept of conservation agriculture is promoted. It is a range of soil management practices that minimise effects on composition, structure and natural biodiversity and reduce erosion and degradation. The conservation agricultural practices include

(a) direct sowing and nil/reduced/minimum tillage,

(b) surface incorporation of crop residues, and

(c) establishment of cover crops in both annual and perennial crops. These concepts are confined to improvement in soil health, and do not refer to farm income. To integrate farm income and soil health through conservation agriculture, the Food and Agriculture Organization (FAO) of the United Nations has focused the concept as resource-saving agricultural crop production. As per FAO definition, the conservation agriculture is to

- achieve acceptable profits,
- high and sustained production levels, and
- conserve the environment (FAO 2009).

The most important components of conservation agriculture are laser land levelling, direct seeded rice and zero tillage. The adoption of conservation agriculture is slow in India, but gaining importance in Punjab and Haryana. Several economic and environmental benefits are realised as a result of adopting conservation agriculture practices. These include:

(i) yield increase (10%-17%),
(ii) water saving (20%-35%),
(iii) energy and oil saving (roughly one million barrels if adopted in 3.5 million ha),
(iv) high rate of internal rate of return (57%), and (v) improved carbon sequestration and reduction of greenhouse gas emission. The adoption constraints include:

- **lack of awareness about the concept,**
- **non-availability of machines and/or services for laser land levelling and zero tillage,**
- **high cost of machines, and**
- **lack of competence for repair of conservation agriculture related machines. The components of conservation agriculture are also adopted in steps and modified by the farmers to suit their skills and resource endowment. In Punjab and Haryana, the adoption of laser land levelling is getting more prominence than the other components. It is followed by direct seeded rice and zero tillage. It is interesting to note a high correlation between adoption of laser land levelling and zero tillage. It is more likely to adopt zero tillage if the land is laser leveled. More research in different agroecologies and for alternative production systems is needed to scale up the adoption of conservation agriculture.**

Climate Smart Technologies

Climate change has now become a reality. It is adversely affecting agricultural production and pushing the poor to below the poverty line . One of the recent reports of the Inter-Governmental Panel on Climate Change (IPCC) is very scary, and it states that human action has been responsible for climate change. It further elaborates that in the absence of appropriate measures to combat climate change, the damage would be more serious than predicted. The small farm holders are more vulnerable to climate change. This group of framers have the least capacity to overcome the consequences, as they have fewer resources to adapt socially, technologically and financially, and thus, are likely to be the worst affected and

To combat impact of climate change, Climate Smart Agriculture (CSA) has been promoted at the global level by the Consultative Group on International Agricultural Research (CGIAR) programme on Climate Change, Agriculture and Food Security (CCAFS). The FAO defines the CSA as, "an approach that helps guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a hanging climate". It is a win-win proposition in the short- and long-run, which contributes to

- **increase in agricultural productivity and farmers' incomes,**
- **adapting to climate change and reducing the risk arising due to climate change, and**
- **improvement in carbon sequestration and/or reduction in green- house gas emissions. The CSA incorporates a comprehensive strategy incorporating social, economic and environmental contexts. The CSA consists of a package of practices, which intends to improve efficiency, reduce the risks and enhance sustainability of natural resources and environment. the effectiveness of CSA practices in mitigating the adverse impact of climate change. The study reveals that the adoption of CSA practices has a huge potential to mitigate the adverse effects of climate change.**

There are several components of CSA technologies. These include stress-tolerant cultivars, minimum tillage, laser land levelling, weather advisory, energy management, site-specific nutrient management and crop diversification. Since most of the components are dealing with resource management, their adoption is location specific.

Biotechnology and Genetic Modified Crops

Application of modern science such as biotechnology and nano-technology in crops provides an opportunity to enhance their genetic potential including agricultural productivity, input requirements and sustainability of agriculture. Agricultural bio- technology is being used as a scientific tool and technique to enhance genetic potential and/or reduce risks due to biotic and abiotic stresses. This includes genetic engineering, molecular markers, molecular diagnostics, vaccines and tissue culture. They help to modify living organisms in plants, animals and microorganisms. Use of biotechnology in breeding has many advantages over the traditional breeding efforts. Tissue culture became very popular in developing and propagating planting material of fruits and vegetables. Tissue culture has created the possibility to generate a whole plant from single cells or tissues, which opened new approaches to plant improvement. It has be- come an essential technique to produce plants with desired genetic characteristics and productivity. There are basically the following goals of tissue culture:

(i) mass propagation of the desired line of the plants,

(ii) obtain virus-free plants,

(iii) rapid mass production of plants for breeding purposes,

(iv) preserve germplasm, and

(v) produce haploids for the breeding programme (ibid).

Biofortification

Biofortification is the process by which the nutrient density of food crops is increased through conventional plant breeding method. In low- and middle-income countries, economic affordability is a major constraint for the consumption of nutritious food that leads to several health complications, especially among children and women.

There are several challenges in scaling up of biofortification varieties:

(i) Non-availability of enough seeds of biofortified varieties for larger areas.

(ii) Non-existence of the value chains of the biofortified varieties.

(iii) Lack of awareness about biofortified varieties among the poor and

undernourished consumers.

(iv) Disconnect between government's social safety net programmes and production of biofortified varieties.

There is a need to integrate nutrition-dense food commodities with the government social safety net programmes, such as the public distribution system (PDS), mid-day meal scheme and the integrated child development programme. There is a need to develop an effective seed value chain of biofortified varieties to up-scale their cultivation and production by engaging the private and public seed sector.

Frontier Technologies

Frontier technologies are known to have positive implications for the agricultural food systems. These include protected agriculture, precision agriculture, vertical farming and hydroponics, among others. Their adoption remains quite low especially in the developing countries. These are popular in east and southeast Asian countries. In these regions, their speedy adoption is reported. These are more popular for production of fruits, vegetables and flowers. Specific case studies on protected agriculture report earning of high returns by cultivating vegetables and flowers. The main drivers of adopting protected agriculture are farmers' education level, experience in protected farming and social interaction. The initial fixed cost is the main hindrance in adopting protected agriculture. However, the new research is launching low-cost protected agriculture systems. For instance, inclusion of renewable energy (especially photovoltaic green house) structures in protected agriculture reduces the cost to a large extent. Based on the global review, it can be stated that the success of protected agriculture depends on various technological considerations, such as tunnel height, covering materials, shading structure, climatic control, frame, size of structure and energy sources.

Other challenges include:

(a) knowledge of the farmers about establishment of the structure, inclusion of crops and supply management,

(b) emergence of new pests and diseases associated with a controlled environment,

(c) heat management inside the protected agriculture structure,

(d) quality and taste issues that are associated with the controlled environment, and

(e) postharvest issues related to the dumping of waste materials

The second prominent example of a frontier technology is precision agriculture. Precision agriculture is the collecting of timely geospatial information on the requirement of soil, plant and animal, and accordingly, prescribing and applying site-specific treatments to increase agricultural production and protect the environment. It substantially reduces the cost of production and improves the input use efficiency. New tools such as remote sensing, Global Positioning System (GPS) and Global Information System (GIS) are applied for taking informed decisions on in- put use for maximising crop yields. It facilitates precise utilisation of agricultural inputs depending upon the crop, soil and weather requirement to optimize the use of fertilizers, pesticide and irrigation requirements for maximum productivity. The precision agriculture is eco-friendly and cost-effective, thereby, minimises use of water, herbicides, pesticides and fertilizers besides the farm implements. It automates and simplifies the entire management decision making process of the field by allowing application of agricultural inputs at the 'right time' and in the 'right amount', as and when necessary.

Adoption of such technologies is largely limited to the developed countries, and there is an increasing attention for their application in developing countries. In India, the precision agriculture technologies are at a preliminary stage. Precision agriculture is being identified as one of the main thrust areas by the working groups of India and USA partnerships. Several states have taken initiatives to promote precision agriculture.

Third prominent example for the frontier technology is vertical farming. The vertical farming refers to a system of crop production that maximizes the use of land by having a vertical design. One of the important advantages of the vertical farming is the scale of operation, and it requires smaller space as compared to the conventional farming. In terms of economic benefits, it saves land and water, reduces costs, provides higher yield, converts waste into assets, minimises risks due to droughts, floods and other shocks, and creates more jobs and employment opportunities. In India, the concept is at a very nascent stage, but needs to be popularised in view of smallholdings.

Another frontier technology is hydroponics. It is basically a method of cultivation of crops without soil by using mineral nutrient solutions in an aqueous solvent. As compared to conventional method of cultivation, hydroponics saves huge water. The other benefits include saving of land and huge costs, increasing crop yields and im- proving quality of produce. It is free of chemicals, and the food from hydroponics is safe and healthy. Vegetables (like tomato, lettuce, cucumbers and several leafy vegetables), fruits (like strawberry) and cannabis, flowers and fodder crops are generally cultivated using the technique of hydroponics. There are some start-ups entering in agri-business and following hydroponics in urban areas. The technique needs to be popularised among small and marginal farmers to increase their income.

Digital Technologies

Adoption and diffusion of digital technologies in agriculture can help in transforming agricultural systems towards sustainability. A growing study on this subject shows that the adoption of technologies such as artificial intelligence, robotics, remote sensing image analysis, optical sensors and equipment design for monitoring have huge potential for sustainable development. the key determinants of digital agriculture technologies are the following:

(i) Farm size: it is positively associated with the adoption of such technologies.

(ii) Biophysical conditions: farmers with better quality lands and resources are

more likely to adopt these technologies.

(iii) Complementary technologies: farmers who already adopted some digital technologies are more likely to advance it with the adoption of more such technologies.

(iv) Labour availability: farmers with permanent skilled labour are positively related with adoption decisions.

(v) Computer use: farmers with computer skills are positively associated with

the adoption of digital technologies.

(vi) Innovative farmers: Innovative and risk-taking farmers are more likely to

adopt digital technologies.

(vii) Capacity development: those farmers having received or are receiving training on the use of these technology are likely to follow the digital practices.

(viii) Information channels: an effective communication channel facilitates use of these technologies.

(ix) Technology attributes: higher the compatibility of digital technology with the existing technologies, the adoption is likely to be higher.

(x) Behavioural factors: higher the inclination of user for digital technologies, higher is the adoption.

A recent study by FAO (2019) shows some interesting examples and their impact on the agriculture food systems:

(i) Use of mobile applications to track the past and current prices helps farmers to strategies the production decisions for the future.

(ii) Mobile application designed to provide early warning about the disease

among livestock are useful in mitigating the risks involved.

(iii) Agriculture robots on the farmers' field to process the information avail-

able, and help farmers to measure and optimise the input use.

(iv) Forecasting tool based geo-mapping, crop planning, individual farm plans, weather, soil, pest and crop data on an almost real-time basis to facilitate farmers in taking and executing optimal decisions on a real time basis.

(v) Artificial intelligence programming in providing real-time solutions to farmers.

The report further highlights the conditions for the success of a digital transformation. These include:

(i) Information technology (IT) infrastructure and networks in rural areas are the minimum conditions for better internet connectivity, its availability and affordability.

(ii) Digital literacy is a primary condition for the success of digital transformation. Effective operations of smart mobile phones, tablets and laptops are the key for the digital literacy.

(iii) Agri perineurial and innovation culture will promote digital agriculture.

(iv) Need for supportive policies and programmes for digital transformation.

Conditions for the Successful Adoption of Agriculture Technologies

In this section, key conditions for the successful adoption and implementation of improved agricultural technologies are presented. the success of adoption of any improved technology relies both on supply and demand side factors. The author characterised the supply side, as origin of the technology, which is driven by its availability and enabling environment for its absorption. The demand side factors, which the author described as the speed of adoption, depends on profitability, availability of supporting inputs, government policies and facilitating institutions and infrastructure. Other studies concludes that if the profit-ability is a sufficient condition, the necessary condition depends on appropriate infrastructure and availability of well-structured organisational network (Joshi and Datta 1990). For a large-scale adoption, there should be a perfect symphony amongst technology traits, enabling policies, effective institutions and appropriate infrastructure. During the Green Revolution period, these were perfectly blended. It is evident that improved technologies were high yielding and giving substantially more profit than the traditional varieties. To support farmers, the government introduced the concept of minimum support prices (MSP) and assured procurement of rice and wheat. The banks were nationalised, and the agriculture sector was included as a priority sector to provide access to credit for the farmers. Each state also started their own seed corporation to ensure affordable seeds of HYVs to the farmers. Agricultural extension system was geared to disseminate components of improved technologies. During the same time, massive investment was made on developing irrigation infrastructure. Such an

enabling environment led to the Green Revolution. In case of natural resource management technologies, an additional condition for success is the people's participation, and how institutional arrangements are made for sharing the cost and benefits. In this section, we shall be focusing on demand side factors such as agricultural extension, capital and knowledge. We have also reviewed some recent studies on how the direct cash transfer scheme is contributing to adoption of improved technologies.

Effective Agricultural Extension Service

Access to effective extension service is one of the most crucial factors for the adoption of agriculture technologies.

The effectiveness of agricultural extension depends upon the aspirations of the farmers to connect with the improved technologies (Joshi et al. 2016). Citing the example of maize revolution in the most backward district of Bihar, Joshi et al. (2016) show that farmers' aspiration to the choice of technology is the key driver for its large-scale adoption. It suggests that policies, while promoting improved technologies, should take into account the farmers awareness level and their aspirations. The available literature suggests measures for further strengthening of agricultural extension system, especially the KRISHAN VIGYAN KENDRAS KVKs. There is a need to connect farmers in a network mode for social-spillover with a targeted approach by taking into account the farmers' aspirations and needs.

Access to Credit

Both theoretical and empirical literature highlight the significant role of credit facilities for the adoption of modern technologies

To enable small and marginal farmers easy access to credit, the government introduced the scheme, known as the Kisan Credit Card (KCC). There are reports that access to KCC is positively associated with the adoption of modern cultivars.

Human Capital

A rich body of the literature reveals the importance of human capital in adopting improved technologies and attaining higher returns. In particular, the education level along with learning outcomes matter the most for the adoption of improved technology . Education and skill development matter starting from the choice of technology to its appropriate implementation. the innovators and early adopters are those who have attained higher education levels. KVKs are accessible to innovators, but not to the early adopters. Therefore, it is argued that the education level along with training and skill development are necessary for adopting improved technologies and attaining higher returns.

Direct Benefit Transfer

Growing evidence suggests that cash transfer schemes raise the likelihood of adoption of improved technologies. Recently, the government has introduced the cash transfer scheme, known as PM-KISAN, with the aim to provide income support to farmers for easing their liquidity needs and to facilitate timely access of inputs. The scheme has significantly helped in purchase of seeds, fertilizers and other inputs.

Agriculture Research and Development: Investment and Returns

Investment in agriculture, both by the public and private sectors, is the key for its growth and prosperity. The rationale for the public investment in the agriculture sector is driven by

(a) economic inefficiencies because of market failures,

(b) inequalities in the distribution of goods and services, and

(c) its potential to trig- ger private investment.

The inefficiency in markets arises from public good, risks, externalities, information asymmetries and so on. The equity issue stems from the fact that the majority of the poor in developing countries depends on the agriculture sector for their livelihoods. Hence, the argument is that the government expenditure is important in those components which boost agriculture sec- tor, especially agriculture research, extension and infrastructure (roads, irrigation, markets, etc).

Often questions are raised on the impact of investment on agriculture, especially agricultural research and technology dissemination. Studies based in Asia, Africa and Latin America show that the investment in agricultural research and development (R&D) is highly productive and significant in improving efficiency and equity.

Learning from International Experiences

A comparison is being made between India and China to learn lessons to further improve the performance of the agriculture sector. Bosworth and Collins (2008) examine the sources of economic growth for India and China for the period 1980-2005. During the period, the per capita GDP has almost doubled in India, but increased seven times in China. The study analysed the sources of growth by decomposing it into agriculture, industry and services.

The agriculture sector has grown by 4.6% per annum in China compared to 2.5% per annum for India from 1978 to 2004. Figure 11 presents the rate of growth (annual rate of change) of output, employment and output per worker for the agriculture sector. It shows that the employment growth in the agriculture sector is 0.3% in China compared to 1.1% for India. In terms of output per worker, the annual growth in China was 4.3% compared to 1.4% for India.

Figure 12 presents the contribution of physical capital, education and TFP to the output per worker. The physical capital contributes 2.3% annually in China com- pared to 0.3% in India. This suggests that the investment in the physical capital drives a large part of the agricultural growth. The contribution of education is al- most same for both China and India. The contribution of TFP is 1.7% for China and 0.8% for India. This suggests that technological intervention is the second important factor for driving China's growth. India needs to learn from the Chinese experiences by allocating more resources in agriculture and agricultural research for continuous flow of improved technologies. It is clear that the future agriculture research and extension would need more resources for developing new technologies to address multiple challenges. We have also tried to examine the institutional and policy reforms that explains China's progress through by agriculture research and agriculture extension systems. One of the major institutional reforms in China was that of the household responsibility system (HRS) or contract responsibility system, which was implemented between 1978 and 1984. In HRS, farmers as a relatively independent economic entity contract for the collective land. Several studies show the HRS accounted for 30% - 50% of the total rise in agricultural output during the period 1978-84 (Fan 1991; Lin 1992; Huang and Rozelle 1996). McMillan et al. (1989) demonstrate that the HRS accounted for 90% of the rise in TFP between 1978 and 1984. Empirical evidence suggests that the reform not only result in increasing agricultural productivity, but also helps in shifting farmers from cereals towards high value crops and livestock. Another major reform was initiated in 2000s to facilitate land consolidation (Huang and Ding 2016). Additional notable innovation in land institutions was the introduction of three separate land rights, namely, village collective landowner rights, individual household land contract rights and land operation rights.

China has also initiated a number of reforms in agriculture research and extension system since the 1980s. These reforms have been classified in four stages as follows:

1. In the first stage (1979-1985), the number of agricultural research institutes has increased from 597 to 1,428. At the same time, the total agricultural re- search staff increased from 22,000 to 1,02,000.

2. In the second stage (1986-1998), the Chinese government emphasised on the commercialisation of agriculture R&D activities. The government changed the budget allocation system from planned base to competitive base (Jin and Jou 2005). However, it resulted in reducing the number of researchers from 1,02,000 to 65,000.

3. In the third stage (1999-2006), the Chinese government focused on the trans- formation of the agriculture R&D towards enterprise-based research and development. To do so, the country has classified agriculture R&D institutes into three functional types, namely, public R&D institutes which were fully funded by the government, science and technology service institutes partially funded by the government, and technology development institutions led by the private sector in a phase-wise manner.

4. In the fourth stage (2007-), a significant expansion of funds for the agri- cultural research were allocated. The technology innovation system, with 50 subsystems for agricultural commodities, has been established. As a result, the number of public sector agricultural researchers in China had reached 96,300 by 2010 itself (Hu et al. 2012).Babu et al. (2015) compared the agriculture research and extension system of China and India with a focus on their goals, institutional structure, investment and human capital. Mandate of National Agricultural Research System (NARS) system in both China and India is to push agriculture production to meet the national food security. In China, NARS is publicly dominated and highly decentralised in terms of management and funding. India follows the agricultural research council model, centred on the Indian Council of Agriculture Research (ICAR). China's NARS is largely funded by the public investment and through competitive funding. While India's funding moves through block grants from the central government to ICAR and State Agricultural Universities (SAUs) as determined by five-year plans (till 2014). In China, there are 1,215 agricultural research institutes and 67 agricultural universities with 55,061 fulltime staff in 2012. In contrast, India has 100 ICAR research institutes and 70 agricultural universities with 9,328 fulltime staff. This clearly indicates that China has larger infrastructure, more human resources and higher funding for agricultural research, extension and education. Therefore, funding for agricultural research, extension and education needs to be expanded strategically in India.

Conclusions and the Way Forward

In this study, an attempt has been made to examine the adoption of improved agricultural technologies related to the genetic enhancement, natural resources management, fertilizers, farm machineries, conservation agriculture and climate smart technologies. Further attempt has also been made to assess the scope of genetically modified crops, frontier technologies and digital agriculture. The main objectives of this review were to investigate:

(a) What are the adoption levels of improved technologies and their impact on farmers' income, agricultural production, natural resources and environment?

(b) What are the constraints in up-scaling improved technologies and to analyse conditions for success of their adoption?

(c) What is the rate of return of agriculture research and extension system? and

(d) What can be learnt from the global perspective on agriculture research and extension services?

The review shows that the adoption of improved technologies varied across commodities and geography. Adoption of improved technologies have shown a positive impact on agricultural productivity and agricultural production. More specifically, these have an impact on increasing farmers' income, conserving natural resources, improving input use efficiencies,

generating employment opportunities and promoting diversification. However, defective policies and incentives have led to degradation of natural resources, especially a fall in water table and deterioration of soil health. Improved technologies also generated employment opportunities in the non-farm sector through strong linkages between farm and non-farm sectors. Demand and supply side factors, such as extension, credit, human capital, technology traits, institutional barriers and enabling environment, play a crucial role in the adoption of improved technologies. Small and fragmented size of land holdings, education level of the farmers, access to knowledge systems and availability of irrigation also deter- mine adoption of improved technologies. Therefore, land consolidation through institutional reforms, connecting farmers with technology delivery systems and markets, and strengthening agricultural credit system are to be addressed for faster and wider adoption of improved technologies.

Social networking is important for faster adoption of improved technologies, but was almost ignored in the past. It is suggested that the social networking should be a part of the strategy for promoting improved technologies. The study also noted that a perfect symphony is needed amongst technology traits, policies, institutions and infrastructure for the accelerated adoption of improved technologies.

Investment in agricultural research and extension significantly contribute to in- creasing productivity and agricultural growth in India. But the spending in agricultural research and extension in India is lower compared to China. This largely ex- plains the slow agricultural growth in the country compared to China. The cross- country evidence highlights that the investment in the agriculture R&D have a huge potential in gaining the marginal returns. Therefore, there is a need to strategies the investment in agriculture research and extension to generate and disseminate im- proved technologies to different agroclimatic regions.

New challenges, such as climate change, degradation of natural resources and under nourishment, need a different approach and larger research resources. It appears that future agricultural research would be more capital intensive, and this would require modern tools, infrastructure and upgraded skills. Next-generation technologies, such as climate smart agriculture, frontier technologies and digital agriculture, require a different approach in technology generation and their dissemination. There is a need to reform agricultural research and extension system by allocating more financial resources, improving capacity of human resources, creating an enabling management structure, promoting multi-disciplinary and multi-institutional research, strengthening public-private partnership, and developing appropriate research infrastructure.

However, we are concerned about the problems and solutions about the agriculture in our country-

List of agricultural problems

First, we are presenting world bank report about Indian agriculture

Overview

While agriculture's share in India's economy has progressively declined to less than 15% due to the high growth rates of the industrial and services sectors, the sector's importance in India's economic and social fabric goes well beyond this indicator. First, nearly three-quarters of India's families depend on rural incomes. Second, the majority of India's poor (some 770 million people or about 70 percent) are found in rural areas. And third, India's food security depends on producing cereal crops, as well as increasing its production of fruits, vegetables and milk to meet the demands of a growing population with rising incomes. To do so, a productive, competitive, diversified and sustainable agricultural sector will need to emerge at an accelerated pace.

India is a global agricultural powerhouse. It is the world's largest producer of milk, pulses, and spices, and has the world's largest cattle herd (buffaloes), as well as the largest area under wheat, rice and cotton. It is the second largest producer of rice, wheat, cotton, sugarcane, farmed fish, sheep & goat meat, fruit, vegetables and tea. The country has some 195 m ha under cultivation of which some 63 percent are rainfed (roughly 125m ha) while 37 percent are irrigated (70m ha). In addition, forests cover some 65m ha of India's land.

Challenges

Three agriculture sector challenges will be important to India's overall development and the improved welfare of its rural poor:

1. Raising agricultural productivity per unit of land: Raising productivity per unit of land will need to be the main engine of agricultural growth as virtually all cultivable land is farmed. Water resources are also limited and water for irrigation must contend with increasing industrial and urban needs. All measures to increase productivity will need exploiting, amongst them: increasing yields, diversification to higher value crops, and developing value chains to reduce marketing costs.

2. Reducing rural poverty through a socially inclusive strategy that comprises both agriculture as well as non-farm employment: Rural development must also benefit the poor, landless, women, scheduled castes and tribes. Moreover, there are strong regional disparities: the majority of India's poor are in rain-fed areas or in the Eastern Indo-Gangetic plains. Reaching such groups has not been easy. While progress has been made - the rural population classified as poor fell from nearly 40% in the early 1990s to below 30% by the mid-2000s (about a 1% fall per year) – there is a clear need for a faster reduction. Hence, poverty alleviation is a central pillar of the rural development efforts of the Government and the World Bank.

3. Ensuring that agricultural growth responds to food security needs: The sharp rise in food-grain production during India's Green Revolution of the 1970s enabled the country to achieve self-sufficiency in food-grains and stave off the threat of famine. Agricultural intensification in the 1970s to 1980s saw an increased demand for rural labor that raised rural wages and, together with declining food prices, reduced rural poverty. However agricultural growth in the 1990s and 2000s slowed down, averaging about 3.5% per annum, and cereal yields have increased by only 1.4% per annum in the 2000s. The slow-down in agricultural growth has become a major cause for concern. India's rice yields are one-third of China's and about half of those in Vietnam and Indonesia. The same is true for most other agricultural commodities.

Policy makers will thus need to initiate and/or conclude policy actions and public programs to shift the sector away from the existing policy and institutional regime that appears to be no longer viable and build a solid foundation for a much more productive, internationally competitive, and diversified agricultural sector.

Priority Areas for Support

1. Enhancing agricultural productivity, competitiveness, and rural growth

Promoting new technologies and reforming agricultural research and extension: Major reform and strengthening of India's agricultural research and extension systems is one of the most important needs for agricultural growth. These services have declined over time due to chronic underfunding of infrastructure and operations, no replacement of aging researchers or broad access to state-of-the-art technologies. Research now has little to provide beyond the time-worn packages of the past. Public extension services are struggling and offer little new knowledge to farmers. There is too little connection between research and extension, or between these services and the private sector.

Improving Water Resources and Irrigation/Drainage Management: Agriculture is India's largest user of water. However, increasing competition for water between industry, domestic use and agriculture has highlighted the need to plan and manage water on a river basin and multi-sectoral basis. As urban and other demands multiply, less water is likely to be available for irrigation. Ways to radically enhance the productivity of irrigation ("more crop per drop") need to be found. Piped conveyance, better on-farm management of water, and use of more efficient delivery mechanisms such as drip irrigation are among the actions that could be taken. There is also a need to manage as opposed to exploit the use of groundwater. Incentives to pump less water such as levying electricity charges or community monitoring of use have not yet succeeded beyond sporadic initiatives. Other key priorities include: (i) modernizing Irrigation and Drainage Departments to integrate the participation of farmers and other agencies in managing irrigation water; (ii) improving cost recovery; (iii) rationalizing public expenditures, with priority to completing schemes with the highest returns; and (iv) allocating sufficient resources for operations and maintenance for the sustainability of investments.

Facilitating agricultural diversification to higher-value commodities: Encouraging farmers todiversify to higher value commodities will be a significant factor for higher agricultural growth, particularly in rain-fed areas where poverty is high. Moreover, considerable potential exists for expanding agro-processing and building competitive value chains from producers to urban centers and export markets. While diversification initiatives should be left to farmers and entrepreneurs, the Government can, first and foremost, liberalize constraints to marketing, transport, export and processing. It can also play a small regulatory role, taking due care that this does not become an impediment.

Promoting high growth commodities: Some agricultural sub-sectors have particularly high potential for expansion, notably dairy. The livestock sector, primarily due to dairy, contributes over a quarter of agricultural GDP and is a source of income for 70% of India's rural families, mostly those who are poor and headed by women. Growth in milk production, at about 4% per annum, has been brisk, but future domestic demand is expected to grow by at least 5% per annum. Milk production is constrained, however, by the poor genetic quality of cows, inadequate nutrients, inaccessible veterinary care, and other factors. A targeted program to tackle these constraints could boost production and have good impact on poverty.

Developing markets, agricultural credit and public expenditures: India's legacy of extensive government involvement in agricultural marketing has created restrictions in internal and external trade, resulting in cumbersome and high-cost marketing and transport options for agricultural commodities. Even so, private sector investment in marketing, value chains and agro-processing is growing, but much slower than potential. While some restrictions are being lifted, considerably more needs to be done to enable diversification and minimize consumer prices. Improving access to rural finance for farmers is another need as it remains difficult for farmers to get credit. Moreover, subsidies on power, fertilizers and irrigation have progressively come to dominate Government expenditures on the sector, and are now four times larger than investment expenditures, crowding out top priorities such as agricultural research and extension.

2. Poverty alleviation and community actions

While agricultural growth will, in itself, provide the base for increasing incomes, for the 170 million or so rural persons that are below the poverty line, additional measures are required to make this growth inclusive. For instance, a rural livelihoods program that empowers communities to become self-reliant has been found to be particularly effective and well-suited for scaling-up. This program promotes the formation of self-help groups, increases community savings, and promotes local initiatives to increase incomes and employment. By federating to become larger entities, these institutions of the poor gain the strength to negotiate better prices and market access for their products, and also gain the political power over local governments to provide them with better technical and social services. These self-help groups are particularly effective at reaching women and impoverished families.

3. Sustaining the environment and future agricultural productivity

In parts of India, the over-pumping of water for agricultural use is leading to falling groundwater levels. Conversely, water-logging is leading to the build-up of salts in the soils of some irrigated areas. In rain-fed areas on the other hand, where the majority of the rural population live, agricultural practices need adapting to reduce soil erosion and increase the absorption of rainfall. Overexploited and degrading forest land need mitigation measures. There are proven solutions to nearly all of these problems. The most comprehensive is through watershed management programs, where communities engage in land planning and adopt agricultural practices that protect soils, increase water absorption and raise productivity through higher yields and crop diversification. At issue, however, is how to scale up such initiatives to cover larger areas of the country. Climate change must also be considered. More extreme events – droughts, floods, erratic rains – are expected and would have greatest impact in rain-fed areas. The watershed program, allied with initiatives from agricultural research and extension, may be the most suited agricultural program for promoting new varieties of crops and improved farm practices. But other thrusts, such as the livelihoods program and development of off-farm employment may also be key.

World Bank Support

With some $5.5 billion in net commitments from both IDA and IBRD, and 24 ongoing projects, the World Bank's agriculture and rural development program in India is by far the Bank's largest such program worldwide in absolute dollar terms. This figure is even higher when investments in rural development such as rural roads, rural finance and human development are included. Nonetheless, this amount is relatively small when compared with the Government's - both central and state - funding of public programs in support of agriculture. Most of the Bank's agriculture and rural development assistance is geared towards state-level support, but some also takes place at the national level.

The Bank's Agricultural and Rural Development portfolio is clustered across three broad themes with each project, generally, showing a significant integration of these themes.

Agriculture, watershed and natural resources management

Water & irrigated agriculture

Rural livelihood development

Over the past five to ten years, the Bank has been supporting:

R&D in Agricultural Technology through two national level projects with pan-India implementation (the National Agriculture Technology Project and the National Agriculture Innovation Project) coordinated by the Government of India's Indian Council for Agricultural Research (ICAR).

Dissemination of Agricultural Technology: New approaches towards the dissemination of agricultural technology such as the Agriculture Technology Management Agency (ATMA) model have contributed to diversification of agricultural production in Assam and Uttar Pradesh. This extension approach is now being scaled-up across India.

Better delivery of irrigation water: World Bank support for the better delivery of irrigation water ranges from projects covering large irrigation infrastructure to local tanks and ponds. Projects also support the strengthening of water institutions in several states (Andhra Pradesh, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh) improved groundwater management practices (for instance, in the upcoming Rajasthan Agriculture Competitiveness Project).

Sustainable agricultural practices through watershed and rainfed agriculture development (Karnataka, Himachal Pradesh, Uttarakhand), soil reclamation efforts (Uttar Pradesh) and, more recently, improved groundwater management practices (for instance, in the upcoming Rajasthan Agriculture Competitiveness Project).

Improved access to rural credit and greater gender involvement in rural economic activities through rural livelihood initiatives undertaken by a number of states (Andhra Pradesh, Bihar, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu) and soon to be scaled up by GOI with Bank support through a National Rural Livelihood Mission.

Agricultural insurance by advising GOI on how to improve the actuarial design and implementation of the insurance program (e.g. rating methodology and product design, index insurance, use of mobile and remote sensing technology to measure yields, etc.).

Improved farmer access to agriculture markets through policy reforms and investments under the Maharashtra Agricultural Competitiveness Project which aims to reform regulated wholesale markets and provide farmers with alternative market opportunities.

The land policy agenda through analytical work as well as non-lending technical assistance in support of GOI's National Land Records Modernization Program.

Better rural connectivity through IDA support to the Prime Minister's National Rural Roads Program (PMGSY), and by connecting rural poor and smallholder farmers through collective action to public services through Self-Help Groups (and SHG federations), Water User Associations and Farmer Producer Organizations. Recently the Bank's Board of Executive Directors approved the National Rural Livelihood Mission, which supports SHG approaches through a pan-India approach.

LAND OWNERSHIP

Problems in implementation of land reforms

Weaknesses with the zamindari abolition

The absence of adequate land records made implementation of these acts difficult.

Personal cultivation: 'Personal cultivation' was very loosely defined which led to not only those who tilled the soil, but also those who supervised the land personally or did so through a relative, or provided capital and credit to the land, to call themselves a cultivator.

Moreover, in states like Uttar Pradesh, Bihar and Madras there was no limit on the size of the lands that could be declared to be under the 'personal cultivation' of the zamindar

Zamindars resorted to large-scale eviction of tenants, mainly the less secure small tenants.

Even after the laws were enacted the landlords used the judicial system to defer the implementation of the laws.

Zamindars refused to hand over the land records in their possession, forcing the government to go through the lengthy procedure of reconstructing the records.

Implementation of the law was made difficult with the collusion between the landlords and lower-level revenue officials.

Weaknesses of tenancy reforms

The provisions introduced to protect the small landowners were misused by the larger landlords with the active connivance of the revenue officials.

The inordinate delays in enacting and implementing the legislations

Voluntary surrenders by tenants also took place as they were 'persuaded' under threat to give up their tenancy rights 'voluntarily'.

No tenancy rights to sharecroppers.

Most tenancies were oral and informal and were not recorded.

Providing security of tenure to all tenants, met with only limited success.

The Green Revolution which started in some parts of India in the late 1960s aggravated the problems, with land values and rentals rising further.

The acquisition of ownership rights by tenants was achieved only partially.

Even today 5% farmers hold 32% of land holdings.

The right of resumption and the loose definition of ‘personal cultivation’ was used for eviction of tenants on a massive scale.

Voluntary surrenders by tenants also took place as they were ‘persuaded’ under threat to give up their tenancy rights ‘voluntarily’.

In West Bengal sharecroppers, known as Bargadars received no protection till as late as July 1970, when the West Bengal Land Reforms Act was amended to accord limited protection to them.

Most tenancies were oral and informal and were not recorded.

Providing security of tenure to all tenants, met with only limited success. There were still large numbers who remained unprotected. So reducing rents to a ‘fair’ level was almost impossible to achieve

Weaknesses in Land Ceiling Legislation

Post-independence India had more than 70 per cent of landholdings in India under 5 acres so the ceiling fixed on existing holdings by the states were very high.

In most states the ceilings were imposed on individual and not family holdings, enabling landowners to divide up their holdings in the names of relatives or make Benami transfers merely to avoid the ceiling.

Further, in many states the ceiling could be raised if the size of the family of the landholder exceeded five.

A large number of exemptions to the ceiling limits were permitted by most states following the Second Plan recommendations that certain categories of land could be exempted from ceilings.

Digitization of land records failed

Insufficient data: Lack of clear and sufficient data and mismanagement between the various agencies handling land records, the data registered at various government levels is not identical.

Progress over the past decade has been uneven, with some states, such as Madhya Pradesh, Andhra Pradesh, Telangana, Chhattisgarh, Tamil Nadu and Maharashtra, doing better than the others. However, there are challenges, even in advanced states such as Maharashtra.

New digitized land records do a good job in reflecting ownership of land, but less so when it comes to recording encumbrances and area of land parcels.

Weaknesses of consolidation of land holdings

The programme failed to achieve its desired objective because the farmers are reluctant to exchange their lands for the new one.

The arguments given by the farmers is that their existing land is much more fertile and productive than the new land provided under land consolidation.

The farmers also complained about nepotism and corruption in the process of consolidation.

The farmers complained that the rich and influential often bribes and manage to get fertile and well-situated land, whereas the poor farmers get unfertile land.

Failure of cooperative farming:

Attachment with Land: **The farmers are not willing to surrender the rights of land in favour of the society because they have too much attachment with it.**

Lack of Cooperative Spirit: **The spirit of cooperation and love is lacking among farmers. They are divided in various sections on caste basis.**

Illiteracy: **some of them are using the old methods of cultivation.**

Lack of Capital: **The co-operative farming societies are also facing the capital shortage problem and these are unable to meet the growing needs of agriculture. Credit facilities to these societies are also not sufficient.**

Re-Payment of Debt: **Sometimes debt is not re-paid in time which creates many problems for the financial institutions. Some members do not realize their responsibility and it becomes the cause of failure.**

1. Small and fragmented land-holdings:

The seemingly abundance of net sown area of 141.2 million hectares and total cropped area of 189.7 million hectares (1999-2000) pales into insignificance when we see that it is divided into economically unviable small and scattered holdings.

The average size of holdings was 2.28 hectares in 1970-71 which was reduced to 1.82 hectares in 1980-81 and 1.50 hectares in 1995-96. The size of the holdings will further decrease with the infinite Sub-division of the land holdings.

The problem of small and fragmented holdings is more serious in densely populated and intensively cultivated states like Kerala, West Bengal, Bihar and eastern part of Uttar Pradesh where the average size of land holdings is less than one hectare and in certain parts it is less than even 0.5 hectare.

Rajasthan with vast sandy stretches and Nagaland with the prevailing 'Jhoom' (shifting agriculture) have larger average sized holdings of 4 and 7.15 hectares respectively. States having high percentage of net sown area like Punjab, Haryana, Maharashtra, Gujarat, Karnataka and Madhya Pradesh have holding size above the national average

Further it is shocking to note that a large proportion of 59 per cent holdings in 1990- 91 were marginal (below 1 hectare) accounting for 14.9 per cent of the total operated area. Another 19 per cent were small holdings (1-2 hectare) taking up 17.3 per cent of the total operated area.

Large holdings (above 10 hectare) accounted for only 1.6 per cent of total holdings but covered 17.4 per cent of the operated area (Table 22.1). Hence, there is a wide gap between small farmers, medium farmers (peasant group) and big farmers (landlords).

The main reason for this sad state of affairs is our inheritance laws. The land belonging to the father is equally distributed among his sons. This distribution of land does not entail a collection or consolidated one, but its nature is fragmented.

Different tracts have different levels of fertility and are to be distributed accordingly. If there are four tracts which are to be distributed between two sons, both the sons will get smaller plots of each land tract. In this way the holdings become smaller and more fragmented with each passing generation.

Sub-division and fragmentation of the holdings is one of the main causes of our low agricultural productivity and backward state of our agriculture. A lot of time and labour is wasted in moving seeds, manure, implements and cattle from one piece of land to another.

Irrigation becomes difficult on such small and fragmented fields. Further, a lot of fertile agricultural land is wasted in providing boundaries. Under such circumstances, the farmer cannot concentrate on improvement.

The only answer to this ticklish problem is the consolidation of holdings which means the reallocation of holdings which are fragmented, the creation of farms which comprise only one or a few parcels in place of multitude of patches formerly in the possession of each peasant.

But unfortunately, this plan has not succeeded much. Although legislation for consolidation of holdings has been enacted by almost all the states, it has been implemented only in Punjab, Haryana and in some parts of Uttar Pradesh.

Consolidation of about 45 million holdings has been done till 1990-91 in Punjab, Haryana and western Uttar Pradesh. The other solution to this problem is cooperative farming in which the farmers pool their resources and share the profit.

Solution

The only solution to this vexing issue is the consolidation of holdings, which entails the redistribution of scattered holdings and the establishment of farms made up of just one or a few parcels as opposed to the several patches that were previously in each peasant's hands. But regrettably, this strategy has not had much success. Up until 1990–1991, there had been a consolidation of roughly 45 million farm holdings. Cooperative farming, in which the farmers combine their resources and divide the profits, is an alternative solution to this issue.

Instability

1. Introduction

Agriculture is an important part of Indian economy. It provides source of livelihood for around 70 per cent of the population. It contributes to 18 per cent of Gross Domestic Product of the economy. It is an important source of raw material for many agro-based industries. India's geographical condition is unique for agriculture because it provides many favourable conditions. There are plain areas, fertile soil, long growing season and wide variation in climatic condition etc. Also, India has been making sincere efforts by using science and technology to increase production. Gross Value Added by agriculture, forestry and fishing is estimated at Rs 17.67 trillion (US$ 274.73 billion) in financial year 2018. Indian agriculture is dominated by the cultivation of food grains which occupy 76% of the total cropped area and account for 80% of the total agricultural production of the country. These cereals include rice, wheat, millet, gram, maize and pulses which are grown to meet the food requirements of India's vast population. Agriculture is considered as backbone of the economy. This is because it contributes to economic development in at least four ways: product contribution i.e. making available food and raw materials; market contribution i.e. providing market for goods produced by other sectors; factor contribution i.e. making available labour and capital to the non-agricultural sector and it also leads to foreign exchange earnings from the export of agricultural items. Indian agriculture is mostly dependent on rainfall whose variability in time and place has adverse effect on agricultural output. It is really a matter of concern that despite five decades of constant endeavour only 41.2% of the total cropped area has been brought under irrigation. Rest is at the mercy of rain-god. That is why when rain fails agricultural production is badly affected, scarcity prevails and prices reach sky high. If the entire agricultural area is brought under irrigation agricultural production may be easily doubled. Agriculture growth and instability has remained subject of intense debate in the agricultural economics literature in India. While the need for increasing agricultural production or growth is obvious, the increase in instability in agricultural production is considered adverse for several reasons. It raises the risk involved in farm production and affects farmers' income and decisions to adopt high paying technologies and make investments in farming. Instability in production affects price stability and the consumers, and it increases vulnerability of low income households to market. Instability in agricultural and food production is also important for food management and macroeconomic stability (Chand and Raju, 2009) [11] . Instability in agricultural production is on the rise due to several factors such as erratic rainfall pattern, low irrigation coverage, and increase in frequency and severity of natural disasters. Instability is a very essential characteristic of agriculture. Since agriculture is dependent on weather conditions, the area, production and yield of the crops are subject to significant variations over time. This study aims at studying the growth and instability in eight principal crops of India. These crops are selected because they are of utmost importance for the country.

Rice

Rice production in India is an important part of the national economy. India is the world's 2nd largest producer with approximately 43 Mio Ha planted area, accounting for 22% of the world's rice production. Rice is a basic food crop and being a tropical plant, it flourishes in hot and humid climate. It is grown in assured irrigated areas and in rain fed areas that receive assured annual rainfall. Hence, it can be grown in both Kharif & Rabi seasons.

Wheat

After rice, wheat is the second most important food-crop grown in India and it is the staple diet for millions of Indians, mainly in the north and north-western parts of the country. Wheat is the main source of protein, carbohydrate and vitamin for people in the rural areas. India is the fourth largest producer of wheat in the world after Russia, the USA and China and accounts for 8.7 per cent of the world's total production of wheat.

Maize

Maize is one of the most crucial cereals produced in different parts of the world under diverse climatic and ecological conditions. Due to its increasing importance, maize has become a major staple and cash crop for smallholder farmers around the developing world. In India, maize is emerging as the third most important crop, after rice and wheat. Maize was traditionally grown as staple food, primarily for household consumption, but its demand for feed and industrial uses has increased rapidly in the recent past. Sugarcane Sugarcane is an important commercial crop of the country occupying around 3.8 million hectares of land with an annual cane production of around 270 million tonnes. That is, it occupies about 2.8% of the cultivated land area and contributes about 7.5 % to the agricultural production in the country. There are 35 million farmers growing sugarcane and another 50 million depend on employment generated by the 571 sugar factories and other related industries using sugar. Pulses Pulses are a very important crop for India. They are an important source of protein, grow quickly, generate good profits for farmers, and contribute to agricultural and environmental sustainability. It is second important constituent of Indian diet after cereals. India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20 per cent of the area under foodgrains and contribute around 7-10 per cent of the total foodgrains production in the country. Cotton Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40 -50 million people are employed in cotton trade and its processing. Oilseeds India is one of the largest producers of oilseeds in the world and occupies an important position in the Indian agricultural economy. It is estimated that nine oilseeds namely groundnut, rapeseed-mustard, soybean, sunflower, safflower, sesame, niger, castor and linseed, accounted for an area of 23.44 million hectares with the production of 25.14 million tonnes.

Fruits

Fruit growing is one of the important and age old practices, practiced in India since ancient times. India is the largest producer of Fruits in the world and is known as fruit basket of world. India is also a major exporter of fruits to the world. The country has exported 326515.56 MT of fresh fruits other than Grapes and Mango to the world for the worth of Rs. 1573.26 crores/ 244.15 USD Millions during the year 2017-18.

1. **Market volatility & price fluctuations**: Farmers in India often face price volatility due to lack of effective market linkages, intermediaries and price information. This leaves them vulnerable to price exploitation and uncertain returns on their investments.

2. **Climate change & natural disasters**: Increasingly unpredictable weather patterns, climate change and occurrences of natural disasters—such as floods, cyclones and droughts—pose significant challenges to the country's agriculture industry. These events can lead to crop losses, livestock mortality and increased vulnerability for farmers.

Solution

Indian agriculture is confronted with high price volatility, climate risks, and indebtedness. Since the majority of farmers—86 percent—are small and marginal with declining and fragmenting landholdings, these uncertainties make them even more vulnerable and risk-prone. The Indian government's last two budgets were pro-agriculture: More resources were allocated to agriculture and a number of programs were initiated to increase irrigated area, improve soil health, promote agro-processing, and cover production risk, among many others. Nevertheless, it appears that agrarian distress is silently spreading across all the states. It seems that all these programs and schemes are disjointed and function independently of each other. India needs a five-point program that addresses agrarian challenges and brings together various ongoing programs under one umbrella:

Increasing incomes. Agricultural transformation is very slow in India. Therefore, the process of generating higher income from agriculture is also slow. Production increase was the main objective than raising incomes. It is welcoming that Prime Minister Narendra Modi proposes doubling the income of farmer —a paradigm shift. This will require several things: An aggressive push to improve technologies by strengthening the seed sector and knowledge dissemination system; agricultural diversification in favor of high value commodities and the development of value chains by linking production and marketing centres; and finally, developing mechanisms to ensure minimum support prices in the event of crash in farm harvest prices. Success will depend on how farmers are aggregated for production and marketing through promotion of contract farming, cluster farming, farmer producer organizations and self-help groups.

Generating employment opportunities. The situation assessment of India reported that more than 40 percent of farmers would like to quit agriculture if alternative opportunities were available. Agriculture is becoming crowded and does not provide regular employment opportunities. In the absence of regular employment in rural areas, the rural population, especially youth, is migrating to urban areas to explore better opportunities and income. By 2020, people aged 15-34 will make up 34 percent of India's population; currently, more than 70 percent of India's youth lives in rural areas. Their energy and enthusiasm need to be tapped in ways that meet their aspirations and transform agriculture and rural economies. But agriculture *per se* will not be able absorb the growing number of youths in rural areas. Incentives should be provided in these areas: Aggregating raw and processed products (one example: lijjat papad , which employs more than 43,000 women); self-employment in agro-processing, agro-advisory, agriculture and rural transport, etc.; private sector engagement in custom-hire services, secondary and tertiary processing; location-specific non-farm employment in micro, small and medium enterprises, linked with the large manufacturing sector; and engagement in government programs, schools, and agriculture extension.

Reducing risks in agriculture. The risks farmers face has been increasing for years. Both production and price risks are creating ongoing agrarian distress. The incidences of droughts, floods, temperature fluctuations, and unseasonal rains and hailstorms are increasing and adversely affecting agricultural production. But even during normal years, farm harvest prices have fallen steeply, badly affecting farmer incomes. The prime minister's national agriculture insurance scheme is now in place to cover some production losses. Though this scheme is good, the compensation is insufficient and does not cover the risk of falling prices. The government should consider launching a "Prime Minister's Climate Resilience Scheme" that covers both production and price risks. Such an approach could bundle promotion of climate-smart agriculture with value added weather advisory services and effective implementation of agricultural insurance, helping to ensure minimum support prices.

Developing agri-infrastructure. Agri-infrastructure—including agricultural markets, cold storage, warehouses, and agro-processing—has not developed in corresponding speed with rising agricultural production. The pace of agri-infrastructure is far behind what it is needed to improve the overall agri-food system. In the past, more focus was given to the production of agricultural commodities. In the absence of adequate agri-infrastructure, the supply chains of agri-food commodities are in the hands of an unorganized, fragmented, and inefficient sector. A better-organized private sector is emerging slowly due to the lack of commercial viability to develop agri-infrastructure. The role of public-private partnerships (PPP) is immense in developing agri-infrastructure for high economic and social gains. The government should form a commission to develop modalities and proposals for public-private partnerships in the agri-infrastructure sector. Many lessons can be learned from PPP's excellent track record in the construction of national highways, the building and functioning of airports, the distribution of power, and other areas. These can be applied in developing rural agri-markets, cold storage, agro-processing, surface irrigation, and agricultural extension, and other elements of agri-infrastrucure. The central government should contribute to the efforts of individual states to develop such viable PPP projects.

Improving quality of rural life. Rural India is still missing basic amenities (including sanitation, hygiene, drinking water, drainage, schooling, and health centers). Three years ago, the prime minister encouraged each member of parliament and the state assemblies to adopt one village and work to transform it into a model village. The main objective was to provide all basic facilities to improve the quality of life in rural areas. The late former President A. P. J. Abdul Kalam originated a similar concept, provision of urban amenities to rural areas (PURA), with the aim of providing urban infrastructure and services in rural hubs to create economic opportunities. The scheme should be revived to improve the quality of life in rural areas. In addition, the several programs and schemes that exist to build social and economic infrastructure should be united for larger impact.

It is high time to revive India's agriculture sector and improve purchasing power at the bottom of the and implementing programs under one umbrella.pyramid to accelerate overall economic growth. This can only be done by focusing on key areas and implementing programs under one umbrella.

Land tenure

Land tenure is the relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. (For convenience, "land" is used here to include other natural resources such as water and trees.) Land tenure is an institution, i.e., rules invented by societies to regulate behaviour. Rules of tenure define how property rights to land are to be allocated within societies. They define how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints. In simple terms, land tenure systems determine who can use what resources for how long, and under what conditions.

Land tenure is an important part of social, political and economic structures. It is multi-dimensional, bringing into play social, technical, economic, institutional, legal and political aspects that are often ignored but must be taken into account. Land tenure relationships may be well-defined and enforceable in a formal court of law or through customary structures in a community. Alternatively, they may be relatively poorly defined with ambiguities open to exploitation.

Land tenure thus constitutes a web of intersecting interests. These include:

Overriding interests: when a sovereign power (e.g., a nation or community has the powers to allocate or reallocate land through expropriation, etc.)

Overlapping interests: when several parties are allocated different rights to the same parcel of land (e.g., one party may have lease rights, another may have a right of way, etc.)

Complementary interests: when different parties share the same interest in the same parcel of land (e.g., when members of a community share common rights to grazing land, etc.)

Competing interests: when different parties contest the same interests in the same parcel (e.g., when two parties independently claim rights to exclusive use of a parcel of agricultural land. Land disputes arise from competing claims.)

Land tenure is often categorized as:

Private: the assignment of rights to a private party who may be an individual, a married couple, a group of people, or a corporate body such as a commercial entity or non-profit organization. For example, within a community, individual families may have exclusive rights to residential parcels, agricultural parcels and certain trees. Other members of the community can be excluded from using these resources without the consent of those who hold the rights.

Communal: a right of commons may exist within a community where each member has a right to use independently the holdings of the community. For example, members of a community may have the right to graze cattle on a common pasture.

Open access: specific rights are not assigned to anyone and no-one can be excluded. This typically includes marine tenure where access to the high seas is generally open to anyone; it may include rangelands, forests, etc, where there may be free access to the resources for all. (An important difference between open access and communal systems is that under communal system non-members of the community are excluded from using the common areas.)

State: property rights are assigned to some authority in the public sector. For example, in some countries, forest lands may fall under the mandate of the state, whether at a central or decentralised level of government.

In practice, most forms of holdings may be found within a given society, for example, common grazing rights, private residential and agricultural holdings, and state ownership of forests. Customary tenure typically includes communal rights to pastures and exclusive private rights to agricultural and residential parcels. In some countries, formally recognized rights to such customary lands are vested in the nation state or the President "in trust" for the citizens.

The right that a person has in an object such as land may be considered as property. The range of property is extensive and includes, for example, intellectual property. In the case of land tenure, it is sometimes described more precisely as property rights to land. A distinction is often made between "real property" or "immovable property" on the one hand, and "personal property" or "movable property" on the other hand. In the first case, property would include land and fixtures (buildings, trees, etc) that would be regarded as immovable. In the second case, property would include objects not considered fixed to the land, such as cattle, etc.

In practice, multiple rights can be held by several different persons or groups. This has given rise to the concept of "a bundle of rights". Different rights to the same parcel of land, such as the right to sell the land, the right to use the land through a lease, or the right to travel across the land, may be pictured as "sticks in the bundle". Each right may be held by a different party. The bundle of rights, for example, may be shared between the owner and a tenant to create a leasing or sharecropping arrangement allowing the tenant or sharecropper the right to use the land on specified terms and conditions. Tenancies may range from formal leaseholds of 999 years to informal seasonal agreements. If the farm is mortgaged, the creditor may hold a right from the "bundle" to recover the unpaid loan through a sale of the mortgaged property in the case of default. A neighbouring farmer may have the right from the "bundle" to drive cattle across the land to obtain water at the river. Box 1 gives some examples of rights.

EXAMPLES OF RIGHTS

A right to use the land.

A right to exclude unauthorized people from using the land.

A right to control how land will be used.

A right to derive income from the land.

A right to protection from illegal expropriation of the land.

A right to transmit the rights to the land to one's successors, (i.e., a right held by descendents to inherit the land).

A right to alienate all rights to the entire holding (e.g., through sale), or to a portion of the holding (e.g., by subdividing it).

A right to alienate only a portion of the rights, e.g., through a lease.

A residuary right to the land, i.e., when partially alienated rights lapse (such as when a lease expires), those rights revert to the person who alienated them.

A right to enjoy the property rights for an indeterminate length of time, i.e., rights might not terminate at a specific date but can last in perpetuity.

A duty not to use the land in a way that is harmful to other members of society, (i.e., the right is held by those who do not hold the right to use the land).

A duty to surrender the rights to the land when they are taken away through a lawful action, (e.g., in a case of insolvency where the right is held by the creditors, or in the case of default on tax payments where the right is held by the state).

At times it may be useful to simplify the representation of property rights by identifying:

use rights: rights to use the land for grazing, growing subsistence crops, gathering minor forestry products, etc.

control rights: rights to make decisions how the land should be used including deciding what crops should be planted, and to benefit financially from the sale of crops, etc.

transfer rights: right to sell or mortgage the land, to convey the land to others through intra-community reallocations, to transmit the land to heirs through inheritance, and to reallocate use and control rights.

Very often, the poor in a community have only use rights. A woman, for example, may have the right to use some land to grow crops to feed the family, while her husband may collect the profits from selling any crops at the market. While such simplifications can be useful, it should be noted that the exact manner in which rights to land are actually distributed and enjoyed can be very complex.

In broad terms, land tenure rights are often classified according to whether they are "formal" or "informal". There can be perceptual problems with this approach because, for example, some so-called informal rights may, in practice, be quite formal and secure in their own context. Despite these perceptual problems, the classification of formal and informal tenure can sometimes provide the basis for useful analysis.

Formal property rights may be regarded as those that are explicitly acknowledged by the state and which may be protected using legal means.

Informal property rights are those that lack official recognition and protection. In some cases, informal property rights are illegal, i.e., held in direct violation of the law. An extreme case is when squatters occupy a site in contravention of an eviction notice. In many countries, illegal property holdings arise because of inappropriate laws. For example, the minimum size of a farm may be defined by law whereas in practice farms may be much smaller as a result of informal subdivisions among heirs. Property rights may also be illegal because of their use, e.g., the illegal conversion of agricultural land for urban purposes.

In other cases, property may be "extra-legal", i.e., not against the law, but not recognized by the law. In some countries, customary property held in rural indigenous communities falls into this category. A distinction often made is between statutory rights or "formally recognized rights" on the one hand and customary rights or "traditional rights" on the other hand. This distinction is now becoming blurred in a number of countries, particularly in Africa, which provide formal legal recognition to customary rights.

Formal and informal rights may exist in the same holding. For example, in a country that forbids leasing or sharecropping, a person who holds legally recognized ownership rights to a parcel may illegally lease out the land to someone who is landless.

These various forms of tenure can create a complex pattern of rights and other interests. A particularly complex situation arises when statutory rights are granted in a way that does not take into account existing customary rights (e.g., for agriculture and grazing). This clash of de jure rights (existing because of the formal law) and de facto rights (existing in reality) often occurs in already stressed marginal rainfed agriculture and pasture lands. Likewise in conflict and post-conflict areas, encounters between settled and displaced populations lead to great uncertainties as to who has, or should have, the control over which rights.

The layers of complexity and potential conflict are likely to be compounded, particularly where, for example, state ownership is statutorily declared and state grants or leases have been made without consultation with customary owners (who are not considered illegal), and where squatters move illegally onto the land.

Land administration

Land administration is the way in which the rules of land tenure are applied and made operational. Land administration, whether formal or informal, comprises an extensive range of systems and processes to administer:

land rights: the allocation of rights in land; the delimitation of boundaries of parcels for which the rights are allocated; the transfer from one party to another through sale, lease, loan, gift or inheritance; and the adjudication of doubts and disputes regarding rights and parcel boundaries.

land-use regulation: land-use planning and enforcement and the adjudication of land use conflicts.

land valuation and taxation: the gathering of revenues through forms of land valuation and taxation, and the adjudication of land valuation and taxation disputes.

Information on land, people, and their rights is fundamental to effective land administration since rights to land do not exist in a physical form and they have to be represented in some way. In a formal legal setting, information on rights, whether held by individuals, families, communities, the state, or commercial and other organizations, is often recorded in some form of land registration and cadastre system. In a customary tenure environment, information may be held, unwritten, within a community through collective memory and the use of witnesses. In a number of communities, those holding informal rights may have "informal proofs" of rights, i.e., documents accepted by the community but not by the formal state administration.

An enforcement or protection component is essential to effective land administration since rights to land are valuable when claims to them can be enforced. Such a component allows a person's recognized rights to be protected against the acts of others. This protection may come from the state or the community through social consensus as described below in the section on "Tenure Security". A stable land tenure regime is one in which the results of protective actions are relatively easy to forecast. In a formal legal setting, rights may be enforced through the system of courts, tribunals, etc. In a customary tenure environment, rights may be enforced through customary leaders. In both cases, people may be induced to recognise the rights of others through informal mechanisms such as community pressures. People who know their rights, and know what to do if those rights are infringed, are more able to protect their rights than those who are less knowledgeable.

Land administration is implemented through sets of procedures to manage information on rights and their protection, such as:

Procedures for land rights include defining how rights can be transferred from one party to another through sale, lease, loan, gift and inheritance.

Procedures for land use regulation include defining the way in which land use controls are to be planned and enforced.

Procedures for land valuation and taxation include defining methodologies for valuing and taxing land.

Efficient procedures allow transactions to be completed quickly, inexpensively, and transparently. However, in many parts of the world, formal land administration procedures are time-consuming, bureaucratically cumbersome and expensive, and are frequently non-transparent, inaccessible to much of the rural population, and are handled in languages and forms that people do not understand. In such cases, high transaction costs may result in transfers and other dealings taking place off-the-record or informally.

Finally, land administration requires actors to implement the procedures. In customary tenure regimes, the customary leaders may play the principal role in land administration, for example in allocating rights and resolving disputes. In a more formal setting, land administration agencies may include land registries, land surveying, urban and rural planning, and land valuation and taxation, as well as the court systems. Where customary tenure has been recognised by the State, functional linkages are being developed between government and customary land administration bodies.

Formalization of the administration of land rights has been promoted as a pre-requisite for economic development. Perceived benefits include increased tenure security and improved access to credit, thereby providing the incentive and ability for farmers to invest in making improvements to the land. Formal administration is also proposed as a means to facilitate a land market, allowing land to move towards its “highest and best use”.

These claims are disputed by others who argue that too often, the flawed design and implementation of projects to formalise property rights have resulted in a reduction of security by concentrating rights to a parcel in the hands of an individual, and neglecting the claims of others, particularly women and other vulnerable groups, who hold partial or common rights. Similarly, it is argued by some that access to credit may not improve with formalisation since many banks are unlikely to accept agricultural land as collateral against loans.

As a result, it has been suggested that formal registration of individual property rights should be considered only in areas of high population density, where customary tenure systems and dispute resolution systems are weak or absent, or where there have been other major disruptions to customary land holdings. However, even where these conditions do not exist, there is growing interest in several countries to formalise the rights of communities to protect them against encroachment from outsiders (e.g., commercial farming operations and even the State). In such cases, the community boundaries are defined, and title to the land is registered in the name of the community. It is then left to the community to undertake its own land administration, including the allocation of rights to land within its boundaries.

In many countries, formal and informal land administration co-exist when legal records do not replace customary rights, or when newly created informal rights come into existence. Tensions can exist between de jure and de facto rights to land. Discrepancies between formal and informal or customary versions of tenure holdings create ambiguities to be exploited. In some countries where formal land administration systems do not function well, different titles may be issued by the State for the same parcel of land. This complicates the legal status of the land since it gives rise to competing claims. The mere act of establishing and documenting land boundaries and titles is not enough; it has to be done in a way that does not make the situation worse. The role of local communities in investigating claims is crucial as they have the knowledge of the local tenure arrangements.

Access to land

Access to land for the rural poor is often based on custom. Customary rights to land in indigenous societies, for example, are usually created following their traditions and through the ways in which community leaders assign land use rights to the community members. These rights of access may have their origin in the use of the land over a long period. They are often rights developed by ancestral occupation and by the use of land by ancestral societies. In such cases, it is through the act of original clearance of the land and settlement by ancestors that rights are claimed.

People also use a wide range of strategies to gain access to land. These include:

Purchase, often using capital accumulated while working as migrants in urban areas.

Adverse possession or prescription (the acquisition of rights through possession for a prescribed period of time). In some countries, this may be the only method for small farmers to gain formal access to vacant or abandoned land and to bring it into productive use.

Leasing, or gaining access to land by paying rent to the owner.

Sharecropping, or gaining access to land in return for paying the owner a percentage of the production.

Inheritance, or gaining access to land as an heir.

Squatting illegally on land.

In addition to such individual strategies, access to land can be provided systematically through land reform interventions by national governments, often as a result of policies to correct historic injustices and to distribute land more equitably. Such land reforms usually occur in situations where much of the land is owned by a relatively small number of land owners and the land is idle or under-utilised (although it should be noted that determining whether land is under-utilised depends on the criteria selected for the assessment). In some countries, land restitution has been an important type of land reform. Other land reform interventions include land redistribution programmes which aim at providing the rural poor with access to land and promoting efficiency and investment in agriculture. These programmes are often, but not always, accompanied by provision of subsidised agricultural services such as extension and credit. In some cases, the state has provided access to idle or under-utilised public land but most often private land holdings have been the source of land for resettlement purposes.

In imposed redistributive land reforms, land is taken from large land holders by the State and transferred to landless and land-poor farmers. Compensation has been paid to the original owners in some reforms but not in others. In some cases, the reforms have benefitted the tenants who worked the land. Such reforms change the structure of land ownership by transforming tenants into owners but do not change the operational holdings. In other cases, the reforms have involved the resettlement of beneficiaries on the expropriated lands and the creation of new farming operations.

Some recent land reform initiatives have been designed so that beneficiaries negotiate with land owners to purchase land using funds provided by the State in the form of grants and/or loans. Beneficiaries are usually required to form a group which identifies suitable land, negotiates the purchase from the seller, formulates a project eligible for state grants and/or credit, and determines how the land will be allocated among the members of the group and what their corresponding payment obligations will be.

While there is broad consensus that land reform plays an important role in rural development where land concentration is high, great controversy surrounds the choice of mechanisms to transfer land from large land owners to the landless and land poor. However, this debate is well beyond the scope of this guide to address.

Tenure security

Security of tenure is the certainty that a person's rights to land will be recognized by others and protected in cases of specific challenges. People with insecure tenure face the risk that their rights to land will be threatened by competing claims, and even lost as a result of eviction. Without security of tenure, households are significantly impaired in their ability to secure sufficient food and to enjoy sustainable rural livelihoods.

Security of tenure cannot be measured directly and, to a large extent, it is what people perceive it to be. The attributes of security of tenure may change from context to context. For example, a person may have a right to use a parcel of land for a 6 month growing season, and if that person is safe from eviction during the season, the tenure is secure. By extension, tenure security can relate to the length of tenure, in the context of the time needed to recover the cost of investment. Thus the person with use rights for 6 months will not plant trees, or invest in irrigation works or take measures to prevent soil erosion as the time is too short for that person to benefit from the investment. The tenure is insecure for long-term investments even if it is secure for short-term ones.

The importance of long-term security has led some to argue that full security can arise only when there is full private ownership (e.g., freehold) as, under such tenure, the time for which the rights can be held is not limited to a fixed period. It is argued that only an owner enjoys secure rights, and holders of lesser rights, such as tenants, have insecure tenure because they are dependent on the will of the owner. It is then implied that security of tenure comes only with holding transfer rights such as the rights to sell and mortgage. Equating security with transfer rights to sell and mortgage is true for some parts of the world but it is not true in many others. People in parts of the world where there are strong community-based tenure regimes may enjoy tenure security without wishing to sell their land, or without having the right to do so, or having strictly limited rights to transfer (e.g., transfers may be limited to heirs through inheritance, or sales may be restricted to members of the community).

The sources of security may also vary from context to context:

An important source is the community and its specific groups such as local farmers' organizations and water users' associations. When neighbours recognise and enforce a person's rights, that person's security increases. In many customary tenure arrangements, people gain property rights through membership of social communities. Maintaining property rights validates membership in the group just as much as membership facilitates the acquisition and safeguarding of property rights.

Governments represent another source of security as they may provide political recognition of some rights. For example, a government may accept the illegal encroachment and settlement of a community on state forest lands and undertake not to evict it. However, in doing so, a government usually recognises the right of the community to occupy the land, but does not go as far as recognising the rights of individual people within the community.

Another source may be the administrative state and the formal legal system. The state may provide security in general by affirming the rights that people hold as well as through specific measures such as providing protection against trespass. Security is often seen to come from protections provided through land registration and cadastral systems, with adjudication of disputes taking place in the formal court system.

In some countries, security can also be provided by coercive structures such as "warlords" that emerge in the absence of an effective state during periods of civil unrest. Of course, this is not a desirable source of security as these structures may in turn prevent the development of strong communities and legal systems necessary for good governance.

The total security enjoyed by a person is the cumulative security provided by all sources. In many cases, increasing security from one or more sources will result in an increase in total security. In many development projects, providing or improving legal security is considered the most important way of increasing security of tenure. Examples of land tenure reforms include the upgrading of informal rights to legally enforceable rights; the upgrading of state-issued permits to leases that provide greater protection to the land users; the introduction of provisions for communities to become the legal owners of their traditional land holdings instead of the rights being vested in the State; and better definition of property rights through improvements to formal land administration systems.

A person's security of tenure may be threatened in many ways. Ironically, attempts to increase the legal security of some may result in others losing their rights. For example, titling and registration projects, if poorly designed, can reduce security of many rural residents by failing to recognise certain rights, often held by women and the poor, and allowing them to be merged into simplistically conceived "ownership" rights. The rights to important uses of the land, for example, to gather minor forest products or to obtain water, may not be recognised by the legal system and may be effectively destroyed as a result. Of course, other types of development projects can also result in the loss of rights to land.

Rights may also be reduced or eliminated if the state starts to enforce existing rules that prevent access to resources. For example, more rigid enforcement of state policy on forest conservation may result in villagers being evicted from land which they have been using for agricultural and grazing purposes.

Tenure insecurity may be caused by social changes. HIV/AIDS, for example, is impacting the security of women in parts of Africa. Widows may lose access to land in a legal sense if they are unable to inherit rights from their husbands, and in a practical sense if they are forced off the farms by male relatives.

People may lose rights when others ignore land tenure rules. Exploitation of unequal power relationships within communities, for example, may result in some members fencing off portions of communal lands for their own exclusive use, thereby denying access by other members of the community to shared grazing lands.

Landlessness may occur, of course, for reasons other than insecure tenure. Some may sell their land through “distress sales” (forced sales) in order to survive in times of crises such as famine, sickness or other calamities. Other reasons for selling land may include the need to meet social pressures such as providing a dowry for daughters upon their marriage.

Solution

Why is secure access to land important for strengthening rural livelihoods? • Land is one of the most important assets that poor rural women and men have, and fulfils essential economic, social and ecological functions. 75% of the world’s poor are rural, depending primarily on agriculture and related activities for their livelihoods • Support to small-scale producers (1.5bn on

Achieving food security and sustainable livelihoods for people now in chronic poverty requires ensuring access to and control of resources by small-scale farmers

Key ingredients for securing access to land:

1. Transparent & inclusive processes for land policy development

2. People-centred land policies

3. Gender equity in access to land

4. Policies reflecting diverse tenure systems

5. Redistributive reforms as an integral policy tool

6. Innovative and accessible systems for the recognition of land rights

7. Develop systems for the monitoring of land rights

8. Adequate response to new global context of transnational land investments

Transparent, inclusive processes for land policy development

• Policy dialogue must engage the full range of stakeholder groups, particularly those highly dependant on land and natural resources • Assistance to national/regional platforms on land

People-centred land policies

• Land policies should explicitly prioritise poverty reduction, promote equity, and meet the needs of vulnerable groups and regulate market-related effects on land ownership

Gender equality in the formulation and implementation of land policy

• Promote gender equality in the formulation and implementation of land policy.

• Support by building capacity of women’s groups and their participation in decision-making processes over land

Recognise diverse tenure systems

• National Land law and policy should recognise and protect non-discriminatory aspects of customary and local tenure systems

• Recognise the diversity and flexibility of multiple and overlapping land rights

Land redistribution for landless and land-poor.

• Land redistribution is an equitable means for redressing past inequities and increasing political, economic, and social stability

Innovative systems for the recognition of land rights

• Capacity building and legal training to gain rights, eg community paralegals.

• Recognise and support customary dispute resolution mechanisms.

• Support collective titling and secure tenure of common-pool resources

• Take advantage of low-cost alternatives to private titles.

Monitoring of land policies and their implementation

• Need for multi-stakeholder systems to monitor, evaluate and report on land policy formulation and implementation.

New Global context: responding to the wave of transnational commercial investment in land

Urgent actions

1. Develop a code of conduct for trans-national land investments, placing local land users in the centre of negotiations

2. Carbon trading mechanisms such as REDD should recognise rights of local land users

3. Develop guidelines for the establishment of equitable community-investor partnerships

4. Support and capacity building to local institutions

SEEDS

Seed is a critical and basic input for attaining higher crop yields and sustained growth in agricultural production. Distribution of assured quality seed is as critical as the production of such seeds. Unfortunately, good quality seeds are out of reach of the majority of farmers, especially small and marginal farmers mainly because of exorbitant prices of better seeds.

In order to solve this problem, the Government of India established the National Seeds Corporation (NSC) in 1963 and the State Farmers Corporation of India (SFCI) in 1969. Thirteen State Seed Corporations (SSCs) were also established to augment the supply of improved seeds to the farmers.

High Yielding Variety Programme (HYVP) was launched in 1966-67 as a major thrust plan to increase the production of food grains in the country.

The Indian seed industry had exhibited impressive growth in the past and is expected to provide further potential for growth in agricultural production: The role of seed industry is not only to produce adequate quantity of quality seeds but also to achieve varietal diversity to suit various agro-climatic zones of the country.

The policy statements are designed towards making available to the Indian farmer, adequate quantities of seed of superior quality at the appropriate time and place and at an affordable price so as to meet the country’s food and nutritional security goals.

Indian seeds programme largely adheres to limited generation system for seed multiplication. The system recognises three kinds of generation, namely breeder, foundation and certified seeds. Breeder seed is the basic seed and first stage in seed production. Foundation seed is the second stage in seed production chain and is the progeny of breeder seed.

Certified seed is the ultimate stage in seed production chain and is the progeny of foundation seed. Production of breeder and foundation seeds and certified seeds distribution have gone up at an annual average rate of 3.4 per cent, 7.5 per cent and 9.5 per cent respectively, between 2001-02 and 2005-06).

Solution

The Indian government created the National Seeds Corporation (NSC) in 1963 and the SFCI in 1969 to address this issue. To increase the farmers' access to better seeds, 13 SSCs (State Seed Corporation) were also set up. The involvement of the seed industry is not only to generate an adequate amount of high-quality seeds but also to accomplish varietal diversity to accommodate the numerous agro-climatic areas of the nation. The Indian seed industry has displayed remarkable growth over the years and is anticipated to offer further potential for development in agricultural production.

In order to accomplish the nation's food and nutritional security goals, the policy declarations are intended to make sufficient amounts of superior-quality seed accessible to Indian farmers at the right time, area, and reasonable rate.

Conditions of agricultural labours

Agricultural labour

It is one of the primary objects of the Five Year Plan to ensure fuller opportunities for work and better living to all the sections of the rural community and, in particular, to assist agricultural labourers and backward classes to come to the level of the rest. One of the most distinguishing features of the rural economy of India has been the growth in the number of agricultural workers, cultivators and agricultural labours engaged in crop production. The phenomena of underemployment, under-development and surplus population are simultaneously manifested in the daily lives and living of the agricultural workers. Agricultural workers constitute the most neglected class in Indian rural structure. Their income is low and employment irregular. Since, they possess no skill or training, they have no alternative employment opportunities either.

Labour is the most important input in increasing production in traditional agriculture. In the early stage of development, since land was available in plenty increase in labour supply led to the clearing of more land for bringing it under cultivation. Agricultural labourers are socially and economically poorest section of the society. Agricultural labourers households constitute the historically deprived social groups, displaced handicraftsmen and dispossessed peasantry. They are the poorest of the poor in rural India. Their growth reflects the colonial legacy of under development and the inadequacies of planning intervention in the past.

The poverty syndrome among agricultural labourers needs to be read against such a background of prolonged rural under development, assetlessness, unemployment, low wages, under-nutrition, illiteracy and social backwardness constitute the poverty syndrome among agricultural labourers. These reinforce each other so as to constitute a vicious circle of poverty.

The Indian agriculture, however, has its own characteristics:

1. Subsistent in Character:

Despite eleven five year plans, in greater parts of the country, Indian agriculture is subsistent in character. The cultivators and farmers grow crops mainly for the family consumption. It is only in the controlled irrigated parts of the country like Punjab, Haryana, western Uttar Pradesh, and Kaveri delta where agriculture has become an agri-business or is market.

2. Heavy Pressure of Population:

The Indian agriculture is characterized by heavy pressure of population. About 70 per cent of the total population of the country is directly or indirectly dependent on agriculture.

3. Predominance of Food Grains:

In both the Kharif (summer) and the rabi (winter) seasons, grain crops occupy the greater proportion of the cropped area.

4. Mixed Cropping:

In the rain-fed areas of the country, mixed cropping is a common practice. The farmers mix millets, maize and pulses in the kharif season and wheat, gram and barley in the rabi season. In the areas of Jhuming (shifting cultivation), ten to sixteen crops are mixed and sown in the same field.

5.High Percentage of the Reporting Area under Cultivation:

In India, about 55 per cent of the total reporting area is under cultivation of crops and pastures. This is much higher when compared with about 4 per cent in Canada, 12 per cent in China, 15 per cent in Japan.

6.Small Size of Holdings and Fragmentation of Fields:

Over 70 per cent of the holdings are either small or marginal, i.e. less than one hectare. The small size of holdings is mainly due to the law of inheritance and other socio-cultural and economic factors.

Labour policy in India has been evolving in response to the specific needs of the situation in relation to industry and the working class and has to suit the requirements of a planned economy. The legislation and other measures adopted by Government in this field represent the consensus of opinion of the parties vitally concerned and thus acquire the strength and character of a national policy, operating on a voluntary basis.

The first Agricultural Labour Enquiry Committee of 1950-51 regarded those workers as agricultural workers who normally worked for 50 per cent of more days on the payment of wages.

The second Agricultural Labour Enquiry Committee, 1956-57 accepted a broad view and included all those workers into agricultural labourers who were badly engaged in agriculture and allied activities like animal husbandry, dairy, piggery, poultry farming etc.

The first committee again classified the agricultural workers into two different categories such as:

- attached labourers are those workers who are attached to some other farmer households on the basis of a written or oral agreement.
- landless labourers who exclusively work for others.
- tenants who work on leased land but work most of the time on the land of others;
- sharecroppers who also work as agricultural labourers.

Condition of agricultural labours:

They remain largely unorganized, and as a result their economic exploitation continues. Their level of income, standard of living and the rate of wages have remained abnormally low.

Agricultural Wages and Income:

In India, the agricultural wages are very low. The First Agricultural Labour Enquiry Committee in its report mentioned that the per capita annual income of agricultural labour families was as poor as Rs 104 in 1950-51 and the annual average income of the household was Rs 447.

After the introduction of improved farming methods and mechanization of the level of income of middle and rich farmers increased but at the same time due to fall in the demand for labour real wages declined.

Employment and Other Working Conditions:

In India the agricultural labourers are facing severe unemployment and underemployment problem as there is no alternative sources of employment. Although the system of bonded labour is abolished but according to NSS (32 round) about 3.5 lakh **bonded labourers** still exist in India.

Factors Responsible for the Poor Conditions of Farm Workers:

(i) Unorganised:

Agricultural labourers in India are totally unorganised as they are ignorant, illiterate and widely scattered. Thus, the farm workers have no capacity to bargain for securing a fair wage level.

(ii) Low Social Status:

Farm workers mostly belong to depressed classes and thus they are lacking the courage to assert their basic rights.

(iii) Seasonal Unemployment:

As the agricultural operations are seasonal thus the farm workers are often facing the problem of seasonal unemployment and under-employment. Farm workers on an average get employment for about 200 days in a year.

(iv) Absence of Alternative Occupations:

In the absence of alternative occupation in the rural areas the farm workers are not getting alternative jobs when they suffer from seasonal unemployment.

(v) Growing Indebtedness:

Agricultural labourers in India are highly indebted. As the level of wages is very poor thus the farm workers have been borrowing from landlords and become bonded labourers ultimately.

Thus, considering these above factors it can be said that the agricultural labourers in India are living in inhuman conditions and in the absence of organized status they are deprived of all the basic amenities of life.

Measures Adopted by the Government to Improve the Conditions of Farm Workers:

In order to improve the conditions of agricultural labourers in India both the central as well as the state Governments have taken various steps since independence. These measures are as follows:

(i) Abolition of Bonded Labour:

In order to remove agrarian slavery after independence Indian constitution has undertaken legislative measures to abolish the practice of bonded labour. Accordingly, the Bonded Labour System (Abolition) Act 1976 was passed and about 2.51 lakh bonded labourers were identified and freed in different parts of the country.

(ii) Minimum Wages Act:

In 1948, the Minimum Wages Act was passed and the state Governments was advised to fix the minimum wages accordingly. But due to some practical difficulties most of the states could not fix minimum wages till 1974.

(iii) Distribution of Landless Laborers:

After passing legislation for fixing ceiling on land holdings, state Government acquired surplus lands and distributed it among the landless labourers. About 74 lakh acres of land were acquired as surplus land and out of which 45 lakh acres were distributed among 41.5 lakh landless labourers. But most of these lands distributed are found unsuitable for cultivation.

(iv) Provision for Housing Sites:

Various states have passed necessary legislations for providing housing sites to agricultural labourers. The Second and Fourth Plans have undertaken various steps for this purpose. Again under Minimum Needs Programme and 20-Point Programme, high priority is being accorded to rural house site-cum-house construction scheme.

(v) Various Employment Schemes:

For providing alternative source of employment among the agricultural labourers various schemes have already been launched by both the central and the state Governments. These schemes include

- Rural Works Programme (RWP),
- Crash Scheme for Rural Employment (CSRE),
- Employment Guarantee Scheme (EGS) by the Government of Maharashtra,
- Food for Work Programme (FWP),
- National Rural Employment Programme (NREP),
- Rural Landless Employment Guarantee Programme (RLEGP),
- Jawahar Rozgar Yojana (JRY) etc.

(vi) Special Agencies:

During the Fourth Plan two special agencies —

Small Farmers Development Agency (SFDA)

Marginal Farmers and Agricultural Labourers Development Agency (MFALA) were developed for conducting Various works like irrigation, land leveling, soil conservation, dairy development, piggery development, poultry breeding etc. During the Fifth Plan both agencies were merged into a single programme.

(vii) 20-Point Programme:

The Government introduced the 20-point economic programme in July 1975 in which steps were taken to improve the economic condition of landless workers and other weaker sections of the society in the rural areas.

These steps include speedy implementation of ceiling laws and then distribute the surplus land among the landless, making provision for housing sites for landless labourers, abolition of bonded labour, liquidation of rural indebtedness.

Suggestions for Improving the Conditions of Agricultural Labourers:

- Implement the Minimum Wage Act seriously
- By improve their bargaining power
- Create alternative sources of employment by developing small scale and cottage industries in the rural areas.
- Improve- the conditions of agriculture by adopting improved intensive methods and multiple cropping.
- Improve the working conditions of agricultural labourers.
- Promote cooperative farming.
- To introduce social security measures for the agricultural workers.
- Introduce compulsory insurance on marginal contribution.
- Institute old age pension schemes for the agricultural workers by the government.

Manures, Fertilizers and Biocides:

Indian soils have been used for growing crops over thousands of years without caring much for replenishing. This has led to depletion and exhaustion of soils resulting in their low productivity. The average yields of almost all the crops are among t e lowest in the world. This is a serious problem which can be solved by using more manures and fertilizers.

Manures and fertilizers play the same role in relation to soils as good food in relation to body. Just as a well-nourished body is capable of doing any good job, a well nourished soil is capable of giving good yields. It has been estimated that about 70 per cent of growth in agricultural production can be attributed to increased fertilizer application.

Thus increase in the consumption of fertilizers is a barometer of agricultural prosperity. However, there are practical difficulties in providing sufficient manures and fertilizers in all parts of a country of India’s dimensions inhabited by poor peasants. Cow dung provides the best manure to the soils.

But its use as such is limited because much of cow dung is used as kitchen fuel in the shape of dung cakes. Reduction in the supply of fire wood and increasing demand for fuel in the rural areas due to increase in population has further complicated the problem. Chemical fertilizers are costly and are often beyond the reach of the poor farmers. The fertilizer problem is, therefore, both acute and complex.

It has been felt that organic manures are essential for keeping the soil in good health. The country has a potential of 650 million tonnes of rural and 160 lakh tonnes of urban compost which is not fully utilized at present. The utilization of this potential will solve the twin problem of disposal of waste and providing manure to the soil.

The government has given high incentive especially in the form of heavy subsidy for using chemical fertilizers. There was practically no use of chemical fertilizers at the time of Independence As a result of initiative by the government and due to change in the attitude of some progressive farmers, the consumption of fertilizers increased tremendously.

In order to maintain the quality of the fertilizers, 52 fertilizer quality control laboratories have been set up in different parts of the country. In addition, there is one Central Fertilizer Quality Control and Training Institute at Faridabad with its three regional centres at Mumbai, Kolkata and Chennai.

Pests, germs and weeds cause heavy loss to crops which amounted to about one third of the total field produce at the time of Independence. Biocides (pesticides, herbicides and weedicides) are used to save the crops and to avoid losses. The increased use of these inputs has saved a lot of crops, especially the food crops from unnecessary wastage. But indiscriminate use of biocides has resulted in wide spread environmental pollution which takes its own toll.

Solution

Organic manures are considered to be crucial for maintaining healthy soil. There is now underutilisation of the nation's potential 650 million tonnes of rural and 160 lakh tonnes of urban compost. By utilising this capability, the twin issues of garbage disposal and soil fertilisation will be resolved. In particular, the government has heavily subsidised the use of chemical fertilisers as an incentive. Chemical fertilisers were seldom ever used during the period of Independence. The use of fertilisers increased dramatically due to government action and a shift in the mindset of certain progressive farmers. To protect the crops and prevent losses, biocides are employed. Increased usage of these inputs has prevented the needless loss of many crops, particularly food crops. However, the extensive use of biocides has led to environmental contamination, which has its own cost.

Irrigation

Although India is the second largest irrigated country of the world after China, only one-third of the cropped area is under irrigation. Irrigation is the most important agricultural input in a tropical monsoon country like India where rainfall is uncertain, unreliable and erratic India cannot achieve sustained progress in agriculture unless and until more than half of the cropped area is brought under assured irrigation.

This is testified by the success story of agricultural progress in Punjab Haryana and western part of Uttar Pradesh where over half of the cropped area is under irrigation! Large tracts still await irrigation to boost the agricultural output.

However, care must be taken to safeguard against ill effects of over irrigation especially in areas irrigated by canals. Large tracts in Punjab and Haryana have been rendered useless (areas affected by salinity, alkalinity and water-logging), due to faulty irrigation. In the Indira Gandhi Canal command area also intensive irrigation has led to sharp rise in sub-soil water level, leading to water-logging, soil salinity and alkalinity.

Irrigation

- Irrigation is the artificial application of water to the soil or agricultural field. It is the replacement or supplementation of rainwater with another source of water. It is used in dry areas and during periods of inadequate rainfall.
- The main idea behind irrigation systems is to assist in the growth of agricultural crops and plants by maintaining with the minimum amount of water required, suppressing weed growth in grain fields, preventing soil consolidation etc.

Well and Tube Well Irrigation

- Wells are mainly found in U.P., Bihar, Tamil Nadu, etc. There are various types of wells – shallow wells, deep wells, tube wells, artesian wells, etc. From the shallow wells water is not always available as the level of water goes down during the dry months. Deep wells are more suitable for the purpose of irrigation as water from them is available throughout the year.
- At places where ground water is available, a tube-well can be installed near the agricultural area. A deep tube well worked by electricity, can irrigate a much larger area (about 400 hectares) than a surface well (half hectares). Tube wells are mostly used in U.P., Haryana, Punjab, Bihar and Gujarat.
- Merits: Well is simplest, cheapest and independent source of irrigation and can be used as and when the necessity arises. Several chemicals such as nitrate, chloride, sulphate, etc. found in well water add to the fertility of soil. More reliable during periods of drought when surface water dries up.
- Demerits: Only limited area can be irrigated. In the event of a drought, the ground water level falls and enough water is not available. Tubewells can draw a lot of groundwater from its neighbouring areas and make the ground dry and unfit for agriculture.

Canal Irrigation

- Canals can be an effective source of irrigation in areas of low level relief, deep fertile soils, perennial source of water and extensive command area. Therefore, the main concentration of canal irrigation is in the northern plain of India, especially the areas comprising Uttar Pradesh, Haryana and Punjab.

- The digging of canals in rocky and uneven areas is difficult and uneconomic. Thus, canals are practically absent from the Peninsular plateau area. However, the coastal and the delta regions in South India do have some canals for irrigation.
- Two types: Inundation canals, which are taken out from the rivers without any regulating system like weirs etc. at their head. Such canals provide irrigation mainly in the rainy season when the river is in flood and there is excess water. Perennial Canals are those which are taken off from perennial rivers by constructing a barrage across the river. Most of the canals in India are perennial.
- Merits: Most of the canals provide perennial irrigation and supply water as and when needed. This saves the crops from drought conditions and helps in increasing the farm production.
- Demerits: Many canals overflow during the rainy season and flood the surrounding areas. Canal irrigation is suitable in plain areas only.

Tank Irrigation

- A tank is developed by constructing a small bund of earth or stones built across a stream. The water impounded by the bund is used for irrigation and other purposes. Tank comprises an important source of irrigation in the Karnataka Plateau, MP, Maharashtra, Odisha, Kerala Bundelkhand area of UP, Rajasthan and Gujarat.
- Merits: Most of the tanks are natural and do not involve heavy cost for their construction and have longer life span. In many tanks, fishing is also carried on, which supplements both the food resources and income of the farmer.
- Demerits: Many tanks dry up during the dry season and fail to provide irrigation when it is required. Lifting of water from tanks and carrying it to the fields is a strenuous and costly exercise.

Drip Irrigation

- In drip irrigation, water is applied near the plant root through emitters or drippers, on or below the soil surface, at a low rate varying from 2-20 liters per hour. The soil moisture is kept at an optimum level with frequent irrigations.
- Among all irrigation methods, drip irrigation is the most efficient and can be practiced for a large variety of crops, especially in vegetables, orchard crops, flowers and plantation crops.
- Merits: Fertilizer and nutrient loss is minimized due to localized application and reduced leaching. Field leveling is not necessary. Recycled non-potable water can be used. Water application efficiency increases. Soil erosion and weed growth is lessened.
- Demerits: Initial cost can be more, can result in clogging, wastage of water, time and harvest, if not installed properly.

Sprinkler Irrigation

- In this method, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. The sprinkler irrigation system is a very suitable method for irrigation on uneven lands and on shallow soils.

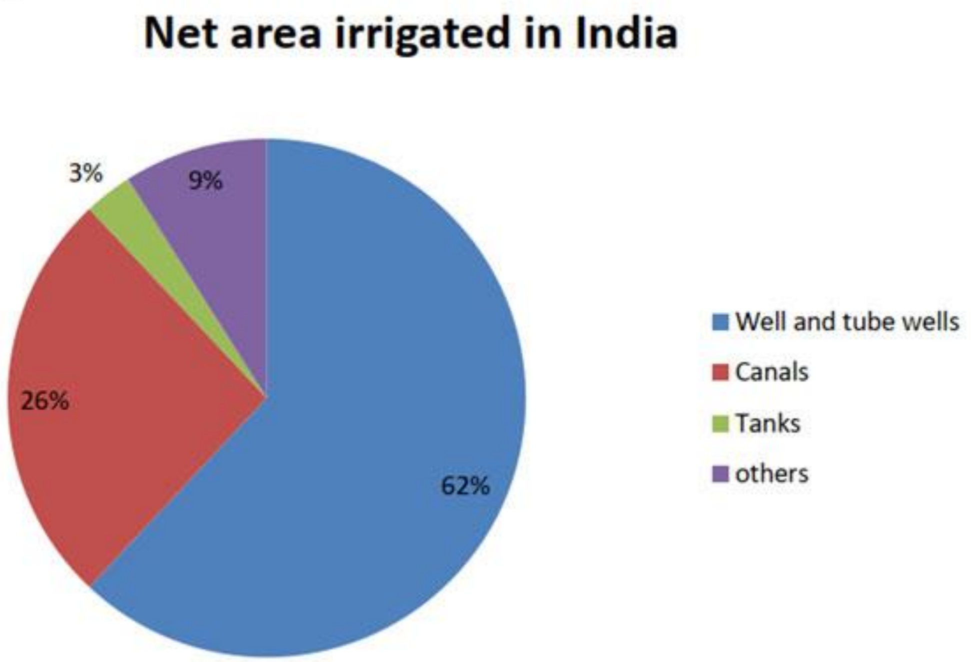
- Nearly all crops are suitable for sprinkler irrigation systems except crops like paddy, jute, etc. The dry crops, vegetables, flowering crops, orchards, plantation crops like tea, coffee are all suitable and can be irrigated through sprinklers.
- Merits: Suitable to all types of soil except heavy clay. Water saving. Increase in yield. Saves land as no bunds etc. are required.
- Demerits: Higher initial cost. Under high wind conditions and high temperature distribution and application efficiency is poor.

Other Types of Irrigation

- Furrow Irrigation: Furrow irrigation is a type of surface irrigation in which trenches or "furrows" are dug between crop rows in a field. Farmers flow water down the furrows and it seeps vertically and horizontally to refill the soil reservoir. Flow to each furrow is individually controlled.
    - One of the difficulties of furrow irrigation is ensuring uniform dispersion of water over a given field. Another difficulty with furrow irrigation is the increased potential for water loss due to runoff.
- Surge Irrigation: Surge irrigation is a variant of furrow irrigation where the water supply is pulsed on and off in planned time periods. The wetting and drying cycles reduce infiltration rates resulting in faster advance rates and higher uniformities than continuous flow.
- Ditch Irrigation: It is a rather traditional method, where ditches are dug out and seedlings are planted in rows. The plantings are watered by placing canals or furrows in between the rows of plants. Siphon tubes are used to move the water from the main ditch to the canals.
- Sub Irrigation or Seepage Irrigation: It is a method of irrigation where water is delivered to the plant root zone from below the soil surface and absorbed upwards. The excess may be collected for reuse.
    - Advantages are water and nutrient conservation, and labor-saving.
    - The outfitting cost is relatively high. Potential problems, such as the possibility of increased presence of disease in recycle water.

Way Forward

The farmers should be acquainted with the type of soil moisture, quality of irrigation water, frequency of irrigation for the proper implementation of irrigation systems.



Measures to Improve Water Storage and Irrigation System

The per capita water availability has come down from 5177 cubic meters in 1951 to 1545, as per the 2011 census. This translates into a decline of about 70 percent in 60 years. The decline is expected to progress further reaching a low of 1140 cubic meters by 2050. As per the government of India, per capita availability of less than 1700 cubic meters is considered a water-stressed condition and when availability drops to 1000, the situation is termed as water scarcity condition. Since there are large variations in both temporal and spatial patterns of precipitation, many regions in the country are already facing the water-stressed or water- scarcity condition.

The challenges faced by the country in water management includes

1. High spatial and temporal variability in respect of rainfall distribution and availability of water resources
2. An increase in population is one of the major causes of declining per-capita water availability
3. Inadequate water storage for meeting future water demand
4. Over-exploitation of groundwater resources
5. Droughts
6. Low water use efficiency

To overcome the above challenges, the following steps are being/may be taken:

1. Watershed Management

Within a watershed, we can manage the land and water resources in a comprehensive manner in such a way that the quality of water and other natural resources is improved, while humans are able to avail the desired goods and services. The implementation of such practices is termed watershed management. Under this, one of the components is checking the wild run-off of rainwater in upper slopes. This reduces soil erosion and increases water percolation, replenishing groundwater reserves. India has witnessed the launch of several schemes for watershed management like the **Desert Development Programme (DDP)**, **Drought Prone Area Programme (DPAP)**, and **Integrated Wasteland Development Programme (IWDP)**. All these have now been integrated into the **Watershed Development Component of Pradhan Mantri Krishi Sinchayee Yojana** (WDC-PMKSY), whose main objective is to restore ecological balance by harnessing, conserving, and developing degraded natural resources like water, soil, vegetative cover, etc. **To strengthen WDC-PMKSY, World Bank-assisted Neeranchal is being run to provide technical assistance to the program.**

Intensive afforestation and reforestation also form an important component of watershed management. Forests decrease the run-off rate and increase the percolation of water. This prevents floods and helps in recharging groundwater. Since the run-off rate decreases, the soil erosion rate also decreases, preventing flooding of water channels and maintaining the capacity of reservoirs of dams. The government is implementing the following three major schemes for the development of forest areas:

1. For afforestation of degraded forest lands, **National Afforestation Programme** (NAP) scheme was launched in 2002.
2. **National Mission for a Green India** (GIM) for improving the quality of forest and increase in forest cover
3. **Forest Fire Prevention & Management Scheme** (FFPM) takes care of forest fire prevention and management measures.

2. Micro-irrigation

Agriculture is a water-intensive activity. Globally, agriculture consumes 70% of the water used for human activities. In India, this number is as high as 90%. This makes micro-irrigation the best solution to the problem of depleting water resources. The micro-irrigation techniques reduce water consumption in agriculture in the range of 30-70%. Fertigation and chemigation are added advantages, leading to the efficient application of fertilizers and pesticides. All this is not just environment friendly, but also highly cost-effective. Also, micro-irrigation results in better crop productivity and helps in bringing cultivable wastelands and water-deficient areas under cultivation.

Micro-irrigation in India has a penetration of just around 20%. The percentage is less than 2 for Uttar Pradesh and Punjab, the two states where water-intensive crops are cultivated and intensive agriculture is practiced in large areas. Though India introduced micro-irrigation way back in 1992, it has been given a thrust as a component of PMKSY (**PMKSY- Per drop more crop**) and as an important part of the National Mission for Sustainable Agriculture.

3. Rainwater Harvesting, Traditional Methods, and Groundwater Recharge

Rainwater harvesting is simply about collecting and storing rainwater at the surface or in sub-surface aquifers to prevent rainwater from getting lost as runoff. Rainwater harvesting is practiced since ancient times in India. **Recently, traditional methods like Johads, led by Waterman of India, Shri Rajendra Singh have got a shot-in-the-arm.** Traditional methods are not only inexpensive but can be implemented by the local population especially in rural areas. Urban areas, however, require more modern methods due to the large-scale concretization of the landscape.

In 2019, Jal Shakti Abhiyan (JSA) was launched in 256 districts in mission mode for improving water availability including groundwater conditions. In addition**,** the **'Jal Shakti Abhiyan – Catch the Rain'** campaign has been launched recently in March 2021 for creating appropriate **Rain Water Harvesting Structures (RWHS)** suitable to the climatic conditions and sub-soil strata before monsoon. *Mission Water Conservation has been launched to ensure synergy between MGNREGS, PMKSY-WDC, and Command Area Development & Water Management (CAD&WM) programmes.*

Under the Environment (Protection) Act, 1986, **Central Ground Water Authority** (CGWA) has been constituted for regulating and controlling groundwater development and management in the country. It advises states on measures to be taken for managing groundwater and issues No Objection Certificate (NOCs) for groundwater abstraction to industries and large-scale projects. It has undertaken Aquifer Mapping of India for formulating aquifer-specific management plans.

Mass awareness programs and National Water Awards have been constituted for incentivising good practices in water conservation and groundwater recharge. World Bank-funded

Atal Bhujal Yojana (ABHY) is being taken up in identifying over-exploited and water-stressed areas for sustainable management of groundwater with community participation.

4. Inter-Linking of Rivers

To overcome the challenge of high temporal and spatial variability in respect of rainfall and availability of water resources, the interlinking of rivers to transfer water from areas with excessive water to areas deficient in water has been envisaged. The interlinking will be done through a network of canals, resulting in the prevention of floods in water excess areas and overcoming droughts in water deficit areas. This will also enhance the irrigation potential of India as well as help in recharging groundwater. There are three components of the project: Himalayan component, southern Peninsular component, and starting 2005, an intrastate rivers linking component. However, due to high ecological, human, and cost impacts, the project has been moving at a slow pace.

5. Rehabilitation of Dams

Along with a variety of other uses, flood prevention is one of the major advantages of reservoirs created by dams. India has more than 5000 large dams in operation and more than 400 are under construction. Being essential to the water security of India, their management and safety become important. To improve the safety and operational performance of more than 200 dams, **Dam Rehabilitation and Improvement Project (DRIP) was launched with World Bank assistance. It was successfully concluded in March 2021.** Since then, DRIP Phase II and III have been given nod to include more than 700 dams under its safety net.

Conclusion

The problem of depleting sources of water can be managed through increasing water use efficiency through micro-irrigation, recharging groundwater aquifers through watershed management, intensive afforestation, and reforestation and rainwater harvesting with a special focus on traditional methods in rural areas, and rehabilitation of dams. Mass awareness campaigns with IEC (information, education, and communication) approach will go a long way in water conservation efforts. Other techniques like recycling wastewater for uses other than human consumption may be taken up in cities. This will free the freshwater for human consumption. All these approaches implemented in synergy, along with population control, will lead to better per capita availability of water.

Ministry of Jal Shakti

New Irrigation Techniques

Water resources development & management are planned, funded, executed and maintained by the State Governments themselves as per their own resources and priorities. In order to supplement the efforts of the State Governments, Government of India provides technical and financial assistance to State Governments to encourage sustainable development and efficient management of water resources through various schemes and programmes.

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was launched during 2015-16 by the Central Government with the following components, Accelerated Irrigation Benefits Programme (AIBP), Har Khet Ko Pani (HKKP), Per Drop More Crop (PDMC) and Watershed Development (WD).

PMKSY is strategize by focusing on end-to end solution in irrigation supply chain, viz. water sources, distribution network, efficient farm level applications, extension services on new technologies & information etc. PMKSY focuses on irrigation techniques by, among others,

i. Promoting efficient water conveyance and field application devices within the farm viz, underground piping system, Drip & Sprinklers, pivots, rain-guns and other application devices etc.;

ii. Promotion of scientific moisture conservation and run off control measures to improve ground water recharge so as to create opportunities for farmer to access recharged water through shallow tube/dug wells,

iii. Creation of new water sources; repair, restoration and renovation of defunct water sources; construction of water harvesting structures, secondary & micro storage, groundwater development, enhancing potentials of traditional water bodies at village level.

iv. Use of Underground Pipelines (UGPL) in the Distribution Network of the projects has been actively promoted for increasing the water conveyance efficiency and overcoming the issues related to Land Acquisition, evaporative/ percolation losses etc.

During 2016-17, ninety-nine (99) on-going Major/ Medium irrigation projects (and 7 phases) in the country having balance estimated cost of Rs.77,595 crore (Central Assistance- Rs.31342.50 crore) under PMKSY-AIBP have been prioritized in consultation with States for completion in phases. Funding mechanism has been approved by the Government for providing Central and State Share under Long Term Irrigation Fund (LTIF) through NABARD. Out of which, AIBP works of 44 projects have been reported to be completed/ almost completed and an additional irrigation potential of 21.45 lakh hectare has been reported to be created by these projects. During 2016-17 to 2019-20, Central Assistance (CA) of Rs.11489.31 crore has been released for these projects.

The HKKP- Command Area Development and Water Management (CADWM) program has been taken up with objectives of utilize Irrigation Potential Created (IPC) under the project soon after its creation; improve water use efficiency; increase agricultural productivity & production; and bring sustainability in the irrigated agriculture in a participatory environment. Out of the 99 prioritized AIBP projects, 88 projects have been included under the ongoing CADWM program targeting Culturable Command Area (CCA) of 45.08 lakh Ha. at an estimated cost of Rs.18799 crore with targeted CA of Rs.8271.00 crore. Total Central Assistance amounting to Rs.2678 crore has been released from 2016-17 till date. As per information provided by the States, about 14.85 lakh Ha CCA has been developed with the reported expenditure of Rs.5302.00 crore. Under CADWM Scheme, States are also encouraged to use the underground pipeline network instead of conventional field channels. The implementation of Participatory Irrigation Management (PIM) is also being promoted through CADWM.

The Surface Minor Irrigation (SMI) and Repair, Renovation and Restoration (RRR) of Water Bodies schemes have multiple objectives like expanding cultivable area under assured irrigation, improving water use efficiency, ground water recharge, improvement and restoration of water bodies thereby increasing the tank storage capacity and revival of lost irrigation potential, increased availability of drinking water, improvement of catchment of tank commands etc.

During 2017-20, under the SMI scheme, CA of Rs.2158.665 crore has been released to States with an achievement of 1.201 Lakh Ha irrigation potential. Further, since 12th plan onwards, 3399 schemes have been reported to be completed upto March, 2020. During 2017-20, under RRR Scheme, Rs.169.24 crore has been released to States with an achievement of 0.5283 Lakh Ha irrigation potential. Further, since 12th plan onwards, 1465 water bodies have been reported to be completed upto March, 2020.

Central Ground Water Board is implementing innovative schemes for Aquifer Rejuvenation under 'Ground Water Management and Regulation' scheme in select overexploited blocks of the Aspirational districts on pilot basis. Water Harvesting and Recharge Augmentation are completed as a pilot project through construction of Bridge cum Bhandaras in districts of Wardha and Amravathi in Maharashtra. Further, a joint Action Plan has been prepared with the Ministry of Rural development for effective implementation of water conservation and artificial recharge structures in convergence with Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS).

Ground Water Irrigation component of PMKSY-HKKP aims to provide financial assistance to States to provide assured ground water irrigation for small and marginal farmers, in rain-fed areas. Schemes is applicable only in areas having stage of ground water development less than 60%, average rainfall more than 750 mm rainfall and with shallow ground water levels (less than 15 m bgl). The scheme is effectively launched in 2019-20, after revision of operational guidelines of the scheme. So far, 15 projects in 12 States have been sanctioned with an estimated cost of Rs.1719.55 crore.

Department of Agriculture, Cooperation & Farmers' Welfare is implementing Per Drop More Crop component of PMKSY. It mainly focuses on water use efficiency at farm level through precision/micro irrigation. Besides promoting precision irrigation (Drip and Sprinkler Irrigation System) and better on-farm water management practices to optimize the use of available water resources, this component also supports micro level water storage or water conservation/management activities to supplement micro irrigation. During 2015-16 to till date, cumulative amount of Rs. 14051.02 crore has been released to States with an achievement of 53.69 Lakh Ha coverage of Micro irrigation.

National Water Mission (NWM) has taken up Jal Shakti Abhiyan: Catch the Rain and Sahi Fasal campaigns for water conservation. "Jal Shakti Abhiyan: Catch the Rain" is under implementation in all districts, rural as well as urban areas, of the country with the main theme "Catch the Rain, where it falls, when it falls". The period of the campaign is from 22nd March, 2021 to 30th November, 2021 – the pre-monsoon and monsoon period in the country. Hon'ble Prime Minister launched "Jal Shakti Abhiyan: Catch the Rain" – 2021 campaign on 22.03.2021 with a view to take water conservation at grass-root level through people's participation to accelerate water conservation across the country.

'Sahi Fasal' campaign was launched by NWM on 14.11.2019 to nudge farmers in the water stressed areas to grow crops which are not water intensive, but use water very efficiently; and are economically remunerative; are healthy and nutritious; suited to the agro-climatic- hydro characteristics of the area; and are environmentally friendly.

This information was given by the Minister of State for Jal Shakti & Social Justice and Empowerment Shri Rattan Lal Kataria in Lok Sabha today.

Solution

The big success of agricultural development in Punjab, Haryana, and the western portion of Uttar Pradesh was sole because more than half of the cultivated area is under irrigation. To increase agricultural productivity, irrigation is still needed for large tracts. Through interstate cooperation on water management, water resources can be used to their most significant potential and distributed easily to the places where it is most needed. The rivers can be linked together, and national canals and channels can be built to strengthen irrigation systems and support farmers in the event that the monsoon fails.

Lack of mechanisation:

In spite of the large-scale mechanisation of agriculture in some parts of the country, most of the agricultural operations in larger parts are carried on by human hand using simple and conventional tools and implements like wooden plough, sickle, etc.

Little or no use of machines is made in ploughing, sowing, irrigating, thinning and pruning, weeding, harvesting threshing and transporting the crops. This is specially the case with small and marginal farmers. It results in huge wastage of human labour and in low yields per capita labour force.

There is urgent need to mechanise the agricultural operations so that wastage of labour force is avoided and farming is made convenient and efficient. Agricultural implements and machinery are a crucial input for efficient and timely agricultural operations, facilitating multiple cropping and thereby increasing production.

Some progress has been made for mechanising agriculture in India after Independence. Need for mechanisation was specially felt with the advent of Green Revolution in 1960s. Strategies and programmes have been directed towards replacement of traditional and inefficient implements by improved ones, enabling the farmer to own tractors, power tillers, harvesters and other machines.

A large industrial base for manufacturing of the agricultural machines has also been developed. Power availability for carrying out various agricultural operations has been increased to reach a level of 14 kW per hectare in 2003-04 from only 0.3 kW per hectare in 1971-72.

This increase was the result of increasing use of tractor, power tiller and combine harvesters, irrigation pumps and other power operated machines. The share of mechanical and electrical power has increased from 40 per cent in 1971 to 84 per cent in 2003-04.

Uttar Pradesh recorded the highest average sales of tractors during the five-year period ending 2003-04 and/West Bengal recorded the highest average sales of power tillers during the same period.

Strenuous efforts are being made to encourage the farmers to adopt technically advanced agricultural equipment's in order to carry farm operations timely and precisely and to economise the agricultural production process.

Solution

Youth employment in farming and similar fields will increase if we support them. They can learn and develop quickly since they already have a core institutional education and expertise.

Additionally, providing small farmers with cutting-edge machinery and sophisticated technology will help increase productivity, quality, and efficiency. Since India's independence, some effort has been made to mechanise agriculture. The Green Revolution that began in the 1960s brought a greater awareness of the need for mechanisation. To enable farmers to own the different types of agricultural machinery, programmes and initiatives have been created to substitute traditional and inefficient methods with modern ones

Soil erosion

Soil erosion is a process by which soil is displaced and transported, has become a pressing concern for the agricultural sector in India. With a rapidly rising population and increasing demand for food, it is imperative to address the challenges posed by soil erosion and safeguard our agricultural lands for sustainable productivity.

In this blog, we will see what is soil erosion, the reasons for soil erosion in India, what are the effects of soil erosion and its profound impact on agriculture.

What is Soil Erosion?

Soil erosion is a natural procedure. It is the process of removal of the topsoil due to natural as well as human activities. It has been significantly accelerated by human activities such as deforestation, improper land-use practices, and uncontrolled construction.

The removal of vegetation, particularly trees, weakens the soil structure, leaving it susceptible to erosion by wind and water.

Additionally, excessive tilling and overgrazing can also contribute to soil degradation and erosion.

Reasons for Soil Erosion in India

There are many reasons for soil erosion in India, which includes deforestation, monsoon rainfall, improper irrigation practices, etc.

Deforestation and Overexploitation

India has experienced substantial deforestation in recent decades, driven by urbanization, infrastructure development, and agricultural expansion. The loss of forests reduces the natural barriers that prevent soil erosion, leading to increased vulnerability.

Monsoonal Rainfall

India's climate is characterized by a monsoonal pattern, with intense rainfall during the monsoon season. Heavy rainfall can cause significant erosion, especially on sloping terrains, where the water's force is more concentrated.

Improper Irrigation Practices

Mismanaged irrigation systems can lead to waterlogging and soil salinization, adversely affecting soil health and promoting erosion.

Unsustainable Agricultural Practices

The overuse of chemical fertilizers and pesticides, along with continuous monoculture, depletes the soil's nutrients, making it more susceptible to erosion.

Impact of Soil Erosion on Agriculture

The consequences of soil erosion on agriculture are far-reaching and threaten food security and rural livelihoods in India.

Loss of Fertile Topsoil

The topsoil, rich in essential nutrients, is the most productive layer for agriculture. Soil erosion removes this fertile layer, reducing crop yields and overall productivity.

Reduced Water Infiltration

Eroded soil loses its ability to retain water, leading to decreased water infiltration and increased surface runoff. As a result, agricultural lands become more susceptible to droughts and floods.

Nutrient Depletion

Erosion not only removes the topsoil but also carries away vital nutrients necessary for plant growth. This nutrient depletion necessitates the application of additional fertilizers, increasing the production costs for farmers.

Sedimentation of Water Bodies

Soil erosion contributes to the sedimentation of rivers, lakes, and reservoirs, reducing their water-holding capacity and impacting irrigation and drinking water supply.

Loss of Biodiversity

Healthy soils support diverse ecosystems, but erosion disrupts this balance, leading to the loss of plant and animal species that rely on stable soil environments.

Different Types of Erosion in India

Many types of erosion are prevalent in India which leads to soil degradation in India . The main types are water erosion, wind erosion, glacial erosion, and coastal erosion, among others.

Water Erosion

Water erosion is one of the most common forms of soil degradation in India, primarily driven by rainfall and surface water flow. It is further classified into Sheet Erosion, Rill Erosion, and Gully Erosion.

Wind Erosion

Wind erosion is prevalent in arid and semi-arid regions of India, where strong winds dislodge and transport loose soil particles. It is a significant problem in regions with little vegetation and exposed soil surfaces.

Glacial Erosion

In certain parts of northern India, glacial erosion plays a dynamic role in shaping the landscape. Glacial movements and the abrasive action of ice and debris can erode soil and rock, leading to the formation of valleys and U-shaped troughs.

Coastal Erosion

Coastal erosion affects India's extensive coastline and is primarily driven by wave action and tidal currents. It can result in the loss of valuable coastal land, threatening human settlements and ecosystems.

Landslide Erosion

In hilly and mountainous regions, landslides can occur due to various factors, including heavy rainfall, deforestation, and seismic activities. Landslides result in the rapid movement of soil and rock downslopes, causing extensive erosion.

Mitigation Strategies for Soil Erosion in India

Addressing soil erosion requires a comprehensive approach involving various stakeholders, including farmers, policymakers, and environmental organizations.

Terracing and Contour Farming

Implementing terracing and contour farming on hilly terrains helps reduce the speed of water runoff, preventing soil erosion and promoting soil conservation.

Afforestation and Reforestation

Initiatives to plant trees and restore degraded forests help stabilize soil, reduce erosion, and enhance biodiversity.

Cover Crops and Crop Rotation

Cover crops and crop rotation methods improve soil health, prevent erosion, and enhance fertility by fixing nitrogen and increasing organic matter.

Conservation Tillage

Reduced or no-till farming methods minimize soil disturbance, keeping the soil structure intact and reducing erosion.

Integrated Watershed Management

Coordinating efforts across entire watersheds can optimize water resources, reduce erosion, and enhance overall ecosystem health.

Government Initiatives

The Indian government has recognized the severity of soil erosion's impact on agriculture and has taken steps to address this issue.

- **Soil Health Card Scheme**: It provides farmers with personalized information about the nutrient status of their soil, promoting judicious use of fertilizers and soil conservation practices.
- **National Mission for Sustainable Agriculture (NMSA):** It aims to enhance the resilience of Indian agriculture to climate change by promoting sustainable practices, including soil conservation.
- **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):** It aims to expand irrigation coverage and improve water-use efficiency, reducing the impact of soil erosion due to improper irrigation practices.

Soil erosion in India poses a significant threat to the agricultural sector, impacting food production, water resources, and biodiversity. Recognizing the gravity of the issue, it is crucial for all stakeholders to collaborate and implement effective strategies for soil conservation. By adopting sustainable practices and supporting government initiatives, we can safeguard our agricultural lands and ensure a secure future for India's agriculture.

solution

Soil Erosion Prevention

Soil erosion is a serious environmental issue . Steps should be taken to curb this problem. Following are some of the methods of soil erosion prevention:

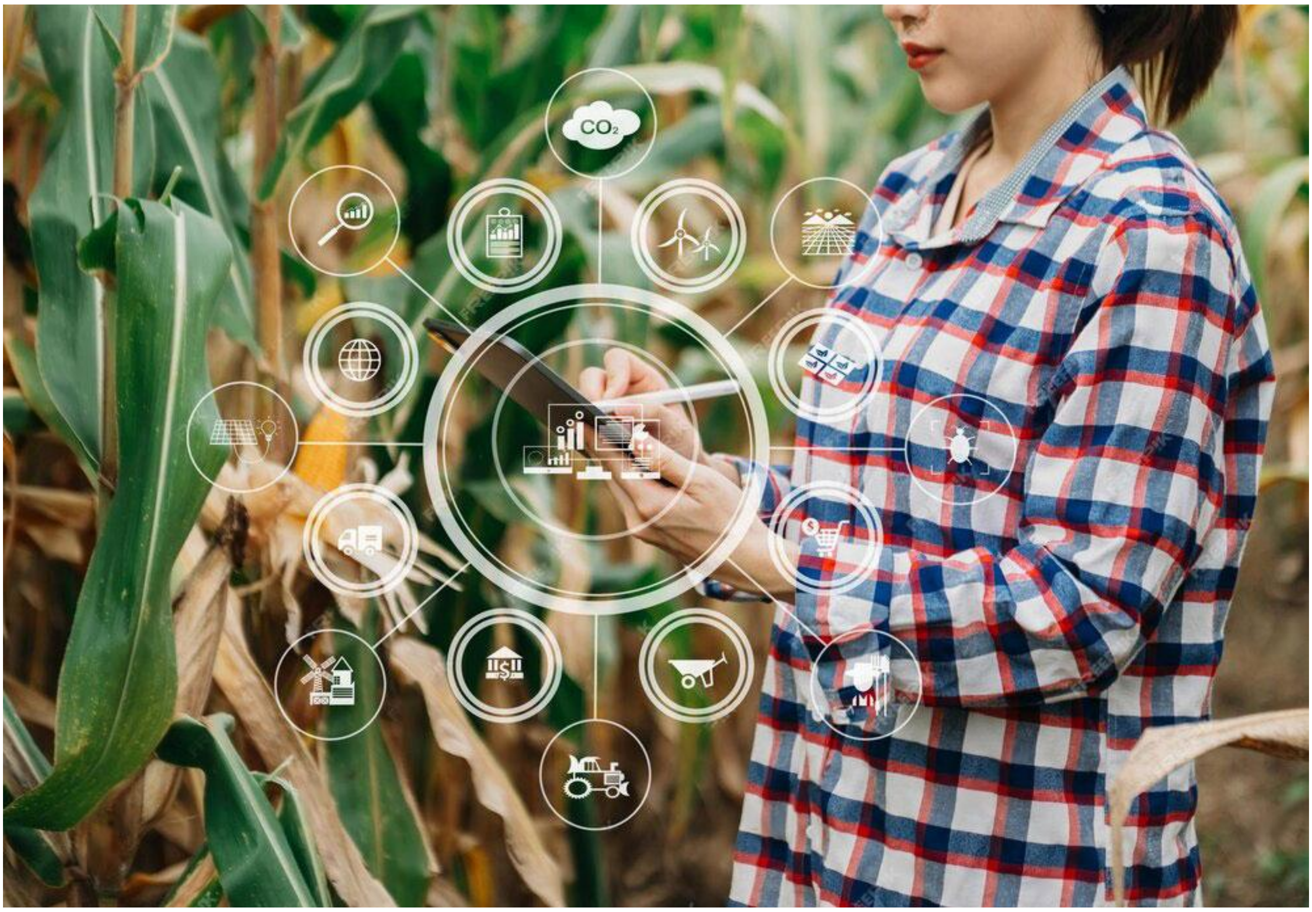
1. Plant trees on barren lands to limit erosion of soil.
2. Add mulch and rocks to prevent the plants and grass underneath to prevent soil erosion.
3. Mulch matting can be used to reduce erosion on slopes.
4. Put a series of fibre logs to prevent any water or soil from washing away.
5. A wall at the base of the slope can help in preventing the soil from eroding.
6. Every household should have a proper drainage system so that water flows down into proper water collecting systems.

Key Points of Soil Erosion

- It is the natural process of wearing away topsoil, but human activities have accelerated the process.

- It is usually caused due to the removal of vegetation, or any activity that renders the ground dry.
- Farming, grazing, mining, construction and recreational activities are some of the causes of soil erosion.
- The effects of soil erosion are not just land degradation. It has led to a drastic increase in pollution and sedimentation in rivers that clogs the water bodies resulting in a decline in the population of aquatic organisms.
- Degraded lands lose the water holding capacity resulting in floods.

The health of the soil is of utmost importance to the farmers and the population that depends upon agriculture for food and employment. There are several challenges to resist soil erosion, but there are solutions to prevent it as well.



Agricultural marketing

Agricultural marketing still continues to be in a bad shape in rural India. In the absence of sound marketing facilities, the farmers have to depend upon local traders and middlemen for the disposal of their farm produce which is sold at throw-away price.

In most cases, these farmers are forced, under socio-economic conditions, to carry on distress sale of their produce. In most of small villages, the farmers sell their produce to the money lender from whom they usually borrow money.

According to an estimate 85 per cent of wheat and 75 per cent of oil seeds in Uttar Pradesh, 90 per cent of Jute in West Bengal, 70 per cent of oilseeds and 35 per cent of cotton in Punjab is sold by farmers in the village itself. Such a situation arises due to the inability of the poor farmers to wait for long after harvesting their crops.

In order to meet his commitments and pay his debt, the poor farmer is forced to sell the produce at whatever price is offered to him. The Rural Credit Survey Report rightly remarked that the producers in general sell their produce at an unfavourable place and at an unfavourable time and usually they get unfavourable terms.

In the absence of an organised marketing structure, private traders and middlemen dominate the marketing and trading of agricultural produce. The remuneration of the services provided by the middlemen increases the load on the consumer, although the producer does not derive similar benefit.

Many market surveys have revealed that middlemen take away about 48 per cent of the price of rice, 52 per cent of the price of groundnuts and 60 per cent of the price of potatoes offered by consumers.

In order to save the farmer from the clutches of the money lenders and the middle men, the government has come out with regulated markets. These markets generally introduce a system of competitive buying, help in eradicating malpractices, ensure the use of standardised weights and measures and evolve suitable machinery for settlement of disputes thereby ensuring that the producers are not subjected to exploitation and receive remunerative prices.

Solution

The government has introduced regulated markets to free the farmer from the grasp of money lenders and intermediaries. These marketplaces typically establish a system of competitive purchasing, aid in the elimination of fraud, secure the use of standardised measurements and weights and provide appropriate mechanisms for dispute resolution, ensuring that the producers are not exploited and earn fair prices.

How to Improve Agricultural Marketing in India ?

The agricultural marketing is in dire need of reforms. Farmers suffer on all accounts, while supply chains are marked by inefficiencies due to unnecessary regulation.

Lists of some reforms that can help agricultural markets in a big way are as follows:

1. Linking Farmers with Markets:

linking small primary producers with markets is one of the major issues in improving livelihoods for millions of poor farming households. So far, the system has impoverished farmers, prevented modernization of agriculture and has led to huge food wastage. Mehta and Singh (2008) write that the Indian farmer suffers as he is not linked to the consumer, which has led to perpetuation of poverty, they write.

2. Improving Infrastructure:

Poor transport, lack of infrastructure and marketing facilities ensure that farmers are unable to get good prices. The monopolistic systems encouraged by APMCs are also a hindrance. Isolated regional markets means that farmers cannot sell their produce where it is needed. Agents, wholesalers and processors enjoy significant clout in agricultural markets.

Intermediaries at each stage earn sizeable margins for little value addition. One way of reducing the length of marketing channels is by limiting intermediaries through better connectivity consisting of roads, railway connections and lorries. This would remove geographical isolation and bring the farmer closer to the consumer. Better and accessible financial services, credit facilities helped by microfinance, will help the famer.

3. Storage Facilities:

Modern systems of storage have still not been constructed in India; they are too expensive for individual farmers and government has not invested in them. Storage infrastructure such as warehouses and cold storages help save the harvested crops. Agricultural produce is still stored in jute bags. As a result, the produce cannot be stored for long. Many farmers resort to distress sale of their produce to clear the loans from moneylenders.

They cannot even wait for government procurement. Nair (2015) reports, "In collusion with unscrupulous local traders and commission agents, government agencies delay procurement of grains by, in some cases, as many as 50-60 days." This causes farmers to sell out to local traders at much lower prices. Storage facilities, even at the government-owned FCI, are lacking; produce is stored in the open, causing huge damage.

4. Direct Sales:

Direct sales help bring the produce close to the customer. Some farmers are able to bring their produce at a highway and sell through makeshift stalls to passing vehicles. However, farmers' markets have not had a major impact on farm incomes as sales through this marketing channel are generally small, both in terms of number of the farmers participating and volumes of produce.

5. Transportation:

Farmers face a double whammy to transport their produce – bad roads and lack of adequate transport. According to Planning Commission Report of the Working Group on Agricultural Marketing Infrastructure for the XII Five Year Plan 2012-17 (2011), transportation and handling facilities for perishable commodities are inadequate and poor.

"Physical infrastructure in market yards is inadequate. Most of the rural primary markets (including livestock markets) have no infrastructure. Due to lack of proper handling facilities at the village level, about 7 percent of food-grains, 30 percent of fruits and vegetables and 10 percent of spices are lost before reaching the market," it says.

6. Access to Finance:

The ability to hold on to stock depends on the financial condition of the farmer. Nair writes that most farmers are under debt; average debt per household is Rs. 47,000, while average income is Rs. 36,973 per annum. Nair (2015) writes, "While average income from 2002-03 to 2012-13 increased by 318 percent, most worryingly, total debt per household increased by 273.5 percent during the same period, proving that while income from sale of agricultural products increased due to a price advantage during the last one decade, it has not translated into a reduction in rural indebtedness." As a consequence, the farmer is always under pressure to sell stocks to meet his burden of debt.

Farmers lack access to formal channels of finance in many parts of the country. Crops are not considered a financial asset against which farmers can take loans. Low-cost warehousing and negotiable receipts with an electronic registry for commodities can bring lenders closer to the farmers keen to pledge their crops.

7. Price Information:

Farmers in remote villages lack the means to track prices in markets and are often at the mercy of agents. Even if they know the prices, they are unable to make use of the information, because harvesting and transporting of a crop cannot be done in a day.

8. Food Processing Facilities:

Food processing is a potential source for driving the rural economy as it helps farmers find a ready market for their produce. A well-developed food processing industry increases farm gate prices, reduces wastages and ensures value addition. It assists farmers in getting knowhow from factories and promotes crop diversification. However, unless government rationalizes food laws, sets up the mega food parks and encourages foreign investment, facilities for food production are unlikely to come up in a big way.

Integrated facilities for procurement, processing, storage and transport complement the food processing industry. Private sector and foreign investments can play a role and for that the government must allow 100 percent FDI in food processing, cold chain infrastructure and retail.

9. Free Trade and an Open Market:

There is an urgent need to open up the agricultural sector by encouraging free trade and an open market. Government intervention creates distortions, cartelization and inaccessibility. Moreover, even the most efficient farm will fail to produce profits if the harvest cannot be sold at the best possible price in a timely manner. That is why, only free trade will promote investment in better quality, crop diversification and packaging.

Importance of Trust:

Most agricultural contracts are verbal and are based on trust. Masuku (2009) finds that trust-worthiness and reputation of wholesale traders significantly affects the proportion of produce sold through them. This is not surprising since institutions such as contracts and enforcement mechanisms are less developed or absent. The development of relational contracts (shaped in a given social system) between supply chain participants is an appropriate strategy for agricultural marketing where formal contracts are non-existent.

Relational contracts characterized by trust and cooperation are self-enforcing, which makes third-party enforcement mechanisms less needed. Marketing cooperatives, therefore, should work on building trust, improving price information networks and establish well-defined contracts that govern exchanges, grades and standards.

Inadequate storage facilities:

Storage facilities in the rural areas are either totally absent or grossly inadequate. Under such conditions the farmers are compelled to sell their produce immediately after the harvest at the prevailing market prices which are bound to be low. Such distress sale deprives the farmers of their legitimate income.

The Parse Committee estimated the post-harvest losses at 9.3 per cent of which nearly 6.6 per cent occurred due to poor storage conditions alone. Scientific storage is, therefore, very essential to avoid losses and to benefit the farmers and the consumers alike.

At present there are number of agencies engaged in warehousing and storage activities. The Food Corporation of India (F.C.I.), the Central Warehousing Corporation (C.W.C.) and State Warehousing Corporation are among the principal agencies engaged in this task. These agencies help in building up buffer stock, which can be used in the hour of need. The Central Government is also implementing the scheme for establishment of national Grid of Rural Godowns since 1979-80.

This scheme provides storage facilities to the farmers near their fields and in particular to the small and marginal farmers. The Working Group on additional storage facilities in rural areas has recommended a scheme of establishing a network of Rural Storage Centres to serve the economic interests of the farming community.

Solution

Many organisations are currently involved in warehouse and storage activities. Among the key organisations working on this project are the Central Warehousing Corporation, State Warehousing Corporation, and the Food Corporation of India (F.C.I.). These organisations aid in creating a buffer supply that can be used in an emergency. From 1979–1980, the Central Government put the nationwide grid of rural godowns into practice.

This plan offers farmers, especially marginal and small-scale farmers, storage facilities close to their fields. For the sake of the farming community's financial interests, the Working Group on Additional Storage Facilities in Rural Areas has suggested a plan to build a chain of Rural Storage Centres.

For smallholder farmers, growing crops is a special adventure that consists of a few challenging components during each farm season, such as **soil preparation**, **planting or sowing**, **pest and disease protection**, **crop maintenance**, and finally**, harvest**. However, one of the greatest challenges for a smallholder farmer has nothing to do with growing crops. It’s the final crop production stage- storage.

Storage is the process of preserving the crops for future use. In other words, it **directly affects the final yield** quantity and fruit quality. Therefore, once the crops are harvested, farmers have to use all their knowledge and available resources to manage the storage properly and **minimize post-harvest food losses**.

Now, the question is, how to properly manage storage with limited resources? This is one of the main concerns for the vast majority of farmers. After all, **small farms (less than 1 hectare) still account for 72% of all farms**. More importantly, even 40% of food loss occurs during the post-harvest stage and storage. In response to this, **there is an urgent need to share the knowledge about simple and low-cost storage practices** that will help farmers preserve their crops despite their financial limitations.

Simple and Low-Cost Storage Solutions

Smallholder farmers usually cannot afford fully equipped storage facilities such as **silos or cooling storage**. However, they can preserve the quality of their crops temporary by using one of the few traditional storage methods:

1. Simple field warehouse

Farmers can store their crops by using **barns, cellars, farm sheds or other simple field structures that are usually made of locally available materials.** Simple field warehouses are mainly used for storing hay, grains, root, and tuber crops.

The exact structure of a field warehouse will vary, depending on climatic conditions (for instance, humid or dry areas), crop requirements (grains require drying), as well as farmer's financial ability. For instance, some farmers can afford ventilation or some other quality long-term storage structure, while others can barely afford to store their crops in jute bags or bulks and build some kind of shed to protect their crops from the rain.

2. Underground storage

Smallholder farmers who grow **root or tuber crops often use underground storage** to preserve their crops. Underground storage is a **farm practice of leaving the crops in the ground until needed**. This method is used mainly for storing potatoes and carrots.

The practice is efficient in preserving crop quality for some time in well-drained soils. However, its main disadvantage is that it occupies a large area of land, and it's not recommended on wet soils. Besides that, in some areas, the crops are vulnerable to cold damage.

3. Pit storage

In order to preserve their crops, farmers often dig pits. The pits are usually used for storing grains, tuber and root crops. The shape, the size, as well as the construction material of the pit will vary from region to region. The costs of storing crops in the pits are usually lower than in above-ground structures.

Properly created pit storage will provide **relatively low and constant temperature** and preserve the crops from rodents and insects.

Still, there are a few disadvantages of pits:

- Digging the pit is **labor intensive**, as well as removing the crop from the pit

- After long storage, the grain can acquire a certain **fermented smell**
- There is always **a risk of water penetration**
- The crops at the top are often **moldy**.

4. Clamp storage

Clamp storage is a low-cost method for preserving root and tuber crops that is based on **insulation of crops with a layer of straw and a dry layer of soil or sand.**

If created properly, the clamp can be an effective storage method. However, it's important to choose a site where the rainfall or snowmelt doesn't accumulate and **protects the clamp from wild animals**, such as rodents.

Aforementioned practices are most commonly used storing methods among smallholder farmers. Aside from that, a few smallholder farmers can always collaborate and invest their resources into one common storage. After all, it's not easy being a smallholder farmer, and **it takes a lot of courage to face all obstacles and produce the food that sustains us all**.

Inadequate transport/ logistics services. / Export hub, guidance.

One of the main handicaps with Indian agriculture is the lack of cheap and efficient means of transportation. Even at present there are lakhs of villages which are not well connected with main roads or with market centres.

Most roads in the rural areas are Kutcha (bullock- cart roads) and become useless in the rainy season. Under these circumstances the farmers cannot carry their produce to the main market and are forced to sell it in the local market at low price. Linking each village by metalled road is a gigantic task and it needs huge sums of money to complete this task.

The main constraints in the transport of agricultural produce in India are inadequate logistics connectivity, support and facilities to ensure the farmers timely delivery of their harvest into the markets; lack of services including mobile cold storage for fresh perishable produce which can't be stored at production centres, but needs transportation immediately; few transport options that can cover longer distances in shorter times, however, they are quite expensive and others. However, 'Kisan Rail' service and the 'Krishi Udaan' scheme, All India Agri Transport Call Centre, Krishi Rath App would deal with these constraints.

Regarding its marketing, there have been constraints related to direct marketing, assurance of better returns, taking account of perishable nature of produce, dependence on the rural primary market viz. weekly haat and wholesale market called mandi, poor market infrastructure, presence of middleman culture, networks practising informal trading, and absence of an institutional mechanism to get engaged with processors, wholesalers, aggregators, large retailers, exporters. With new farm laws, warehouse-based trading module, e-NAM portal, these limitations could be overcome.

Although rural families often make their living from many different types of work, improvements in farming have proved to be the path toward widespread, poverty-reducing growth in the rural economy. Successful agricultural transformations have focused on the farming household, providing opportunities for farmers to earn a better income. For some, that will mean raising farm productivity or shifting the mix of production to include higher-value crops and livestock. For others, the right choice will be to do less farming and take advantage of employment options off the farm. As farmers have more money in their pockets, they spend more in the local economy, creating jobs, opportunity, and more demand for agricultural goods. The question is how to accelerate, sustain, and scale these growth cycles. For that, a well-crafted agricultural plan is required as part of a country's overall economic development approach. There are six elements that distinguish a superior agricultural plan.

Prioritized and differentiated strategies

Developing an agricultural transformation plan demands prioritization—a plan will not succeed if it tries to cover everything. Instead, it should focus on the changes that are most likely to kick-start rural economic growth. Successful plans identify goals in a limited number of crop and livestock value chains, cross-cutting agriculture sector enablers (such as lower transportation costs or access to irrigation), and specific geographies.

A second related success factor is differentiation. Successful agricultural transformation plans differentially target agri-food systems and geographic areas with tailored strategies. For example, more productive land that is already well connected to markets, such as irrigated land can support large- or small-scale farms; agribusiness is easier to scale there. In more remote areas, though, with bad roads, poor-quality land, and less well-connected markets, different strategies are needed. These might involve greater focus on staple crop productivity and social safety nets. Most plans don't make these distinctions.

A third related success factor lies in weighing the trade-offs among multiple objectives. Governments work toward a number of different goals, including growth in agro-processing, reduced unemployment, lower poverty incidence, food self-sufficiency, economic growth, increased exports, or lower rates of malnutrition. If these trade-offs are explicitly considered and communicated when developing the agricultural transformation plan, it is possible to tailor the choice of value chains, cross-cutting enablers, and geographies to differentially achieve the government's chosen goals. For example, one strategy might focus on raising the productivity of smallholder farmers' food crops in a particular region where rural poverty and stunting (from malnutrition) rates are high, while a concurrent strategy focuses on what is needed to accelerate growth in the coffee sector to boost export revenue and job creation. When the trade-offs among multiple objectives are not explicitly integrated into the agricultural transformation plan, progress is characterized by under delivery across too many, sometimes competing, objectives.

Market-driven opportunities for farmers

Agricultural transformations often focus too much on volume rather than value and on productivity of row crops rather than opportunities for high-value crops, downstream processing, and livestock. Farmers everywhere are businesspeople. Farming households in developing countries balance a portfolio of crops, livestock, and nonfarm work. Because they feed their families with some of the farm output as well as sell into markets, they make decisions based on their potential profit, risk, and cash flow across family food consumption as well as sales. Too often, agricultural plans recommend particular commodities without paying attention to this basic calculus of farmer household economics. Successful agricultural transformation plans give farmers the opportunity to raise their household incomes.

private-sector stakeholders concluded that the most effective way to address rural poverty was to grow high-value crops (for example, tomatoes and olives) on irrigated lands (while accelerating investment in irrigation) to supply regional urban, European, and other export markets. This choice dramatically increased the income opportunities for small farmers and has led to an average land productivity increase of 30 percent.

In some cases, high-value crops or livestock will not be a viable opportunity for farmers, and promoting the intensification of row crops makes more sense. Even then, the focus should be profitability for the farmer, including attention to sustainability, quality, storage, and processing.

Change agents identified and mobilized

The success of any agricultural transformation relies on how well millions of smallholders and small- and medium-size enterprises can be helped to change farming practices as quickly and effectively as possible. The critical enabler, without which an agricultural transformation is likely to fail, is a frontline “change agent” that helps farmers modify their practices. Change agents are people who farmers trust and interact with regularly. The high-level objectives of a transformation are realized in practice only when they are effectively translated to smaller, on-farm shifts. For example, increased productivity in the dairy sector might be achieved through farmers accessing better animal health technologies and better cattle breeds or joining dairy cooperatives to sell their milk. Change agents provide the critical interface with farmers. To catalyze this, a change agent might be the person providing extension knowledge, offering financing for farming inputs such as fertilizer, aggregating crops, or facilitating marketing services. For example, a change agent can help farmers make the transition from growing wheat to more complicated but lucrative opportunities such as raising tomatoes, vegetables, and orchard crops.

Effective change agents exist in both the public and private sectors. Many scholars cite countries’ investments in national agricultural extension services as critical to agricultural transformation. Ethiopia’s investments in expanding the agricultural extension system are believed to have accelerated its agricultural transformation. Other mechanisms for organizing farmer-facing change agents, though, have also played critical historical roles in transformation. Agricultural cooperatives, for example, can provide technical assistance to farmers but can also fundamentally change the farmers’ risk and potential revenue by providing access to storage, equipment, finance, and marketing services. Small-scale stockists, or input dealers, also have an important influence on the changes required among smallholder farmers if agricultural transformation is to succeed (for example, promoting the adoption of improved, higher-yielding varieties of seed).

Morocco designated farm managers who interacted with a large number of smaller farmers through contracts as the main category of change agent. In each case, the countries made a big effort to recruit, support, and manage the performance of these change agents. Other kinds of organizations with change agents include warehouse aggregators, food processors, inputs distribution centers, and farmer collectives.

The appropriate choice of change agent might vary depending on what part of the transformation plan is involved and the characteristics of the country's agri-food systems. The key is to ensure the use of appropriate metrics and incentives, sufficient training, and performance management of the change agents. Selecting change agents is critical in every agricultural transformation, yet we rarely see this step addressed systematically.

Finding the right starting points for scale

Change in agricultural systems requires multiple parallel advancements. For example, improvements in agricultural extension and seed systems might enable farmers to switch to a more productive hybrid seed, but lack of access to fertilizer (upon which the hybrid depends) could prevent productivity increases and leave the farmer unwilling to buy hybrid seed next time. As in any complex economic system, when so many elements are interrelated, any one of them can become a constraint and stall progress.

A common reaction to this interdependency problem is to try to move all elements ahead in a highly prescribed way, specifying interventions up and down value chains and creating complex plans with a high potential for failure. Instead, the best agricultural transformation plans have two critical characteristics: they anticipate the need for agility, and they selectively focus on the points of the system where small changes are likely to cause larger shifts. These focus areas could be within specific geographies or within particularly influential value chains.

Overly prescriptive and inflexible strategies in agricultural transformation fail because of the complexity of agriculture-based economies. For example, designing a national promotion of new varieties of high-yielding maize among smallholders, along with investment plans for storage and marketing, may not work if the storage facilities are not placed in the right locations. Suppose the production of maize in some areas outstrips storage capacity. Roads are bad, and transport to other markets is prohibitively expensive. In these areas, the glut of maize depresses the local market price, and farmers may return the next season to growing their old, cheaper varieties of maize because they lost money on the new one. A different, less top-down approach might be to enable change agents to set local targets and work with farmers who know the economics of maize production all too well. As changes begin to occur, the most critical success factor is that the plan allows for learning and that it is flexible enough to be adjusted as understanding progresses.

As localized systems, parts of value chains, or changes in geographic regions are better understood, the learning from those successes can be applied at greater scale. Starting with less comprehensive and prescribed plans and demonstrating success with more flexible learning models can also attract champions, additional talent, and more investment that can be used in scaling up.

This is normal change management in the private sector. For example, a transformation of 50 manufacturing plants may start with three plants and scales up from there. But in public-sector transformations, the need for equity across the population often leads to single-solution national programs, such as untargeted fertilizer subsidies. These broad interventions often do not succeed, because stakeholders have not taken the time to learn the nuances of where and how best to implement them.

Pragmatic approach with an investor mind-set

Approaching transformations with an investor mind-set is critical to the success of the process. In kick-starting agricultural transformations, coordination among government, donors, and civil society is critical, but it is equally important from the start to plan for private-sector engagement. Without this, the transformation may proceed more slowly, stall, or not reach scale.

Agricultural transformation plans with an investor mind-set include three strategic planning components. First, the plan identifies public investments that complement likely private-sector investment. These are investments in areas where returns are low and/or risks are high. They can include typical public goods (such as rural advisory services or training) as well as investments in commodities or geographies that are important to transformation but unlikely to garner private investment. Second, a good agricultural transformation plan identifies public investments designed to catalyze additional private-sector engagement. This may be, for example, through risk guarantees, cost sharing, innovative public–private partnerships, targeted subsidies, or provision of infrastructure conditional on private investment. Last, agricultural transformation plans with an investor mind-set anticipate changes in the enabling environment that will be necessary as the transformation progresses to support increasing private-sector engagement. These policies, laws, and regulations are usually across multiple sectors in addition to agriculture, including banking, trade, and land policies.

Progress on enabling policies

Agricultural transformation is more than changes in farming practices. It is about catalyzing transformation of a country’s rural economy. As such, more than agricultural trade and subsidy policies are in play. For example, laws and regulations that influence banking, labor, infrastructure, land ownership and access, access to water, telecommunications, taxes, and insurance are also critical considerations.

Land policy is often cited as a pivotal factor in determining whether a country’s agricultural transformation can simultaneously achieve sustained progress and inclusivity (contributing to widespread poverty reduction). Land policy is a good illustration of how critical it is for policies to be dynamic—changing over time to prevent transformations from stalling. For example, land ownership or tenure may be key at the start of an agricultural transformation as a way of influencing farmers’ investment in their production. However, rental markets may soon become important as some farmers move out of agriculture into other jobs and need income from their land.

Finally, effective policy making for agricultural transformation needs to become more evidence-based over time. Policy makers should invest in making use of existing data and analytics to comparatively assess the costs and likely outcomes of different potential transformation programs. Policy makers also need to use data and analytics to set reasonable targets and redirect programs where outcomes are not meeting targets. Evidence-based policy making builds better plans and integrates accountability into the systems responsible for implementing the policies.

How to do it

The first part of this article focused on best practices for what to do in a successful agricultural transformation and what should be included in a high-quality national agricultural plan. The delivery elements of transformation, however, are often even more neglected and represent a big opportunity to increase success rates. Even in the private sector, McKinsey research shows that 65 percent of transformations that aim to improve the performance of large companies fail to accomplish their goals. The most important factor that distinguishes successful transformations is attention to the soft side—the "how to do it" part.

Willingness to change

The most important factor in the soft side is the willingness of governments, donors, farmers, companies, and civil society organizations to take risks and change behaviors to pursue a better outcome. Sometimes a new prime minister or agricultural minister arrives with a vision to transform the sector, and the momentum of good leadership spurs progress. Other times, change readiness can be encouraged through incentives (for example, compacts through the Millennium Challenge Corporation or contingent private-sector investment commitments), through exposure (for example, World Economic Forum regional meetings or rankings in internationally accepted development indices), or by showing a way forward that convinces key stakeholders.

However, it occurs, commitment from the highest levels of government is needed before and during the development of agricultural transformation plans. Both political and financial capital are at stake for public-sector investors, and securing high-level commitment will ensure the development process produces more clearly defined practical plans that have a higher likelihood of being implemented.

Sometimes, though, a country is just not ready for change, either because it is undergoing conflict or because the wider political system itself is not ready to work on agricultural transformation.

Key stakeholders should make a big effort to ensure and maintain a country's change readiness. But there should be a clear-eyed evaluation—if change readiness really is not present and there is no good prospect for movement, then it is best to stop wasting resources. In the meantime, many steps can be taken to improve the national welfare, but this does not have to be approached with a transformation mentality.

Leadership alignment

For a transformation to succeed, there must be a common understanding of the plan, stakeholder roles, and approach to management of the process. At the highest level, key government ministries, the local and international private sectors, and donors must be aligned. Ethiopia and Morocco both invested more than a year of intense study and stakeholder engagement to craft their agricultural transformation plans. Nigeria undertook a process of deeply engaging 24 bank CEOs and key government leaders in developing its agricultural bank lending program, NIRSAL. Many tools and processes exist to achieve common understanding, but getting there requires commitment from leaders across different sectors.

The alignment must also extend from the national to local level, into provinces and districts, and across multiple ministries. Transformation planning, leadership alignment, and budget coherency that is developed at the national level, and only in the ministry of agriculture, will fail when the interventions interact with more local governments or with other enabling issues (for example, transportation, trade, or finance). In addition to alignment between national and local decision makers, successful planning often includes an appropriate decision-making mandate for lower governmental levels (for example, states in Nigeria, provinces in Morocco, and districts in Ethiopia) and cross-ministerial collaboration processes.

Leadership skill building

Most successful transformations can be traced to specific single individuals who had an extra-ordinary impact on the project. Often this is left to chance, but there is great upside to a more systematic approach to supporting key leaders, from high-level government officials to frontline employees. In private-sector transformations, leadership training and peer networks are made available, even when the goal is just a few million dollars of profit improvement. In large-scale public-sector transformations, where the goal is to improve the lives of millions of people, the return on investment for leadership skill building is tremendous.

A well-known principle in adult learning is that skill building works best when it is connected to real work and practical problem solving. With this in mind, we believe there is great value in the creation of an academy focused on building the next generation of leaders in an agricultural transformation. Here, groups of 20 or so leaders responsible for agricultural transformations in their countries jointly go through an 18-month leadership journey using a “field and forum” approach. They would assemble every few months for intense technical and leadership training, and then return to their roles at home, with remote access to both expert support and a peer network. This approach costs relatively little but produces better individual leaders and facilitates alignment in a country’s top team.

Managing the transformation

An agricultural transformation is not just a planning exercise. It takes management over time. Our experience suggests that creating a project management office (PMO) can greatly increase the chances of carrying out a successful large-scale change program. A PMO can concentrate talent, monitor implementation, act as a source of truth, and, in general, help get things done. The office can apply accepted project management technologies to break the transformation into discrete initiatives, each with specific goals, timing, and responsibility. A PMO is also charged with engaging relevant stakeholders when problems arise.

There is a case for using existing structures such as ministries rather than creating a temporary new organization. However, our experience shows that, depending on the country, the positives of a PMO (improved coordination, management of progress toward targets, increased ability to learn and adjust implementation over time) can greatly outweigh the negatives (high transaction costs, the potential for added complexity in political channels). Most large-scale transformations in the private sector use versions of PMOs. Some countries with recent success in agricultural transformations are using PMOs (including Ethiopia and Morocco).

There has been strong progress on country and state-level agricultural development plans throughout the world, but we believe there are still large opportunities for improvement, as described in the first part of this article. The how-to elements of a transformation described in the second part offer an even greater opportunity to accelerate agricultural transformations. Our experience suggests that they are the biggest controllable factors leading to successful conclusions. They are high-return-on-investment actions that can make the "what to dos"—the larger investments in areas such as processing facilities, roads, and fertilizer—have a much likelier chance of success.

Agricultural transformation is essential to the future well-being of developing nations and therefore also to a world with more equitable economic development. We hope that this article contributes to the thinking about agricultural transformation and encourages governments and other stakeholders to reflect on the steps they should take next.

Agricultural and Processed Food Products Development and Authority (APEDA) has devised a strategy to

promote Export of Agricultural and Horticulture products grown in **North-Eastern (NE) states.**

- **Created a platform in Assam** for the exporters to get the products directly from the producer group and the processors.
  - The **platform will link the producers and processors of Assam and exporters from other parts of the country** that would expand the base of the export pockets in the **North-Eastern states.**

What is the Significance of NER in Agri Exports?

- The NE region is **geopolitically important as it shares international boundaries** with China and Bhutan, Myanmar, Nepal and Bangladesh making it the potential hub for the export of agricultural produce to neighbouring countries as well as other foreign destinations.
- It witnessed an **85.34 % growth in the export of agricultural products** in the last six years as it increased from USD 2.52 million in 2016-17 to USD 17.2 million in 2021-22.
  - The major destination of export has been Bangladesh, Bhutan, the **Middle East**, the UK and Europe.
- Assam and the other states of North East Region have a favourable climate condition and the soil type for growing almost all agricultural and horticultural crops.
- The NER produces huge marketable surplus in a number of perishable commodities, such as banana, pineapple, orange and tomato.

What are the Initiatives to Promote NER as Agri Export Hub?

- Mission Organic Value Chain Development for North East Region (MOVCD-NER): It is a Central Sector Scheme, a sub-mission under National Mission for Sustainable Agriculture (NMSA), launched by the Ministry of Agriculture and Farmers Welfare for implementation in the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, during the 12th plan period.

- The scheme aims to development of certified organic production in a value chain mode to link growers with consumers and to support the development of entire value chain starting from inputs, seeds, certification, to the creation of facilities for collection, aggregation, processing, marketing and brand building initiative.

▪ Training Programmes:
  - APEDA signs a MoU with Assam Agriculture University, Jorhat to conduct various training programmes on pre-harvest and post-harvest management and other research activities for the promotion of export from the region.

▪ Virtual Buyer Seller Meet:
  - During Covid-19 period, **APEDA** continued to push its export plans through Virtual Buyer Seller Meet in association with the Embassy of India located in different countries with exporters from NER regarding the sourcing of pineapple, ginger, lemon, orange, etc.

▪ Trade Fairs:
  - **APEDA** also organised Virtual Trade Fairs during the pandemic and facilitated the export to foreign countries.

▪ Branding Local Products:
  - **APEDA also extended its support for branding and promotion of North East products such as KIWI Wine, processed foods, carrying out a wet sampling of Joha Rice Pulao, Black Rice kheer, etc.**

▪ Capacity building:
  - **APEDA organised skill development programmes for manufacturers, exporters and entrepreneurs to utilise the local produce for value addition.**

▪ Workshop on Food Quality and Safety management:
  - **APEDA facilitated a workshop on Food Quality and Safety Management for Export of Processed Food Products for boosting exports of agricultural and processed food products from NER through sustainable food value chain development.**

India is a Land of Rich Diversities : Huge Untapped Potential India is known as a Land of Rich Diversities in the world. It's Geographical & Demographical uniqueness in Cultures, Language and Surroundings, Environment and Diverse Agro–climatic Zones bears a Rich Source of Resources, Artistic Works, Crafts, Crops and Variety of Foods and other Products. India's rich cultural heritage and traditional diversity are reflected by a wide variety of handicrafts made by artisans from all over our country. The crafts of India are Diverse, Rich in History, Culture and Religion. Indian Crafts include metalwork, wood work, cloth, textiles and fabric, jewelry, terra cotta objects, pottery and objects made from cane and bamboo. Some crafts such as woodwork, painting and stonework are featured as architectural elements and as objects of art.

India's Farmers, Artisans, Weavers, Engineers, Small Entrepreneurs, the MSME sector and others are the strength of the whole Nation. India Needs to Preserve its Vibrant and Culturally Rich, Centuries-old Roots in the form of its stunning Arts and Crafts and Traditional Creative Works. Also it is Essential to Explore & Create some Commercial Value to the Beneficiaries and make them Live, Prosper and to Sustain our Traditional & Cultural Values and Preserve our Wealth. Each District of India can be characterized as an exclusive source of distinct and distinguished products, but Remain Untapped. If the Potential of each District is Tapped fully and Realized, then it will Fuel Economic Growth, Generate Employment, Boost Rural Entrepreneurship, Enhances Exports and Truly Transforms to move towards the goal of 'Aatmanirbhar Bharat'. Districts as Export Hubs Initiative Hon'ble Prime Minister in his Independence Day speech on 15th August, 2019 highlighted the need to channelize the Unique Potential of each District of the country and convert them into export hubs.

Taking his Vision forward, Department of Commerce through DGFT launched the "Districts as Export Hubs" initiative and since then has been working with the States / UTs and the districts directly to Create Institutional Mechanisms for Facilitating and Promotion of Exports Of Identified Products / Services from the Districts. Export Promotion Based on Local Strengths Districts as Export Hubs is the first such initiative of Government of India which tries to Target Export Promotion, Manufacturing and Employment Generation at Grass Root Level and has made States and Districts accountable for the Export Growth from the Districts in the Country.

It is a Great Transformational Step to realize the potential of a district. The initiatives aim to Link Local Producers in Rural and Remote Districts with Global Supply Chains, make them Self-reliant and bring them into the Economic Mainstream. The Objective is to enable MSMEs, Farmers, Artisans and Small Industries to get Benefit of Export Opportunities in the Overseas Markets, Promote Exports of our Traditional Products based on our Local Strengths and shift focus on District led Export Growth for Self-sufficiency and Self- Reliance and as a whole Increase Competitiveness & Boost Exports from the Nation. Products at District Level Identified Under the 'Districts as Export Hubs Initiative', products and services (including GI Products, Agricultural Clusters, Toy Clusters etc.) with export potential have been identified in all districts of the country in consultation with the stakeholders including the States / UTs.

Under the District as Export Hub (DEH) initiative, products including agricultural products with export potential have been Identified in all 733 Districts Across the country. The list of such identified products and services gets updated regularly on the basis of inputs received from the States / UTs. District as Export Hub Initiative also strives to achieve the objectives of Agriculture Export Policy by Promoting Value Added Exports.

Districts as Export Hubs :

Institutional or Policy Interventions Following are Institutional or Policy Interventions taken.

- Preparation of State Export Strategy / Policy by all State / UT Governments
- Product/Service identification in each District
- Constitution of District Export Promotion Committees(DEPC)
- Preparation of District Export Action Plans(DEAPs)
- Monitoring implementation of DEAPs
- Identifying Agricultural Clusters in the Districts
- Mapping GI product in each District
- Export Development Centres (E-Commerce in Districts) Institutional Mechanism State Export Promotion Committees (SEPC) at the State Level District Export Promotion Committees (DEPCs) at the district level ICEGATE / DGCIS Generates District-wise Export Data to Track the Export Performance from each District. In the initial phase, product/services (GI products, agricultural clusters, toy clusters etc.) with export potential in each District have been identified District Export Action Plans (DEAP)

A District Export Action Plan may include the following:

> District Profile

> Industries Profile

> Major Products (Goods and Services) Exported from District

> Other Products/Sectors with Potential to export in Future

> Identifying the bottlenecks faced by the Industry

> Identifying institutional responsibilities, specifics of policy, regulatory and operational reform

> Identifying infrastructure/utilities/logistics/Policy interventions required. > Action Plan must define quantifiable targets with specific timelines for their implementation.

> Clear identification of incentives/Support provided by the State and Central Government.

> Training and development needs for identified export products > Analysis of the export data of the District and ways and means to effectively capture it.

> Mid-term and long-term export strategy/suggestions to promote the District as Export Hub.

Govt. to develop 50 Districts as Export Hubs: Under the proposed scheme, the government will select 50 districts through a challenge, and they will receive ₹50 crore each. The districts will be assessed on parameters such as plans for exports, efforts to plug infrastructure and logistics gaps, and cluster approach to exports. As it will be a centrally sponsored scheme, the Directorate General of Foreign Trade (DGFT) has proposed that the Centre pays 60% of the estimated cost, with the rest borne by the respective states. Progress Made- Districts as Export Hubs State Export Promotion Committee (SEPC) has been constituted in all the 36 States/UTs District Export Promotion Committee (DEPC) has been constituted in all the 36 States/UTs. Products/Services with export potential have been identified in all 733 Districts across the country (Including Agricultural & Toy clusters and GI products in these Districts). State Export Strategy has been prepared in 28 States/UTs. State Nodal Officers/Export Commissioners are nominated in 34 States/UTs. DEPC meetings has already been conducted in 679 Districts Draft District Export Action Plan (DEAP) has been prepared by the RAs of

DGFT for 497 Districts out of which 112 are formally notified by DEPCs. A web portal to monitor the progress of District Export Action Plan in all the Districts has been developed for updating the progress made. Toy manufacturing clusters have been identified in 12 Districts. State-specific Agriculture Export Plans with focus on agricultural exports have been prepared by 16 Sates/UT's. 47 product-district clusters have been identified under the Agriculture Export Policy (AEP) for promoting export-oriented production. These apart Virtual global outreach event/Buyer Seller meets; Sensitization Workshops; Export promotion events are being organized. State specific export brochures are being prepared. Additional attributes in the Shipping Bill have been incorporated from 15th February, 2020 to capture District and State of origin of goods exported. (circular No 09/2020; 5th February, 2020) ICEGATE has started generating District wise export data from September 2020 onwards. This data will act as a baseline indicator for measuring export performance in the Districts. Way Forward Support Local Exporters : Local Government Bodies should be involved in the implementation of the District Export Action Plan. It include specific actions required to Support Local Exporters or Manufacturers in producing or manufacturing identified products in adequate quantity and with the requisite quality, for reaching potential buyers outside India, thereby Creating Economic Value. Strengthening Infrastructure & Logistic Network : Lacks sufficient Infrastructure is a Major Challenge being Faced by Exporters specially at District and Sub-district Levels. Focus should be to Develop Robust Infrastructure Network – Transport & Logistics Facilities – Road, Rail, Ports & Dry Port Connectivity and their Linkage to Manufacturing Hubs or Clusters, Warehouses, Testing Labs, Certification Centers, Uninterrupted Power Supply, Reliable Internet Facilities etc. that will help Indian exporters compete in the Global Market more Competitively. Capacity Building : Efforts should be undertaken on capacity building of manufacturers, entrepreneurs and small exporters on complex Procedures, Documentation and Export Compliances thereby facilitating Export of Goods and Services. Promote Export Dynamism : Export growth can Stimulate Economic Growth in a variety of ways. Encourage Product Specialization, Product Innovations, Creative Developments, Support to Overcome Size Limitations and achieve Economies of Scale, Global Market Access. Role of e-Commerce and Digital platforms: E-commerce will allow tier-II and tier-III manufacturers to be a part of global marketing platforms. Digitalization improve Export Competitiveness. Role of Financial Institutions : Financial Institutions such as the National Bank for Agricultural and Rural Development and the Small Industries Development Bank of India should take a Leading Role to easily Provide Credit to Traders and Manufacturers. Details can be Viewed in YouTube Conclusion The outcome will be dependent on the implementation of District Export Action Plans (DEAP) that will lead to improvement in trade specific ecosystem within the districts. This will support and enhance export logistics and infrastructure, disseminate information to support scaling up of local businesses and provide ease of access to the exporters in the form of branding, packaging, testing, certification etc. to make them export competitive. The quantifiable targets identified in the DEAPs will guide the various government agencies both at the Center and the State/UT to work collectively to resolve issues faced by the exporters of the District. In the next 5 years, it is targeted that export growth of double digits is registered from 350 Districts of the country, with significant growth in the exports of identified products/services from each District.

Scarcity of capital/ agricultural finance funding proper system.

Agriculture is an important industry and like all other industries it also requires capital. The role of capital input is becoming more and more important with the advancement of farm technology. Since the agriculturists' capital is locked up in his lands and stocks, he is obliged to borrow money for stimulating the tempo of agricultural production.

The main suppliers of money to the farmer are the money-lenders, traders and commission agents who charge high rate of interest and purchase the agricultural produce at very low price. All India Rural Credit Survey Committee showed that in 1950-51 the share of money lenders stood at as high as 68.6 per cent of the total rural credit and in 1975-76 their share declined to 43 per cent of the credit needs of the farmers.

This shows that the money lender is losing ground but is still the single largest contributor of agricultural credit. Rural credit scenario has undergone a significant change and institutional agencies such as Central Cooperative Banks, State Cooperative Banks, Commercial Banks, Cooperative Credit Agencies and some Government Agencies are extending loans to farmers on easy terms.

Steps to Increase Availability of Credit to Rural Areas

The Government has taken several policy measures from time to time to increase the availability of institutional credit to farmers. These, inter-alia, include the following:

• In terms of Reserve Bank's extant guidelines on lending to priority sector, a target of 40 per cent of Adjusted Net Bank Credit (ANBC) or Credit Equivalent amount of Off-Balance Sheet Exposures (OBE), whichever is higher, as on March 31 of the previous year, has been mandated for lending to the priority sector by domestic scheduled commercial banks, both in the public and private sector. Within this, a sub-target of 18 per cent of ANBC or Credit Equivalent amount of OBE, whichever is higher, as on March 31 of the previous year, has been mandated for lending to agriculture sector.

• The Government has been setting an annual target for the flow of credit to the agriculture sector. The agriculture target for 2012-13 is fixed at Rs.5,75,000 crore against the target of Rs.4,75,000 crore in 2011-12.

• The interest Subvention Scheme is being implemented by the Government of India since 2006-07 to make short-term crop loans upto Rs.3 lakh for a period of one year available to farmers at the interest rate of 7 per cent per annum. The Government of India has since 2009-10 been providing additional interest subvention to prompt payee farmers. The additional subvention was 1% in 2009-10, 2% in 2010-11 and 3% in 2011-12. The Government has in the Budget speech of 2012-13 announced continuation of these schemes in 2012-13.

• RBI has also advised banks to waive margin/security requirements for agricultural loans upto Rs. 1,00,000.

• The Agricultural Debt Waiver and Debt Relief Scheme (ADWDRS), 2008 was implemented by the Government. This Scheme has de-clogged the lines of credit that were clogged due to the debt burden on the farmers and make the farmers eligible for fresh loans. Under the Scheme Rs. 52,275.55

crore has been released by the Govt. through RBI and NABARD to give benefit to 3.45 crore farmers.

• Banks have been advised to issue Kisan Credit Cards (KCC) to all eligible farmers and General Credit Cards (GCC) to non-farmers. A new scheme for KCC has been circulated by NABARD which provides for KCC as an ATM card which can be used at ATM/Point of sale (POS) terminals.

• In view of the above initiatives of the Government, the number of farm loan accounts has increased from 482.30 lakh in 2009-10 to 646.57 lakh in 2011-12.

This information was given by the Minister of State for Finance, Shri Namo Narain Meena in written reply to a question in Rajya Sabha today.

Organization of agricultural credit in India

Agricultural credit is considered as one of the most basic inputs for conducting all agricultural development programs. After independence, the Government adopted the institutional credit approach through various agencies like co-operatives, commercial banks, regional rural banks etc. to provide adequate credit to farmers, at a cheaper rate of interest. Moreover, with growing modernization of agriculture during the post-green revolution period, the requirement of agricultural credit has increased further in recent years

The government has been raising credit target for the farm sector every year, With the aim of doubling farmers' income by 2022. The agricultural credit flow has increased consistently over the years, exceeding the target set for each fiscal.

Credit is a critical input in achieving higher farm output. Institutional credit will also help delink farmers from non-institutional sources where they are compelled to borrow at usurious rates of interest.

Since Green revolution, the investment requirements for cultivation has continuously increased, as almost all inputs like seeds, pesticides, fertilizers, motor pump sets, tractors, pipe lines, etc., are to be purchased and several other services such as tractors, sprayers, rotors, harvesters etc., are to be hired from the market.

Types of agricultural credit

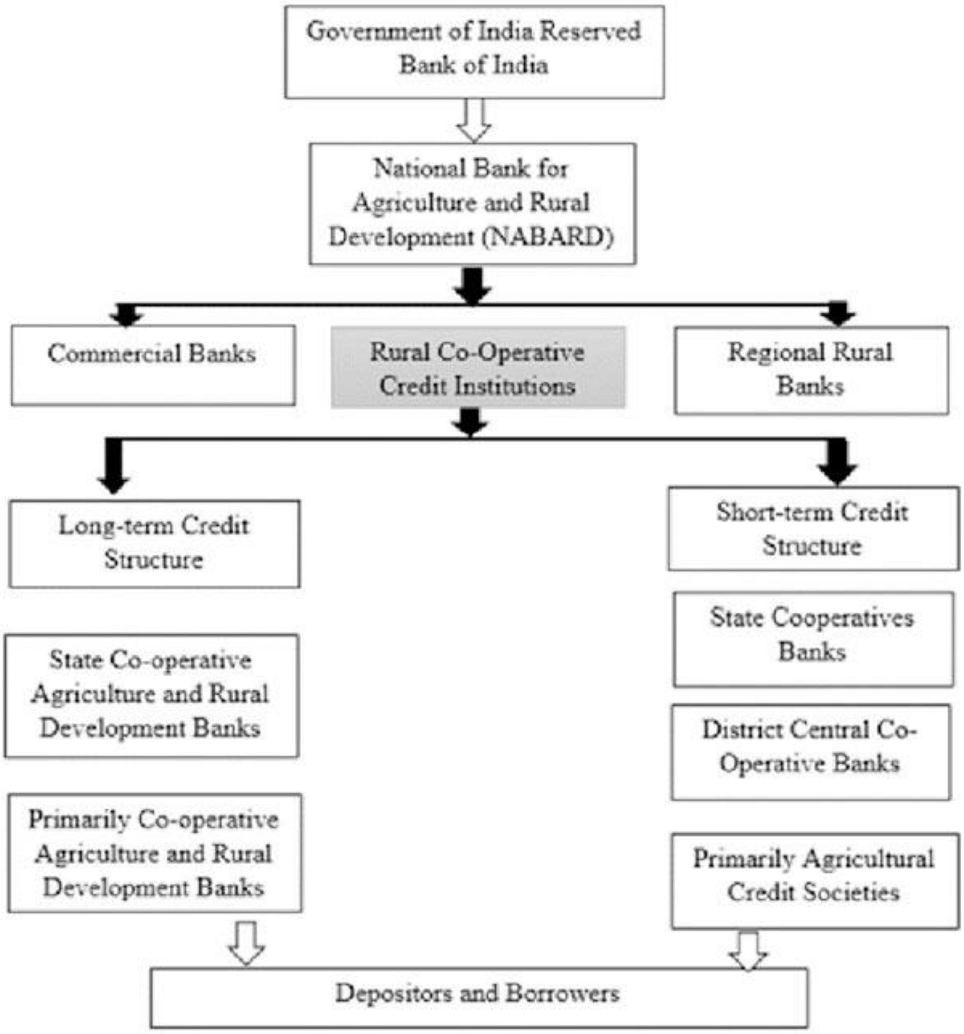
Considering the period and purpose of the credit requirement of the farmers of the country, agricultural credit in India can be classified into three major types:

- **Short term credit:** The Indian farmers require credit to meet their short term needs viz., purchasing seeds, fertilizers, paying wages to hired workers etc. for a period of less than 15 months. Such loans are generally repaid after harvest. The Indian farmers require credit to meet their short term needs viz., purchasing seeds, fertilizers, paying wages to hired workers etc. for a period of less than 15 months. Such loans are generally repaid after harvest and are called short term credit. In fact, the proportion of such loans has been quite high.

- **Medium-term credit:** This type of credit includes credit requirement of farmers for a medium period ranging between 15 months and 5 years and it is required for purchasing cattle, pumping sets, other agricultural implements etc. Medium-term credits are normally larger in size than short term credit.
- **Long term credit:** Farmers also require finance for a long period of more than 5 years just for the purpose of buying additional land or for making any permanent improvement on land like the sinking of wells, reclamation of land, horticulture etc. Thus, the long term credit requires sufficient time for the repayment of such loan.

Sources Agricultural Credit:

- Sources of agricultural credit can be broadly classified into institutional and non-institutional sources.
    - Non-Institutional sources include moneylenders, traders and commission agents, relatives and landlords, but
    - Institutional sources include co-operatives, commercial banks including the SBI Group, RBI and NABARD.
- The major institutional credit agencies in India are Commercial Banks (CBs), Regional Rural Banks (RRBs) which are mainly sponsored by the Scheduled Commercial Banks and state governments. There are also the Cooperative Banks which are further divided into rural cooperatives and urban cooperatives.
- Scheduled Commercial Banks are largest credit providers followed by Cooperatives and Regional Rural Banks. It is observed that after the nationalization of commercial banks of India in 1969, the commercial banks as a whole have increased consistently its share in institutional credit to agriculture sector.



Government steps for providing Agriculture Credit to Farmers:

- ### Kisan Credit Card (1998-99):

The Kissan Credit Card (KCC) scheme was launched in 1998 with the aim of providing short-term formal credit to farmers. Owner cultivators, as well as tenant farmers, can avail loans to meet their agricultural needs under this scheme at attractive rates of interest. RBI monitors it for SCBs and NABARD monitors the scheme with respect to Cooperative Banks and RRBs. Now Cooperative sector are under RBI. Budget 2018-19 extended this provision to Animal Husbandry and Fisheries.

- ### Agriculture Market Infrastructure Fund (AMIF) – NABARD:

For development and upgradation of rural agriculture markets. It was announced in 2018 Budget for developing and upgrading agricultural marketing infra in the 22,000 Gramin Agricultural Markets (GrAMs) and 585 APMCs. At present, GrAMs are being developed by MGNREGA Funds. Scheme is demand driven. It will be created with NABARD and will provide the state/ UT governments subsidized loans for their proposal for developing marketing infrastructure in 585 APMCs and 10,000 villages.

- **Interest subvention scheme:**

The Interest Subvention Scheme is being implemented by NABARD and RBI.

The interest subvention scheme for farmers aims at providing short term credit to farmers at the subsidized interest rate. The policy came into force with effect from Kharif 2006-07. The scheme is being implemented for the year 2018-19 and 2019-20.

- **NABARD Fund of Rupees 700 crore VCF for Rural Agriculture Startups:**

In agricultural credit, one of the major concerns of the lending institutions is to cover credit risks involved in extending loans to the farmers. However, no provisions are in place to cover the market risks faced by the farmers. One of the possible ways out is to link Farmer Producer Organizations (FPOs), marketing cooperatives and integrators with banks, as exemplified by the SHG-bank linkage programme. These producer organizations and integrators can be potential channels for extending credit to the farmers across the entire value chain. Organizing farmers into groups will enable them to reap the benefits of economies of scale as well as of assured markets for their produce. The poultry industry in India, for instance, is majorly organized and commercial (80 percent). Poultry farmers (operating on different farm sizes) are linked with big integrators such as Venkateshwara Hatcheries, Suguna poultry farm etc. through contracts where farmers raise poultry birds of certain quantity and quality at pre-determined prices and integrators provide inputs, technical guidance and credit along with the commitment to buy back the fully grown birds. This is a win-win model which covers market risks of farmers and credit risks of integrators. Liberal lending by banks to such mature business models and FPOs can ensure guaranteed returns with relatively low risks and uncertainties. In addition to ensure inclusiveness, FPOs with greater percentage of small and marginal farmers can be categorised as a priority area for extending loans. Next, Kisan Credit Cards (KCCs) and Self-Help Group Bank Linkage Programme are two such innovations that have credibly improved the reach of formal credit to the last mile. The government documents (such as the Economic Survey) claim that the cumulative number of KCC issued hasreached 150 million as of March 2016. But as already highlighted in the analysis, the NAFIS survey presented a somewhat puzzling figure that only about 10 percent of farmers have used KCC in the agricultural year 2015-16. As there are no detailed studies on KCC's current use, further research is needed to understand its dynamics better, and to find ways to strengthen its reach and use. Issuance of KCC in remote villages should be expedited to ensure financial inclusion of more farmers, especially of small and marginal ones. This will ensure timely and affordable credit to the resource-constrained farmers' groups by overcoming the challenges of collateral stipulations. In addition, KCCs should be made Aadhaar enabled and a centralized database should be created across the states to track the number of KCCs issued, in operation, amount of loan availed, defaults at any bank etc. by a farmer. Such a robust mechanism will ensure credit monitoring, which is absent from the current system. Another benefit of KCC is that it can also cater to the consumption credit needs of farming families. As it is learnt that SHGs credit lending is a very small part of the overall credit needs of the agricultural sector, it is a matter of further study to look at the challenges involved and to find ways to incentivize credit in agriculture and allied sector through SHGs. Further, to ensure financial inclusion of small and marginal farmers, the banking system also needs to adhere to the Priority Sector Lending (PSL) guidelines issued by the RBI. They mandate that at least 8 percent of Adjusted Net Bank Credit (ANBC) or credit equivalent amount of off-balance sheet exposure, whichever is higher, be for small and marginal farmers (out of 18 percent stipulated for the agricultural sector). Tradable PSL certificates are a step in the right direction. However, the data for direct and indirect credit should continue to be captured separately for policy evaluation overtime and to ensure that the banks do not short-change farmers and lend proportionally more to activities that were previously included under indirect finances. For efficiency and financial sustainability, the interest subvention scheme should focus on small and marginal farmers only and transactions should be tracked at the individual farmer level for transparency. As the ill effects of generalized debt waivers on financial health of the banking sector as well as on the credit culture are quite clear, such policy measures should be discontinued. Additionally, 28 to provide efficient credit delivery, unfolding innovative business models such as Bharat banking, Business Correspondent/Business Facilitator, and Joint Liability Group lending need scaling up. Last, but not the least, the policy of interest subvention needs a serious review. A subvention of 5 percentage points, i.e., giving loans at 4 percent while the normal rate being 9 percent, seems to have led to significant diversion of agri-loans to non-agriculture purposes. As is shown in this paper, in some states, especially Kerala and some other southern states, agri-loans amount to substantially more than 100 percent of the value of agri-inputs. This is a clear indication that agri-loans are being used for other purposes. It is better to empower farmers by giving direct income support on per hectare basis rather than by hugely subsidising agriculture credit. We hope with these improvements, the agri-credit system can serve the needs of the farming community even better, and it can also be a role model for many smallholder economies of SubSaharan Africa and South and Southeast Asia.

Training and updating the farmers about the new technology annexure 92

Training of Farmers and Farmers' groups

Activity	**Pattern of Assistance**	**Name of Scheme**
Training of groups of 50-150 farmers on seed production and seed technology	Rs. 15,000/- per group	Seed Village Programme under NMAET
Training of Farmers in recognized institutes (stipend, boarding, lodging and to & fro transportation cost would be provided to farmers).	Rs. 5200/- per farmer per month	Post Harvest Technology Management under SMAM (NMAET)
Farmers training	Rs. 24,000/- per training for 2 days for 30 farmers per batch (@ Rs. 400/- per farmer per	NMOOP

	day).	
Training on plant protection measures to groups of 40 farmers	i) Rs. 29,200/- per Farmer Field School of NGOs/ Private Bodies ii) Rs. 26,700/- in case of state govt. organisations.	NMSA
Training on Repair, Maintenance, Operation and selection of various Agricultural Machinery & Equipments and Post Harvest Management	Rs. 4000/- per person	Sub-Mission on Agricultural Mechanisation (SMAM) under NMAET
2 days training of farmers on Vegetable Production and Related Areas	Rs. 1500/- per training / farmer excluding transport	Vegetable Initiative for Urban Clusters (VIUC)
Promotion of Farmers Associations/ Groups of 15-20 farmers and tie up with Financial Institutions and Aggregators	Rs. 4075/- per farmer in three installments spread over 3 years	VIUC
Organization of awareness programme for the farmers on the Gramin Bhandaran Yojana by National Institute of Agricultural Marketing (NIAM), Jaipur, (for 3 days duration)	Rs. 30,000/- programme	Integrated Scheme for Agricultural Marketing (ISAM)/(Gramin Bhandaran Yojana)
Training of farmers outside the state upto 50 man-days / Block	Rs. 1250/- per farmer per day which includes transportation, boarding and lodging of farmers	ATMA Scheme (NMAET), Sub schemes NHM/ HMNEH under MIDH
Training of farmers within the State (100 man-days / block)	Rs. 1000/- per farmer per day which includes transportation, boarding and lodging of farmers	ATMA Scheme (NMAET)
Training of farmers within the district (1000 man-days per Block)	Rs. 400/- per farmer per day which includes transportation, boarding and lodging of farmers for residential training; otherwise, Rs. 250/- per farmer per day if training is not	ATMA Scheme (NMAET), Sub schemes NHM/ HMNEH under MIDH

	residential	
Cropping System Based Training	Rs. 14,000/-per training consisting of 4 sessions @ Rs. 3500/- each session	NFSM
Training on selection, operation and maintenance of tractors and other agricultural machines	Stipend of Rs. 1200/- per farmer along with to and fro charges in ordinary class and also free lodging for user level course for the duration of one week to six weeks	Promotion and Strengthening of Agricultural Machines through Training, Testing and Demonstration
Training to farmers including field demonstrations; Capacity building of stakeholders/farmers through ield visits on concept of Integrated Farming, Climate change adaptation, Good Agriculture Practices on soil, water and crop management.	Rs. 10,000/- per training session for 20 participants or more. Rs. 20,000/- per demonstration for a group of 50 participants or more.	NMSA
Training programme for On-Farm Water Management/Micro Irrigation	Rs. 50,000/- per training programme for 30 participants for a duration of at least 2-3 days	NMSA
Training and Demonstration on Soil Health	Training to farmers including ield demonstrations; Rs. 10,000/-per training session for 20 participants or more. Rs. 20,000/- per Front Line Field Demonstration	NMSA
Assistance for training on seed production and seed technology for a group of 50 to 150 farmers.	Rs. 15,000/- per training (for 3 one-day training programmes): (i) At the time of sowing of seed crop: training on seed production technique, isolation distance, sowing	Certiied seed production of oilseeds, pulses, fodder and green manure crops through Seed Village Programme under NMAET

	practices and other agronomic practices. (ii) At the time of lower initiation stage of the crop. (iii) After harvest and at the time of seed processing	

Recommendation

Farmers require ongoing education to stay aware of fast-moving developments in technology, science, business management, and an array of other skills and fields that affect agricultural operations. NIFA initiatives increase farmers' knowledge in these areas and help them adopt practices that are profitable, environmentally sound, and contribute to quality of life.

Importance of Farmer Education

Farmers — beginning and experienced — are critical to creating rural prosperity in the United States. However, farmers face unique challenges and require education and training to ensure their success.

Training helps farmers to incorporate the latest scientific advances and technology tools into their daily operations. The results of enhancing their operations with these tools increases efficiency and can also lead to:

- Less harm to the environment
- Reduced food contamination
- Reduction of the need for water and chemicals for crops
- Increased profits

1. **Lack of farmers' empowerment**: Farmers' voices and representation in policy-making processes are often inadequate. Restricted farmers' empowerment and involvement result in policies and initiatives that may not address their specific challenges effectively.

PROGRAMS

1) Farm Safety

2)Enhancing Agricultural Opportunities for Military Veterans

The Enhancing Agricultural Opportunities for Military Veterans Program provides grants to non-profits to increase the number of military veterans gaining knowledge and skills through comprehensive, hands-on and immersive model

farm and ranch programs offered regionally that lead to successful careers in the food and agricultural sector.

3) Extension Risk Management Education Program

The Extension Risk Management Education Program to be established

4) Farm Financial Management

Farm management involves successfully integrating the factors of production land, labor, and financial resources to realize an economically viable, ecologically sound, and socially responsible farm business.

5) Urban, Indoor, and Emerging Agriculture

The Urban, Indoor, and other Emerging Agricultural Production Research, Education, and Extension Initiative to support research, education, and extension activities that facilitate development of urban, indoor, and other emerging agricultural production systems.

6) Beginning Farmer and Rancher Development Program

The Beginning Farmer and Rancher Development Program provides grants to organizations for education, mentoring and technical assistance initiatives for beginning farmers and ranchers.

7) Farm and Ranch Stress Assistance Network

The purpose of the Farm and Ranch Stress Assistance Network Program is to establish a network that connects individuals who are engaged in farming, ranching, and other agriculture-related occupations to stress assistance programs. The establishment of a network that assists farmers and ranchers in time of stress can offer a conduit to improving behavioral health awareness, literacy, and outcomes for agricultural producers, workers and their families.

8) Beginning Farmer and Rancher Development Program

9) Farm and Ranch Stress Assistance Network

10) From Learning to Leading: Cultivating the Next Generation of Diverse Food and Agriculture Professionals

11) Youth Farm Safety Education and Certification Program

12) Emergency Citrus Disease Research and Extension Program Pre-Application

13) Community Food Projects Competitive Grants Program.

proper guidance about artificial intelligence in agriculture.

Technology has redefined farming over the years and technological advances have affected the agriculture industry in more ways than one. Agriculture is the mainstay occupation in many countries worldwide and with rising population, which as per UN projections will increase from 7.5 billion to 9.7 billion in 2050[1], there will be more pressure on land as there will be only an extra 4% of land, which will come under cultivation by 2050. This means that farmers will have to do more with less. According to the same survey, the food production will have to increase by 60% to feed an additional two billion people. However, traditional methods are not enough to handle this huge demand. This is driving farmers and agro companies to find newer ways to increase production and reduce waste. As a result, Artificial Intelligence (AI) is steadily emerging as part of the agriculture industry's technological evolution. The challenge is to increase the global food production by 50% by 2050[2] to feed an additional two billion people.AI-powered solutions will not only enable farmers to improve efficiencies but they will also improve quantity, quality and ensure faster go-to-market for crops.

Artificial Intelligence in Agriculture

Using AI for intelligent spraying of chemicals – Brings in cost savings

Every day, farms produce thousands of data points on temperature, soil, usage of water, weather condition, etc. With the help of artificial intelligence and machine learning models, this data is leveraged in real-time for obtaining useful insights like choosing the right time to sow seeds, determining the crop choices, hybrid seed choices to generate more yields and the like.

AI systems are helping to improve the overall harvest quality and accuracy – known as precision agriculture. AI technology helps in detecting disease in plants, pests and poor nutrition of farms. AI sensors can detect and target weeds and then decide which herbicide to apply within the region. This helps in reduced usage of herbicides and cost savings. Many technological companies developed robots, which use computer vision and artificial intelligence to monitor and precisely spray on weeds. These robots are able to eliminate 80% of the volume of the chemicals normally sprayed on the crops and bring down the expenditure of herbicide by 90%. These intelligent AI sprayers can drastically reduce the number of chemicals used in the fields and thus improve the quality of agricultural produce, and bring in cost efficiency.

Using AI-based robots for farm harvesting – Tackling the labor challenge

Have you ever wondered who actually picks the produce from the agricultural land? Well, in most cases, it is not the traditional farm worker but robotic machines that are capable of doing bulk harvesting with more accuracy and speed that are responsible for getting the produce on your kitchen table. These machines help improve the size of the yield and reduce waste from crops being left in the field.

Many companies are working on improving agricultural efficiencies. There are products like autonomous strawberry-picking machine[1] and a

vacuum apparatus that can harvest mature apples from trees. These machines use sensor fusion, machine vision and artificial intelligence models to identify the location of the harvestable produce and help pick the right fruits.

Agriculture is the second largest industry after Defense where service robots market have been deployed for professional use. The International Federation of Robotics estimates that as many as 25,000 agricultural robots have been sold —matching the number used for military purposes.

Using AI for predictive analytics – Enables right decision-making

Predicting the best time to sow

The difference between a profitable year and a failed harvest is just the timely information on a simple data point of timing of sowing the seed. To combat this, scientists of ICRISATused a predictive analytics tool to arrive at a precise date for sowing the seeds to obtain maximum yield. It even gives insights on soil health and fertilizer recommendations in addition to a 7-day weather forecast.

Crop yield predictions and price forecasts

For many farmers, the biggest worry is the price fluctuation of the crop. Due to unstable prices, farmers are never able to plan a definite production pattern. This problem is highly prevalent in crops like tomatoes that have very limited shelf time. Companies are using satellite imagery and weather data to assess the acreage and monitor crop health on a real-time basis. With the help of technologies like big data, AI and machine learning, companies can detect pest and disease infestations, estimate the tomato output and yield, and forecast prices. They can guide the farmers and governments on the future price patterns, demand level, type of crop to sow for maximum benefit, pesticide usage etc.

Innovative startups are using AI in the field of agriculture. A Berlin-based agricultural tech startup3developed a multi-lingual plant disease and pest diagnostic app, which uses various images of the plant to detect diseases; a smartphone collects the image that is matched with a server image and then a diagnosis of that particular disease is provided and applied to the crop using intelligent spraying technique. In this way, the application uses AI and ML to solve plant diseases. Over seven million farmers have downloaded this app and it has helped identify over 385 crop diseases among field crops, fruits, and vegetables.

To summarize, AI solves the scarcity of resources and labor to a large extent and it will be a powerful tool that can help organizations cope with the increasing amount of complexity in modern agriculture. It is high time that big companies invest in this space.

Can AI replace the knowledge that farmers have always had? The response is probably no for now-but definitely in the near future, AI will complement and challenge the way decisions are made and improve farming practices. Such technological interventions are likely to lead to better agricultural practices, yields, and qualitatively improve the lives of farmers.

The global human population is exploding, with an estimated 9.9 billion of us on the planet by 2050 and with food demand projected to leap 35%—56% in that time. And that's not to mention climatic changes that make resources like water and farmable land scarcer.

Luckily, technology provides us with yet another solution: AI.

From leveraging computer vision technology for crop and soil monitoring to disease detection and predictive analytics, the agriculture industry is entering a whole new phase of evolution—thanks to AI.

Not only is there potential, but also rapidly growing interest and investment:

- Forbes reports that global spending on "smart" agriculture, including AI and machine learning, is projected to triple to $15.3 billion by 2025.
- Research suggests that the market size of AI in agriculture should expect a compound annual growth rate (CAGR) of 20%, reaching $2.5 billion by 2026.

And that's just the tip of the iceberg!

In this article, we'll take a look at some of the most promising AI technologies transforming the agriculture sector.

Here's what we'll cover:

1. Crop and soil monitoring
2. Insect and plant disease detection
3. Livestock health monitoring
4. Intelligent spraying
5. Automatic weeding
6. Aerial survey and imaging

7. Produce grading and sorting

Crop and soil monitoring

Let’s start from the ground up.

Micro and macronutrients in the soil are critical factors for crop health and both the quantity and quality of yield.

Then, once crops are in the soil, monitoring the stages of growth is also essential to optimizing production efficiency. It’s vital to understand interactions between crop growth and the environment in order to make adjustments for improved crop health.

Now, traditionally soil quality and crop health were determined by human observation and judgment. But this method is neither accurate nor timely.

Instead, we can now use drones (UAVs) to capture aerial image data, and train computer vision models to use this for intelligent monitoring of crop and soil conditions.

Visual sensing AI can analyze and interpret this data to:

- track crop health
- make accurate yield predictions.
- detect crop malnutrition much faster than humans AI models can inform farmers of specific problem areas so that they can take immediate action.

Now let’s look at some real examples of how computer vision is helping keep their crops healthy and productive.

Observing crop maturity

Manual observation of wheat head growth stages is just the kind of labor-intensive process that AI can help with in precision agriculture.

Researchers achieved this by collecting images of wheat at different "heading" stages across three years and in different lightings, which enabled them to create a "two-step coarse-to-fine wheat ear detection mechanism".

This computer vision model was then able to *outperform* human observation in accurately identifying wheat growth stages, meaning that the farmers no longer had to make daily treks into the fields to examine their crop.

Or imagine having to check the ripeness of tomatoes by hand on an industrial level. Well..

AI can help with that, too!

Ripe vs. not ripe tomatoes annotated with bounding boxes using V7

Another study examined how well computer vision can detect maturity in tomatoes. Researchers created an algorithm that analyzed color from five different parts of the tomato, and then made maturity estimates based on this data.

How did it do?

Shockingly well! The algorithm achieved a successful detection and classification rate of 99.31%.

Overserving and estimating crop growth and maturity is hard, labor-intensive work for farmers. But AI is proving capable of handling much of that work with both ease and impressive accuracy.

Pro tip: Looking for the perfect bounding box tool? Check out 9 Essential Features for a Bounding Box Annotation Tool.

Hitting the Ground with Computer Vision

Getting back to the importance of soil, another study set out to see how well computer vision can characterize soil texture and soil organic matter (SOM).

Ordinarily, evaluating soil requires farmers to dig up samples and bring them to a lab for time- and energy-intensive analysis. Instead, researchers decided to see if image data from an inexpensive handheld microscope could be used to train an algorithm to do the same thing.

Sure enough, the computer vision model managed to make sand content and SOM estimates with accuracy comparable to costly lab processing.

So, not only can computer vision eliminate a large amount of the difficult, manual labor involved in crop and soil monitoring, in many cases it does it more effectively than humans can.

Insect and plant disease detection

We've seen how AI computer vision can detect and analyze crop maturity and soil quality, but what about agricultural conditions that are less predictable?

Using image recognition technology based on deep learning, we can now automate detection of plant diseases and pests. This works using image classification, detection, and image segmentation methods to build models that can "keep an eye" on plant health.

Take a look at how this works:

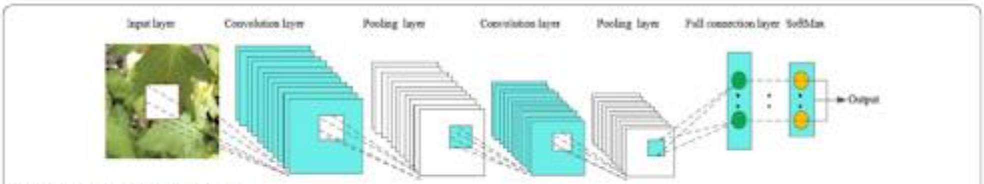
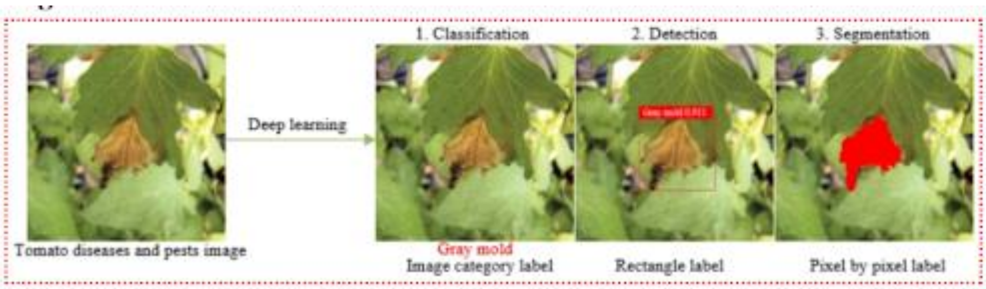


Fig. 2 The basic structure of CNN



Definition of plant diseases and pests detection problem

Keeping out the bad apples (diagnosing disease severity)

A good example of this in action comes from a study of apple black rot (which we'd all probably prefer off our apples!).

[Researchers](#) trained a Deep Convolutional Neural Network using images of apple black rot which had been annotated by botanists according to four major stages of severity.

As with our previous examples, the alternative to computer vision requires a lot of labor-intensive human searching and evaluation. Fortunately for farmers, the AI model in this study was able to identify and diagnose disease severity with an accuracy of 90.4%!

Researchers in another study went even further by using an improved YOLO v3 algorithm to detect multiple diseases *and* pests on tomato plants.

Armed with a digital camera and a smartphone, the researchers took photos at local tomato greenhouses and identified 12 different cases of either disease or pests.

Once the model was trained using the images, which varied in resolution and size of the object featured, it achieved a disease and pest detection accuracy of 92.39% with a detection time of just 20.39 ms.

Not too shabby!

Finding bugs with code

And say you'd like to know not only *if* your crops have pests, but *how many* there are, computer vision systems for insect detection has that covered as well.

TPotato beetles labeled using V7's auto-annotation tool

Did we mention that this works for flying insects, too?

They're certainly not the most fun to capture and count by hand.

[Researchers](#) first set up a sticky trap to capture six different species of flying insect and collect real-time images. They then based the detection and coarse counting method on YOLO object detection, and the classification and fine counting on Support Vector Machines (SVM) using global features.

When all was said and done, their computer vision model was able to identify bees, flies, mosquitoes, moths, chafers, and fruit flies with an accuracy of 90.18%, and count them with 92.5% accuracy.

These studies show that the future of AI computer vision for monitoring the health of our food systems is promising. Not only can it reduce labor inefficiencies, but it can do so without sacrificing reliability of the observations.

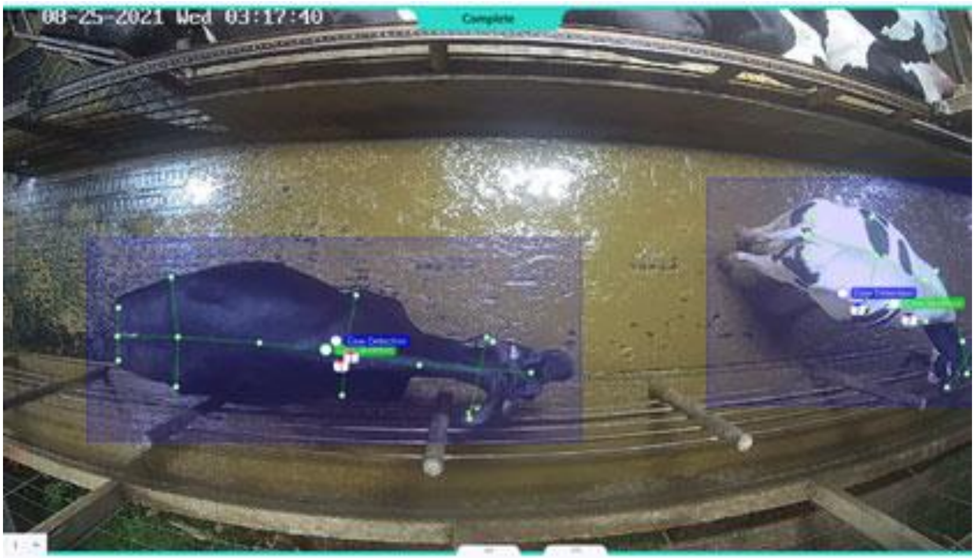
Livestock health monitoring

So far we've focused mainly on plants, but there's more to agriculture than wheat, tomatoes, and apples.

Animals are another major component of our agriculture systems, and they tend to need a bit more tracking than plants. Can computer vision keep up with cows, chickens, and pigs on the move?

Well, if it can track a fly, it can certainly track a cow.

Check out below how one of V7's users—CattleEye's [training data](#) allows for tracking and annotating of cattle using bounding boxes and key points.



Cows annotated with bounding boxes and key points using V7

CattleEye is a great example of an AI-first company in the agriculture industry. They use overhead cameras and computer vision algorithms to monitor cattle health and behavior.

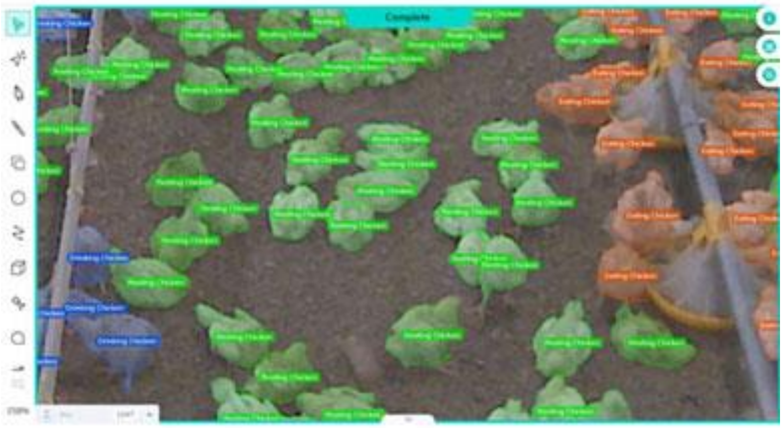
This means that spotting a problem isn't dependent on a cattle farmer being right there next to the cow. Instead, the cattle can be tracked and monitored remotely and in real-time so that farmers can be notified as soon as a problem is observed.

Of course, this isn't just limited to cattle. Computer vision can also:

- Count animals, detect disease, identify unusual behavior, and monitor significant activities such as giving birth.

- Collect data from cameras and drones (UAVs).
- Combine with other technologies to keep farmers informed on animal health and access to food or water.

Plus, take a look at how this image of chickens has been annotated with V7.



Drinking, eating, and resting chickens annotated using V7's auto-annotate tool

The algorithms are trained to look at video data and determine what the chickens are up to – whether they're drinking, eating, sleeping, or doing something odd that may be indicative of disease or behavioral problems.

Build ML workflows. Deploy AI faster.

Plot the best routes for your training data with 8 workflow stages to arrange, connect, and loop any way you need.

The present challenges that plague Indian agriculture are limited knowledge and insufficient infrastructure, especially in the rural areas. Problems related to lack of infrastructure, such as irrigation, market and transport, add huge costs to farmers' operations. In addition, there are no proper delivery systems. There are several schemes to bring development to agriculture. But there is no effective delivery mechanism that can improve productivity, reduce costs, or increase price realization at the grassroots level. Moreover, without government support, the issues only worsen. Thus, corporate farming could be a solution to the Indian agrarian sector, but it needs serious consideration, innovations and better policies, so that neither the business houses nor the farmers incur huge losses.

The current critical issues that plague Indian agriculture are the knowledge and infrastructure deficits, especially in rural areas. Problems related to irrigation infrastructure, market infrastructure and transport infrastructure add high costs to farmers' operations. Another issue is the lack of delivery mechanisms. There are a number of schemes aimed at bringing development to agriculture. We do not have effective delivery mechanisms that can translate into effective facilitation in terms of increasing productivity, decreasing cost, or increasing price realisation at the ground level. Moreover, inadequate Government support exacerbates these issues. Thus, corporate farming could be a solution to the Indian agrarian sector, but it needs deep thinking and innovation and better policies so that neither the corporates nor the farmers are at a loss.

The needs of small farmers, who are most vulnerable to the monsoons, should be prioritised, and more people should have access to services like financing and crop insurance. This will guarantee that the agriculture sector is sustainable and meets the nation's demands. It is crucial to take measures to lessen the population explosion in agriculture by diversifying the sector and the rural economy as a whole by fostering rural non-farm businesses.

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Intelligent spraying

We've seen that computer vision is good at spotting disorders in agriculture, but it can also help with preventing them.

UAVs equipped with computer vision AI make it possible to automate spraying of pesticides or fertilizer uniformly across a field.

With real-time recognition of target spraying areas, UAV sprayers are able to operate with high precision both in terms of the area and amount to be sprayed. This significantly reduces the risk of contaminating crops, humans, animals, and water resources.

While the potential here is great, currently some challenges still exist. For example, spraying a large field is much more efficient with multiple UAVs, but assigning specific task sequences and flight trajectories for individual crafts can be tricky.

But that doesn't mean it's game over for intelligent spraying.

Researchers from Virginia Tech have devised a smart spray system based on servo motor-controlled sprayers that use computer vision to detect weeds. A camera mounted on the sprayer records the geo-location of weeds and analyzes the size, shape, and color of each pesky plant in order to deliver precise amounts of herbicide with precision targeting.

In other words, it's a kind of weed terminator. But unlike *the* Terminator, the accuracy of the computer vision system allows it to spray with such accuracy that it manages to avoid collateral damage to crops or the environment.

Pro tip: Looking for the perfect data annotation tool? Check out 13 Best Image Annotation Tools.

Automatic weeding

Intelligent sprayers aren't the only AI getting into weed... er, weeding. There are other computer vision robots taking an even more direct approach to eliminating unwanted plants.

Now, spotting a weed in the same way that computer vision can spot an insect or oddly-behaving chicken doesn't actually eliminate very much work for the farmer. To be of even greater help the AI needs to both find *and* remove the weed.

Weed and mature corn field annotation using V7

Being able to physically remove weeds not only saves the farmer quite a bit of work, but also reduces the need for herbicides and thus makes the whole farming operation much more environmentally friendly and sustainable.

Robots in the weeds

Luckily, object detection can do a great job of identifying weeds and distinguishing them from the crops. However, the real power comes when computer vision algorithms are combined with machine learning to build robots that perform automatic weeding.

All this pretty well introduces BoniRob, an agricultural robot that uses camera and image recognition technology to find weeds and remove them by driving a bolt into the earth.

It learns to distinguish between weeds and crops through image training on leaf size, shape, and color. That way BoniRob can roll through a field eliminating undesirable plants without the risk of destroying anything of value.

And while our AI friends are out in the fields anyway, perhaps there are other jobs they could do.

A group of scientists is working on making this a reality with designs for agricultural robots that detect weeds as well as soil moisture content.

This way, it can move through a field, removing weed and delivering appropriate amounts of water to the soil as it goes.

Experimental results for this system show that its plant classification and weeding rates are both at or above 90%, all the while keeping deep soil moisture content at 80 ± 10%.

Ai-driven agriculture bots are developing quite the resume!

Aerial survey and imaging

At this point it’s probably unsurprising that computer vision also has some terrific applications for surveying land and keeping an eye on crops and livestock.

Cattle detection from aerial imagery

But that doesn’t make it any less significant for smart farming.

AI can analyze imagery from drones and satellites to help farmers monitor crops and herds. That way they can be notified immediately if something looks amiss without having to constantly observe the fields themselves.

Aerial imaging is also useful for boosting the precision and efficiency of pesticide spraying. As mentioned previously, ensuring that pesticides only go where they’re intended saves money as well as the surrounding environment.

Produce grading and sorting

Finally, AI computer vision can continue to help farmers even once the crops have been harvested.

Just as they are able to spot defects, disease, and pests as the plants are growing, imaging algorithms can also be used to sort “good” produce from the defective or just plain ugly.

By inspecting fruit and vegetables for size, shape, color, and volume, computer vision can automate the sorting and grading process with accuracy rates and speed much higher than even a trained professional.

Picture perfect produce

Take carrot sorting, for example.

It's laborious and usually done by hand. However, researchers have developed an automated sorting system that uses computer vision to pick out carrots that have surface defects or are not the correct shape and length.

A "good" carrot, then, is one that's the right shape (a "convex polygon") and does not contain any fibrous roots or surface cracks.

On these three criteria, the computer vision model was able to sort and grade carrots with accuracy rates of 95.5%, 98% and 88.3%, respectively.

Further, bringing us back to the classic tomato, another study found that AI with machine learning was able to use image data with seven input features to grade tomato quality with 95.5% accuracy.

In both cases, the amount of painstaking manual labor saved is enormous. And it's all thanks to a bit of AI training on what a "good" carrot or tomato looks like.

Pro tip: Read What is Data Labeling and How to Do It Efficiently to learn more about data annotation.

The future of AI in Agriculture: Farmers as AI engineers?

Throughout human history, technology has long been used in agriculture to improve efficiency and reduce the amount of intensive human labor involved in farming. From improved plows to irrigation, tractors to modern AI, it's an evolution that humans and agriculture have undergone since the invention of farming.

The growing and increasingly affordable availability of computer vision stands to become another significant step forward here.

With considerable changes occurring in our climate, environment, and global food needs, AI has the ability to transform 21st century agriculture by:

- Increasing efficiency of time, labor, and resources.
- Improving environmental sustainability.
- Making resource allocation "smarter".
- Providing real-time monitoring to promote greater health and quality of produce.

Of course, this will require some shifts in the agricultural industry. Farmers' knowledge of their "field" will need to be translated into AI training, and this will depend on greater technical and educational investments within the agricultural sector.

But then again, innovation and adaptation are nothing new in agriculture. Computer vision and agricultural robotics are just the latest way farmers can adopt new technology to meet growing global food demands and increase food security.

ARTIFICIAL INTELLIGENCE OF AGRICULTURE IN INDIAN ECONOMY

Agriculture continues to be the backbone of Indian economy. Over 37.7% of total land is used for crop production and in India, 46% of land is employed in agricultural activities. However, traditional agriculture and recent population trends are not synchronous. The already vast population of 1.4 billion people is still rising which commands an increase in food production and employment which brings forth the question of agricultural automation.

In an era marked by exponential technological advancement, artificial intelligence (AI) is emerging as a transformative force across numerous industries. Among its most promising applications is its potential to revolutionize agriculture – a sector vital to global food security and economic stability. AI's integration into agriculture is enabling innovative solutions that enhance productivity, sustainability, and resource management, ushering in a new era of agricultural development.

Precision Agriculture: Navigating Fields with Data

One of the most prominent areas where AI is making a profound impact is precision agriculture. AI-powered systems can analyze vast amounts of data to provide real-time insights into soil conditions, moisture levels, and crop health. This allows farmers to apply fertilizers, pesticides, and water precisely where and when they are needed, reducing waste and minimizing environmental impact. Furthermore, machine learning algorithms can identify disease outbreaks or pest infestations early, enabling targeted interventions and preventing potential crop losses.

AI is enabling farmers to harness data from sensors, drones, satellites, and weather forecasts to make highly informed decisions tailored to each specific section of their fields.

Optimizing Resource Management

Agriculture is deeply intertwined with the availability of resources like water and energy. AI helps optimize their usage by predicting demand, monitoring consumption, and suggesting strategies for efficient resource allocation. For instance, machine learning algorithms can process historical data to forecast water requirements for irrigation, considering factors like weather patterns and crop growth stages. This prevents overwatering and conserves water resources, which is particularly crucial in regions facing water scarcity.

Similarly, AI-driven energy management systems can analyze energy consumption patterns on farms and recommend ways to minimize waste. From powering equipment to running climate control systems in greenhouses, optimizing energy usage not only reduces costs for farmers but also contributes to a more sustainable agricultural industry.

Crop Yield Prediction and Supply Chain Management

AI's predictive capabilities extend to estimating crop yields with remarkable accuracy. By assimilating data from various sources such as satellite imagery, historical yields, and weather forecasts, AI algorithms can generate reliable predictions. These forecasts empower farmers to plan their harvests, manage labor, and negotiate contracts with buyers more effectively.

Furthermore, AI aids in streamlining the agricultural supply chain, facilitating real-time tracking of produce from farm to market, reducing spoilage and minimizing post-harvest losses. Enhanced supply chain transparency also ensures fair compensation for farmers and helps consumers make informed choices about the origin and quality of the products they purchase.

Empowering Smallholder Farmers

While large-scale agribusinesses have the resources to adopt advanced technologies, smallholder farmers often face barriers to accessing such tools. However, AI has the potential to bridge this gap by providing cost-effective solutions that cater to their specific needs. Mobile applications with AI capabilities can deliver localized information about weather forecasts, pest management, and crop recommendations. These tools empower smallholder farmers to make informed decisions that enhance their productivity and income.

AI Intervention in Indian Argi Sector

The Indian agriculture sector, deeply rooted in the country's culture and economy, sustains the livelihoods of millions while facing significant challenges. With a vast and diverse landscape, varying climate conditions, and a predominantly smallholder farming model, Indian agriculture encounters issues such as yield variability, resource inefficiency, and post-harvest losses. However, the introduction of AI-led technologies holds immense promise to revolutionize this sector.

By leveraging AI's capabilities in data analysis, predictive modelling, and precision farming, Indian farmers can gain insights into localized weather patterns, optimal planting times, and resource allocation, leading to improved crop yields and reduced waste. AI-powered solutions can help address these longstanding challenges, enhancing the sustainability and productivity of Indian agriculture while ensuring food security for its growing population.

The Path Ahead

Artificial intelligence is poised to drive a transformative shift in agriculture, fostering innovation and sustainable development. The agricultural sector is expected to be the 2nd major segment by 2025. Niti Aayog has adopted nurturing the AI ecosystem in India and welcomed a theme of 'AI for all'.

Through precision agriculture, resource optimization, supply chain enhancement, and empowerment of smallholder farmers, AI is addressing challenges that have persisted for generations. As the world's population continues to grow, harnessing the power of AI in agriculture becomes more imperative than ever before. By embracing AI-driven solutions, the agricultural sector can pave the way for a future where food security is assured, resources are conserved, and rural economies thrive.

Era of Artificial Intelligence: Prospects for Indian Agriculture

Artificial intelligence (AI) is silently but increasingly entering Indian agriculture and hence affecting our society at large. Even though machine learning (which is a subset of AI) has been used for classifications and prediction purposes for, to cite a few, food grading and crop yield forecasting, recently, the new set of deep learning algorithms have heralded the possibilities of taking the research and applications of AI to much higher levels and with much more accuracy. Similarly, other AI techniques are making inroads in all fields including agriculture. Amid high expectations about how AI will help the common man and also transform his mind set, thoughts and attitude towards the benefits that it may bring, there are certain concerns about the ill-effects of such sophisticated technologies as well. In the end, if AI systems can enhance farmers in terms of their social and economic wellbeing, we should be open to innovating new upcoming technologies with AI as their soul.

Technology, as we know, has improved drastically over the last half century. Explosion in digitised data and advances in Information and Communication Technology (ICT) can play a pivotal role in achieving digital agriculture with the use of modern digital devices and Artificial Intelligence (AI) to develop solutions for smart agriculture.

What's artificial about intelligence in AI?

Let us start formally as to what an AI is? AI is an area of computer science that emphasizes the creation of tangible or intangible systems which not only behave intelligently but also display behaviour to the same level as human beings think and act (and in times to come, better than them), achieving human-like performance in all cognitive tasks using purely logical reasoning. Thus, while the 'artificial' in AI can be understood as 'non-biological', the 'intelligence' can be taken as 'ability to accomplish complex goals or tasks. AI is the cognitive process one can associate with human thinking like speech recognition, natural language understanding and translation, knowledge management, image analysis, decision making, learning etc. which will make systems powerful and useful.

There are three types of AI: ANI, AGI, and ASI. The first type, ANI (Artificial Narrow Intelligence) - is all over the place, like Google maps, it's awesome at finding efficient routes to places while riding a car, or can be likened to a chess playing program. Number two would be AGI (Artificial General Intelligence) - this would be like a computer that is as smart as a human in all aspects. So, anything we can do with our brain, it can do, including learning. AI is getting powerful day by day what with applications leading to machines and systems leading to more advanced AI i.e. ASI (Artificial Super Intelligence) – this would be when a computer or a system is better than a human being – wiser, more creative, more socially adept, and this ranges from being a little bit better to being smarter than the sum of all humanity combined.

AI is the next big thing happening

Now let us proceed foreseeing how AI can help the common man in the years to come. Technology has advanced at such an accelerating pace that what has been achieved during the past 15 years or so from the early 2000s is much more than what has been achieved during the 30 years past 1970s. In this era, we have computers in our pockets now connected to the Internet giving us a plethora of options like streaming video and music straight from our smartphone at any moment, with information in our finger tips, thanks to the omniscient Google Baba! Let us extrapolate this phenomenal leap jump in innovations to the development of AI. At this speed, development in AI should take a lot less time because with repeated instructions and experiences, AI can re-wire its own thinking to improve itself. After all, AI like everything else has two sides: while there are practical applications of AI, a chief and visible application that stands out being the robot, scientists are constantly finding out ways to programme safeguards to make sure AI, which on one hand enables technologies, on the other hand, does not destroy our daily lives by affecting the lives all around us. It seems not so far-fetched nowadays that people have started casually discussing about AI in their conversations, with many general articles appearing in newspapers. People did talk about climate change earlier, and that had a great role to what led towards useful steps being taken to prevent it. Now people are having conversations about AI and that will circumvent all the misgivings about the same. So if we want to do something, increasingly talking to people about AI seriously would be a good place to start. Detecting deadly diseases, reducing accident risks, predicting consumer behaviour and helping farmers increase crop yields are some of the AI-based innovations that Microsoft is addressing. From Apple's intelligent personal assistant SIRI or Cortana of Microsoft to IBM's Watson to self-driving cars, AI is progressing rapidly. Another popular example includes Google Maps, Ridesharing in cabs, Face recognition in Facebook photo upload, Face unlock in Mobile, search and recommendation in online shopping sites etc. The internet giant Google is moving into an "AI first" world and is currently using AI technologies for numerous applications. In a recent Google AI event, it has been told that it is up to people's imagination to make things happen in the AI world. Google operates two of the top AI research labs in the world viz., DeepMind in London and Google Brain in California. AI has become an essential part of the technology industry. Research associated with AI is highly technical and specialized. The core problems of AI include programming computers for certain traits such as Knowledge, Reasoning, Problem solving, Perception, Learning, Planning, Ability to manipulate and move objects etc. Mathematical analysis of Machine Learning (ML) algorithms and their performance is a well-defined branch of statistical cum soft computing. ML being a core part of AI has advanced from Artificial Neural networks (ANN), Fuzzy systems, Genetic Algorithms and/ or their hybrid approaches to what are called Deep Learning techniques like Convolutional NN, Generative NN etc. This involves, but not limited to, learning without any kind of supervision with an ability to identify patterns in streams of inputs (be it text, numbers, images, voices, video etc.), or learning with adequate supervision involving classification and numerical regressions. Here classification determines the category an object belongs to and regression deals with obtaining a set of numerical input or output examples, thereby discovering functions enabling the generation of suitable outputs from respective inputs. These concepts existed earlier in ML also in attempting to mimic the human brain, but the sophisticated deep learning of AI can boost accuracy to a much greater extent.

Robotics is also a major field related to AI. Robots require intelligence to handle tasks such as object manipulation and navigation, along with sub-problems of localization, motion planning and mapping. The Robot Sophia is an excellent example of potentials of AI. An added advantage of AI systems is that, once programmed to perform and evolve for doing specific tasks, they are shorn of bias common to humans and this lack of biasness can have a positive impact on the interaction between AI systems and the society at large.

Can Indian agriculture benefit from AI?

Natural Language Processing (NLP), Robotics, Machine Learning (ML), Automated Reasoning, Knowledge Representation, Expert Systems, Computer Vision, Speech Recognition, Automated Data Analytics, Virtual Reality, Augmented Reality, Internet of Things (IoT), Cloud Computing, Statistical Computing, Deep Learning etc. are some major sub-areas of AI having huge potential in solving complex problems of agriculture.

NITI Aayog has recently released a discussion paper wherein it envisions AI solutions for key sectors including agriculture. In agriculture, there is a great potential of AI machines to provide information to farmers on the quality of soil, when to sow, where to spray herbicide, and where to expect pest infestations. Thus, if AI systems can advise farmers on best practices, India could see a farming revolution. However, such a futuristic scenario has a formidable challenge of scaling it up to cover the entire value chain with factors like capacity expansion and cost reduction in mind. Globally, AI-driven technologies are emerging to help in improving the efficiency with respect to crop and soil monitoring, weather forecasting, predictive agricultural analytics, markets and supply chain efficiency. The cloud computing infrastructures with the use of, data ecosystems, Internet of Things (IoT) and AI enables the development of digital agriculture and strengthen the farmers in practicing smart farming, smart irrigation, smart fertilizer application, and disease/ pest diagnosis/ detection, smart spraying, and harvesting. Machine learning and soft computing methods with pattern recognition through image and video (drone cameras, satellite imagery) data processing are being widely used world-wide in

monitoring and managing various farm operations and predicting the incidence of disease/ pests, weather forecasts, time of application and optimum dose of chemical sprays, time of harvest, life of produce etc. Deep Learning is concerned with algorithms inspired by the structure and function of the brain called Artificial Neural Networks (ANNs). Deep learning can solve more complex problems particularly those consisting of large number of features, because here more complex models are used, which allow massive parallelization. Deep learning techniques is being used effectively on image data for segmentation which results in disease/ variety identification and crop yield estimation and prediction with far more accuracy.

Agriculture will for sure immensely benefit from AI applications. AI can be used to create intelligent systems which are embedded in machines that can work with higher accuracy and speed than humans and at the same time be responsive like humans. AI together with Internet of Things (IoT) and Sensor Technology can be the great enabler of precision agriculture. AI can also play a critical role along with remote sensing technology in wide scale implementation of Climate Smart Agriculture. Some of the AI Techniques like Mobile based Recommender Systems and Expert Systems can drastically increase the adoption rate of agriculture technologies like high yielding or disease resistant varieties, innovative farm implements thereby helping in increasing farmer’s income. These AI techniques can also be the enabler of the paradigm shift of location based advisory services to the personalized and context specific advisory for the millions of farmers of our country. Automation, Sensors, Drones, IoT, Solar Power aided with AI provide new opportunities for business and entrepreneurs to deliver innovative solutions as service at affordable prices to the farmers. Precision farming one another area where we can benefit from AI and it can also help farmers to maximise the space they have, to be more precise about the types of crops, weather pattern and when and where we should go for raising crops. The best thing that AI can do in agriculture is to avoid drudgery and tedium from many agricultural operations so that we can put our time and efforts in much better ways of finding an array of creative AI innovations to surpass human capabilities. At the national level, AI based automatic grading and sorting are already being done for vegetables and fruits with a view of creating an international Agri commodity standard aiding reliable trading across country boundaries. Deep learning and advanced image processing techniques are used for viewing images and pictures thus digitizing food quality. But scaling up the utility to expand to several products and also across geographical locations need millions of more such images. This can be quite farfetched unless such images are collected, digitised and annotated. It is a fact that the biggest agricultural data lies with the government and hence the onus is entirely up to them to annotate it and make it usable. Hence both quality and quantity have a direct bearing on efficacy of deep learning. In addition, for certain other situations like solar or electricity power planning, deep learning needs data over many years to predict power generation.

AI based adaptive e-learning and decision support systems can also help students towards learning new concepts and able to identify areas where students are deficient providing more focus on that content. These systems can generate new problems from source material. These online systems can actually generate better material and more comprehensive testing than typical classroom curriculum.

AI: Data is the new oil

being a research organization with a primary role of discovery or generation of new knowledge requires to build its organizational knowledgebase which is not only human understandable but also machine understandable. Ontologies being the latest AI based knowledge representation technique can play crucial role in not only creating scientific repositories of generated knowledge but can also enable various applications to use this knowledge for generating intelligent decisions. India being a multi-lingual society with majority of farmers being non-literate, AI techniques like auto-translation among various languages, text to speech and speech to text in Indian languages can help the poor farmers in accessing the required knowledge generated by the National Agricultural Research and Education System (NARES).

For any AI application to be successful, underlying databases and the processes employed to populate these databases must be reliable, secure and updated at any given point of time. It is essential for the AI based system to provide intelligent decisions based on the underlying database. AI systems are data-guzzling machines learning from large reams of historical data as input for identifying relationships among data elements and make decisions. Hence, we should take concerted efforts to collect and digitize data better under focussed projects if we desire to see AI solutions powering agriculture. We should also ponder as to what we do about this data, where to store them and also as to what are we going to do around getting intelligence out of that data. Ultimately, the AI-enabled solutions cannot sustain without a steady supply of fresh data to improve and evolve itself which can only come from non-AI (human) sources. Thus, knowledge engineering should become a core part of AI research.

Machines can often act and react like humans only if they have abundant information/ data relating to the world. AI must have access to objects, categories, properties and relations

between all of them to implement knowledge engineering. Without a sound database, initiating common sense, reasoning and problem-solving power in machines is a difficult and tedious task.

The road ahead for AI

Opportunities abound in AI and the onus lies on us to ideate, innovate and create AI based systems for the benefit of agriculture towards our well-being. Having said that, there will always a bit or lot of 'artificiality' in AI leaving space for humaneness in the humans to intervene, if not interfere, in the way AI systems will affect our lives. It is up to our imaginations and passion to make AI solutions to enhance the way we do agriculture in the days to come.

Summary

AI has both non-biological and human aspects embedded in it. Needless to say, diffusion of AI in all application arenas will also bring a paradigm shift in the way we do research and development in agriculture now. AI systems require continuous feeding of new information and increasing the amount of information in the backend databases used for performing tasks with almost accuracy, including mapping the history of and guiding the predictions from such systems. In this way, the AI systems will get evolved over time akin to human perfection in addition to adaptability.

AGRI POTENTIAL IN INDIA

ROBUST DEMAND

*Factors contributing to the sharp growth in demand for processed foods include increasing urbanization, increasing disposable incomes, changing spending patterns/ priorities, the emergence of nuclear families, and the growing need for convenience foods in dual-income nuclear families.

*The demand for organic products in the Indian market is growing and is anticipated to rise with a CAGR of 25.25% between 2022-27.

*A total of 521.27 LMT rice has been anticipated for procurement for the upcoming KMS 2023-24, up from 496 LMT produced during the previous KMS 2022-23.

ATTRACTIVE OPPORTUNITIES

*Entry of foreign players has been key to sustainable growth in some sectors such as dairy.

*Trends indicate a sharp increase in on-the-go eating, snacking in between meals, switching to healthier eating alternatives, pre-cooked ready-to-eat meals, and increasing consumption of organic foods. This has led to a host of new opportunities in the consumer foods market for both domestic and international companies to build a stake in this fast-growing processed food market.

POLICY SUPPORT

*Online, Competitive, Transparent Bidding System with 1.74 crore farmers and 2.39 lakh traders put in place under the National Agriculture Market (e-NAM) Scheme.

*A new sub-scheme of PM Matsya Sampada Yojana with a targeted investment of Rs. 6,000 crore (US$ 729 million) to be launched to further enable activities of fishermen, fish vendors, and MSEs, improve value chain efficiencies and expand the market.

*Through several Digital Initiatives, such as the National e-Governance Plan in Agriculture, the construction of Digital Public Infrastructure, digital registries, etc., the government has taken various steps to ensure access to IT across the nation.

COMPETITIVE ADVANTAGE

*India has access to several natural resources that provides it a competitive advantage in the food processing sector. Due to its diverse agro-climatic conditions, it has a wide-ranging and large raw material base suitable for food processing industries.

*In India, agriculture is the primary source of livelihood for ~55% of the population.

INTRODUCTION

India is one of the major players in the agriculture sector worldwide and it is the primary source of livelihood for ~55% of India's population. India has the world's largest cattle herd (buffaloes), the largest area planted for wheat, rice, and cotton, and is the largest producer of milk, pulses, and spices in the world. It is the second-largest producer of fruit, vegetables, tea, farmed fish, cotton, sugarcane, wheat, rice, cotton, and sugar. The agriculture sector in India holds the record for second-largest agricultural land in the world generating employment for about half of the country's population. Thus, farmers become an integral part of the sector to provide us with a means of sustenance.

Consumer spending in India will return to growth in 2021 post the pandemic-led contraction, expanding by as much as 6.6%. The Indian food industry is poised for huge growth, increasing its contribution to world food trade every year due to its immense potential for value addition, particularly within the food processing industry. The Indian food processing industry accounts for 32% of the country's total food market, one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth.

Foodgrain production in India touched 330.5 million metric tonnes (MT) in 2022-23 (3rd Advance Estimate). India is the world's 2nd largest producer of food grains, fruits and vegetables and the 2nd largest exporter of sugar. A total of 521.27 LMT rice has been anticipated for procurement for the upcoming KMS 2023-24, up from 496 LMT produced during the previous KMS 2022-23.

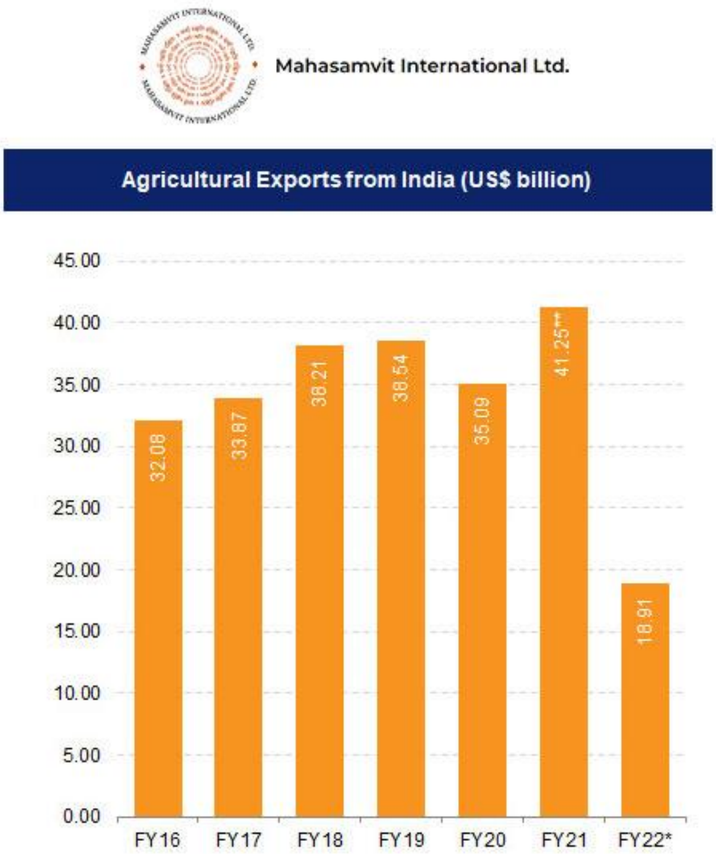
According to Inc42, the Indian agricultural sector is predicted to increase to US$ 24 billion by 2025. Indian food and grocery market is the world's sixth largest, with retail contributing 70% of the sales. As per the First Advance Estimates for 2023-24 (Kharif only), total foodgrain production in the country is estimated at 148.5 million tonnes.

Rabi crop area has increased by 3.25%, from 697.98 lakh hectares in 2021-22 to 720.68 lakh hectares in 2022-23. This is a 22.71 lakh hectare, a 13.71% increase over the average sown area in 2021-22. As per the First Advance Estimates for 2023-24, rice is estimated at 1,063.13 lakh tonnes during the kharif season.

In 2022-23 (as per the second advance estimate), India's horticulture output is expected to have hit a record 351.92 million tonnes (MT), an increase of about 4.74 million tonnes (1.37%) as compared to the year 2021-22.

In 2022-23, of the 141 million hectares of gross sown area in the country, nearly 73 million hectares, or 52%, had irrigation access.

The Agriculture and Allied industry sector witnessed some major developments, investments and support from the Government in the recent past. Between April 2000-September 2023, FDI in agriculture services stood at US$ 4.77 billion.



According to the Department for Promotion of Industry and Internal Trade (DPIIT), the Indian food processing industry has cumulatively attracted a Foreign Direct Investment (FDI) equity inflow of about US$ 12.35 billion between April 2000-September 2023. This accounts for 1.89% of total FDI inflows received across industries.

During 2023-24 (April-October), processed vegetables accounted for US$ 446.84 million, miscellaneous preparations accounted for US$ 758.94 million and processed fruits, juices and nuts accounted for US$ 367.85 million.

Rapid population expansion in India is the main factor driving the industry. The rising income levels in rural and urban areas, which have contributed to an increase in the demand for agricultural products across the nation, provide additional support for this. In accordance with this, the market is being stimulated by the growing adoption of cutting-edge techniques including blockchain, artificial intelligence (AI), geographic information systems (GIS), drones, and remote sensing technologies, as well as the release of various e-farming applications.

In terms of exports, the sector has seen good growth in the past year. India's agricultural and processed food products exports stood at US$ 27.01 billion in 2023-24 (April-October).

The exports for principal commodities in 2023-24 (April-October) were the following:

- Marine Product: US$ 4.58 billion
- Basmati and Non-Basmati Rice: US$ 5.86 billion
- Spices: US$ 2.24 billion
- Buffalo Meat: US$ 2.09 billion
- Sugar: US$ 1.49 billion
- Miscellaneous processed items: US$ 967 million
- Oil Meal: US$ 894 million

INVESTMENT

Some major investments and developments in agriculture are as follows:

- In December 2023, NBCC signed an MoU with the National Cooperative Development Cooperation (NCDC) and NABARD for the construction of (1,469-grain storage units) the world's largest grain storage plan in the cooperative sector.
- India to host the 27th WAIPA World Investment Conference in New Delhi from December 11-14, 2023.
- In December 2023, Tata-owned Rallis India launched NAYAZINC fertilizer.
- In December 2023, NITI Aayog and IFPRI signed a Statement of Intent to strengthen policy frameworks for agricultural transformation and rural development.
- In November 2023, India signed deals to export 5,00,000 tons of new season basmati rice in Europe and the Middle East.
- In October 2023, the President of India launched the Fourth Krishi Road map of Bihar.
- In October 2023, Coal India, partnered to invest Rs. 3,095 crore (US$ 371.69 million) in fertiliser JV to boost output.

- Government has set up a special fund called the Food Processing Fund (FPF) of approximately US$ 265 million in the National Bank for Agriculture and Rural Development (NABARD) for extending affordable credit to designated food parks and food processing enterprises in the designated food parks.
- In June 2023, Mother Dairy invested US$ 48.33 million (Rs. 400 crore) to set up a unit in Nagpur.
- In 2022, the Government of India is planning to launch Kisan Drones for crop assessment, digitization of land records, and spraying of insecticides and nutrients.
- In October 2022, Prime Minister Mr. Narendra Modi inaugurated PM Kisan Samman Sammelan 2022 and released PM-KISAN Funds worth Rs. 16,000 crore (US$ 1.93 billion)
- In August 2022, a Special Food Processing Fund of Rs. 2,000 crore (US$ 242.72 million) was set up with National Bank for Agriculture and Rural Development (NABARD) to provide affordable credit for investments in setting up Mega Food Parks (MFP) as well as processing units in the MFPs.
- In August 2022, Mr. Narendra Singh Tomar, Minister of Agriculture and Farmers Welfare inaugurated four new facilities at the Central Arid Zone Research Institute (CAZRI), which has been rendering excellent services for more than 60 years under the Indian Council of Agricultural Research (ICAR).

- Consumer spending in India will return to growth in 2022 post the pandemic-led contraction, expanding by as much as 7%.
- The organic food segment in India is expected to grow at a CAGR of 10% during 2015-¬25 and is estimated to reach Rs. 75,000 crore (US$ 9.1 billion) by 2025 from Rs. 2,700 crore (US$ 386.32 million) in 2015.
- The processed food market in India is expected to grow to Rs. 3,451,352.5 crore (US$ 470 billion) by 2025, from Rs. 1,931,288.7 crore (US$ 263 billion) in FY20 on the back of government initiatives such as planned infrastructure worth US$ 1 trillion and Pradhan Mantri Kisan Sampada Yojna. The food processing industry employs about 1.77 million people. The sector allows 100% FDI under the automatic route.
- From 2017 to 2020, India received ~US$ 1 billion in agritech funding. With significant interest from investors, India ranks third in terms of agritech funding and the number of agritech start-ups. By 2025, Indian agritech companies are likely to witness investments worth US$ 30-35 billion.
- Nestle India will invest Rs. 700 crore (US$ 85.16 million) in the construction of its ninth factory in Gujarat.
- The performance of the agriculture and allied sector has been buoyant over the past several years, much of which is on account of the measures taken by the government to augment crop and livestock productivity, ensure certainty of returns to the farmers through price support, promote crop diversification, improve market infrastructure through the impetus provided for the setting up of farmer-producer organizations and promotion of investment in infrastructure facilities through the Agriculture Infrastructure Fund.
- As per the economic survey 2022-23, Rs. 13,681 crore (US$ 1.6 billion) were sanctioned for Post-Harvest Support and Community Farms under the Agriculture Infrastructure Fund.
- Private investment in agriculture increases to 9.3% in 2020-21.
- Institutional Credit to the Agricultural Sector continued to grow to Rs. 18.6 lakh crore (US$ 226 billion) in 2021-

GOVERNMENT INITIATIVES

Some of the recent major Government initiatives in the sector are as follows

- In the Union Budget 2023-24:

    - Rs. 1.24 lakh crore (US$ 15.9 billion) has been allocated to the Department of Agriculture, Cooperation and Farmers' Welfare.
    - Rs. 8,514 crore (US$ 1.1 billion) has been allocated to the Department of Agricultural Research and Education.
- Through several Digital Initiatives, such as the National e-Governance Plan in Agriculture (NeGP-A), the construction of Digital Public Infrastructure (DPI), digital registries, etc., the government has taken a number of steps to ensure access to IT across the nation.
- The Soil Health Card site has been updated and connected with a Geographic Information System (GIS) system, allowing all test results to be captured and shown on a map. Samples are now being gathered using a mobile application as of April 2023 under the new system.
- The Agricultural Technology Management Agency (ATMA) Scheme has been implemented in 704 districts across 28 states and 5 UTs to educate farmers. Grants-in-aid are released to the State Government under the scheme with the goal of supporting State Governments' efforts to make available the latest agricultural technologies and good agricultural practices in various thematic areas of agriculture and allied sector.
- Since its inception, i.e. from 01.04.2001 to 31.12.2022, a total of 42,164 storage infrastructure projects (Godowns) with a capacity of 740.43 Lakh MT have been assisted in the country under the Agricultural Marketing Infrastructure (AMI) sub-scheme of the Integrated Scheme for Agricultural Marketing (ISAM).
- The Centre has granted permission to five private companies to conduct cluster farming of specified horticulture crops on approximately 50,000 hectares on a trial basis, with a total investment of US$ 91.75 million (Rs. 750 crore). The five companies chosen through a bidding process for the pilot cluster farming program are Prasad Seeds, FIL Industries, Sahyadri Farms, Meghalaya Basin Management Agency.
- 27,003 Loans have been sanctioned in the country under credit linked subsidy component of the PM Formalisation of Micro Food Processing Enterprises Scheme (PMFME).
- In July 2022, the PM Formalisation of Micro food processing Enterprises (PMFME) scheme was launched for providing financial, technical and business support for setting up/ upgradation of micro food processing enterprises in the country with an outlay of Rs. 10,000 crore (US$ 1.27 billion).
- The Indian government is planning to launch Kisan Drones for crop assessment,

digitization of land records, and spraying of insecticides and nutrients.

- NABARD will assist in the creation of a blended capital fund with a focus on the agricultural start-up ecosystem which will be used to fund agriculture and rural enterprise startups that are related to the farm product value chain.
- A network of 729 Krishi Vigyan Kendras has been established at the district level across the country to ensure that newer technologies such as improved variety seeds of crops, new breeds/ strains of livestock and fish, and improved production and protection technologies reach farmers.
- In October 2021, the Union Minister of Home Affairs and Cooperation launched the 'Dairy Sahakar' scheme in Anand, Gujarat.
- Ministry of Civil Aviation launched the Krishi UDAN 2.0 scheme in October 2021. The scheme proposes assistance and incentive for the movement of agri-produce by air transport. The Krishi UDAN 2.0 will be implemented at 53 airports across the country, largely focusing on Northeast and tribal regions, and is expected to benefit farmers, freight forwarders, and airlines.
- In October 2021, the Agricultural and Processed Food Products Export Development Authority (APEDA) signed a Memorandum of Understanding (MoU) with ICAR-Central Citrus Research Institute (ICAR-CCRI), Nagpur, for boosting exports of citrus and its value-added products.
- In October 2021, the Union Ministry of Agriculture and Farmers Welfare announced that 820,600 seed mini-kits will be distributed free of cost in 343 identified districts across 15 major producing states under a special programme. This programme is likely to boost production and productivity by speeding up the seed replacement rate and subsequently, help in increasing farmers' income.
- In September 2021, Prime Minister Mr. Narendra Modi launched 35 crop varieties with special traits such as climate resilience and higher nutrient content.
- Prime Minister of India launched the Pradhan Mantri Kisan Samman Nidhi Yojana (PM-Kisan) and transferred Rs. 2,021 crore (US$ 284.48 million) to bank accounts of more than 10 million beneficiaries on February 24, 2019. As per the Union Budget 2021-22, Rs. 65,000 crore (US$ 8.9 billion) was allocated to Pradhan Mantri Kisan Samman Nidhi (PM-Kisan).
- The Indian government has initiated Digital Agriculture Mission for 2021-25 for agriculture projects based on new technologies such as artificial intelligence, blockchain, remote sensing and GIS technology, drones, robots, and others.
- In September 2021, the Union Ministry of Agriculture and Farmers' Welfare signed five MoUs with CISCO, Ninjacart, Jio Platforms Limited, ITC Limited, and

NCDEX e-Markets Limited. This MoU will have five pilot projects, which will help farmers make decisions on the kind of crops to grow, the variety of seeds to use, and best practices to adopt to maximise yield.

- With a budget of US$ 1.46 billion, the 'Production-Linked Incentive Scheme for Food Processing Industry (PLISFPI)' has been approved to develop global food manufacturing champions commensurate with India's natural resource endowment and to support Indian food brands in international markets.
- Under Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PM FME), an outlay of Rs. 10,000 crore (US$ 1.27 billion) over a period of five years from FY21 to FY25 has been sanctioned.
- In April 2021, the Government of India approved a PLI scheme for the food processing sector with an incentive outlay of Rs. 10,900 crore (US$ 1.48 billion) over a period of six years starting from FY22.
- The Agriculture Export Policy, 2018 was approved by the Government of India in December 2018. The new policy aimed to increase India's agricultural export to US$ 60 billion by 2022 and US$ 100 billion in the next few years with a stable trade policy regime.
- The Government of India is going to provide Rs. 2,000 crore (US$ 306.29 million) for the computerisation of the Primary Agricultural Credit Society (PACS) to ensure cooperatives are benefitted through digital technology.
- The Government of India launched the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) with an investment of Rs. 50,000 crore (US$ 7.7 billion) aimed at the development of irrigation sources for providing a permanent solution to drought.
- Government plans to triple the capacity of the food processing sector in India from the current 10% of agricultural produce and has also committed Rs. 6,000 crore (US$ 729 million) as investments for mega food parks in the country, as a part of the Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters (SAMPADA).
- The Government of India has allowed 100% FDI in the marketing of food products and in food product E-commerce under the automatic route.
- To enhance the income of farmers, the government has taken initiatives across several focus areas. Income support is provided to farmers through PM KISAN Scheme, crop insurance is assured through the Pradhan Mantri Fasal Bima Yojana, and irrigation facilities are ensured under Pradhan Mantri Krishi Sinchai Yojana.
- Access to institutional credit is being provided through Kisan Credit Card and other channels.

- Under the e-NAM initiative, markets across the length and breadth of the nation are now open to farmers, to enable them to get more remunerative prices for their produce. Online, Competitive, Transparent Bidding System with 1.74 crore farmers and 2.39 lakh traders put in place under the National Agriculture Market (e-NAM) Scheme.
- The umbrella scheme Pradhan Mantri Annadata Aay SanraksHan Abhiyan (PM-AASHA) ensures Minimum Support Price (MSP) to farmers for various Kharif and Rabi crops while also keeping a robust procurement mechanism in place.
- As per the Economic Survey 2022-23, Rs. 13,681 crore (US$ 1.6 billion) were sanctioned for Post-Harvest Support and Community Farms under the Agriculture Infrastructure Fund.
- In order to increase the level of food- processing industry and encouraging rural entrepreneurship across the country including rural areas, the Ministry of Food Processing Industries (MoFPI) is implementing the Central Sector Umbrella Scheme Pradhan Mantri Kisan SAMPADA Yojana (PMKSY), Production Linked Incentive Scheme for Food Processing Industry (PLISFPI) and centrally sponsored PM Formalization of Micro Food Processing Enterprises (PMFME) Scheme.
- The PMFME Scheme provides financial, technical and business support for setting up/upgradation of 2 Lakh micro food processing enterprises through credit-linked subsidy during five years from 2020-21 to 2024-25 with an outlay of Rs. 10,000 crore (US$ 1.27 billion).
- Under component schemes of PMKSY, MoFPI mostly provides financial assistance in the form of grants-in-aid to entrepreneurs for the creation of modern infrastructure and setting up of food processing/preservation industries including Cold Chains with associated infrastructure like primary processing facilities, collection centres, pre-conditioning, pre-cooling, ripening, packing, etc.
- As per the Union Budget 2023-24, A new sub-scheme of PM Matsya Sampada Yojana with the targeted investment of Rs. 6,000 crore (US$ 729 million) to be launched to further enable activities of fishermen, fish vendors, and micro & small enterprises, improve value chain efficiencies, and expand the market.
- Digital Public Infrastructure for Agriculture: agriculture will be built as an open source, open standard, and interoperable public good. this will enable inclusive, farmer-centric solutions through relevant information services for crop planning and health, improved access to farm inputs, credit, and insurance, help for crop estimation, market intelligence, and support for the growth of the agri-tech industry and start-ups.
- To enhance the productivity of extra-long staple cotton, Government will adopt a

cluster-based and value chain approach through Public Private Partnerships (PPP). This will mean collaboration between farmers, the state and industry for input supplies, extension services, and market linkages.

- Computerisation of 63,000 Primary Agricultural Credit Societies (PACS) with an investment of Rs. 2,516 crore (US$ 305.9 million) initiated.
- Rs. 20 lakh crore (US$ 24.41 billion) agricultural credit targeted at animal husbandry, dairy and fisheries.
- To make India a global hub for 'Shree Anna', the Indian Institute of Millet Research, Hyderabad will be supported as the Centre of Excellence for sharing best practices, research and technologies at the international level.

The agriculture sector in India is expected to generate better momentum in the next few years due to increased investment in agricultural infrastructure such as irrigation facilities, warehousing, and cold storage. Furthermore, the growing use of genetically modified crops will likely improve the yield for Indian farmers. India is expected to be self-sufficient in pulses in the coming few years due to the concerted effort of scientists to get early maturing varieties of pulses and the increase in minimum support price.

In the next five years, the central government will aim US$ 9 billion in investments in the fisheries sector under PM Matsya Sampada Yojana. The government is targeting to raise fish production to 220 lakh tonnes by 2024-25. Going forward, the adoption of food safety and quality assurance mechanisms such as Total Quality Management (TQM) including ISO 9000, ISO 22000, Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practices (GMP), and Good Hygienic Practices (GHP) by the food processing industry will offer several benefits.

Through the Ministry of Food Processing Industries (MoFPI), the Government of India is taking all necessary steps to boost investments in the food processing industry in India. Government of India has continued the umbrella PMKSY scheme with an allocation of Rs. 4,600 crore (US$ 559.4 million) till March 2026.

References: Agricultural and Processed Food Products Export Development Authority (APEDA), Department of Commerce and Industry, Union Budget 2021-22, 2022-23, Press Information Bureau, Ministry of Statistics and Programme Implementation, Press Releases, Media Reports, Ministry of Agriculture and Farmers Welfare, Crisil, Union Budget 2023-24, Economic Survey 2022-23.

Now the 30 initiatives

EXHIBIT 1

Vegan projects

The world of Food Processing is transitioning at a fast pace globally. In India, we are seeing the development of a vibrant infrastructure in this sector along with faster dissemination of knowledge and technologies. Traditionally, we were provisioned to spectate a limited variety of food products, but presently the food plate is diversified with exquisite assortments. This is an indication of the growth and proliferation of the Indian Agri-Food Industry with the involvement of multiple stakeholders co-creating a newer Food Sphere.

Plant-based food and its presence in India is not novel, as millions of Indians live on a proper plant- based diet, including dairy. But when we compare the present scenario in India to the West, the emergence of Plant-based foods in the recent past has revolutionized the Indian food processing industry. We are now seeing the presence of 'mock meat', which almost tastes like its counterpart, plant- based dairy alternatives, which are taste-neutral and sometimes filled with intrinsic flavours as per consumers' liking. Innovations in Food Processing Technologies have allowed us to create plant-based alternatives that taste much like regular dairy/meat products. Plant-based foods are more sustainable, healthier and cruelty-free and are more closely rooted in the values of Indian culture.

Consumers are becoming more conscious about their food consumption and the perilous impact of conventional agricultural practices on animals and the environment, intensifying the demand for plant- based food options. The plant-based food industry has the potential to be poised as an effective alternative for supermarket chains and restaurants alike. It will galvanize the food processing industry and bring together a range of customers to enjoy such products.

Given the necessity and significance of plant- based foods for encouraging more sustainable and healthy consumption habits, with this report which highlights the significance of the plant-based food industry and the importance of the sector. We acknowledge the efforts made by the experts in preparing this report which will be released at the National Conference on Plant-based Food: Capturing Avenues to Intensify the Food Processing Industry. We hope the report will provide helpful information and insights to the policymakers, industry constituents and other stakeholders and will aid in strengthening the Indian food processing industry while moving towards an Aatmanirbhar Bharat. The opportunity before the Indian plant-based movement is enormous, and there has never been a better time for it. Rising demand for plant-based foods and conscious consumers have resulted in unprecedented innovations in the sector around the world. From innovations like plant-based meats, dairy, poultry, and seafood to alternative materials like plant-based leather, wool, and fur, the shift and inclusivity of a vegan diet and lifestyle is obvious.

It is expected that within the next decade, 20% of meat, eggs, and dairy consumed globally will be plant-based. This is just the start.

It's a dream come true for Vegan First to see the recent growth of the plant-based sector. Since we launched Vegan First in 2016, we've seen a sharp rise in vegan and ethical consumption in the country, and around the world in all sectors - food, fashion, and cosmetics.

India is one of the biggest growing economies in the world - that combined with our culture being rooted in values of non-violence and harmonious coexistence - makes India the promised land for a successful plant-based economy. Rising middle- class consumers want to make healthier, more environmentally friendly choices and are eager to try new and more sustainable and cruelty-free foods.

EXHIBIT 2

Potato Products. Potato Balls, Nuggets and French Fries Manufacturing Business. Profitable Business Ideas in Potato Processing Industry

Potato balls are a trendy dish liked by most of the kids. This classic dish is prepared by boiling the potatoes, mashed and mixed with chopped green onions, grated carrot, spiced with fresh ground black pepper, mayonnaise and yoghurt; made into small balls and deep fried until crispy and crunchy. Taste best with any sauce or chutney.

Potatoes are considered as comfort food which is liked by most of the people either it is boiled, baked or fried. It is an important food staple and number one vegetable crop in the world. Potatoes are available year-round as they are harvested somewhere every month of the year.

Potato balls are easy to prepare and is a great addition for breakfast, brunch or tea time and can also be easily carried in lunch packs or served for small parties. Potato balls are yummy deep fried mashed potato balls which can also have a stuffing of mozzarella cheese in the centre. This of course would not be a regular item and is good for an occasional treat or a party appetizer as potato is a rich carbohydrate source. Potatoes provide the body with an essential source of fuel and energy.

Most of the appetizers and snacks from the Indian cuisine are made with a very modern addition to the Indian meal to suit the taste of the people. The essence of Indian cuisine mainly lies in the aroma of spices that are blended together and added to enhance the flavor and nutrition of each dish. There are a variety of Indian snacks that are popularly made with potatoes and are favorite to many which includes the aloo tikki, Alu Vadi, Potato Cutlets, Aloo Bhonda, Aloo Noodle Cutlet etc.

Potato nuggets is very tasty dish that can be prepared quickly and is very much liked by kids. It is the mixture of potato and bread crumb. It can be given in lunchbox for kids. It is very crispy potato nuggets recipe. Potato nuggets is very easy to make at home in few minutes. Potato nuggets is a tasty breakfast of morning and mostly loved by kids.

French fries are among the highest saleable potato products. This is the most abundant processed potato and can be found in many varieties such as lattice cut, wedges, curly, batter dipped, seasoned, or straight –cut including French Fries on menu is one of the easiest ways to increase sales and profits for the companies.

Potato Processing Market

Global Potato Processing market is expected to grow from $19.74 billion in 2016 to reach $32.45 billion by 2023 with a CAGR of 7.3%.

Rapid urbanization, progress in the standard of living, easy availability, consumer preferences for convenience foods and favorable packaging are the major factors propelling the market growth. In addition factors such as soaring demand for applications such as snack foods and prepared ready meals, increase in the number of retail channels such as hypermarkets and supermarkets and rapid growth of the fast food industry are driving the market growth.

However, high costs incurred for storage and transportation and health issues associated with the consumption of processed potatoes such as obesity and diabetes are the factors hindering the market growth.

The potato processing industry is a booming which is undergoing a progression period due to the growing global demands for vegetarian food products, a growth of processed food industry, and consumer demand for higher quality and sustainability. The processed food industries market is valued at more than the US $2.2 trillion dollars globally and consist of more 420,000 businesses.

Potato processing market by type is segmented into Frozen, dehydrated, chips and snack pellets, and others which include flour, canned potato, potato granules and starch. Consumption of frozen potato products like French fries is increasing due to the increasing number of fast food chains and restaurants. Most important advantage of frozen potatoes is its prolonged shelf life and comparatively less time required for cooking. Rapidly increasing number of Quick Service Restaurants in the developing countries is expected to increase the demand for frozen products in the forecast period. Chips and snack pellets are the second largest segment due to increasing popularity of chips and ease of access.

Increasing number of consumers aligning towards ready to cook and ready to eat food products such as French fries and other potato based snacks items in all classes of people is boosting the market for potato flakes and powder. Rapidly changing trends, increasing millennial population and people looking for more suitable snacking and choice of food with less indulgence are expected to drive the potato processing market growth.

The global market for potato processing is anticipated to vary due to its high dependency on a steady supply of potato varieties at a reasonable value for continuous processes. Concerns related to health associated with the consumption of processed potatoes such as diabetes and obesity, along with high costs incurred for storage and transportation can pose as a restraint for the market growth.

Based on application, the market is segmented into snacks, ready-to-cook & prepared meals, and others (food additives in soups, gravies, bakery, and desserts). The consumption of processed potato products in ready-to-cook & prepared meals application is estimated to account for the largest market share in 2017. Processed potato products used in ready-to-cook & prepared meals is a booming market due to the increase in consumer preference for convenience food products, busy work schedules, and on-the-go consumption habits.

Apart from ready-to-cook & prepared meals, processed potato products also find applications in the snacks segment, such as potato-based snacks with low carbs, low salt, air-dried, baked products with a number of flavors, which also drives the demand for potato processing market.

Some of the key players in the Potato Processing market are Intersnack Group GmbH & Co. Kg, The Kraft Heinz Company, Idahoan Foods LLC, Aviko B.V., Leng-D’or, The Little Potato Company Ltd, Limagrain Céréales Ingrédients, Agrana Beteiligungs-AG, Farm Frites International B.V., Mccain Foods Limited, Agristo NV, J.R. Short Milling Company, Lamb Weston Holdings, Inc and J.R. Simplot Company.

Processed Potatoes Market

The global processed potatoes market to grow at a CAGR of 4.88% during the period 2017-2021. The latest trend gaining momentum in the market is growing focus on expanding production capabilities for potato processing. To cater to the growing global demand for processed potato products, manufacturers are focusing on expanding their production capabilities. They are finding tremendous growth opportunity in all global markets owing to the rising consumer preference for on-the-go snack products. The increase in production capacity ensures that they are well-positioned to cater to customers' growing needs across markets.

Changes in consumer lifestyle, increase in disposable income, and growth in demand for convenient and easy-to-prepare food have led to higher consumption of packaged processed potato products. To cater to this higher demand, manufacturers are expanding their production facilities, which will lead to an increase in the overall growth and revenue of the global packaged processed potato products market.

The sector has witnessed steady growth globally in recent years with the mushrooming of convenient stores, specialty stores, hypermarkets, and supermarkets. Supermarkets and hypermarkets form one of the most popular distribution channels of packaged products, including packaged processed potato products. Discounted prices, attractive shelf displays, and pleasant shopping experiences are some of the factors that attract consumers to supermarkets and hypermarkets. Growing internet use globally has also given a boost to online retailing, which is boosting the growth of the global packaged processed potato products market.

Indian Frozen Potato Products Market

Potato is one of the most produced and consumed crops in India and forms an important part of the regular diet. It is consumed in the form of different snack foods as well as elaborate dishes. Some of the most popular potato snacks include wedges, fries, patties, etc. In recent years, the demand for frozen potato products in India has increased on account of their introduction by various national and multinational companies.

Additionally, frozen potato products have rapidly gained prominence in the country as they are convenient to cook and come in a large variety of flavours and shapes.

The biggest factor catalysing the growth of the frozen potato products market is the expansion of fast-food service restaurants, such as Subway, McDonald's, Burger King, KFC, etc., in the country. Moreover, introduction of new product variants with different flavours have attracted a larger consumer-base for frozen potato products, in turn, boosting the growth of the market. Busy lifestyles, inflating income levels and high purchasing power of the consumers in the region have further created a shift towards easy-to-cook food products, thereby maintaining the growth prospects of the market. Looking forward, the market value is projected to reach US$ around 1,631 million by 2024, expanding at a CAGR of 12.5% during 2019-2024.

In recent years, the demand for frozen potato products in India has increased on account of their introduction by various national and multinational companies. Additionally, frozen potato products have rapidly gained prominence in the country as they are convenient to cook and come in a large variety of flavours and shapes.

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Top Lucrative Business Ideas for Startups in potatoes

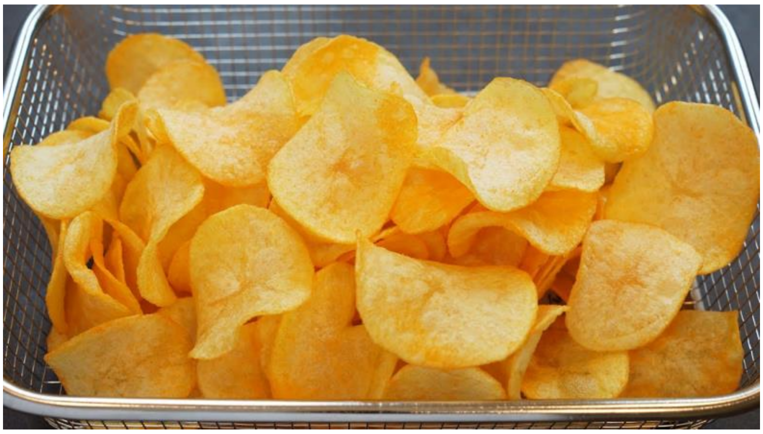
POTATO PROCESSING INDUSTRY:

The potato processing industry is a booming which is undergoing a progression period due to the growing global demands for vegetarian food products, a growth of HoReCa sector, hotel dining, a growth of processed food industry, and consumer demand for higher quality and sustainability. The processed food industries market is valued at more than the US $2.2 trillion dollars globally and consist of more 420,000 businesses.

Fresh potatoes are boiled, fried or baked and used in a flabbergasting range of recipes like potato pancakes, potato dumplings, mashed potatoes, twice-baked potatoes, potato soup, and many more recipes. But global consumption of potato as food is shifting from fresh potatoes to processed food products. Food processing is done to enhance the taste, flavor and shelf life of the potato. One of the leading items in processed potato segment is frozen potatoes, which includes French fries served in most of the quick service restaurants (QSRs) worldwide. Another processed product, the potato crisp is considered as a leader of snack foods in the developed countries. Potato flour is utilized in the food industry to bind meat mixes and thicken gravies and soups. In some countries, starch of potatoes is converted into fermentable sugars which are utilized in alcoholic beverages, for instance, vodka.

POTATO BASED PRODUCTS:

- Potato Chips & Wafers



- Potato Granules

- Potato Wine
- Alcohol
- Vodka
- Sticks
- Instant Mashed Potatoes
- French Fries
- Potato Specialties
- Dehydrated, Frozen Potato
- Potato Starch
- Potato Powder
- Flakes & Pellets
- Liquid Glucose

We will produce marketing and to create EOU and EOZ and export and sell both b2b and b2c.

EXIHIBIT 3

BANANA PRODUCTS AND WAFFERS AND POWDER-/ TAMARIND BASED ALL PRODUCTS- EXIHIBIT 3

Banana Products: Banana Flavour, Banana Puree, Banana Based Industries, Banana Processing, Banana Concentrate, Banana Pulp, Banana Wine, Banana Beer, Banana Chips, Wafers, Banana Powder and value added products

Banana is a fruit mostly grown in India, South America, and the Caribbean islands. Some of them also grow in Central America and some parts of Asia. Banana is edible, and many products are made by using banana Puree and banana pulp. An industry has grown based on banana products, and it is an integral part of the global industrial agro-business. Most of the grown bananas are exported out of the growing region, and they are used in making several products that are being sold all over the world.

Products Made by Using Banana

Banana Wine and Beer: Both banana beer and wine are alcoholic beverages. Banana beer is mostly used in East Africa. Fermentation mashed bananas make them. In addition to that, millet and sorghum are added to it. On the other hand, banana wine is a fruit wine made only by using bananas.

Banana Chips and Wafers: Banana Chips are made with finely chopped banana slices. At first, the banana slices are dried, and then they are deep-fried in oil. The flavour is decided before frying. If they are meant to be sweet, the slices are coated with honey and sugar, and if it meant to be salty and spicy, then the coating of salt and spices are given to them. The chips are mostly found in India and Indonesia.

Banana Powder: Banana powder is made by processing edible fruit. The banana powder is mostly used in making milkshakes and foods for children. It is also used as an ingredient to make various types of cakes and cookies.

Market Outlook of Banana Based Industry

India produces and exports the largest number of bananas. India exports 24.8 million tonnes of banana, which is 25.7% of the total output. As of 2016 net worth of the total exported products are worth 11.8 billion USD. On a global scale, a total amount of 97.5 million tons of banana is produced.
As with every passing day, consumers of these banana-based products are becoming health conscious. The use of ingredients with high nutritional value is one of the positive trends that will help the industry grow in the upcoming future. Among all the banana-based products, the banana

powder is the most selling products all around the world. Improved marketing and new product development will be beneficial in the growth of the business.

Segmentation of the Industry

The banana-based products industry is well segmented into various parts. The segmentations are done based on the geographical condition, application of the products.

Market Growth Rate

It is expected that the industry will grow at a CAGR of 1.21% between 2019 and 2024. Asia-Pacific region leads the global market with a consumption rate of 61 percent. And as of 2019, the market has grown another 5 percent compared to the 2018 market analysis.

Why Invest in This Industry and What Are The Trends of The Market?

As an investor, you should invest in this industry because the demand for banana-based products is increasing. The growth rate looks promising, and the market growth will reach new heights by the end of 2024. The market trends that have dominated the banana-based industry are increasing health consciousness among consumers. The Asia-Pacific region has dominated the banana market in the whole world. Nowadays, people are aware that banana is enriched with vitamins, minerals, protein, and dietary fibres. Using bananas, several products can be made that are also a reason for the increase in demand. The farming model and large fields used for producing bananas have made the Asia-Pacific region the largest banana market.

Conclusion

Like any other business, follow all the business trends and invest wisely. As various products are made using bananas, try to match the market's demand by ensuring that the production rate is high. The industry is highly beneficial, so there is a high chance that the investment will not go in vain.

Prospective Value-Added Products of Bananas

1. Banana Flour

Banana flour is a gluten-free flour made from green bananas that have been dried out as well as ground right into a fine powder. It is frequently made use of in gluten-free baking, as well as in the manufacturing of snacks, morning meal cereals, as well as baby food. Banana flour has a high starch material that makes it an excellent thickening representative for soups,

sauces, as well as gravies. It also has a reduced glycemic index, which implies that it is taken in more gradually by the body, making it a good alternative for people with diabetes or those trying to drop weight.

2. Banana Chips

Banana chips are a popular snack in numerous nations, including India, the Philippines, and Indonesia. They are made by cutting ripe bananas and then deep-frying them in oil. The outcome is a crunchy, crunchy treat that can be flavored with a variety of spices, such as salt, sugar, or seasonings. Banana chips are also available in baked and dried variations, which are healthier options for people wanting to lower their fat intake.

3. Banana Juice

Banana juice is a refreshing beverage that is high in minerals and vitamins. It is made by blending ripe bananas with water and also any other wanted active ingredients, such as honey, milk, or yogurt. Banana juice can likewise be mixed with various other fruits or vegetables, such as strawberries or spinach, to produce a nourishing as well as delicious smoothie mix.

4. Banana Wine

Banana wine is a fermented alcohol that is made from ripe bananas. It is a preferred drink in many parts of Africa and Asia, where bananas are plentiful. The manufacturing procedure for banana red wine entails mashing the bananas and after that including yeast to the blend. The yeast ferments the all-natural sugars in the bananas, creating alcohol. Banana wine can be taken in as is, or it can be mixed with other juices or carbonated water to create a fizzy, fruity drink.

5. Banana Fiber

Banana fibre is a natural textile fibre that is made from the stem of the banana plant. It is a lasting option to synthetic fibres, as it is naturally degradable as well as eco-friendly. Banana fibre is made use of to make a variety of items, including bags, floor coverings, and also garments. It is additionally used in the production of paper and other paper products.

Banana powder making business has many opportunities. You can use the banana powder in cosmetics, pharmaceuticals, food, and animal feed industries. Here is a list of the different banana making business ideas.

- **Manufacture of infant food**
- **Bakery products**
- **Seasoning**
- **Puffed food**
- **Banana brew/wine**
- **Making skin moisturizers**
- **Making animal feed**
- **Banana flakes**

Unlike fresh banana products like puree, banana powder has a shelf life of up to one year. As long as you have a banana powder business strategy, investing in banana powder is a worthwhile idea.

The Manufacturing Process of Banana Powder

Banana powder is among the most popular banana products. Banana powder is a product of processed bananas. The manufacturing process involves the following.

1. First, wash the ripened bananas in warm water.

2. Convert the bananas to a paste by passing them through a chopper and colloid mill

3. Next, you add a solution of sodium metabisulphite. Sodium metabisulphite improves the color of the finished powder.

4. Lastly, you dry the paste into powder using either spray drying or drum drying. Many banana powder manufacturers prefer drum drying because it recovers nearly all the solids.

5. You can package and store the finished banana powder for up to a year.

Apart from ripened bananas, you can also process banana powder from dried green bananas. If you store it in airtight containers, this powder can last for several months without expiring.

List of Profitable Business Ideas on Tamarind Seed Processing and By Products

List of Profitable Business Ideas on Tamarind Seed Processing and By-Products. Tamarind (Tamarindus Indica) Processing Industry. Processed Products of Tamarind.

Tamarind Kernel Powder, Gum from Tamarind Seed Powder, Tamarind Pulp from Tamarind, Tamarind Juice Powder, Oil from Tamarind Seed, Tartaric Acid, Food Colour, Crude Pectin, Tamarind Oil)

India is the world's largest producer of Tamarind, with a production of over 2 lakh tonnes. Tamarind is cultivated in Karnataka, Tamil Nadu, Chhattisgarh, Kerala, Andhra Pradesh, Maharashtra and Telangana.
Tamarind Pulp is used in numerous culinary preparations. It is also a raw material for the preparation of wine like beverages. The tamarind kernel powder is found to be extensively used for

its sizing properties, in textile, confectionary, cosmetics and pharmaceutical industries. The testa is used in dyeing and tanning industry. The tender leaves and flowers are used as vegetables. In medicine, it is used as appetizing, laxative, healing and anti-helmintic. It is also used against fluorosis. Around 50,000 tonnes of Tamarind is exported in various forms including fresh fruit, deseeded dry tamarind and Tamarind powder.

Tamarind extract is used in a variety of food products to enhance flavor and health benefits. Traditionally, tamarind extracts were used in juices due to its coolant property and were excessively consumed in the Middle Eastern region. It is a regularly used food ingredient in Asia and Latin America regions. Tamarind extract is used for manufacturing of tamarind concentrate, which is used in the preparation of blends for fruit juice, sauces, pickles etc. Tamarind extracts are used as natural preservatives, owing to its antifungal, antiseptic and antimicrobial properties. The other health benefits of tamarind extract are that it acts as an antioxidant. It is used to cure digestive problems, conjunctivitis, common cold, fever etc. Tamarind extracts are also used in cosmetic products. It acts as a bleaching and skin hydrating agent in cosmetic products. The fragrance oils made from tamarind extract has a sour and sweet essence. It is incorporated as a fragrance ingredient in a variety of products such as soaps, candles, air fresheners, bath oils, aromatherapy products, incense sticks, laundry products etc.

The use of tamarind extract in the rapidly growing food industry is expected to be a major driver for the growth global tamarind extract market. Tamarind extracts are as an alternative for chemical preservatives such as lactic, acetic, benzoic acids etc. The increasing consumer awareness regarding food safety and health benefits of natural preservatives is anticipated to boost global tamarind extract market. The rise in demand and production of processed food and adoption of natural processing techniques by the food industry is expected to drive global tamarind extract market growth. Tamarind extract is an important ingredient in cosmetic and fragrance industry. The upsurge in consumer demand for organic food and ayurvedic medicines is expected to propel the growth of global tamarind extract market.

The global tamarind extract market can be divided into five regions, namely North America, Latin America, Europe, Asia-Pacific (APAC) and the Middle East & Africa (MEA). APAC holds major share in global tamarind extract market. India is the major manufacturer and exporter of tamarind extract. The increasing investment in the healthcare industry and adoption of ayurveda is expected to drive tamarind extract market growth in the region. North America and Europe accounts for a significant share in global tamarind extract market. This is attributed to the mature food processing industries in these regions. Tamarind extract is used as a major ingredient in fruit juices in the desert regions of the Middle Eastern region due to its cooling effect.

The following industries have been proven to be quite Profitable:

TAMARIND PULP FROM TAMARIND

Tamarind is widely used in vegetable preparation or producing sour taste in different kind of foods, snacks etc. It is generally used as paste forms or water extracts and produces good sour taste. Generally it contents tartaric acid, red colour pigment, fruit sugars, minerals etc.

TAMARIND JUICE CONCENTRATE

Tamarind is a fruit of highly soured nature having big trees all over India. Tamarind cultivation is used for the extraction of its fruit juice and pulp. The tamarind pulp is the chief agent for souring curries, sauces, chutneys and certain beverages and stored for marketing in a number of ways.

TAMARIND BASED PRODUCTS- TARTARIC ACID, FOOD COLOUR, CRUDE PECTIN, TAMARIND OIL, TAMARIND PROTEIN

India is the major producer of tamarind in the world. In the tropic zone, tamarind is used in many dishes or traditional drinks, but the commercial cultivation of the crop was initiated only recently. Every part of the tree is useful, specially the fruit. The sweetish acidic pulp of the fruit is the product of commerce.

EXTRACTION OF OIL FROM TAMARIND SEEDS

Tamarind is one of the best vegetable products which is largely used by the domestic people as well as in the hotels, dhabas and restaurants for the food preparation as sour taste. This has very good palatable sour taste. After extraction of pulps from tamarind there is bye product of tamarind seed.

CORRUGATED CARTON BOXES GUM POWDER (TAMARIND KERNEL POWDER BASE)

It is basically gum powder made from tamarind kernel, dimethyl hydantion formaldehyde, polyvinyl alcohol all the required raw material and machinery is easily available in India. Few private organizations are engaged in the manufacturing of corrugation gum powder.

GINGER OIL/ POWDER/PASTE - EXHIBIT 4

Ginger Cultivation, Ginger Processing and Ginger value added Products

Ginger is very important commercial crop grown for its aromatic rhizomes which is used both as a spices and medicine. Ginger is valued for the dried ginger spice and preserved, crystallised ginger. Ginger is a perennial plant but is usually grown as an annual for harvesting as a spice. Ginger is best grown in partial shade and can be incorporate as an intercrop in coconut, coffee and orange plantations.
Ginger possesses a warm pungent taste and a pleasant odor, hence it has a wide use as a flavoring in numerous food preparation, beverages, ginger bread, soups, pickles and many soft drinks. There are two general types of ginger viz. fresh green ginger used for the preparation of candied ginger (in sugar syrup) and dried or cured ginger applied in the spice trade, for extracts, oleoresins and for the distillation of its volatile oil.
Several cultivars of ginger are grown in different ginger growing are as in India and they are generally named after the localities where they are grown. Some of the prominent indigenous cultivars are Maran, Kuruppampadi, Ernad, Wayanad, Himachal and Nadia. The exotic cultivar 'Rio-de-Janeiro' have also become very popular among cultivators.
Ginger is one of the excellent spice crops cultivated in Asia and India accounts for 40% of the world's ginger production. Ginger root has high demand in national and international markets due to its excellent uses and benefits. Farmers can make gold out of it. It belongs to the Zingiberaceae family, and is closely related to turmeric, cardomon and galangal. At the local market, households go for ginger because of its health benefits.

· While ginger helps common illnesses, it's positive effect on more serious health conditions cannot be disregarded.

· Ginger has been used as a digestive aid for thousands of years by ancient cultures. Its carminative properties promote the elimination of intestinal gas to prevent bloating and

flatulence, while its intestinal spasmolytic properties relax the gastrointestinal muscles to soothe an upset stomach.

· Ginger contains chromium, magnesium and zinc which can help to improve blood flow, as well as help prevent chills, fever, and excessive sweat.

· Fungal infection one of the trickier issues to control because they're increasingly resistant to conventional medicine, fungal infections don't stand a chance against ginger.

An increasing demand for ginger in India coupled with a drop in domestic production is resulting in India becoming a net importer. India is the world's largest producer and consumer of ginger. Ginger can be processed into a wide variety of products. Many products can be manufactured from ginger like dehydrated ginger, ginger candy, ginger powder, ginger oil and oleoresins and so on. Ginger is an important commercial crop with versatile applications. As condiment, ginger is used for flavoring many food products like tomato sauce or ketchup, salad dressings, meat sausages, gravies, pickles, curry dishes and so on.
In the food industry, its powdered form is widely used as a condiment/flavoring agent in salad dressings, tomato ketchup and sauce, pickles, gravies, meat sausages, curry dishes, etc. It can be used as pharmaceuticals for the production of herbal medicines in the treatment of cold fever. Ginger powder is also used for fragrance in soaps and cosmetics. Ginger oil obtained by the steam distillation of the dried ginger is mainly used in the flavoring of beverages, confectionery and perfumes. Powder ginger has very good domestic as well as export market.

There is a large market for both fresh and dried ginger. Ginger oil is obtained from the root of the herb Zingiber officinale. The peculiar hot taste and pungent taste of ginger can be attributed to the presence of an acrid compound called gingerol. The demand of ginger oil is ever increasing. It has good export and domestic demand. New entrepreneurs can well ventured in to this field. The demand is expected to reach at 4,212 tonnes by the year 2022.

Different Value-Added Products of Ginger:

Ginger Oil:

Steam distillation is used to produce essential oils, whereas solvent extraction is used to produce oleoresins. As a result, whereas oleoresins also contain components that are soluble in the solvent used in the extraction process, essential oils only contain the volatile portion of the spice.

The food industry prefers oils and oleoresins to dry spices for flavoring because they are more stable, cleaner, and contaminant-free. They may also be standardized by mixing oils from various sources.

The ginger pungency is caused by gingerols, of which gingerol is the most prevalent. However, during the distillation process, heat causes gingerols to break down, thus they are more plentiful in oleoresin extractives. Zingerone and shogaols, which are also decomposition

by-products of gingerol, are other substances with a pungent quality. Oleoresin was previously produced in the nation that imported it, but more recently, producing countries have realized the value-added of creating their extractives. Food preparation and the production of soft drinks and ginger beer both employ essential oils.

Ginger Candies:

Ginger Candy (Crystallized Ginger) is a delectable condiment that is simultaneously sweet, sour, spicy, crunchy, and chewy. Due to its many therapeutic characteristics, ginger candy promotes health and treats a variety of diseases. Ginger helps in easing throat issues and muscular discomfort. You can create it at your home and serve it as sweets, or you can add it for an extra taste boost, by adding it to your recipe for fruit cake or cookies.

Ginger Powder:

The dried ginger root is used to make ginger powder. Typically, fresh ginger root is sun-dried before being pulverized into a thin white powder. Many different cuisines use it. Numerous health enthusiasts are becoming aware of the various advantages of ginger powder. This powder is highly favored in part because of its long shelf life. Various languages use different names for it, like Telugu’s sonti, Kannada's shunti, Gujarati's soonth, Marathi's suntha, Hindi's saunth, and Malayalam's chukku.

Ginger Paste:

The canned ginger paste was developed experimentally as a value-added product in Hawaii with rising ginger output. In India, diced and macerated ginger, 35% garlic, and 15% salt are typically used to make a ginger paste.

Dried Gingers:

The majority of Indian ginger shipped is washed, dried, unpeeled, or rather loosely peeled. Ginger has a deeper hue and a greater monoterpene concentration, which results in a more pungent scent with camphoraceous overtones; it has a high oil content and degree of pungency; therefore, it is more potent than other types of ginger is typically chosen for the manufacture of oleoresins and oils. Typically, dried ginger is pulverized and then used to create spices and masalas for stews, marinades, gravies, and other dishes. Teas are brewed with powdered or crushed dried ginger.

ONION POWDER/PASTE- EXIHIBIT- 5

Onion is an important fresh vegetable consumed all over the world. India ranks first in acreage in the world covering about 480 thousand ha (21 per cent of the world area) and second in production

after China, with over 15 million tons. Onion is produced in the states of Maharashtra, Karnataka, Madhya Pradesh, Rajasthan, Gujarat, Andhra Pradesh and Bihar which together constitute around 70 percent of the area under onion.
Onion is the largest vegetable produced and consumed not only in India but also in the world. Although, it is classified as vegetable, it is mainly used in cuisines and culinary preparations. Onion is believed to have originated in Asia, though it is likely that onions may have been growing wild on every continent.

Top 10 Onion Producing States Maharashtra:

· Maharashtra
· Karnataka
· Madhya Pradesh
· Bihar
· Gujarat
· Rajasthan
· Haryana
· Andhra Pradesh
· Telangana
· Uttar Pradesh

Maharashtra ranks first in Onion production with a share of 28.32%. Onion powder is a processed form of dehydrated onion that can add the same flavor as fresh onions in a convenient manner. As a flavoring agent, onion powder is currently being used in a number of food and non-food products like- snacks, sauces, salads, soups, gravies, appetizers, seafood, meats, etc. Although, it is slightly less pungent than fresh onions, even its little amount can replace the chopping of a whole medium-sized onion. Thus, it is quite easier to handle compared to fresh onions and saves a lot of time while cooking as no chopping is required. Onion powder is also easier to pack and unlike fresh onions does not require refrigerated storage.

Onion is an important vegetable crop grown in India and forms a part of daily diet in almost all households throughout the year. Onion is one of the most important but perishable groups known. It is also used for medical purpose.

On account of rapid urbanization, hectic schedules and rising working population, the demand for onion powder is witnessing a tremendous growth, particularly in India. In order to save time, consumers are not willing to indulge in difficult cooking procedures such as chopping onions. Apart from this, food processing represents one of the largest sectors in India which is bolstering the demand for onion powder. Moreover, onion powder is used in ready-to-eat food products, like packaged soups, sauces, oats, noodles, pasta, frozen food and instant mixes. Further, onion powder is used in seasonings, dry rubs, marinades and condiments for preparing appetisers, seafood and meat.

Dehydrated onions register widespread consumption worldwide, predominantly due to growing popularity of convenience/packaged food products. Manufacturers are constantly striving to provide nutrition-rich dried products through their offerings of on-the-go or ready-to-cook meals and snacks, which is believed to be another key factor impacting adoption of dry vegetables globally.

Rising consumer awareness about the improved shelf life of dehydrated foods has contributed to the growing adoption of dry onions among consumers, especially within developing economies. Volatility in production and pricing of vegetables primarily due to seasonal variations, and availability and utilization of resources, has been identified to be a decisive factor influencing the market scenario.

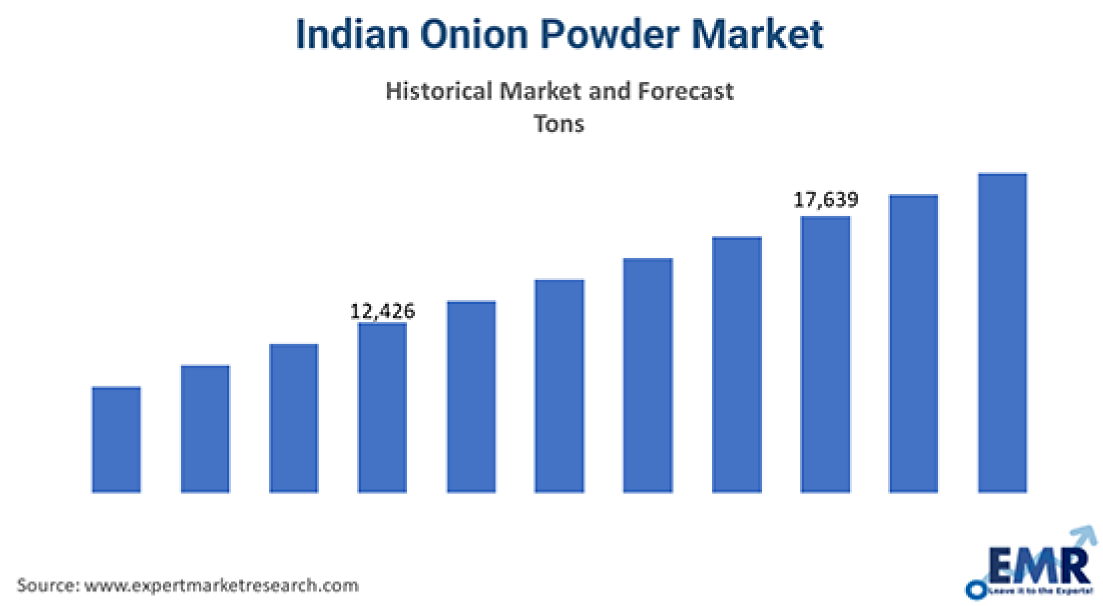
Value added products of onions

Onion paste

Onion powder.

Indian Onion Powder Market Outlook

The Indian onion powder market size was at about 13,988.82 tons in the year 2022. The Indian onion powder market is further expected to grow at a CAGR of 6% between 2023 and 2028 to reach a volume of almost 19,843.9 tons by 2028.



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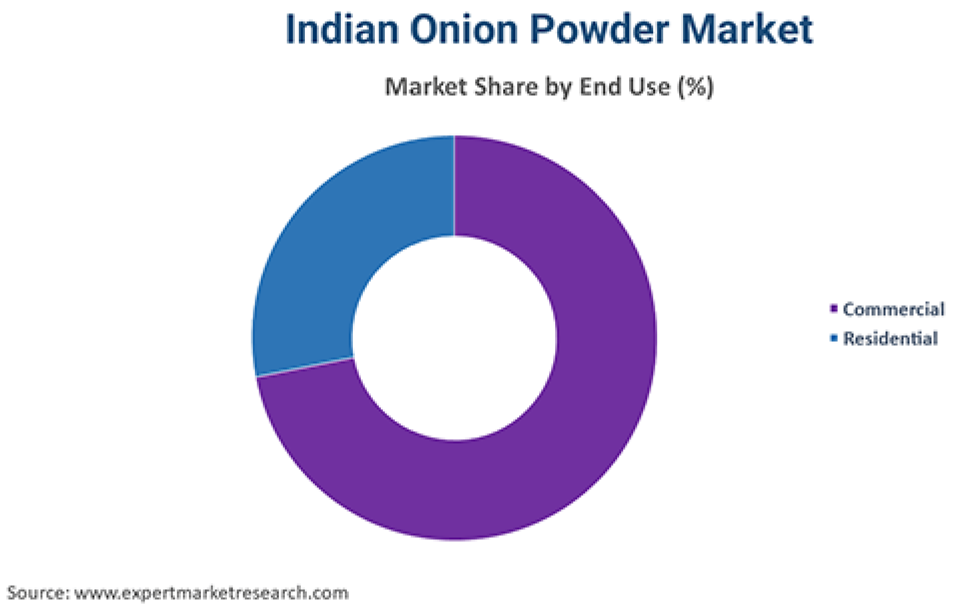
The onion powder industry in India is contributing to the growth of the global market. The industry is led by Gujarat, which holds the largest market share in India. The state has the largest number of onion powder production plants in India. The product is extensively used in India for its numerous culinary purposes due to its several benefits, such as easy transportation, long-shelf life, insignificant calorie count, and wide availability.

Market Segmentation

Onion powder is the processed form of dehydrated onions, which tastes less pungent comparatively. The product is extensively used in the preparation of several food products, such as snacks, salads, soups, and gravies, to enrich their flavour. Onion powder contains several nutrients, including iron, protein, calcium, carbohydrate, folate, cholesterol, potassium, manganese, magnesium, phosphorus, and vitamin B-6 and C. Other benefits associated with onion powder are longer shelf-life, insignificant calorie count, and easy storage and transportation.



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The Indian onion powder market is bifurcated on the basis of the end-use sectors into:

- **Commercial**
- **Residential**

Presently, the commercial sector represents the largest end-use segment owing to the rising demand for packaged food products.

On the basis of application, the industry is divided into:

- **Food Processing**
- **Healthcare**

The food processing sector is the leading segment, holding the majority of the market share as a result of the flourishing food industry in India.

Based on packaging, the industry is segmented into:

- **Bulk Packaging**
- **Pouches**

Currently, bulk packaging represents the leading packaging segment.

Regionally, the market for onion powder in India is divided into Gujarat, Maharashtra, Madhya Pradesh, Rajasthan, and others.

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Market Analysis

The Indian onion powder market is driven by its extensive use in the production of ready-to-cook food products like noodles, oats, pasta, instant mixes, and frozen food items. These products are further being driven by the rapid urbanisation, increasing working population, and hectic work schedules. Moreover, onion powder is used in dry rubs, seasonings, marinades, and condiments for preparing seafood, appetisers, and meat. There is an increasing preference for the use of this product, as it helps save time, and the consumers are spared from the difficult task of chopping onions for cooking requirements, further aiding the industry growth. Manufacturers within the food industry are undergoing changes to meet the standards of processed goods in India, further propelling the industry growth. The Ministry of Food Processing Industries (MoFPI) is encouraging the growth of this sector by increasing investments, thereby providing further impetus for the market growth of onion powder in India.

GARLIC POWDER/PASTE- EXIHIBIT - 6

Garlic Market Forecast, Trend Analysis and Growth

Garlic is a plant from the onion family it has a very unique and strong taste and smell and is used in cooking to flavors. Garlic is considered one of the most important crops in most Asian

countries. It is an ideal food that provides a wide range of nutrients with a lot of health benefits. In India, garlic is used in almost every home and hence it has fairly constant market demand. Garlic is used in various food preparations such as chutneys, curry powders, curried vegetable meat products, etc. Even the raw garlic is also used in Not only raw garlic is used in various second-generation products but also used as a popular remedy for different disorders. India is considered a key player in the garlic export industry, along with countries such as South Korea, China, and Egypt. India's garlic production mainly comes from the northern and central parts. The garlic produced by these parts is considered to be of superior quality. NPCS researchers found out that India exported 18,000 tons in the first quarter of the year valued at Rs 123.84 crore, an overwhelming upsurge of 169% in quantity and 107% in value, the maximum growth among the spices exported from India including the usual top-performing ones like chili, cumin, and spice oleoresins. India stands at the second-highest producer of garlic globally at 5.29%, China being the world leader of garlic in production donating to 77.07% of world capacity followed, South Korea at 2.08%, and Russia at 3.98 %.

Variety of Garlic Based Products:

The consumption of pickled garlic by Korean, cannot be ignored, which is about 60 pounds a year. Whereas the homemade pickled market is easily available and easy to make at home. Another easy to sell garlic product is garlic pesto sauce, it is easy to make with the garlic and herbs easily available in the market. Gourmet chefs love it and generally pay a premium price for convenience. A quite expensive garlic product is garlic vinegar, it is widely being used by a lot of trendy chefs. Due to its popularity and profit garlic growers make bottles of this gourmet product. A lot of researchers found that garlic can provide effective, safe, and cheap insecticide. A very basic garlic spray can kill up to 95% of common pests. Garlic insecticide profit margins are huge. Gourmet garlic powder has also made its place in the spice market. It is easy to make a food product that has a lot of superior products and is healthy to eat.

Production and Growth

The market of garlic is anticipated to bring in the US $ 19,488.2 million in revenue by the end of the year 2022. From 2019-2024, it is anticipated that the garlic market will rise at a CAGR of 4.7% globally. Garlic holds the title of the most important crop in the majority of Asian countries. Therefore, Asia-Pacific holds a 90% share of the market globally, in terms of consumption of garlic. The global market for garlic extract is a growing phase and is anticipated to record a significant growth rate over the forecasted period. In a lot of the region, black garlic that is being obtained from fresh garlic is als0 in high demand as it is considered more beneficial than fresh garlic. Hard neck garlic is also an emerging industry gaining nearly two-third revenue share of the garlic market towards the end of 2017. Hard neck garlic is also projected to create incremental opportunities between 2017 and 2022.

Conclusion

We are committed to offering an unbiased and independent market research solutions to their clients. The project report by on "Garlic and Garlic based Products" provides all the major components of the industry and all the data is compiled after months of executive research.

Garlic products

As Spice or Condiments • Gives Flavour, Aroma and Taste.

Food Products

• Chutneys,

Pickles,

Dips,

Curry Powder

, Sauces,

Ketchups

• Garlic Powder,

Garlic Salt,

Garlic Vinegar,

Garlic Bread, etc

PROCESSED PRODUCTS

• Commercial Forms of Dehydrated Garlic

• Garlic Powder

• Odourless Garlic Powder

• Garlic Salt

• Oil of Garlic

• Garlic Oleoresin

DEHYDRATED GARLIC FLAKES OR PIECES

GARLIC PASTE:

PICKLED GARLIC

HERBAL BUTTER AND CHEESE – EXIHIBIT -7

There are various kinds of Natural butter which are extracted from the several trees, plants, seeds or roots. They all remain solid at room temperature and contain solid or semi-solid fat oils. Fat oils make them excellent emollients and protecting agents.

Their composition of active ingredients, fatty acids, and oils, however, is quite different which differentiates their properties for example soothing, anti-inflammatory, moistening, or anti-oxidants activities.

it's time to embark on a tasteful exploration of vegan butter—the smooth and creamy sensation that's melting hearts and toasts everywhere? Whether you're a committed herbivore, an adventurous omnivore, or just someone who believes in the magic of a perfectly buttered croissant, this article is about to take you on a dairy-free delight ride through the world of vegan butter.

Embracing a plant-based lifestyle doesn't mean bidding farewell to the indulgent richness of buttery goodness. Whether you've recently learned about the atrocities of dairy farming, you're looking to switch to more sustainable food choices, or you recently learned about the power of a plant-based diet for human health, you've come to the right place.

Butter is one of the easiest dairy-free switch-outs you can make in your fridge (aside from replacing cow's milk with plant-based milk). With the abundance and quality of vegan butter products in the marketplace today, you can easily replace it without tasting the difference. And plant-based butter works just the same in recipes and cooking.

Whether you need some butter to spread on a grilled cheese, blend with sugar in a vegan birthday cake with dairy-free buttercream frosting, butter your morning toast, or melt on a baked potato, this guide to vegan butter has got you covered! And for those feeling a little culinary boldness, we've got a mouthwatering vegan butter recipe that's going to rock your spatula, too.

1. coconut oil-based buttery spread can be used to butter toast or to make decadent sauces.

2. Peanut Butter

Peanut butter is a food paste or spread made from ground, dry-roasted peanuts. It commonly contains additional ingredients that modify the taste or texture, such as salt, sweeteners, or emulsifiers

3. Shea Butter

The Shea tree, scientifically known as Butyrospermum Parkii,

4.Cocoa Butter Deodorize

This Incredible Butter is extracted from cocoa beans of the Theobroma Cacao plant. Strongly flavored cocoa butter can be used in dark chocolates, but because of large demands for milk chocolates, strong butter is deodorized to create white butter.

5. Cocoa Butter Ultra Refined.

This incredible butter is obtained from the Cacao tree, scientifically known as Theobroma Cacao. The cacao tree mostly grows in tropical regions, such as Africa, Mexico, etc. Cocoa butter is ideal for body care products.

6. Mango Butter Ultra Refined

This amazing butter is extracted from the Mango tree, scientifically known as Mangifera indica. It will grow in sub-tropical regions of India, and Burma. And also in other parts of the globe as well. Mango butter is rich in content C 18:0 and C 18:1 fatty acids and rich in antioxidants such as Vitamin A, Vitamin E & Vitamin C.

7. Kokum Butter Normal.

It is obtained from the fruit kernel of the Garcinia tree, scientifically known as Garcinia Indica. The kokum tree is mostly grown in western ghat regions and central east regions known as Konkan regions. Kokum butter has great benefits for the skin, body, and hair.

8. Kokum Butter Ultra Refined

This amazing butter originated from kokum plants, scientifically known as Garcinia Indica. It is one of the hardest vegetable butter and is stable as well which is obtained from fruit kernel. It exhibits emollient properties and has high oxidative stability.

9. Aloe Butter

Aloe butter is a pure "Aloe" that blends with coconut oil to form white aloe butter. Aloe butter is perfect in cosmetics & skin care products such as lotions, creams & body butter.

COCONUT PRODUCTS- EXIHIBIT -8

Coconut Products

Kernel Based Coconut Products

Coconut Water based Products

Coconut Inflorescence Based Food Products

Coconut Convenience Food Products

Coconut Shell Based Products.

Kernel Based Coconut Products

1. Virgin Coconut Oil

Coconut oil obtained from coconut milk is called virgin coconut oil. Traditional and modern methods are available for the manufacture of virgin coconut oil. In the traditional method, milk extracted from grated coconut kernel is boiled to get oil. Of late, the traditional method has been partially mechanized using a bridge press and mechanical grater. The modern method of extracting oil from fresh coconut kernel is known as wet processing.

The Virgin coconut oil is considered superior for use as edible oil, hair oil and baby oil because of its pleasing aroma and purity. It is applied on the body of babies to protect from skin diseases. Because of its low FFA content, this oil has a longer shelf life.

2. Desiccated Coconut

Dehydrated coconut meat in the grated and shredded form is desiccated coconut (DC). A large number of units in India are manufacturing DC which is mainly absorbed by the confectionery and other food industries. DC is also used as a substitute to grated coconut in various household preparations. DC is available in different grades based on the fineness of the material.

3. Coconut Milk

Coconut Milk is the oil-protein-water emulsion obtained by squeezing fresh grated coconut kernel. The undiluted and diluted forms are called coconut milk and the concentrated form is coconut cream. Coconut milk is obtained by extraction of fresh coconut wet gratings with or without water. This is an instant product, which can either be used directly/diluted with water to make various preparations such as fi sh & meat dishes, curries, sweets, deserts, puddings, cocktails, cakes, cookies, coconut jam, ice creams etc. It can also be used in the manufacture of bakery products and for coconut milk fl avouring food stuffs. Preserved forms of coconut milk such as canned cream or milk and dehydrated whole milk are now available in many coconut growing countries. Commercial production of these products has been promoted in the Philippines, Thailand, Indonesia, Western Samoa, Sri Lanka and Malaysia and to some extent in India. Indonesia is the leading exporter of coconut milk followed by Sri Lanka, Thailand and Philippines.

Coconut Skimmed Milk

plant protein and is an invaluable material for the preparation of milk substitutes. Coconut skimmed milk is a solution of the soluble components of coconut after the cream is separated in a cream separator. Skimmed milk is a good source of quality protein suitable for the preparation of many useful food products or as supplemental protein source, especially in regions deficient in animal proteins. Freshly prepared coconut milk from pared kernel is filtered through a 120 mesh vibrating screen and the pH of the filtered milk is raised from 6.3 to 7.0 with the additions of sodium hydroxide. The milk is then pasteurized at about 60oC for one hour and subsequently centrifuged in a cream separator to yield the aqueous phase or the protein rich skimmed milk.

Coconut powder

Coconut flour

Spray Dried Coconut Milk Powder/

Spray drying is the best method for the preservation of coconut milk. Spray dried coconut milk powder is reconstituted into coconut milk by adding water which can be used to make various food preparations. The product offers additional advantages such as less storage space, bulk packaging at reduced cost and longer shelf life. Technology for the manufacture of spray dried coconut milk powder is available with the Coconut Development Board.

Coconut Cream

Processed and packed coconut cream is a ready-touse product which can either be used directly or diluted with water in various edible preparations. Coconut cream when partially defatted is called coconut milk. Coconut cream/ milk is used as an ingredient in household recipes and as a component of processed foods. Coconut milk is also used as coconut cream, a mixer in alcoholic drinks. Coconut milk/cream is available in pouches, bottles and tetra packs. Technology for the manufacture of coconut cream is available with Coconut Development Board.

Coconut Chips

Coconut chips are a ready-to-eat snack food. It is prepared in salted and sweetened forms. The Central Plantation Crops Research Institute, Kasaragod has standardized the process for preparation of chips. Coconuts of 9-10 months are used for the preparation of chips.

Coconut Oil

Coconut oil is rather a unique cooking oil as it contains the short and the medium chain saturated fatty acids. It fi nds extensive use in the food industry due to its characteristics such as easy melting behaviour, resistance to oxidative rancidity, pleasing fl avour and good digestibility. Coconut oil has gained importance as a dietary fat because of its high content of lauric acid, the source of monolaurin in the body and 16W content of Omega 6. It can be used

for manufacturing margarine and shortenings. Coconut oil is preferred as a fat in the preparation of fi lled milk, infant milk powder, ice-cream and confectionery and bakery products. Because of its stable character, coconut oil is the preferred fat for deep frying.

Studies undertaken by the Biochemistry Department, University of Kerala showed that coconut oil-

Does not elevate blood total cholesterol and increases blood HDL cholesterol

If consumed along with coconut kernel, lowers blood cholesterol

Does not elevate LDL cholesterol or LDL cholesterol/HDL cholesterol ratio

Decreases serum triglycerides

A large number of branded coconut oil in consumer packs are marketed in the country. Coconut oil is refined for industrial use. The refined coconut oil is water white in colour with no aroma. Since coconut oil has the lowest level of unsaturated fatty acids among all vegetable oils, the cost of hydrogenation is much less than all other oils.

Copra

Two types of copra, namely the milling and the edible, are made in India. The milling copra is used to extract oil while the edible copra is consumed as a dry fruit. Edible copra is made in the forms of balls and cups. Copra contains the highest percentage of oil compared to other oil seeds. It contains 15-20 percent carbohydrates, 9 percent protein and 4.10 percent crude fiber besides 65-68 percent fat. The carbohydrate fraction consists of a large percentage of cellulose and sucrose together with other sugars. Besides glucose and fructose, the presence of galactose, raffinose and pentoses is also reported.

Coconut Water based Products

Tender Coconut Water

The water of tender coconut (TCW) is a sterile, nutritious and thirst quenching health drink. It possesses therapeutic properties. The TCW has a calorifi c value of 17.4 per 100gm.

TCW is rich in potassium and other minerals. Sugars form an important constituent of the TCW. The concentration of sugars in the nut water steadily increases from about 1.5 per cent

to 5-5.5 per cent in the early months of maturation and then slowly falls reaching about 2 per cent at the stage of the full maturity of the nut.

Vinegar

Coconut vinegar is made from fermented coconut water and is used extensively as a preservative and flavoring agent in pickles, salads, sauces and many other condiments. Coconut vinegar is also made from the sap of the coconut tree and is similar to the fresh coconut water. Naturally fermented coconut vinegar is rich in minerals and vitamins such as beta carotene, calcium, iron, magnesium, phosphorous, potassium and sodium. Raw, unfi ltered organic coconut vinegar is similar to the one that is fermented naturally. Coconut vinegar helps in digestion and improves the quality of cooked meat and fi sh. It is a healthier alternative to synthetic vinegar.

Coconut squash

It is a nourishing and refreshing healthy soft drink concentrate prepared by mixing coconut water, sugar and natural preservatives like lemon and ginger. It is rich in vitamins and minerals with low calorie. The product has a shelf life of three months under ambient conditions. The product is a new item and is gaining popularity in Asia and Pacific countries.

Nata-de-coco

Nata-de-coco a cellulosic white to creamy yellow substance formed by acetobacter acetisub species Xenium, on the surface of sugar enriched coconut water / coconut milk / plant extract / fruit juices or other waste materials rich in sugar.

It is popularly used as a dessert. It is also used as an ingredient in food products, such as ice cream, fruit cocktails, etc. "Nata" is a Spanish word, derived from the latin word "Natare" meaning "to float". Nata making plays an important role in the development of our coconut industry because of the growing interest in its production from coconut water, an abundant waste product of coconut processing units.

Nata can be prepared from various fruits like banana, pineapple, tomato etc. and the product named after the media used, like "Nata de coco" from coconut, "Nata de pina" from pineapple etc. We can also use coconut milk, finely shredded coconut meat or coconut water in preparing Nata.

Coconut Inflorescence Based Food Products

Neera

The vascular sap collected from immature unopened coconut inflorescence is popularly known as Neera in fresh form. It is a sugar containing juice and is a delicious health drink and a rich

source of sugars, minerals and vitamins. It is sweet and oyster white in colour and translucent. It is tapped from the coconut inflorescence and is filtered, pasteurized and bio preservatives added to preserve the product. Treated Neera can be preserved in cans upto two months at room temperature. It can also be packed in tetra packs or glass bottles. Tapping can be done for six months in a year. It is an abundant source of minerals, 17 amino acids, vitamin C, broad spectrum B vitamins and has a nearly neutral pH.

Coconut Jaggery

Fresh neera when boiled to 118-120o C and allowed to cool for solidification. The solid mass is known as coconut jaggery or 'gur'. Coconut jaggery is made in traditional coconut growing tracts in the country on a cottage scale. Calcium and phosphorus are the important minerals contained in coconut jaggery. Treacle is another product manufactured from sweet toddy. It is obtained by boiling down the toddy. Fresh toddy is also a good source of baker's yeast. The fresh neera rapidly ferments and the sugar is replaced by about 5-8 per cent alcohol, which on distillation yields arrack. Fermented neera on acetic fermentation yields vinegar containing 4-7% acetic acid.

Coconut Palm Sugar

The coconut palm syrup or jaggery can be crystallized to produce fine granules of sugar. Transition of coconut jaggery into a ground granule sweetener is more accepted by global markets. The recovery of palm sugar from coconut palm jaggery is 15%. The application of this sugar is tremendous and offers huge potential owing to its most important health attributes, the low Glycemic index and the high nutrient content. It can be the most suited alternative sweetener, especially when agave sugar is being rejected owing to the high fructose content. This alternative sugar industry is estimated to be a $1.3 billion industry and hence the market prospects are enormous.

Coconut Flower Syrup

This is a product similar to jaggery with high content of minerals. It is a rich source of potassium. It has good content of sodium and is free from total fats and cholesterol. It is produced when fresh Neera is heated and concentrated into syrup. The input output ratio is 6:1. The syrup has 50% sucrose content and possess low glycemic index at the levels of 35 GI which indicates that low levels of sugar gets absorbed into the blood thus making it safe for diabetic patients.

Coconut Convenience Food Products

Coconut Biscuits

Coconut biscuits are ready to eat snack products prepared from maida and coconut powder. It can be prepared in different varieties through addition of cocoa, butter; ginger etc. The product has a shelf life of three months under ambient conditions. It is mainly consumed as a snack item. Coconut biscuits are highly nutritious and delicious with low calories and high fiber content and is one of the healthiest snack items which is quite popular and is in great demand in Asia and Pacific countries, USA, European countries, Middle East and African countries.

Coconut Candy

Coconut candy is prepared from grated coconut mixed with coconut milk. It has high fiber content and helps prevent intestinal sluggishness. It is a newly introduced product mainly produced in Asia and Pacific Countries.

Coconut Chocolate

It is a sweet confectionery item prepared from coconut gratings sugar, milk butter with a coating of chocolate. It is rich in protein, carbohydrate and fiber. It can be made more delicious through addition of cashew, badam and other dry fruits. The product has a shelf life of three months under refrigerated conditions. The product is having extensive demand in Europe, North America, Australia, Middle East and China.

Coconut Burfi:

It is a snack prepared by roasting coconut gratings. A procedure for preparation of coconut burfi was standardized. Coconut gratings (after extraction of fat) were roasted, then added fat at the rate of three percent and sugar at ten percent gave highest organoleptic qualities. The product has good nutritive value with protein (10.23%), Ash (2.1%) and carbohydrates (60.87%).

Coconut Shell Based Products



Coconut Shell Powder

Coconut shells free from contamination of coir pith, etc., are broken into small pieces and fed into a pulveriser. The powder from the pulveriser is fed into a cyclone and the parallel product is collected in bag filters. The shell powder is then fed into a vibrating sieving machine and packed according to mesh size requirements for various end uses. The rejects from the sieving machine can be recycled in the pulverizer for size reduction. The main requirements for consistent good quality of coconut shell powder are proper selection of shell of proper stage of maturity and efficient machinery.

Coconut Shell Charcoal

Shell Charcoal is obtained by burning the shell of fully matured coconuts with a limited supply of air so that they do not burn away to ash but are only carbonized. The manufacture of shell charcoal shows from the coconut shell has become a very important economic and commercial activity. Furthermore, coconut shell charcoal, which was relatively a minor product in the past, has now developed into a general commercial commodity due to its intrinsic value as a raw material for the manufacture of activated carbon. Coconut shell charcoal are of two types: viz Coconut shell charcoal and granulated shell charcoal.

Activated Carbon

The process of activation is carried out in two stages. Firstly the coconut shell is converted into shell charcoal by carbonization process which is usually carried out in mud-pits, brick kilns and metallic portable kilns. The coconut shell charcoal is activated by reaction with steam at a temperature of 900oC -1100oC under controlled atmosphere in a rotary kiln. The reaction between steam and charcoal takes place at the internal surface area, creating more sites for adsorption. The temperature factor, in the process of activation is very important. Below 900oC the reaction becomes too slow and is very uneconomical. Above 1100°C the reaction becomes diffusion controlled and therefore takes place on the outer surface of the charcoal resulting in loss of charcoal.

Project Opportunities in Mango Pulp Processing Industry (Food & Agriculture Sector). Mango Pulp Extraction Unit with Cold Storage

India is the home of mangoes. A large number of varieties are found in almost all parts of the country. Mango Pulp is prepared from selected varieties of Fresh Mango Fruit. Fully matured Mangoes are harvested, quickly transported to the fruit processing plant, inspected and washed. Selected high quality fruits go to the controlled ripening chambers; Fully Ripened Mango fruits are then washed, blanched, pulped, deseeded, centrifuged, homogenized, concentrated when required, thermally processed and aseptically filled maintaining sterility. The preparation process includes cutting, de-stoning, refining and packing. In case of aseptic product the pulp is sterilized and packed in aseptic bags. The refined pulp is also packed in cans, hermetically sealed and retorted. Frozen pulp is pasteurized and deep-frozen in plate freezers. The process ensures that the natural flavour and aroma of the fruit is retained in the final product.

Mango puree, which is often called as mango pulp, is a smooth and thick product which is processed in such way that the insoluble fibrous parts of the ripe mangoes are broken up. It retains all of the fruit juice and a huge portion of fibrous matter naturally, which is found naturally in the raw fruit. In few industries, the mango puree is pasteurized in order to increase its shelf life. In terms of consumption and import, the Middle-East region leads the market, followed by the European Union with over 20% of total world imports. The largest user of the mango puree in Europe is the fruit juice industry, but it also has applications in other segments such as ice cream and baby food industry as well.

The market for mango pulp grew exponentially which is expected to continue. India is the leader among major mango growers with widely recognized variety of mangoes (primarily Alphonso, Totapuri and Kesar) being used in the manufacturing of pulp.

Mango Pulp/Concentrate is perfectly suited for conversion to juices, nectars, drinks, jams, fruit cheese and various other kinds of beverages. It can also be used in puddings, bakery fillings, fruit meals for children and flavours for food industry, and also to make the most delicious ice creams, yoghurt and confectionery.

Mango pulp is used as a major food ingredient in the making of mango juice, nectars, juice blends, dairy, bakery, baby food manufacturing, ice-creams etc. However, in recent years the popularity of mango has spread to the western markets with consumers showing interest in the taste. The US juice industry and fresh market has shown consistent interest in both fresh mango and its processed products. The US juice industry has been making more and more use of mango pulp in its orange juice blends.

Two main clusters of Mango Pulp are there in the country, which has around 65 processing units with a good backward linkage of Alphonso and Totapuri variety of mangoes. These clusters are Chittoor in the state of Andhra Pradesh and Krishnagiri in the state of Tamil Nadu. Some of the Processing units are in the state of Maharashtra and Gujrat.

India is largest mango pulp exporter in the world. Mango production is throughout India. However, most of the pulp industries are established in Southern and Western India and these regions account for major proportion of export that happens from India.

The mango pulp industry in Krishnagiri district of Tamil Nadu is the second largest exporter of pulp in the country, generate between rupees 400 to 500 crores of foreign exchange annually. Krishnagiri district is also the second largest mango pulp producer in the country after Chittoor in Andhra Pradesh.

The mango pulp is being exported to many countries, including UAE, European countries, Singapore and Malaysia.

India Facts and Figures:

India is also a major exporter of Mango Pulp in the world. The country has exported 1, 35,621.22 MT of Mango Pulp to the world for the worth of Rs. 864.97 crores / 129.29 USD Millions during the year 2016-17.

India produces 350,000 tonnes of mango pulp annually, 50 per cent of the estimated 700,000 tonnes of global mango pulp production. It exports 200,000 tonnes of pulp, while 150,000 tonnes is consumed domestically.

Mango pulp is an important value added product having good demand in domestic as well as international market. Changing food habits in the country has increased consumption of fruit and fruit products and hence market for fruit juice/concentrates/ powder/ slices/ dices have also increased. Increasing number of nuclear families in India particularly in urban and semi urban areas, and increasing number of working women in the country has increased demand of processed fruit products such as mango pulp and beverages.

The prospects for mango pulp exporters India is on the upward swing as demand is growing exponentially. The mango fruit industry is gearing up to meet this increased demand and mango pulp manufacturers are investing in infrastructure and resources to cater to this.

The Global Mango Pulp market seen an increasing growth due to the several benefits of mango Pulp such as it prevents cancer, prevents heart disease, helps lower cholesterol, improves digestion, prevents asthma, improves eye health, regulates blood pressure, and improves immunity and many other benefits. It also has a high amount of vitamin A, vitamin C, potassium, protein and fiber due to which it helps prevents infection in pregnant women and also helps prevent eye problem in newborns. It also enhances skin health due to the presence of carotenoids.

What are mango waste products?

Mango waste products that include mango peel, mango seed or kernel and mango fibre have enormous nutritional and functional value, the same as mango puree. Mango pulp is an important mango byproduct and raw material for all secondary processed mango products. Mango pulp, also known as mango puree, is a thick and smooth substance manufactured by breaking up the insoluble fibrous sections of ripe mangoes. The byproducts of mango retain fresh flavour, sweetness and nutrients since the puree is extracted naturally. Processed fruit manufacturers in India are well-equipped with advanced technology and manufacturing facilities to meet the demand of local and international markets. The fruit juice industry is the major consumer of aseptic mango pulp.

Processed products of mango – mango byproducts

The mango is one of the essential fruits with a high potential for processed food products in developed and developing countries. Mango is the world's second most traded tropical fruit and ranks seventh in production. Mango puree, pulp, and concentrate are the primary processed products. The mango pulp makes most of the standard secondary processed products. The secondary processed products include fruit juices, fruit drinks, nectars, dairy products, baby foods and other processed products.

The Important byproducts of mango

Mango seeds

Mango powder

Mango peel

Mango fiber

Mango leather

Mango seeds – The most crucial mango by product

Mango byproducts such as peel and mango seeds are high in bioactive compounds such as carotenoids, polyphenols and dietary fibres. The byproducts of wastes during mango processing are used to manufacture animal feeds. This increases the value of fruit, thereby reducing wastage. At ABC Fruits, we manage to separate the peels, mango seed, and fibre with the help of destoner machinery. The peel and fibre are used to produce biogas. The mango seeds are used as the boiler feed. ABC Fruits is also a mango seed supplier that supplies mango seeds to livestock feeds.

Apart from the animal feeds as pallets, Mango seeds are also used for human consumption. Mango seed powder is another additional product made from mango seeds. The mango seed powder has enormous health benefits. Mango seed powder is used to manufacture traditional medicines and other skin and hair care products. Mango seed adds great value addition to the economy and small-scale businesses.

Mango powder – One of the in-demand mango byproducts

Mango powder is another secondary processed product manufactured from mango pulp. Mango powder is used to enhance a variety of foods and beverages, including ice cream, yoghurt, and the confectionery industry. The dried mango powder is manufactured by dehydrating aseptic mango pulp to a moisture level of 3% via spray or drum dryer. Mango jams and jellies are also manufactured as per the same process of manufacturing mango powder. The dried mango powder is mostly used for culinary purposes. It has replaced the use of tamarind to create a tangy flavour. It is also called amchur powder in the north Indian region. Due to its enormous health benefits, including antioxidants and vitamins, mango powder has created a good demand in the B2B industry.

Mango peel

Mango peel is an important byproduct in the mango processing industry. It contributes 15-20% of the total weight of the fruit. The mango peel is a good source of biologically active substances such as carotenoids, polyphenols, and Vitamins. Mango peels contain more polyphenols than pulp that can be used in various food formulations. This increases the value of the fruit and improves its economic importance. Recent research also shows that lactic acid can be produced from mango peels. Mango peels are now widely used in the pharmaceutical industry for creating herbal extracts and for R&D purposes.

Mango Fibre

Mango dietary fibre has generated a lot of attention as a functional food ingredient in recent years. The presence of phenolic compounds confers inherent antioxidant capacity. As a result, it is capable of producing low-cost nutritional dietary supplements. Research shows mango peel powder will be a great antioxidant source. This will contribute a great value addition to the mango fruit. The destoner machinery separates the peels and fibre. The fibre is also used as an organic fertilizer to produce biogas that fuels boilers or generators.

Mango leather

The Netherlands imports 55% of all mangoes in Europe, making it one of the leading importers and traders of mango. The trade hub imported 1,80,000 tonnes of vegetables and 500000 tonnes of fruits in 2019. The Netherlands-based company manufactures mango leather from the waste of mango. This product often referred to as vegan leather, is made from waste and spoiled mangoes. This adds value to the economy, reduces waste, and creates an environment-friendly product.

Research and ideas are also being carried out in India to produce mango leather. Since India is the largest producer of mangoes, we are rich in raw materials. Technical Know-how could create a lot of opportunities and play a role in improving the GDP.

Enhanced value of mango fruit processing

Although selling mangoes as fruits is the most prevalent technique followed by small-scale growers across developing nations, processing the fruit into a healthy and safe product without altering its flavour and taste adds more value. Since pulp/puree is used as a primary processed product for producing other products, the net profit derived from processing into various products has consistently increased over the years. Processing mango into various products increases the potential and reduces the post-harvest losses reported in mango.

Mango float

Served during festive occasions and other celebrations, this sweet dessert uses sliced ripe mangoes, Graham crackers and whipped cream.

Mango puree

Mashed peeled ripe mango served plain or occasionally mixed with yogurt, smooth or chunky, are among good solid foods to introduce to weaning babies.

Mango concentrate

Product is processed to remove certain ratio of the natural water content found in the mango and produce a concentrated product in smaller volume.

Mango juice

Drink mix composed of several ingredients, including sugar, food preservatives, coloring agents and nutrients. Mango drink

Mango juices are generally processed from the fresh and natural ripe alphonso mangoes that are procured from the finest of orchids. Processed mango juice has a delicious taste with the natural aroma of the finest of mangoes - the alphonso.

These fruit drinks are free from artificial flavors, colors, preservatives and other synthetics.

These juices taste really tangy and refreshing and you wont get the feeling that it is a processed fruit drink.

Since it is a processed one, it does not innate nutrients, because it is being processed in such a way that it retains its nutrients as such, hence it will contain the same amount of vitamins and minerals it had naturally.

It is a real boon for all the mango lovers, because once it becomes off season it becomes very difficult or rather we can say no chances of getting a mango to relish on, so these kind of processed mango fruit drink comes in as saviors to all the mango craze people to quench their mango thirst.

Squash is a concentrated form of a fruit drink, where you can use two spoons full to a glass of water, dilute it and drink.

Mango nectar

Composed of mango concentrate, water and added nutrients.

Mango fruit cocktail

Used in salads.

Mango flavored ice cream

Mango Bar

Mango bars are made from a variety of popular mango pulps; it is an excellent source of vitamin A and C, potassium, fiber and beta carotene.

Mango bars are very famous mainly because it tastes like eating a mango, which comes handy and is available even in off season.

These bars taste delicious and hence they are also used in mixing it with milk and cream for that flavor.

They are hundred percent natural, with no added sugar or sweeteners, gluten free which are suitable for vegans.

It is less messy unlike the real fruit, where you can have it in your office desk and have whenever you want.

It is a natural energy boosting bar, which can be had before and after work outs. It is a readily available source of glucose.

Tasty cold dessert treats.

Mango candy

Candies are generally referred to as sweets or confectioneries. It is a familiar food treat available in different varieties and flavors.

This type of candy comes under the hard candies category; they are hard in texture, which is boiled till hard.

These mango candies have the richness of real, juicy sweet mangoes. When you pop in one mango candy, take your time, roll it around in your mouth, feel the real taste of mangoes go down your throat.

You can eat them anywhere and everywhere, but do remember to enjoy it very slowly!!

Mango preserves and jams

Used as sandwich spreads. Mango Jam

Jam, is loved by everyone irrespective of the age and especially by the kids. Mango jams have the natural real flavor, which are considered as the perfect topping for a morning toast, which is nutritious, filling and tasty as well. And to top it,

Jams made with mangoes, hmmmm it's like a plum over a rich cheese cake. Sounds yummy, right? Yes, mango jams are yummy as well.

There are range of delectable flavored jams and jellies which are manufactured from fresh fruits without the use of harmful preservatives and flavor enhancers it retains and possesses all the nutritional value of the fruit.

Mango essence

The mango essence is manufactured by capturing the fresh fruit's aroma and flavor.

The essence is obtained by extracting the volatile aromas from the pulp through condensation.

The powerful sensory qualities of this mango essence make it perfect for adding natural fruit taste, flavour and aroma to snacks, frozen delicacies, beverages and confectioneries.

When it is added as a flavoring agent, it does its job, great!! It gives an amazing real taste to the product to which you add it.

Canned mango pulp or slices

Before canning the mango undergoes several unit processes such as sorting, washing, peeling and so on. Generally peeling is done manually and the delicate pieces alone are packed in sterilized cans or tins.

You can use these pieces in mango juices, shakes, puddings or convert them into some other processed food product. You can enjoy the mouth watering taste of the real mangoes in the form of fruit pulp, all round the year.

These tinned or canned pulp or slices are very tasty to consume, as they have been packed by stringent quality control method

Mango pickle

A variety of pickle prepared using mango.

Mango seeds

This can be used for nursery planting materials.

Fertilizer

Mango peel, seeds, leaves, branches can be used as organic fertilizer.

Medication

Specialized fruit, leaves and plant extract for drugs and medicine.

We will make mango EOU AND MANGO EOZ to export and marketing.

DIABETIC FOOD – EXHIBIT 10

There are few food items are largely used as diabetic food. There is no ill effect produce by taking of this food by the diabetic patient. It is now manufactured in India by some organized sectors. It has good export scope though there is good indigenous demand of the food. All the plant and machineries are indigenously available.

Diabetic food is special kind of food product, which can be used by the diabetic patient directly without any side effect in the body or any direct effect on the body. It is basically made by using the used food articles which contains protein for bodies as their main body constituent with fiber content or without content of caloric sugar and fat. These food materials are basically defatted Soya flour, Mushroom, Orange juices, Yeast extract base products and many other herbal base products like garlic extract, ginger extract or paste. There is plenty of basic raw materials available in India for the production of dibetic food. Variety of plant and machineries required for the manufacturing of the products. Most of all the plant and machineries are available in India. There is very negligible amount of water pollution produce, which can be controlled by the measure amount of treatment. There is about more than 20% of the population are dibetic people on that base it can be predict that if there is unique dibetic food is available which will get the good market. There are very few manufacturers producing dibetic products, most of the products are Parma base or health drinks. As a whole there is good scope to manufacture this product. Here we will discuss about the Atta used specially for dibetic people as well as general people.

Diabetic diet refers to the diet that is recommended for sufferers of diabetes mellitus. There is much controversy regarding what that diet should consist of. The diet most often recommended is high in dietary fiber, especially soluble fiber, but low in fat (especially saturated fat) and low in sugar. Recommendations of the fraction of total calories to be obtained from carbohydrate are generally in the range of 40 to 65%, but recommendations can vary as widely as from 16 to 75%. Diabetics may be encouraged to reduce their intake of carbohydrates that have a high glycemic index (GI), although this is also controversial. (In cases of hypoglycemia, they are advised to have food or drink that can raise blood glucose quickly, such as lucozade, followed by a long-acting carbohydrate (such as rye bread) to prevent risk of further hypoglycemia.) A sugar substitute is a food additive that duplicates the effect of sugar in taste, usually with less food energy. Some sugar substitutes are natural and some are synthetic. Those that are not natural are, in general, called artificial sweeteners. The majority of sugar substitutes approved for food use are artificially synthesized compounds. However, some bulk natural sugar substitutes are known, including sorbitol and xylitol, which are found in berries, fruit, vegetables, and mushrooms. Some non-sugar sweeteners are polyols, also known as "sugar alcohols". These are, in general, less sweet than sucrose but have similar bulk properties and can be used in a wide range of food products. Sometimes the sweetness profile is 'fine-tuned' by mixing with high-intensity sweeteners. As with all food products, the development of a formulation to replace sucrose is a complex proprietary process. Market Survey Type II diabetes has emerged as a leading cause of death and disability worldwide. In 2010, an estimated 285 million people were living with diabetes. The number of people with diabetes in developing nations is expected to rise 69% by the year 2030 â€“

outpacing even the â€˜pessimistic scenarioâ€™ forecasts of earlier global disease models. In 2007 around 23.6 million Indians, had diabetes. Another 57 million Indians have what is called pre-diabetes, in which individuals have higher than normal blood glucose levels, but not enough to be classified having diabetes. Many of these individuals will be diagnosed with diabetes in the future and also have a higher risk of developing heart disease and having a stroke. The market opportunities for bulk, intermediate, and consumer diabetic foods are significant. The overall size of the diabetic packaged food market reached US$ 282.9 in 2009. Packaged foods that are labeled as "suitable for diabetics," lowâ€“glycemic (i.e. foods containing carbohydrates that do not cause a large rise in blood glucose), or low in sugar, are particularly good growth markets. As the number of consumers with diabetes rises, naturally healthy foods, in both packaged and non-packaged formats, will also benefit from diabetic trends. Less processed foods that may not include labels or product claims, such as fruits and vegetables, lean meat; low-fat dairy products and whole grains are often recommended by doctors for individuals with diabetes, as well as the general public. However, producers of these naturally healthy foods may even benefit from labelling claims promoting their natural health benefits, as added incentives for people with diabetes to purchase them. Sometimes the simple words "suitable for diabetics" on product packaging (along with nutritional values and ingredient information to back up the claim), provide consumers with added confidence that they are choosing the right product for them. In the global market today, there is a clutter of diabetic snack bars such as those with uncooked cornstarch to prevent hypoglycemia (low blood glucose level) or with resistant starches to reduce hyperglycemia (high blood glucose level). These bars also contain fiber and sugar alcohols. There are also 'diabetic', 'low carb', 'diet', or 'light' drinks, green teas, jams, spreads, cakes, pies, and desserts, adding to the crowd of options available. As far as sweeteners go, the wave of Aspartame-related consumer complaints has dented the credibility of artificial sweeteners and strengthened the case for naturally occurring sweeteners such as tagatose. The FAO/WHO's Joint Expert Committee on Food Additives (JECFA) recently recommended tagatose, a new, naturally occurring, low-calorie sweetener, for use as a food additive. This sweetener, developed by the biotechnology firm, Spherix, has been declared Generally Recognized as Safe (GRAS) in the United States. Among the ingredients that are gaining prominence in the diabetic's diet are fenugreek seeds (rich in carbohydrates and soluble fiber), ginseng (one of the most widely used herbs worldwide), and insoluble dietary wheat fiber. Antioxidants, such as lycopene from tomatoes and tocotrienols, and tocopherols from oil seeds and cereal, are known to help prevent diabetes. In the weight-loss product market, widely used insulin aids include chromium picolinate (chromate), chromium polynicotinate, conjugated linoleic acid, and hydroxycitric acid.

A list of healthier foods for people with diabetes, and foods to limit or avoid

Foods to eat

Foods to limit or avoid

Understanding food packaging

Sample grocery list

Impact of diet

Foods for other conditions

Summary

A nutritious, balanced diet is helpful for managing prediabetes or type 2 diabetes. Meals and snacks should draw on a range of foods from all groups, including fruits, vegetables, whole grains, pulses, and dairy.

Eating a balanced diet can have a considerable impact on managing type 2 diabetes or preventing prediabetes from becoming type 2 diabetes.

Being mindful of carbohydrate intake, eating smaller meals regularly, and choosing healthier, nutrient-dense options can help a person reduce the risks health experts associate with diabetes.

Making a grocery list of healthier foods is one strategy that can help people with diabetes stay on track.

This article will provide a list of healthier foods for individuals with diabetes or prediabetes. It will also discuss which foods a person should limit or avoid.

Get the latest diabetes updates in a weekly newsletter. Whether it's for you or a loved one, we gather research on risk factors, nutrition, treatment, and more.

Good foods for diabetes

Choosing satisfying, nutrient-dense foods that meet individual nutrition requirements can help people living with type 2 diabetes manage their condition.

The American Diabetes Association advises people to always read the nutrition facts label of a product. This is the best way to know how many grams of carbohydrates and how many calories are in the food.

Vegetables

Vegetables form the basis of a nutritious diet. They are excellent sources of vitamins, minerals, and fiber.

Fiber and complex carbohydrates, present in many vegetables, can help a person feel full. This, in turn, can deter overeating, which may lead to undesirable weight gain and problems with blood sugar.

Some vegetables to add to the shopping list includeTrusted Source:

broccoli

carrots

greens

peppers

tomatoes

potatoes

corn

green peas

Beans and legumes

Beans, lentils, and other pulses are great sources of dietary fiber and protein.

The high fiber content of foods in the pulse family means that the digestive tract absorbs fewer carbohydrates than it does from low fiber, high carbohydrate foods.

This means that these foods are excellent carbohydrate choices for individuals with diabetes. People can also use them in place of meat or cheese.

Below are some examples of legumes to pick up in canned, frozen, or dried form:

black beans

lentils

white beans

garbanzo beans

kidney beans

pinto beans

Also, pressure- or slow-cooking beans may help improve their digestibility.

Learn more about the health benefits of beans here.

Fruit

Fruit can have a high sugar content, but the sugar in whole fruit does not count toward free sugars. Therefore, people with diabetes should not avoid fruit.

The following fruits make solid additions to the diet of anyone who has type 2 diabetes, thanks to their low glycemic load:

apples

avocado

blackberries

cherries

grapefruit

peaches

pears

plums

strawberries

Learn more about fruit and diabetes here.

Whole grains

Whole grains can be an effective way for people with diabetes to manage their blood glucose levels, since they often have a lower glycemic index.

People should avoid bleached and refined carbohydrates, such as white bread and white pasta, and instead choose some of the following when consuming grains:

100% whole wheat or legume-based pasta

whole grain bread with at least 3 grams of fiber per slice

quinoa

wild rice

100% whole grain or whole wheat flour

cornmeal

oatmeal

millet

amaranth

barley

Whole grains will also leave a person feeling full longer and can have more flavor than highly processed carbohydrates.

Dairy

Dairy products contain essential nutrients, including calcium and protein. Some research suggests that dairy has a positive effect on insulin secretion in some individuals with type 2 diabetes.

Some of the best options to add to one's diet are:

Parmesan, ricotta, or cottage cheese

low fat or skim milk

low fat Greek or plain yogurt

Learn about the best type of milk for diabetes here.

Plant-based proteins include beans and bean products, such as:

black beans

kidney beans

pinto beans

refried beans

hummus

falafel

lentils

peas

edamame

tempeh

tofu

Learn more about plant-based proteins here.

Dressings, dips, spices, and condiments

Plenty of flavorings and dressings can be great for those trying to manage their blood sugar.

The following are some tasty options that people with diabetes can choose from:

vinegar

olive oil

mustard

any spice or herb

any variety of extract

hot sauce

salsa

To make a vinaigrette, whisk together equal amounts of olive oil and balsamic or another vinegar and add salt, pepper, mustard, and herbs to taste.

Remember to account for the carbohydrates a dressing provides.

Barbecue sauces, ketchup, and certain salad dressings may also be high in fat, sugar, or both, so it is necessary to check the nutrition facts label before buying any of these products.

Dessert foods

People with type 2 diabetes can have desserts, but they should be mindful of portion sizes and of how often they consume these foods.

The following are some low calorie or low carbohydrate dessert options that have less of an impact on blood sugar levels than regular desserts:

popsicles with no added sugar

100% fruit popsicles

sugar-free gelatin

pudding or ice cream sweetened with zero-calorie or low calorie sweeteners such as stevia and erythritol

Fruit-based desserts — such as homemade fruit salad without added sugar, or mixed summer fruits — can be a tasty and healthy way to finish a meal.

However, it is advisable to account for the sugar in fruit when counting carbohydrates.

Learn about sweets and desserts for people with diabetes here.

Sugar-free options for diabetes

A person with diabetes will need to manage their sugar intake. However, sugar-free foods may still affect a person's blood glucose.

"Sugar-free" means that a food item does not contain added sugar, but the product itself can contain carbohydrates, which affect blood glucose levels.

Sugar alcohols are one example of this. Manufacturers often use these low-calorie sweeteners in sugar-free chewing gum, candy, ice cream, and fruit spreads. Common sugar alcohols include:

xylitol

erythritol

sorbitol

maltitol

These are types of carbohydrates and can raise blood glucose levels.

A person may wish to opt for sugar substitutes. In most cases, a serving of a sugar substitute will have little impact on blood glucose levels.

Common sugar substitutes include:

saccharin

neotame

aspartame

sucralose

stevia

advantame

Learn more about the best sweeteners for people with diabetes here.

Snacks

For cravings between meals, a person can try:

homemade popcorn, but not ready-made or sweetened varieties

nuts, but not sweetened ones

carrot or celery sticks with hummus

small amounts of fresh fruit paired with a protein or fat, such as an apple with almond butter

Learn more snack ideas for people with diabetes here.

Drinks

Water is healthy for everyone, including individuals with diabetes.

There are other options, but beverages such as milk and juice can contain high levels of carbohydrates and will affect a person's blood sugar. Therefore, it is important to account for these as one would for food.

Here are a few options a person with diabetes may wish to consider:

unsweetened ice or hot tea

unsweetened coffee

low fat or skim milk

unsweetened plant-based milks

sparkling water

Learn why doctors may not recommend diet soda for people with diabetes here.

Foods to limit or avoid

People with type 2 diabetes should limit or avoid the same foods that are less healthy for individuals without the condition. They should also avoid foods that cause considerable blood sugar fluctuations.

A person following a low or very low carbohydrate meal plan should avoid consuming large amounts of:

simple carbohydrates

saturated and trans fats

sugar in the form of candy, ice cream, and cakes

More specifically, people should limit their intake of:

packaged and fast foods, such as baked goods, sweets, chips, and desserts

white bread

white pasta

white rice

fried foods such as french fries

sugary cereals

sugary drinks

processed meats

red meat

It is also advisable to avoid low fat products that have replaced fat with sugar. Fat-free yogurt is a good example.

People living with prediabetes or type 2 diabetes can try swapping some foods for healthier versions. This may include choosing whole grain rice, pasta, or bread or replacing fried potatoes with baked potatoes.

Cooking food at home is usually the best option, as it allows people to avoid the added sugars that are present in many ready-made food items.

Learn more about foods to avoid with diabetes here.

Understanding food packaging

Food packaging can be confusing. Most food items need a nutrition facts label, but many people have difficulty reading it or knowing what to look for.

Here are some helpful tips for a better understanding of packaging labels and messages:

Read the nutrition facts label:

Even if a food claims to be lower in fat or sugar, that does not mean it actually is. It is important to look for and read through the nutrition facts label on the packaging to understand what the food contains.

Look for specific nutrition facts: The information can be confusing for many people. The most important information for individuals with diabetes to look for is the total grams of carbohydrates per serving and how big a serving is.

Count carbohydrates: Dietary fiber is a form of carbohydrate, and it may appear under the listing for total carbohydrates. The body does not digest dietary fiber, so a person can subtract it from the total carbohydrates in the food. This is a more accurate way of counting the carbohydratesTrusted Source.

Read the ingredients list: The list of ingredients runs from the highest total content to the lowest. If sugar is at the top, it is the main ingredient.

Look for hidden sources of sugar: Sugar can have many different names on ingredient lists, including corn syrup, fructose, and dextrose. Being aware of sugar's multiple identities can help a shopper avoid all types of added sugars.

Limit or avoid artificial sweeteners: Older researchTrusted Source suggests that artificial sweeteners may have a negative effect on health and can encourage sweet cravings. However, not all scientistsTrusted Source agree. Popular artificial sweeteners include aspartame, sucralose, neotame, saccharin, and acesulfame potassium.

Sample grocery list

A grocery list will usually vary from week to week, based on a person's needs and wants. However, individuals may consider using the following sample list as a starting point:

apples

tomatoes

whole strawberries

fresh or frozen vegetables or both

corn

cucumber

fresh basil

a bagged salad

onion

red bell pepper

romaine lettuce

yellow or green squash or zucchini

boneless, skinless chicken breasts

wild-caught salmon fillet

unsweetened almond or flax milk

1–2% milk

fresh mozzarella cheese

Parmesan cheese

sweet potatoes

wild rice mix

honey

unsweetened, olive oil-based dressing

low sugar, low sodium barbecue sauce

olive oil

olive oil spray

black pepper

reduced sodium soy sauce

salt

coffee

walnuts, almonds, or other raw nuts

Was this helpful?

Impact of diet on diabetes

Several factors can affect diabetes management. An individual can manage many of these, including:

what they eat, how much of it, and how often

their carbohydrate intake

how frequently they monitor their blood sugar

the amount of physical activity they engage in

the accuracy and consistency of any medication dosing they use

sleep duration and quality

Even small changes in one of these areas can affect blood sugar regulation.

If a person eats mindfully, measures food portions every day, incorporates daily physical activity, gets restful sleep, and takes medication as directed, their blood sugar levels can improve significantly.

With proper blood sugar management comes a lower risk of complications such as heart disease, coronary artery disease, kidney disease, and nerve damage.

It is also important for people to manage what they eat and increase physical activity where appropriate. This can help a person reach or maintain a moderate body weight.

Foods for other conditions

Diabetes can occurTrusted Source with other conditions, such as kidney and cardiovascular disease.

In some cases, the dietary needs for these different conditions change very little. In other cases, a person may need to follow an eating plan much more carefully. Doing this may help address some of their symptoms.

An individual can contact a doctor or dietitian for food guidance.

Below, we list examples of foods to eat or avoid with some coexisting conditions:

Diabetes and hypertension

People with high blood pressure, or hypertension, and diabetes may follow a similar dietary plan to those with only diabetes.

However, individuals with hypertension should also reduce sodium and caffeine intake.

A person with both diabetes and hypertension should:

choose foods with low sodium content

avoid or limit coffee and other caffeinated beverages

avoid or limit foods that are high in saturated and trans fats

Diabetes and celiac disease

People with celiac disease need to avoid products containing wheat, barley, and rye, as their bodies cannot process the gluten that is present in these products.

A person with both celiac disease and type 2 diabetes should check food labels to ensure that the food they buy is free from gluten.

Learn about alternatives to gluten here.

Diabetes and obesity

People with obesity and diabetes should follow the same food rules as people with only diabetes.

For example, it is advisable to:

avoid or limit foods high in carbohydrates and saturated and trans fats

monitor portion sizes, especially in the case of foods that contain carbohydrates, fat, or both

limit salt intake to help avoid complications from high blood pressure

The best option is to follow a nutritious diet consisting primarily of fruit, vegetables, lean proteins, and high fiber carbohydrates.

A dietitian or doctor can help create a food plan that is suited to each individual's needs and lifestyle.

To help you stay on top of diabetes, we'll send you actionable tips on eating wisely, news on research breakthroughs, and more.

Summary

There is no special diet for individuals living with prediabetes or type 2 diabetes. The key is to follow a nutritious, balanced diet. People can try increasing the amounts of vegetables, beans, legumes, fruit, and whole grains they eat. Lean protein is also very important.

Experts advise people who are following a low or very low carbohydrate eating plan to avoid packaged and fast foods, sugary snacks, and white bread, pasta, and rice. Whole grain bread, pasta, and rice are often good alternatives to more processed grain foods.

Some people find it useful to make a shopping list before going to the grocery store. This can help them avoid buying products that are not the best options for their health needs.

FOOD CONCENTRATE- EXIHIBIT- 11

Food Processing, it's By Products, Growth and Demand: Globally

Food processing is basically the transformation of agricultural products into food. Processing food in many forms is included in food processing from grinding grain to make flour to home cooking to complex industrial methods used in making convenience food. Several things include food processing such as basic preparation of food, alteration of food product, and lastly techniques preservation and packaging. A lot of new products have been innovated due to food processing such as concentrated fruit juices, dried coffee, and ready-to-eat foods. India's food processing sector is very wide and covers fruits, vegetables, spices, meat, dairy products, alcoholic beverages, and some other consumer product groups like confectionery, chocolate, and high protein food, etc.

Growth and Employment

The processed food accounts for 10% of India's total exports, growth in the food processing sector is anticipated to open a lot of opportunities for investors having strong connections in the agro-value chain. Globally the food processed industries hold the value of over 2 trillion dollars and comprise over 400,000 businesses. A properly built food processing sector with a higher level of processing helps in lessening wastage, improves value addition, promotes crop diversification, and ensures a better return to the farmers. The food processing sector concluded as much as 8.83 % of the gross value in 2017-2018. The processed food export value during the year 2018-2019 was of the order of US $35.50 billion accounting for 10.70 % of India's total exports.

The food processing market is expected to reach an estimated $4.1 trillion by 2024 with a CAGR of 4.3% from 2019 to 2024. Moreover, between 2018 and 2019, the value of imported processed food was the US $19.32 billion. Overall the number of people engaged in registering the food processing sector was 18.54 Lakhs. The unregistered food processing sector supported employment to 51.11 lakh workers.

Status of Food Processing In India

The future of the food processing market looks quite promising with emerging opportunities in beverage, dairy, the seafood industry, and meat. The main reason for this industry's growth is the high demand for ready-to-eat food products, evolving lifestyles, and more number of nuclear families and working females. India is known as the land of spices that provides different varieties worth over Rs 3500 crores amounting to 25-30% of global production, which is processed for value –addition and export. The food production of India is projected at 500 million tones and the food processing industry has a lot of growth potential. India is one of the largest and developing markets for food products that are growing at about 1.6 % yearly. Globally, the food products industry is anticipated to reach $8,127.2 billion by the year 2023. During the last 5 years ending 2017-2018, food processing in India has been growing on an average growth rate of around 8.41% in comparison to around 3.45% in agriculture at 2011-2012 prices. The food processing sector is also emerging as a vital segment for the Indian economy in terms of its contribution to GDP, employment, and investment. The industry of food processing is one of the important employment intensive segments constituting 12.43% of employment generators in all registered factory sectors in 2016-2017. According to researchers, the processed fruit and vegetable segment will be witnessing the highest growth in the upcoming years due to people getting inspired towards a vegan diet.

What is Concentrate?

1.1 Concentrate concept

What is Concentrate? In the simplest terms, Juice Concentrate is extracted from fresh and pure fruit and vegetable ingredients, then steam separated to reduce weight. Concentrate provides more flexible options in transportation and storage.

To make Juice Concentrate, the whole fruit must be thoroughly washed, scrubbed, and mashed or mixed to create a fruit blend. Much of the water content is then extracted and evaporated. Depending on the nature of each product and to meet the needs of customers.

After processing, the product is stored at the right temperature to increase shelf life. The optimal temperature to store Concentrate is from -5 degrees C to -18 degrees C.

1.2 Uses of Concentrate

What are the uses of Concentrate? Juice products in the concentrated form will have more convenient storage and longer shelf life. As it does not take up as much space as raw juice, you can save on transportation and storage costs.

Concentrate is often used in food and drink that only needs the scent and flavor of the fruit, such as sodas, cocktails, drink mixes, pies, jelly, etc. If the texture and strong scent of the fresh fruit is required, you can combine Puree and Concentrate or add fresh fruit to the dish as many chefs have done creatively.

2. Advantages of Concentrate compared to fresh fruit

Fresh fruit usually has a short shelf life apart from seasonal factors, Juice Concentrate is a great alternative idea, still ensuring to meet the requirements of health and safety, nutrition and natural taste retention, and convenient usage.

Compared to seasonal fresh fruits, Concentrate always ensures an abundant source of supply, uniformity in color and taste, and ready-to-serve. From Concentrate, you can make a variety of beverages such as soda, shaved ice, milk tea, fruit tea, etc.

Unopened products can be stored easily in normal conditions, in a cool place, and away from direct light. Once opened products are kept refrigerated to ensure the best state.

Juice concentrate saves money, time, and labor and reduces waste from removing the skins of fresh fruits.

3. What are the health benefits of Concentrate?

Concentrate or concentrated fruit mixture attracts many users because of its convenience, reasonable price, easy storage, and versatile features. They also provide some of the same health benefits as fresh fruit. Because Concentrate is dehydrated, it provides the body with many times more nutrients than fresh fruit of the same volume.

3.1 Rich in essential nutrients

Juice Concentrate of fruit and vegetables are healthiest if made with 100% fresh fruit or vegetables – with no additives such as added sugar or salt after the concentrate process.

3.2 Retain beneficial nutrients

Concentrate contains beneficial plant compounds such as carotenoids, anthocyanins, and flavonoids. They have been linked to many health benefits, for example, improved heart health and reduced inflammation.

The flavonoids in orange juice help fight obesity-related chronic inflammation. In one study, obese people who drank orange juice after meals for at least seven consecutive days had reduced markers of inflammation.

3.3 May promote skin health

Many juice concentrates are rich in vitamin C and antioxidants, which can promote skin health and slow the effects of skin aging, boosting the immune system.

Concentrated juice can be a reasonable substitute for fresh juice

4. What are some of the popular fresh fruit concentrates?

4.1 Passion fruit

Passion fruit is a nutrient-rich tropical fruit that is easy to process into a drink to help purify the body. Although a passion fruit is small, it contains a lot of vitamins, minerals, and antioxidants beneficial for health. Passion fruit concentrate is a convenient product with many uses in cooking, mixing, baking, ice cream making, and any products with fruit ingredients.

4.2 Mango

Mango is a perfect ingredient for beer, wine, spirits making industry, other product processing industries, or to make a naturally flavored drink.

Mango concentrate has a high nutritional value because it contains large amounts of vitamins A, B, C, and E, protein, carbohydrates, and fiber. Add mango concentrate to any beverage, smoothie, jam, yogurt, dessert mix, milkshake, or mousse for a delicious fresh mango flavor.

4.3 Dragon fruit

Dragon fruit is a tropical fruit famous for its bright red skin, juicy flesh, and sweet taste. Dragon fruit is low in calories but packed with vitamins, minerals, and beneficial plant compounds such as polyphenols, carotenoids, and betacyanins.

Concentrated dragon fruit juice is made from fresh dragon fruit with a sweet and sour taste, packed according to standards to ensure health and safety, and the taste of fresh fruit.

4.4 Tomato

Tomato juice concentrate is not only the main ingredient in the classic Bloody Mary cocktail but is also enjoyed as a delicious and healthy drink.

While many people consider tomatoes a vegetable due to their common culinary uses, it is biologically classified as fruit. However, many companies categorize tomato juice as vegetable juice due to its taste in addition to its low sugar content factor.

HERBAL PLANTATIONS- EXHIBIT- 12

Ministry of Finance has announced Rs.4000 crore package under Atma Nirbhar Bharat for promotion of Herbal Cultivation. The Ministry of Ayush has prepared a draft Scheme for

cultivation and marketing of medicinal plants. Proposal has been submitted for the approval of the Cabinet.

Ministry of Ayush, Government of India had implemented Centrally Sponsored Scheme of National Ayush Mission (NAM)to promote the cultivation of medicinal plants. Under „Medicinal Plants‟ component of the NAM Scheme, market driven cultivation of 140 prioritized medicinal plants in identified clusters/zones was supported and implemented in a mission mode through selected State Implementing agencies throughout the country including Andhra Pradesh. As per the scheme guidelines, the support was provided for:

Cultivation of prioritized medicinal plants on farmer‟s land.

Establishment of nurseries with backward linkages for raising and supply of quality planting material.

Post-harvest management with forwarding linkages.

Primary processing, marketing infrastructure etc.

To encourage the farmers for cultivation of Medicinal Plants, the Ministry of Ayush has provided subsidy @30%, 50% and 75% of cultivation cost of prioritized plant species throughout the country including Andhra Pradesh. The Ministry of Ayush has supported 4349 hectare area within a budget of Rs. 744.60 lakh in Andhra Pradesh under cultivation of Medicinal Plants through National AYUSH Mission (NAM) scheme from the Financial Year 2015-16 to 2020-21.

In addition to this, National Medicinal Plants Board, Ministry of Ayush, Government of India is implementing a scheme entitled "Central Sector Scheme on Conservation, Development and Sustainable Management of Medicinal Plants" wherein the following activities are supported:

Information Education and communication (IEC) activities like Training / Workshops / Seminars/ Conferences etc.

In-situ conservation / Ex-situ conservation.

Livelihood linkages with Joint Forest Management Committees (JFMCs) / Panchayats / Van Panchayats / Biodiversity Management Committees (BMCs) / Self Help Groups (SHGs).

Promotional activities including establishment of nurseries, marketing and trade of medicinal plants produce.

National Medicinal Plants Board, Ministry of Ayush has supported 02 training programmes and 01 nursery project to the Andhra Pradesh State Biodiversity Board. NMPB has also supported 01 awareness programmes for the stakeholders on conservation and sustainable utilization of medicinal plants resources to the Andhra Pradesh Medicinal and Aromatic Plants Board, Andhra Pradesh during the financial year 2015-16 to 2020-21.

National Medicinal Plants Board (NMPB), Ministry of Ayush facilitates to create market linkage for medicinal plants raw materials and not the AYUSH products. NMPB has launched e-CHARAK mobile application as well as a web portal for the promotion and marketing of medicinal plants/herbs. "e-CHARAK" is a platform to enable information exchange between various stakeholders, mainly farmers, involved in the medicinal plants sector across the country. "e-CHARAK" application supports different local languages and it also provides a fortnightly market price of 100 Medicinal Plants from 25 herbal markets across India.

There are several plants, which when coupled with a health life style, can be of preventive and therapeutic use in susceptible and high risk groups of patients. Hepatoprotective medicinal plants have been quite extensively investigated experimentally but clinical trial in hepatitis or liver cirrhosis are not easy to carry out. Every herbal plants have its own specific use for the production of specific drugs from specific herbs. It has large end use in the pharmaceutical industry. India is richly endowed with a wide range of plant species. Many of these plants possess tremendous medicinal values and being used extensively for such purposes. Indias exports of herbal products and essential oils are currently only around Rs.2000 million each year. There are a large number of well-established manufacturers and dealers of herbal products within the country. The large Indian market absorbs most of the production of Indian firms. There is a fair scope for new entrepreneurs in this field.

Sr.No Common name Scientific name Plant type

1 Agnimantha Premna integrifolia Shrub

2 Alexandrian laurel Calophyllum inophyllum Tree

3 Annato Bixa orellana Shrub

4 Arjuna Terminalia arjuna Tree

5 Asparagus Asparagus racemosus Shrub

6 Beal Aegle marmelos Tree

7 Beleric Myrobalan Terminalia bellarica Tree

8 Betlevine Piper betle Climber

9 Black currant Carissa caronda Shrub

10 Bone setter Cissus quandrangularis Climber

11 Bullet wood Mimusops elengi Tree

12 Butterfly pea Clitoria ternatea Climber

13 Champaka Michelia champaka Tree

14 Chebulic

Myrobalan

Terminalia chebula Tree

15 Cinnamon Cinnamomum verum Tree

16 Citron Citrus medica Tree

17 Citronella Cymbopogon winterianus Grass

18 Conessi Tree Holarrhena antidysentrica Tree

19 Coral tree Adinanthera pawonia Tree

20 Curry leaf Murraya koenigii Shrub

21 Cutch Tree Acacia catechu Tree

22 Eucalyptus Eucalyptus glabra Tree

23 Fever nut Caesalpinia bonduc Shrub

24 Five Leaved chaste Vitex Nigundo Shrub

25 Flame of the forest Butea monosperma Tree

26 Giloy Tinospora cordifolia Climber

27 Guggal Commiphora wightii Shrub

28 Henna Lawsonia inermis Shrub

29 Indian Aloe Aloe vera Herb

30 Indian oleander Nerium oleander Shrub

31 Iron wood Mesua ferrea Tree

32 Jamun Syzigium cumini Tree

33 Jasmine Jasminum sambac Shrub

34 Kadamba Neolamarckia cadamba Tree

35 Khirni Manilkara hexandra Tree

36 Lemon grass Cymbopogon flexuosus Grass

37 Lime Citrus X Latifolia Tree

38 Madhunashini Gymnema sylvestre Climber

39 Mahagony Swietenia mahagoni, Tree

40 Mahuva Maduca indica Tree

41 Malabar Nut Adathoda zeylanica Shrub

42 Narkya NathapodytisnimmonianaTree

43 Neem Azadirachta indica Tree

44 Night Jasmine Nyctanthes arbor-tristis Shrub

45 Orange jasmine Murraya paniculata Shrub

46 Pongemia Pongemia pinnata Tree

47 Purging cassia Cassia fistula Tree

48 Putranjeeva Putranjeeva Roxburghii Tree

49 Red Physic Nut Baliospermum montanum Shrub

50 Red Sanders Pterocarpus santalinus Tree

51 Rosary Pea Abrus precatorius Climber

52 Sandal wood Santalum album Tree

53 Sesbania Sesbania grandiflora Tree

54 Shamee Prosopis cineraria Tree

55 Simaruba Simaruba glauca Tree

56 Sita Ashoka Saraka asoka Tree

57 Soap Nut Sapindus Sp Tree

58 Soap Pod Cassia sinuat Herb

59 Star goose berry Phyllanthus acidus Tree

60 Trumpet tree Oroxylum Indicum Tree

61 Vetiver Chrysopogon zizanioides Grass

62 Wax apple Syzygium samarangense Tree

63 White teak Gmelina arborea Tree

64 Wood apple Limonia acidissima Tree

65 Ylang ylang Canaga odorata Tree.

ORGANIC AGRI FARMING / tissue culture/ green house projects EXHIBIT-13

The Organic Farming Industry and its Future: What Lies Ahead for This Sector?

People from all walks of life are more than ready to invest in healthy and chemical free produce that can benefit their overall health in the long run.

Organic farming has been an integral part of agricultural practices across the world for quite a long time now. The sustainable practice of producing and harvesting food stuffs like fruits & vegetables without using any type of chemicals has always garnered both appreciation and interest from many. These days, people from all walks of life are more than ready to invest in healthy and chemical free produce that can benefit their overall health in the long run, and are doing their bit to promote healthy living within the society.

In India, where the agriculture industry is the biggest in terms of human resource and total farming area, organic farming has been the most natural method of growing crops using natural fertilizers and manures like cow dung and organic compost. Following the green revolution and introduction of modern technology during the early 1960s in this sector, the Indian agriculture industry managed to transform for the better. It gradually witnessed a shift from traditional farming methods to introduction of synthetic fertilizers in an effort to safeguard and guarantee the safety of crops from various pests, diseases, and crop destroying insects.

These policies and initiatives ensured faster production of crops and accelerated the development of modern farming methods. Nevertheless, the usage of various chemicals & pesticides during different stages of farming and packaging made such products highly

contaminated by the time it reached end consumers; and posed great danger to their overall well-being.

Challenges Hindering the Growth of Organic Farming in India

However, despite such positive facts, the analysis suggests that many agronomists are unconvinced about sustainability of growth and future of the Indian organic farming industry mostly due to lack of awareness about this sector, and consequent lack of branding and promotion for higher realization.

Furthermore, the study also stated that while the central government has taken some effort to create awareness about organic farming, this space

requires the intervention of the state government as well. More than anything else, they can help in encouraging farmers to focus more on organic farming practices and minimize utilization of chemicals and pesticides.

Organic Farming in India – What do the numbers suggest?

According to a report published earlier in 2016 in a joint study conducted by industry body Assocham, and private research firm TechSci Research, the Organic foods market in India is estimated to be over USD 0.50 Billion. It is further projected to treble in the upcoming years, reaching up to USD 1.36 Billion within the next four years, i.e. by 2020. Overall, the organic foods segment in the country witnessed an estimated 25 per cent to 30 per cent growth, which is quite encouraging.

Why we need to start focusing and creating more awareness around organic farming?

In recent times, it has been observed by many industry insiders that certain farmers have begun to rely on unethical farming practices to increase production of crops. According to 101 India – an online youth-focused news portal, it was recently reported that some vegetable farmers use silicone sprays, colored dyes, and injections to keep the produce "fresh' prior to selling them to customers. In the video report, a farmer is seen demonstrating how he, and many other vegetable vendors use silicone sprays to make unsold vegetables retain freshness by delaying the ageing process.

The eye opening report also revealed how most green vegetables are given their bright green color with the use of Malachite green, an industrial dye. Products were also shown to be injected with the oxytocin hormone to make them grow overnight by accelerating the maturing process. Furthermore, despite being aware of the harmful side-effects of such

products, the farmers revealed that they had to rely on such methods in order to earn enough to feed their families. They also said that most customers tend to avoid buying vegetables which look old, but are actually fresh.

If this does not seem like an imminent danger to one's health, consider this:

Following are some insights of certain market players in the Indian organic farming segment that are based on some troubling current trends in consumer buying activity, and the current market situation within this space:

Current perceptions of most consumers towards Fruits & Vegetables:

99.9 per cent of consumers are not aware about the source of produce, like fruits, vegetables, & greens that they buy and consume.

What's more, most consumers do not make any efforts to know or find out about the source of farm produce.

Low ticket size and high frequency of repetitive purchase are some of the key factors for the aforementioned issue.

Current Market Situation in the Organic Fruits & Vegetables (F&V) category:

Most organic stores in India are similar to retail shops that includes buyers & sellers. Since the organic produce sellers do not grow the produce sold via such stores, even they arenot the most reliable source when it comes to seeking information about organic produce. The main reason for this lies in the fact that such store owners usually do not have control over the consistency in quality, color, texture, and / or finish of the final product.

Additionally, some of these organic stores in India are about the hype, and rarely about the quality of the produce being sold.

Going by such facts, it is evident why creating more awareness about organic farming in India has become a matter of extreme importance these days. However, things have certainly begun to look bright on this front, at least in some states in India.

Sikkim – India's first fully organic state

Following some comprehensive policy implementation and rigorous efforts, the Indian state of Sikkim has been officially named the first fully organic state in the country in 2015. The geographically diverse, yet landlocked regionalso became India's cleanest state following the enactment of certain rules & guidelines, which regulated the use of plastic bottles and Styrofoam goods across the region.

The move to make this state completely organic came following the introduction of the "Sikkim Organic Mission' project back in 2003. This was done in an effort to eliminate usage of harmful chemical fertilizers and pesticides, apart from creating awareness among farmers about the benefits of organic produce

Following this development, some state government officials across India have begun to design and implement various policies that can benefit the organic farming industry in the long run.

For example, the National Centre of Organic Farming under the Ministry ofAgriculture and Farmers Welfare has announced an initiative called the National Project on Organic Farming(NPOF) – a central sector scheme that has been continuing since the10th Five Year Plan. The main objective of this initiative is to promote organic farming across the country via technical capacity building of all the major stakeholders, including human resource development, transfer of technology, and promotion &production of quality organic and biological inputs. Apart from that, this governing body also plays a vital role in creating awareness and publicity for this sector through print and electronic media.

What's more, with India becoming a prominent startup hub, many new players have entered the organic foods market in an attempt to exploit the growing opportunities available within this segment.

Emergence of new players in the Indian organic farming space

Over the past couple of years, it has been observed that the organic farming sector in India is entering a transformation stage due to an increase of new ventures that have begun to disrupt the market with their one-of-a-kind offerings. In an effort to promote a healthier lifestyle, these players are playing a pivotal role by providing consumers with naturally grown wholesome organic produce.

Although these players have cropped in various megacities across the country, the biggest concentration of such startups was found to be situated in the city of Bangalore (Bengaluru). Known as the IT hub of India, Bangalore's multicultural and tech savvy youth population is one of the key reasons why this city has become a fertile breeding ground for several organic farming startups. Driven by an ever increasing urban population, Bangalore is gradually witnessing a rising demand for organically grown food stuff – a trend that shows no signs of slowing down anytime soon.

Future of Organic Farming in India

According to an industry insider, India currently holds a prominent position among 172 countries that actively practice organic agriculture globally. At present, the country is home to more than 6, 50,000 organic producers, 699 processors, 669 exporters, and 7, 20,000 hectares

under cultivation. However, with only a meagre 0.4 per cent of total agricultural land area designated for organic cultivation, it is evident that this industry still has a long way to go in terms of growth.

Moreover, since the organic food segment is still at a nascent stage in India, both the government and other private players will have to develop a strong policy framework that can benefit all involved. For now, it can be safely concluded that the organic farming industry in India holds immense potential to grow, provided it receives steady investment, and benefits from both existing and new initiatives, which can further its growth.

Introduction

Precision farming is generally defined as information and technology based farm management system to identify, analyse and manage variability within fields for optimum profitability, sustainability and protection of the land resource. Precision farming is concerned more with managing small areas within fields rather than on the fields itself and presumes that the farmer who effectively uses information earns higher returns than those who do not. However in the Indian Context with its severeland fragmentation precision farming has to do more with the precise application ofagricultural inputs based on soil, weather and crop requirement to maximise sustainable productivity, quality and profitability.

Hi tech Agriculture is one method of precision farming on a smaller scale where plant protection and fertigation are applied at the root zone and plants are grown in precise conditions of temperature and humidity for uniformity and maximisation of yield. There are two approaches viz., Greenhouse / poly house system and open air system.

Greenhouse technology

Growing of crops in green houses has proved to be the best way of utilizing the crops potential. Computerized control of irrigation, fertilization (Fertigation) and microclimate in green house enable precise monitoring of the most important production practices. In temperate regions where the climatic conditions are extremely adverse and no crops can be grown high value crops can be grown continuously by providing protection from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases through Greenhouse Technology.

Advantages of greenhouses:

1. The yield may be 10-12 times higher than that of outdoor cultivation dependingupon the type of greenhouse, type of crop, environmental control facilities.

2. The technology is ideally suited for vegetables and flower crops where uniformity in yield is very important.
3. Year round production of floricultural crops and Off-season production of vegetable and fruit crops is possible.
4. Disease-free and genetically superior transplants can be produced continuously.
5. Efficient utilisation of chemicals, pesticides to control pest and diseases and efficient use of Water.
6. Production of quality produce free of blemishes.
7. Most useful in monitoring and controlling the instability ofvarious ecological system.

Greenhouses – World Scenario

There are more than 50 countries now in the world where cultivation of crops is undertaken on a commercial scale under cover. The major countries are the USA, Spain, Canada and The Netherlands. In Asia, China and Japan are the largest users of greenhouses. The United States of America
has a total area of about 4000 ha under g
around 25,000 ha and Italy 18,500 ha. The
grown flowers and vegetables all over the world. With about 89,600 ha undercover, the Dutch greenhouse industry is probably the most advancedin the world. The development of greenhouse technology in China has been faster than in any other country in the world. With a modest beginning in late seventies, the area under greenhouses in China has increased to48,000 in recent years. Japan also has more than 40,000 ha under greenhouse cultivation of which nearly 7500 ha isdevoted to only fruit orchards.

for green house technology. The National Committee on the use of Plastics in Agriculture(NCPA-1982) has recommended location specific trials of greenhouse technology for adoption in various regions of the country.

The commercial utilization of greenhouses started from 1988onwards and now withthe introduction of Government’s liberalization policies and developmental initiatives, several corporate houses have entered to set up 100% export oriented units. In just four years, since implementation of the new policies in 1991, 103 projects withforeign investment of more than

`.80 crores have been approved to be set up in the country at an estimated cost of more than `.1000 crores around Pune, Bangalore, Hyderabad and Delhi. Thus the area under climatically controlled greenhouses of these projects is estimated to be around 300ha. Out of which many have already commenced exports and have received very encouraging results in terms of the acceptance of the quality in major markets abroad and the price obtained.

Classification of greenhouses:

Greenhouse structure of various types are used for crop production. The different types of greenhouses based on shape, utility, material and construction are briefly given below:

1. Greenhouse type based on shape:

For the purpose of classification, the uniqueness of cross section of the greenhousescan be considered as a factor. The commonly followed types of greenhouses based onshape are:

a) Lean to type greenhouse.
b) Even span type greenhouse.
c) Uneven span type greenhouse.
d) Ridge and furrow type.
e) Saw tooth type.
f) Quonset greenhouse.
g) Interlocking ridges and furrow type Quonset greenhouse.
h) Ground to ground greenhouse.

1. Greenhouse type based on Utility

a) Greenhouses for active heating.
b) Greenhouses for active cooling.

2. Greenhouse type based on construction

a) Wooden framed structure.
b) Pipe framed structure.

c) Truss framed structure.

3. Greenhouse type based on covering material

a) Glass glazing.
b) Fibre glass reinforced plastic (FRP) glazing (Plain sheet, corrugated sheet.)
c) Plastic film (UV stabilized LDPE film, Silpaulin type sheet, Net house)
d) Based on the cost of construction (High cost Green House, Medium cost Green House, Low cost Green House)

4. Computerised green houses

In general farmers prefer the manually Controlled System or Semi-Automatic Controlled System because of low investment. However, Manual systems require a lot of attention and care and are very difficult and cumbersome to maintain uniformenvironment inside the Green House. Ultimately this affects crop production and results in non-uniform growth and low quality of the crop.

The Computerized Control System provides a faster and more precise operation in the Green House and also stores, displays and prints the Green House information asneeded. In addition, computer can perform the required operations as per a pre- scheduled programme

Components and Features of a green-house based Hi-tech Agriculture system

Polythene

Polyhouse / Green housesare made of transparent, tight, cheap and flexible polythene. This enables cultivation of vegetables and other crops in any season of the year depending upon their requirement, becausetemperature and humidity can easily be controlled in Polyhouses as they prevent

the thermal radiation from escaping which increases the temperature and energy andthus helps in the process of photosynthesis. It is well established that for the production of energy vegetable, fruits and

flower crop, the polyhouses are constructed with the help of ultraviolet plastic sheets, so that they may last for more than 5 years.

Sheets are usually of 1501-micron thick plastic sheet and draped around bamboo or iron pipes which are more durable but costlier.

Heating Systems

Heating is usually required in winter season. Generally the solar energy is sufficient to maintain inner temperature of polyhouse but when this is insufficient, via media like construction of a tunnel below the earth of polyhouse, covering the northern wallof the house by jute clothing, covering whole of the polyhouse with jute cloth duringnight and installing solar heating systems can be considered.

Cooling systems

In summer season when ambient temperature rises above 40^0C during daytime, the cooling of polyhouse is required. This is done by providing adequate ventilation andremoving the internal air of polyhouse out of it in a natural manner or by installing high power fans which need to be switched on at regular intervals. Installation of cooler on eastern or Western Wall can also be done to keep the temperature low andmaintain proper humidity. Alternatively Water-misting mechanism can be installed.

Shading systems

Certain plants are damaged due to very high light intensity during summer. Shadingreduces light intensity and cools the microclimate inside the greenhouse. Shade paints (lime or Redusol or Vari clear), agro-shade nets or retractable thermal screens are generally used and operated manually or through automatic devices.

Watering systems

Water quality is very important and often overlooked. Total salt-content levels, alkalinity levels, the balance of individual ions such as boron and fluoride can all haveserious bearing on crop success. The water sources should be tested before a greenhouse is established. Electrical conductivity level should be 0.75 – 1.5 dS/m anda pH of 6-7. Automatic watering system through drips or overhead foggers are generally used depending upon the crop.

Fertigation

It varies from single broad casting of fertilizers to use of soluble grade fertilizers overdifferent operating systems. One of the most modern technologies is currently offered by Priva – Phillips Nutriflux or Van Vliet Midi Aqua Flexilene System. Both the systemhave nutrient plant demand of nutrients in relation to EC/pH of the media, temperature, RH, light intensity, crop growth, mineral deficiency, etc.

Photoperiod control

Several plant species flower only when they are exposed to specific light duration. Yield and quality of flower crops could be increased with artificial lighting during night hours. Cyclic lighting is most effective. Short day conditions in greenhouses

Can be created with fully automatic, semi-automatic or manual 'black out' system using good quality black polythene sheets, especially for chrysanthemum.

Control system

A manual or semi-automatic control system is less capital intensive but requires a lotof attention and care. Recently, computerized control systems are available which can integrate temperature, light intensity, relative humidity, CO_2, plant moisture, nutrient requirement, and plant-protection measures.

Equipment's needed

In case of permanent polyhouse structure steel and fibre made glass are galvanised hallow pipe-having glass or transparent polythene sheet structure is needed. For small farmers they can build up the polyhouse they require bamboo structure on which polythene sheet is used for cover purpose. For irrigation facility sprinkler irrigation unit is needed, while for controlling the air temperature ventilators are required.

Roof of Polyhouse

should be made of G.I. pipe.

In case of construction of polyhouse plastic film, nylon, acrylic, vinyl, polycarbonate and polyethylene film can be used for the roof purpose. At present among the available polyfilm, use of film of 200 microns or 800 gauge thickness ultraviolet protective film is considered. The framework of polyhouse

Watering system

Micro irrigation system is the best for watering plants in a greenhouse. Micro sprinklers or drip irrigation equipment can be used. In micro sprinkler system, waterunder high pressure is forced through nozzles arranged on a supporting stand at about 1 feet height. This facilitates watering at the base level of the plants.

Equipment required for drip irrigation system include

i) A pump unit to generate 2.8kg/cm^2 pressure
ii) Water filtration system – sand/silica/screen filters
iii) PVC tubing with dripper or emitters

Drippers of different types are available

i) Labyrinth drippers
ii) Turbo drippers
iii) Pressure compensating drippers – contain silicon membrane which assures uniform flow rate for years
iv) Button drippers- easy and simple to clean. These are good for pots, orchards andare available with side outlet/top outlet or micro tube out let
v) Pot drippers – cones with long tube **Water output in drippers**

a. 16mm dripper at 2.8kg/cm2 pressure gives 2.65 litres/hour (LPH).

b. 15mm dripper at 1 kg/cm2 pressure gives 1 to 4 litres per hour

Filters: Depending upon the type of water, different kinds of filters can be used.

Gravel filter: Used for filtration of water obtained for open canals and reservoirs that are contaminated by organic impurities, algae etc. The filtering is done by beds of basalt or quartz**.**

Hydrocyclone: Used to filter well or river water that carries sand particles.

Disc filters: Used to remove fine particles suspended in water

Screen filters: Stainless steel screen of 120 mesh (0.13mm) size. This is used for secondstage filtration of irrigation water.

Fertigation system

Fertigation systems are automatic mixing and dispensing units which consist of system pumps and a supplying device. The fertilizers are dissolved separately in tanks and are mixed in a given ratio and supplied to the plants through drippers.

Fertilizer Injectors

Fertilizer injectors are of two basic types. Those that inject concentrated fertilizer into water lines on the basis of the venturi principle and those that inject using positive displacement. The most common in use in Kerala is the Venturi Sytem. Basically these injectors work by means of a pressure difference between the irrigation line and the fertilizer stock tank. These injectors are inexpensive and are suitable for small areas. Large amounts of fertilizer application would require huge stock tanks due to its narrow ratio.

General problems of fertigation

Nitrogen tends to accumulate at the peripherous of wetted soil volume. Hence, only roots at the periphery of the wetted zone alone will have enough access to Nitrogen. Nitrogen is lost by leaching and denitrification. **Phosphorous** accumulates near emitter and P fixing capacity decides its efficiency. **Potassium** moves both laterally and downward and does not accumulate near emitter. Its distribution is more uniform than N&P. Excepting boron, all micronutrients accumulates near the emitter ifsupplied by fertigation. Boron is lost by leaching in a sandy soil low in organic matter. But chelated micronutrients of Fe, Zn can move away from the emitter but not faraway from the rooting zone.

Media preparation

The media used in greenhouse generally have physical and chemical properties which are distinct from field soils.

- A desirable medium should be a good balance between physical properties like water holding capacity and porosity.
- The medium should be well drained.
- pH of 5.0 to 7.0 and the soluble salt (EC) level of 0.4 to 1.4 dS/m is optimum for most of the greenhouse crops
- Low pH can be raised by using amendments like lime (calcium carbonate) and dolomite (Ca-Mg carbonate) and basic, fertilizers like calcium nitrate, calcium cyanamide, sodium nitrate and potassium nitrate while high pH can be reduced by amendments like Sulphur, gypsum and Epsom salts, acidic fertilizers like urea, ammonium sulphate, ammonium nitrate, mono ammonium phosphate and aqua ammonia and acids like phosphoric and sulphuric acids.
- It is essential to maintain a temperature of the plug mix between 70 to 75°F. Irrigation through mist is a must in plug growing. Misting for 12 seconds every 12 minutes on cloudy days and 12 seconds every 6 minutes on sunny days is desirable.
- The pH of water and mix should be monitored regularly.

Desirable nutrient level in greenhouse growth media

S. No.	Category	Concentration (mg/l)			
		NO3	**N**	**P**	**K**
1.	Transplants	75	125	10-15	250-300
2.	Young pot & foliage plants	50	90	6-10	150-200
3.	Plants in beds	125	225	10-15	200-300

Pasteurization of greenhouse plant growing media

Greenhouse growing medium may contain harmful disease causing organisms, nematodes, insects and weed seeds, so it should be decontaminated by heat treatment or by treating with volatile chemicals like methyl bromide, chloropicrin etc.

Agent	Method	Recommendation
Heat	Steam	30 min at 180° F
Methyl bromide	10 ml/cu. ft. of medium	Cover with gas proof cover for 24-48 hr. Aerate for 24-28 hr before use.

Chloropicrin	(Tear gas) 3-5 ml/cu. ft. of medium	Cover for 1-3 days with gas proof cover after sprinkling with water. Aerate for 14 days or until no odour is detected before using.
Basamid	8.0 g/cu.ft. of medium	Cover for 7 days with gas proof cover and aerate for atleast a week before use.
Formalin	20 ml/l of water (37%)	Apply 2 l/cu.ft. cover for 14 to 36 hr and aerate for at least 14 days.

Disinfection of the growing media can also be achieved by fungicides or bactericides

Fungicides and their effect on a few fungi

Chemical	Rate of application	Effect against
Captan	2 g/l of water	*Pythium, Fusarium, Rhizoctonia and Phytophthora. Some extent to root and stem rot, white mold,black rot, crown rot and damping off.*
Metalaxyl + Mancozeb (Ridomil MZ 72 WP)	1 g/l of water	*Pythium, Phytophthora, Fusarium* and other soil borne pathogens

Fumigation in greenhouse

Physical propagation facilities such as the propagation room, containers, flats, knives,working surface, benches etc. can be disinfected using one part of formalin in fifty parts of water or one part sodium hypochlorite in nine parts of water. An insecticidesuch as dichlorvos sprayed regularly will take care of the insects present if any. Careshould be taken to disinfect the seed or the planting materials before they are movedinto the greenhouse with a recommended seed treatment chemical for seeds and a fungicide –insecticide combination for cuttings and plugs respectively. Disinfectant solution such as trisodium phosphate or potassium permanganate placed at the entryof the greenhouse would help to get rid of the pathogens from the personnel enteringthe greenhouses.

Environmental control

Temperature control

A thermostat can be coupled to water circulating pump or exhaust fan for controllingthe temperature inside the greenhouse.

Relative humidity control

A humidistat coupled to water circulating pump or exhaust fan is used to control therelative humidity inside the fan and pad greenhouse. The maximum achievablerelative humidity is 90% only in fan regulated (FR) greenhouse. The RH in Non ventilated (NV) GH can be increased by providing foggers.

Light intensity control

In certain areas where natural illumination is absent or very low, illumination for plants may be provided by artificial sources. Incandescent bulbs generate excessive heat and are unsatisfactory in most instances. Fluorescent tubes are useful as the sole source of light for African violets, gloxinias and many foliage plants which grow satisfactorily at low light intensities.

Problem Management in Greenhouses

The troubles which arise in the culture of crops in the greenhouse may be divided into several groups a) failure to supply the essential factors for optimum growthsuch as light, moisture, carbon dioxide and heat in amounts necessary for eachindividual crop b) fertilizer deficiencies c) fertilizer excesses d) toxic gases e) attacks by insects, animals, and allied pests and f) susceptibility to fungus, bacteria and virus troubles.

A. Fertilizer deficiencies: Symptoms of deficiencies of various fertilizers have beenstudied over a period of years with plants in greenhouses.

i. Chlorosis - This is a term used to denote the loss of normal green colour from the foliage whether it is on the older, more mature leaves or the younger foliage. Theentire leaf may be affected or just areas between the veins, in which case the yellowingis most usually in irregular patches shading into the green colour. Sometimes only the margin of the leaf or leaflets may be yellow, while the centre of the foliage is almost a normal green.

ii. Necrosis - This refers to the death of the area severely affected by chlorosis. Necrotic spots or areas can also be caused by spray or aerosol damage, sunscald and other such factors which may have no relation of fertilizer.

iii. Nitrogen deficiency - Generally the entire plant becomes lighter green, but the effect will be most noticeable on the older foliage. Gradually the oldest leaves loose their green colour, and most plants become yellow. The flowers are smaller and maylack well-developed colour.

iv. Phosphorus deficiency - A purplish coloration developing first on the undersideof the petiole, or leaf stem, which spreads to the main veins of the leaf is characteristicof this deficiency.

v. Calcium deficiency - In sand culture, a typical symptom is the development of short clubby roots followed in a matter of several weeks by their death. In many cases insufficient calcium is associated with a low pH of the soil.

vi. Iron deficiency - This is a rather common trouble although an actual lack of iron may not be the primary cause. As iron deficiency becomes more intense, necrotic areas appear on scattered portions of the yellow coloured leaves and the affected foliage may drop. Iron can become deficient in soil, but often the symptoms of this deficiency are induced by other causes from injury to the roots by over-watering or over fertilization. Nematodes or other soil pests interfering with root growth can also induce iron chlorosis symptoms.

- green **Boron deficiency** - The number of cases where this is a limiting factor are few, and most of them are with certain rose andcarnation varieties. The new foliage is thick or leathery and quickly becomes chlorotic. The rose flowers are usually very malformed.The stem tip dies, giving rise to growth of shoots immediately below, which in turn die at the tip, and a 'witches broom' effect is observed. Because deficiency symptomscan sometimes be confused with the effects of some other environmental factor of cultural practice, a thorough review of fertilizer application, soil testing, soil type, watering practices, and other procedures is warranted before hasty conclusions are reached.
- Fertilizer excesses - An unfortunate belief among many growers is that when aplant does not grow under apparently favourable conditions, the trouble can be overcome by applications of fertilizer. This practice has resulted in untold damage orloss of crops, as more often than not the original trouble could have been too much fertilizer in the soil. If additional fertilizer is applied when no more is needed, the results can be very injurious. Sometimes the difference between a high but safe nutrient level and an injurious nutrient level is not very great and the margin of safety may be extremely small. The plants exhibit heavy, rank growth, with large, dark leaves that are often crisp and break easily. Additional nitrogen may inhibit root action, causing typical symptoms of iron chlorosis. If

the root system is killed, the plants wilt excessively and never recover. This yellowing of the top foliage is very common in chrysanthemums.

Linkages – Backwards and Forwards

A. **Procurement of Planting Material:** The planting material (seedlings) can be procured from approved centres managed by the Department of Agriculture or fromthe different campuses of the Agricultural Universities and KVKs and also from approved private nurseries.

B. **Transport: Normally, vegetables and flowers immediately after harvest is graded, packed, and sent to market. Thus, as such there is no need of precooling or refrigerated van to transport the produce.**

C. **Marketing: Vegetables so cultivated have good and robust demand in the major cities of Kerala. However, for effective price realisation branding may be necessary at a local scale and dedicated marketing channels can be thought of.**

Financing Aspects

a. Subsidy: The State Horticulture Mission, Government provides subsidies upto50% of the cost subject to a maximum of `. 325/$m^2$ for hi-tech and `. 125/m^2 for normal poly houses, limited to 1000 m^2/beneficiary. 50% of cost subject toa maximum of `. 3500 per 500 m^2 limited to 2 ha per beneficiary will be given as subsidy for shade nets also. The back ended subsidy will be provided to financing bank in respect to the beneficiaries immediately after the release of first instalment of loan. The subsidy admissible to the borrower under the scheme will be kept in the Subsidy Reserve Fund A/c – borrower-wise in the books of the financing banks.

Subsidy is also available for mulching at 50% of the total cost subject to a maximum of `. 7000/ha limited to 2 ha per beneficiary and for Plastic Tunnel upto 50% of cost subject to a maximum of `.5000/1000 Sq.m limited to 5 ha per beneficiary.

The national Mission on Micro irrigation offers a subsidy of 60% of system cost for small and medium farmers in the State.

Refinance to Banks: The 90% of the amount financed to the borrower under the scheme by banks will be eligible for the refinance from NABARD.

b. Bank Finance

i. Term Loan: The banks may finance 85-90% of the project cost as term loan. Theeligible amount of subsidy would also be allowed as term loan.
ii. Margin Money: The entrepreneurs should normally meet 10-15% of the project cost out of their own resources.
iii. Interest Rate: Interest rate will be decided by financing banks from time to time. However, the repayment programme has been worked out at 14% rate of interest.
iv. Security: Banks may obtain security as per RBI norms.
v. Repayment: The principal and interest will be repayable in ten years, with moratorium of 01 year.

Income and Capital return under Greenhouse Cultivation

The yield under poly house cultivation can be achieved to the level of 5-8 times ascompared to the open crop cultivation. Various trialsconducted at agro research centres in northern India indicates that capsicum (planted in mid-September), cucumber (planting –midOctober) and tomato (November planting) under
poly house produced 1060kg, 1460 kg and 1530 kg per 100 square meter. The duration of these crops were 4- 9 months and more than 90% of total yield were obtained during off-season (during winter before the start of summer) which fetches significantly higher market price (2-4 times than normal season). Further, the crop duration can be extended up to the July–August with the application of micro irrigation and fertigation and yield can be achieved to the level of 20-25 kg/m2. Therefore, it is possible to harvest a single crop round year with minimum additional inputs and higher income can be generated. Further Cut Flowers like Carnations, Gerbera, Lilly,Rose, orchids, antheriumetc. can be grown under polyhouses/ net houses giving highreturns and top quality produce. The potential of floriculture under protected cultivation

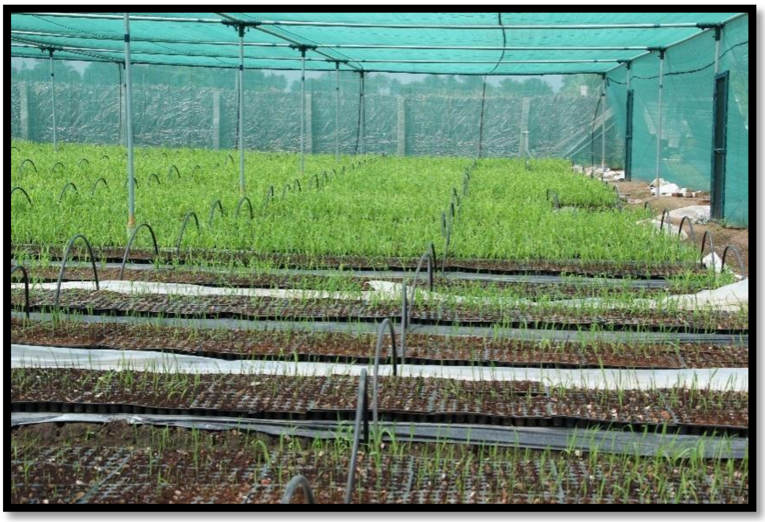
is huge for Indian and global markets.

The cost of construction of poly house depends on location of site, size and shape ofpoly house, poly house structure (wooden or GI/ Steel) and types of poly house (naturally ventilated or environmental controlled). The cost of bigger naturally ventilated poly house (1000 m^2) ranges from `.900 to 1150 per square meter whereas the environmental controlled poly houses require 2 to 3 times investments over previous one depending on the automation gadgets installed. The per unit area construction cost of smaller size poly houses are more as compared to larger poly house. Similarly the cost of cultivation in larger poly house is significantly lower thansmaller poly house.

It is possible to get back the investment on poly house within a period of 3 to 5 years period. If a entrepreneurs /cultivator go for poly house for nursery productionof high yielding vegetable plants in an area where large scale vegetable cultivation is done, in such condition he can get back his investment within 2-3 years by providing quality planting materials to vegetable or flower growers.

The success of the Polyhouse / net house Project depends upon the scale of project. Minimum recommended project with right economic viability and long-term sustainability is around 1 -2 acres.

Economic size



1. Generally the length of the polyhouse is 25-30 feet and width 4-5 feet.
2. The direction of poly house is always East to West, so that the maximum sunshine is available.
3. The house should not beconstructed in shade.
4. The size of polyhouse may differ depending on the necessity.
5. The poly houses are kept cold or hot depending upon the season.

Green House Farming Detailed Project Report Contain all aspects of Green House Farming Projects Project is According to the Current year . Including the Cost of Projects, Market Demand, Project Profitability and Feasibility.

Green Houses are frames of inflated structure covered with a transparent material in which crops are grown under controlled environment conditions. Greenhouse cultivation as well as other modes of controlled environment cultivation have been evolved to create favorable micro-climates, which favours the crop production could be possible all through the year or part of the year as required. Greenhouses and other technologies for controlled environment plant production are associated with the off-season production of ornamentals and foods of high value in cold climate areas where outdoor production is not possible. The primary environmental parameter traditionally controlled is temperature, usually providing heat to overcome extreme cold conditions. However, environmental control can also include cooling to mitigate excessive temperatures, light control either shading or adding supplemental light, carbon dioxide levels, relative humidity, water, plant nutrients and pest control.

With the recent revolution in modern agricultural cultivation the use of Green House Farming increase tremendously in the near future. So, there will be wide scope for new entrepreneurs to venture into this project.

Detailed Project Report contains

Introduction

Properties

Uses & Applications Green House Farming.

Present Indian Market Position

Future Demand

Green House Cultivation Technique.

Future of Green House Farming Business.

Names and Addresses of Existing Units

Green House Structure.

List of Machineries

Miscellaneous Items and Accessories

Electrification

Seed, Fertilizer, Electricity and Water

Maintenance

Suppliers/Manufacturers of Green House.

List of Raw Materials

Availability of Raw Materials

Cost/Rates of Raw Materials

Requirement of Staff & Labour

Personnel Management

Skilled & Unskilled Labour

Requirement of Land Area

Rates of the Land

Built up Area,

Cost of Raw Materials

Cost of Land Buildup Area.

Cost of Machineries

Fixed Capital Investment

Working Capital

Project Cost

Capital Formation

Cost of Production

Profitability Analysis

Break Even Point,

Cash Flow Statement for 5 Years

Depreciation Chart

Projected Balance Sheet

Land Man Ratio etc.

Project Reports cover all the aspects of business, from analysing the market, confirming availability of various necessities such as plant & machinery, raw materials to forecasting the financial requirements. The scope of the report includes assessing market potential, negotiating with collaborators, investment decision making, corporate diversification planning etc. in a very planned manner by formulating detailed manufacturing techniques and forecasting financial aspects by estimating the cost of raw material, formulating the cash flow statement, projecting the balance sheet etc.

Tissue culture

Plant tissue culture was a new addition to the methods of plant breeding that developed around the 1950s. Since the conventional breeding techniques could not fulfil the required demand of crops, tissue culture came around as a grand leap in breeding practices. It makes use of parts of a plant to generate multiple copies of the plant in a very short duration. The technique exploits the property of totipotency of plant cell which means that any cell from any part of the plant can be used to generate a whole new plant.

Types of Plant tissue culture

Seed Culture

Embryo Culture

Callus Culture

Organ Culture

Protoplast Culture

Anther Culture

Procedure of Plant tissue culture

The part(s) of the plant used for culturing is known as explants. The explants are cultured in-vitro on a nutrient medium that caters to fulfil its nutritional requirements. The nutrient medium must provide the following:-

Macronutrients – This includes elements like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S) which is required for proper growth and morphogenesis.

Micronutrients – **Elements like iron (Fe), manganese (Mn), zinc (Zn) etc., which are also crucial to the growth of tissues.**

Carbon or Energy source – **This is one of the most crucial ingredients of the nutrient media. Sucrose is the most widely used carbon source among other carbohydrates that serve to provide C, H, and O.**

Vitamins, amino acids, and other inorganic salts.

Apart from these, the culture media also serves as a medium for supplying phytohormones or plant growth regulators to the issues which bring about their morphogenesis as per requirement. The tissues of the explants first lose their specificity to form a hard brown lump known as callus. The callus then splits to develop a plant organ or a whole new plant depending upon the quantity and composition of phytohormones supplied. The entire process requires strict aseptic conditions to be maintained at all times as a single contamination can ruin an entire batch of plants.

Uses of Plant tissue culture

Tissue culture is used to develop thousands of genetically identical plants from one single parent plant known as somaclones, and this process is known as micropropagation. The method offers an advantage over other methods as it can be used to develop disease free plants from disease-rode plants by using their meristems (apical and axillary) as explants.

Since this method produces new plantlets by the score of thousands, it has been used extensively for the production of commercially important plants including food plants like tomato, banana, apple etc. The most notable example of the application of micropropagation was observed in the farming of orchids as it rose exponentially due to the availability of millions of plantlets due to tissue culture methods.

Tissue culture is the in vitro aseptic culture of cells, tissues, organs or whole plant under controlled nutritional and environmental conditions often to produce the clones of plants. The resultant clones are true-to type of the selected genotype. The controlled conditions provide the culture an environment conducive for their growth and multiplication. These conditions include proper supply of nutrients, pH medium, adequate temperature and proper gaseous and liquid environment.

Plant tissue culture technology is being widely used for large scale plant multiplication. Apart from their use as a tool of research, plant tissue culture techniques have in recent years, become of major industrial importance in the area of plant propagation, disease elimination, plant improvement and production of secondary metabolites.Small pieces of tissue (named explants) can be used to produce hundreds and thousands of plants in a continuous process. A single explant can be multiplied into several thousand plants in relatively short time period and space under controlled conditions, irrespective of the season and weather on a year round basis . Endangered, threatened and rare species have successfully been grown and conserved by micropropagation because of high coefficient of multiplication and small demands on number of initial plants and space.

In addition, plant tissue culture is considered to be the most efficient technology for crop improvement by the production of somaclonal and gametoclonal variants. The micropropagation technology has a vast potential to produce plants of superior quality, isolation of useful variants in well-adapted high yielding genotypes with better disease resistance and stress tolerance capacities . Certain type of callus cultures give rise to clones that have inheritable characteristics different from those of parent plants due to the possibility of occurrence of somaclonal variability , which leads to the development of commercially important improved varieties. Commercial production of plants through micropropagation techniques has several advantages over the traditional methods of propagation through seed, cutting, grafting and air-layering etc. It is rapid propagation processes that can lead to the production of plants virus free . Coryodalisyanhusuo, an important medicinal plant was propagated by somatic embryogenesis from tuber-derived callus to produce disease free tubers. Meristem tip culture of banana plants devoid from banana bunchy top virus (BBTV) and brome mosaic virus (BMV) were produced. Higher yields have been obtained by culturing pathogen free germplasm in vitro. Increase in yield up to 150% of virus-free potatoes was obtained in controlled conditions.

The main objective this is to describe the tissue culture techniques, various developments, present and future trends and its application in various fields.

Basics of plant cell and tissue culture

In plant cell culture, plant tissues and organs are grown in vitro on artificial media, under aseptic and controlled environment. The technique depends mainly on the concept of tot potentiality of plant cells , which refers to the ability of a single cell to express the full genome by cell division. Along with the totipotent potential of plant cell, the capacity of cells to alter their metabolism, growth and development is also equally important and crucial to regenerate the entire plant . Plant tissue culture medium contains all the nutrients required for the normal growth and development of plants. It is mainly composed of macronutrients, micronutrients, vitamins, other organic components, plant growth regulators, carbon source and some gelling agents

in case of solid medium . Murashige and Skoog medium (MS medium) is most extensively used for the vegetative propagation of many plant species in vitro. The pH of the media is also important that affects both the growth of plants and activity of plant growth regulators. It is adjusted to the value between 5.4 - 5.8. Both the solid and liquid medium can be used for culturing. The composition of the medium, particularly the plant hormones and the nitrogen source has profound effects on the response of the initial explant.

Plant growth regulators (PGR's) play an essential role in determining the development pathway of plant cells and tissues in culture medium. The auxins, cytokinin's and gibberellins are most commonly used plant growth regulators. The type and the concentration of hormones used depend mainly on the species of the plant, the tissue or organ cultured and the objective of the experiment . Auxins and cytokinin's are most widely used plant growth regulators in plant tissue culture and their amount determined the type of culture established or regenerated. The high concentration of auxins generally favors root formation, whereas the high concentration of cytokinin's promotes shoot regeneration. A balance of both auxin and cytokinin leads to the development of mass of undifferentiated cells known as callus.

Maximum root induction and proliferation was found in Stevia rubidian, when the medium is supplemented with 0.5 mg/l NAA . Cytokinin's generally promote cell division and induce shoot formation and axillary shoot proliferation. High cytokinin to auxin ratio promotes shoot proliferation while high auxin to cytokinin's ratio results in root formation . Shoot initiation and proliferation was found maximum, when the callus of black pepper was shifted to medium supplemented with BA at the concentration of 0.5 mg/l . Gibberellins are used for enhanced growth and to promote cell elongation. Maximum shoot length was observed in Phalaenopsis orchids when cultured in medium containing 0.5 mg/l GA3 (unpublished).

Tissue culture in agriculture

As an emerging technology, the plant tissue culture has a great impact on both agriculture and industry, through providing plants needed to meet the ever-increasing world demand. It has made significant contributions to the advancement of agricultural sciences in recent times and today they constitute an indispensable tool in modern agriculture .

Biotechnology has been introduced into agricultural practice at a rate without precedent. Tissue culture allows the production and propagation of genetically homogeneous, disease-free plant material . Cell and tissue in vitro culture is a useful tool for the induction of somaclonal variation . Genetic variability induced by tissue culture could be used as a source of variability to obtain new stable genotypes. Interventions of biotechnological approaches for in vitro regeneration, mass micropropagation techniques and gene transfer studies in tree species have been encouraging. In vitro cultures of mature and/or immature zygotic embryos are applied to recover plants obtained from inter-generic crosses that do not produce fertile seeds . Genetic engineering can make possible a number of improved crop varieties with high yield potential and resistance against pests. Genetic transformation technology relies on the technical aspects of plant tissue culture and molecular biology for:

Production of improved crop varieties

Production of disease-free plants (virus)

Genetic transformation

Production of secondary metabolites

Production of varieties tolerant to salinity, drought and heat stresses

Germplasm conservation

In vitro cell and organ culture offers an alternative source for the conservation of endangered genotypes. Germplasm conservation worldwide is increasingly becoming an essential activity due to the high rate of disappearance of plant species and the increased need for safeguarding the floristic patrimony of the countries. Tissue culture protocols can be used for preservation of vegetative tissues when the targets for conservation are clones instead of seeds, to keep the genetic background of a crop and to avoid the loss of the conserved patrimony due to natural disasters, whether biotic or abiotic stress . The plant species which do not produce seeds (sterile plants) or which have 'recalcitrant' seeds that cannot be stored for long period of time can successfully be preserved via in vitro techniques for the maintenance of gene banks.

Cryopreservation plays a vital role in the long-term in vitro conservation of essential biological material and genetic resources. It involves the storage of in vitro cells or tissues in liquid nitrogen that results incryo-injury on the exposure of tissues to physical and chemical stresses. Successful cryopreservation is often ascertained by cell and tissue survival and the ability to re-grow or regenerate into complete plants or form new colonies. It is desirable to assess the genetic integrity of recovered germplasm to determine whether it is 'true-to-type' following cryopreservation. The fidelity of recovered plants can be assessed at phenotypic, histological, cytological, biochemical and molecular levels, although, there are advantages and limitations of the various approaches used to assess genetic stability. Cry bionomics is a new approach to study genetic stability in the cryopreserved plant materials. The embryonic tissues can be cryopreserved for future use or for germplasm conservation.

Embryo culture

Embryo culture is a type of plant tissue culture that is used to grow embryos from seeds and ovules in a nutrient medium. In embryo culture, the plant develops directly from the embryo or indirectly through the formation of callus and then subsequent formation of shoots and roots. The technique has been developed to break seed dormancy, test the vitality of seeds, production of rare species and haploid plants. It is an effective technique that is employed to shorten the breeding cycle of plants by growing excised embryos and results in the reduction of long dormancy period of seeds. Intra-varietal hybrids of an economically important energy plant "Jatropha" have been produced successfully with the specific objective of mass multiplication. Somatic embryogenesis and plant regeneration has been carried out in embryo cultures of Jucara Palm for rapid cloning and improvement of selected individuals. In addition, conservation of endangered species can also be attained by practicing embryo culture technique. Recently a successful protocol has been developed for the in vitro propagation of Khayagr and ifoliola by excising embryos from mature seeds. The plant has a high economic value for timber wood and for medicinal purposes as well. This technique has an important application in forestry by offering a mean of propagation of elite individuals where the selection and improvement of natural population is difficult.

Genetic transformation

Genetic transformation is the most recent aspect of plant cell and tissue culture that provides the mean of transfer of genes with desirable trait into host plants and recovery of transgenic plants . The technique has a great potential of genetic improvement of various crop plants by integrating in plant biotechnology and breeding programmes. It has a promising role for the introduction of agronomically important traits such as increased yield, better quality and enhanced resistance to pests and diseases [64].

Genetic transformation in plants can be achieved by either vector-mediated (indirect gene transfer) or vectorless (direct gene transfer) method [65]. Among vector dependant gene transfer methods, Agrobacterium-mediated genetic transformation is most widely used for the expression of foreign genes in plant cells. Successful introduction of agronomic traits in plants was achieved by using root explants for the genetic transformation [66]. Virus-based vectors offers an alternative way of stable and rapid transient protein expression in plant cells thus providing an efficient mean of recombinant protein production on large scale.

Recently successful transgenic plants of Jatropha were obtained by direct DNA delivery to mature seed-derived shoot apices via particle bombardment method. This

technology has an important impact on the reduction of toxic substances in seeds thus overcoming the obstacle of seed utilization in various industrial sector. Regeneration of disease or viral resistant plants is now achieved by employing genetic transformation technique. Researchers succeeded in developing transgenic plants of potato resistant to potato virus Y (PVY) which is a major threat to potato crop worldwide. In addition, marker free transgenic plants of Petunia hybrida were produced using multi-auto-transformation (MAT) vector system. The plants exhibited high level of resistance to Botrytis cinerea, causal agent of gray mold.

Protoplast fusion

Somatic hybridization is an important tool of plant breeding and crop improvement by the production of interspecific and intergeneric hybrids. The technique involves the fusion of protoplasts of two different genomes followed by the selection of desired somatic hybrid cells and regeneration of hybrid plants. Protoplast fusion provides an efficient mean of gene transfer with desired trait from one species to another and has an increasing impact on crop improvement. Somatic hybrids were produced by fusion of protoplasts from rice and ditch reed using electrofusion treatment for salt tolerance.

In vitro fusion of protoplast opens a way of developing unique hybrid plants by overcoming the barriers of sexual incompatibility. The technique has been applicable in horticultural industry to create new hybrids with increased fruit yield and better resistance to diseases. Successful viable hybrid plants were obtained when protoplasts from citrus were fused with other related citrinae species . The potential of somatic hybridization in important crop plants is best illustrated by the production of intergeneric hybrid plants among the members of Brassicaceae . To resolvethe problem of loss of chromosomes and decreased regeneration capacity, successful protocol has been established for the production of somatic hybrid plants by using two types of wheat protoplast as recipient and protoplast of Haynaldiavillosa as a fusion donor. It is also employed as an important gene source for wheat improvement .

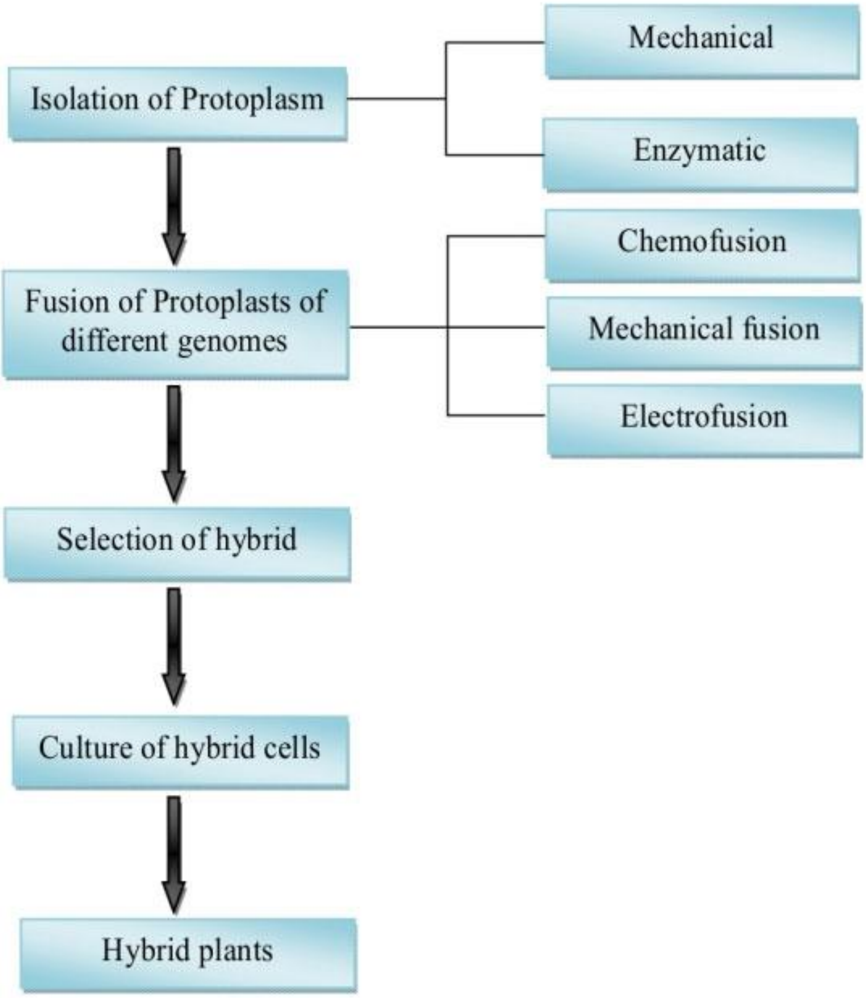


Figure 1.

Schematic representation of production of hybrid plant via protoplast fusion

Haploid production

The tissue culture techniques enable to produce homozygous plants in relatively short time period through the protoplast, anther and microspore cultures instead of conventional breeding.

Haploids are sterile plants having single set of chromosomes which are converted into homozygous diploids by spontaneous or induced chromosome doubling. The doubling of chromosomes restores the fertility of plants resulting in production of double haploids with potential to become pure breeding new cultivars . The term androgenesis refers to the production of haploid plants from young pollen cells without undergoing fertilization. Sudherson et al. reported haploid plant production of sturt's desert pea by using pollen grains as primary explants. The haploidy technology has now become an integral part of plant breeding programs by speeding up the production of inbred lines and overcoming the constraints of seed dormancy and embryo non-viability . The technique has a remarkable use in genetic transformation by the production of haploid plants with induced resistance to various biotic and abiotic stresses. Introduction of genes with desired trait at haploid state followed by chromosome doubling led to the production of double haploids inbred wheat and drought tolerant plantswere attained successfully .

Current and future status of plant tissue culture

The past decades of plant cell biotechnology have evolved as a new era in the field of biotechnology, focusing on the production of a large number of secondary plant products. During the second half of the last century the development of genetic engineering and molecular biology techniques allowed the appearance of improved and new agricultural products which have occupied an increasing demand in the productive systems of several countries worldwide. Nevertheless, these would have been impossible without the development of tissue culture techniques, which provided the tools for the introduction of genetic information into plant cells. Nowadays, one of the most promising methods of producing proteins and other medicinal substances, such as antibodies and vaccines, is the use of transgenic plants. Transgenic plants represent an economical alternative to fermentation-based production systems. Plant-made vaccines or antibodies (plantibodies) are especially striking, as plants are free of human diseases, thus reducing screening costs for viruses and bacterial toxins. The number of farmers who have incorporated transgenic plants into their production systems in 2008 was 13.3 million, in comparison to 11 million in 2007.

Techniques of plant tissue culture

11.1. Micropropagation

Micropropagation starts with the selection of plant tissues (explant) from a healthy, vigorous mother plant. Any part of the plant (leaf, apical meristem, bud and root) can be used as explant. The whole process can be summarized into the following stages as shown in Figure 2.

Stage 0: Preparation of donor plant

Any plant tissue can be introduced in vitro. To enhance the probability of success, the mother plant should be ex vitro cultivated under optimal conditions to minimize contamination in the in vitro culture.

Stage I: Initiation stage

In this stage an explant is surface sterilized and transferred into nutrient medium. Generally, the combined application of bactericide and fungicide products is suggested. The selection of products depends on the type of explant to be introduced. The surface sterilization of explant in chemical solutions is an important step to remove contaminants with minimal damage to plant cells. The most commonly used disinfectants are sodium hypochlorite, calcium hypochlorite, ethanol and mercuric chloride ($HgCl_2$) . The cultures are incubated in growth chamber either under light or dark conditions according to the method of propagation.

Stage II: Multiplication stage

The aim of this phase is to increase the number of propagules . The number of propagules is multiplied by repeated subcultures until the desired (or planned) number of plants is attained.

Stage III: Rooting stage

The rooting stage may occur simultaneously in the same culture media used for multiplication of the explants. However, in some cases it is necessary to change media, including nutritional modification and growth regulator composition to induce rooting and the development of strong root growth.

Stage IV: Acclimatization Stage

At this stage, the in vitro plants are weaned and hardened. Hardening is done gradually from high to low humidity and from low light intensity to high light intensity. The plants are then transferred to an appropriate substrate (sand, peat, compost etc.) and gradually hardened under greenhouse.

Somatic embryogenesis and organogenesis

Somatic embryogenesis: is an in vitro method of plant regeneration widely used as an important biotechnological tool for sustained clonal propagation . It is a process by which somatic cells or tissues develop into differentiated embryos. These somatic embryos can develop into whole plants without undergoing the process of sexual fertilization as done by zygotic embryos. The somatic embryogenesis can be initiated directly from the explants or indirectly by the establishment of mass of unorganized cells named callus.

Plant regeneration via somatic embryogenesis occurs by the induction of embryogenic cultures from zygotic seed, leaf or stem segment and further multiplication of embryos.Mature embryos are then cultured for germination and plantlet development, and finally transferred to soil

Somatic embryogenesis has been reported in many plants including trees and ornamental plants of different families. The phenomenon has been observed in some cactus species . There are various factors that affect the induction and development of somatic embryos in cultured cells. A highly efficient protocol has been reported for somatic embryogenesis on grapevine that showed higher plant regeneration sufficiently when the tissues were cultured in liquid medium. Plant growth regulators play an important role in the regeneration and proliferation of somatic embryos. Highest efficiency of embryonic callus was induced by culturing nodal stem segments of rose hybrids on medium supplemented with various PGR's alone or in combination. This embryonic callus showed high germination rate of somatic embryos when grown on abscisic acid (ABA) alone. Somatic embryogenesis is not only a process of regenerating the plants for mass propagation but also regarded as a valuable tool for genetic manipulation. The process can also be used to develop the plants that are resistant to various kinds of stresses and to introduce the genes by genetic transformation. A successful protocol has been developed for regeneration of cotton cultivars with resistance to Fusarium and Verticillium wilts.

Organogenesis: refers to the production of plant organs i.e. roots, shoots and leaves that may arise directly from the meristem or indirectly from the undifferentiated cell masses (callus). Plant regeneration via organogenesis involves the callus production and differentiation of adventitious meristems into organs by altering the concentration of plant growth hormones in nutrient medium. Skoog and Muller were the first who demonstrated that high ratio of cytokinin to auxin stimulated the formation of shoots in tobacco callus while high auxin to cytokinin ratio induced root regeneration.

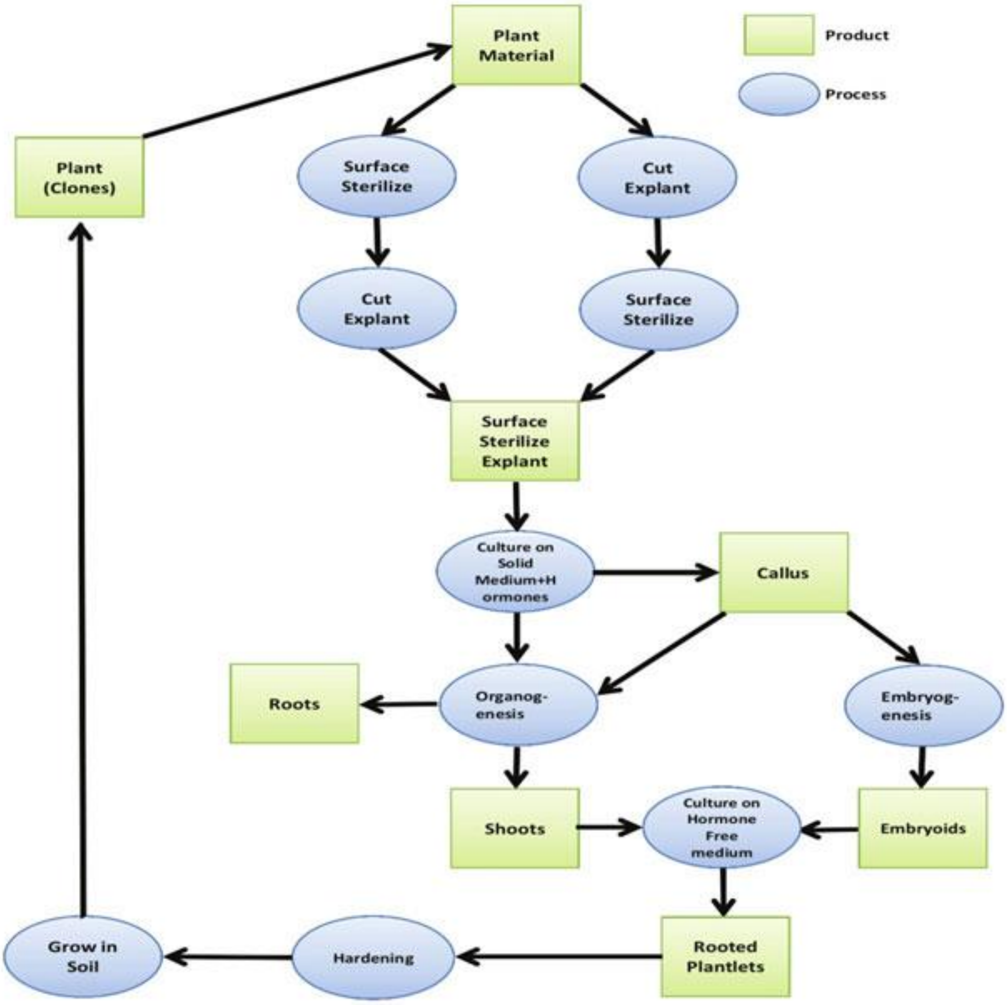


Figure 2.

Flow chart summarizing tissue culture experiments.

Tissue culture in pharmaceuticals

Plant cell and tissue cultures hold great promise for controlled production of myriad of useful secondary metabolites. Plant cell cultures combine the merits of whole-plant systems with those of microbial and animal cell cultures for the production of valuable therapeutic secondary metabolites. In the search for alternatives to production of medicinal compounds from plants, biotechnological approaches, specifically plant

tissue cultures, are found to have potential as a supplement to traditional agriculture in the industrial production of bioactive plant metabolites . Exploration of the biosynthetic capabilities of various cell cultures has been carried out by a group of plant scientists and microbiologists in several countries during the last decade .

Cell suspension culture: Cell suspension culture systems are used now days for large scale culturing of plant cells from which secondary metabolites could be extracted. A suspension culture is developed by transferring the relatively friable portion of the callus into liquid medium and is maintained under suitable conditions of aeration, agitation, light, temperature and other physical parameters. Cell cultures cannot only yield defined standard phytochemicals in large volumes but also eliminate the presence of interfering compounds that occur in the field-grown plants. The advantage of this method is that it can ultimately provide a continuous, reliable source of natural products. The major advantage of the cell cultures includes synthesis of bioactive secondary metabolites, running in controlled environment, independently from climate and soil conditions. A number of different types of bioreactors have been used for mass cultivation of plant cells. The first commercial application of large-scale cultivation of plant cells was carried out in stirred tank reactors of 200 liter and 750 liter capacities to produce shikonin by cell culture of Lithospermumerythrorhizon . Cell of Catharanthusroseus, Dioscoreadeltoidea, Digitalis lanata, Panaxnotoginseng, Taxuswallichiana and Podophyllumhexandrum have been cultured in various bioreactors for the production of secondary plant products.

A number of medicinally important alkaloids, anticancer drugs, recombinant proteins and food additives are produced in various cultures of plant cell and tissues. Advances in the area of cell cultures for the production of medicinal compounds has made possible the production of a wide variety of pharmaceuticals like alkaloids, terpenoids, steroids, saponins, phenolics, flavanoids and amino acids . Some of these are now available commercially in the market for example shikonin and paclitaxel (Taxol). Until now 20 different recombinant proteins have been produced in plant cell culture, including antibodies, enzymes, edible vaccines, growth factors and cytokines . Advances in scale-up approaches and immobilization techniques contribute to a considerable increase in the number of applications of plant cell cultures for the production of compounds with a high added value. Some of the secondary plant products obtained from cell suspension culture of various plants are given in Table 1.

Hairy root cultures

The hairy root system based on inoculation with Agrobacterium rhizogenes has become popular in the last two decades as a method of producing secondary

metabolites synthesized in plant roots . Organized cultures, and especially root cultures, can make a significant contribution in the production of secondary metabolites. Most of the research efforts that use differentiated cultures instead of cell suspension cultures have focused on transformed (hairy) roots. Agrobacterium rhizogenes causes hairy root disease in plants. The neoplastic (cancerous) roots produced by A. rhizogenes infection are characterized by high growth rate, genetic stability and growth in hormone free media. High stability and productivity features allow the exploitation of hairy roots as valuable biotechnological tool for the production of plant secondary metabolites. These genetically transformed root cultures can produce levels of secondary metabolites comparable to that of intact plants. Hairy root technology has been strongly improved by increased knowledge of molecular mechanisms underlying their development. Optimizing the composition of nutrients for hairy root cultures is critical to gain a high production of secondary metabolites . Some of the secondary plant products obtained from hairy root culture of various plants are shown in Table 2.

Tissue culture facilities at Qarshi industries

Plant tissue culture Lab was established in 2004 with the objectives to raise endangered medicinal plant species and the plants difficult to raise through traditional methods for conservation and mass propagation. We have so far propagated 12 medicinal plant species (PlumbagozeylanicaL., NicotianatabacumL., Artemisia absinthiumL., Rosa damascenaMill.,Althea roseaL.,SteviarebaudianaBertoni., JatrophacurcasL., Phalaenopsis,PipernigrumL., SolanumtuberosumL., Araucaria heterophyllaSalisb.

Franco.,TaxuswallichianaZucc.) and currently working on propagation of commercially important endangered woody plant species like Taxuswallichiana. Commercialization of some fruit and vegetable crops are underway. The protocols developed for The Moth Orchid, Tobacco, Honey Plant, Potato and Physic nut are presented as case studies.

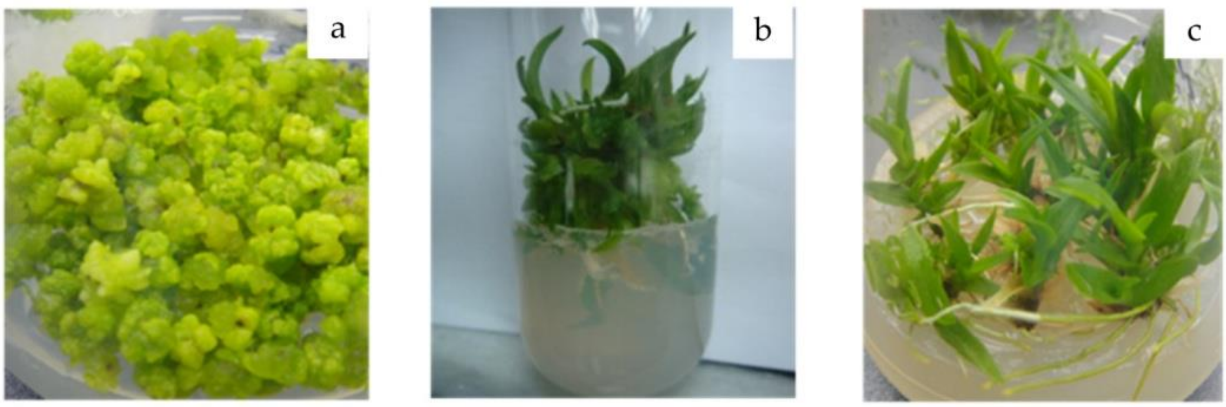
Case study 1

Micropropagation of Phalaenopsis "The Moth Orchids"

Orchids are usually grown for the beauty, exoticism and fragrance of their flowers. They are cultivated since the times of Confucius (ca. 551 - 479 BC). Some orchids are commercialized not for their beauty, but for uses in food industry. They are also used medicinally as a treatment for diarrhea and as an aphrodisiac. The vegetative propagation of phalaenopsis is difficult and time consuming. In addition, the desired characteristics of seedlings and uniformity are not attained.

In vitro propagation studies of phalaenopsis “the moth orchids” had the objective to develop a protocol for plant regeneration from callus. Thus in vitro culture techniques are adopted for quick propagation of commercially important orchid species. Regeneration from callus gives a way to rectify the problem of explants shortage. The callus of phalaenopsis previously obtained from the mature orchid plant was used as explant source. The callus was maintained on MS medium added with 3.0 % sucrose, 0.8 % agar, and different concentrations of BAP and 2, 4-D. Callus was sub-cultured after every 30 days for proliferation. Maximum callus proliferation was obtained when the medium was supplemented with 0.5 mg/l BA. Fresh green and non-friable callus was obtained. For shoot regeneration and elongation, the callus was transferred to MS medium supplemented with BAP and GA3 at different concentrations. Maximum shoot elongation was obtained in medium supplemented with 1.0 mg/l GA3 as shown in Figure 3 a, b, c.

The regenerated shoots showed excess root development when transferred to medium added with 2.0 mg/l IBA. Further research work will focus on different potting medium compositions best suited for acclimatization of regenerated plants. As a high value crop, the mass production of orchids will provide a good opportunity of marketing locally as a good source of income.



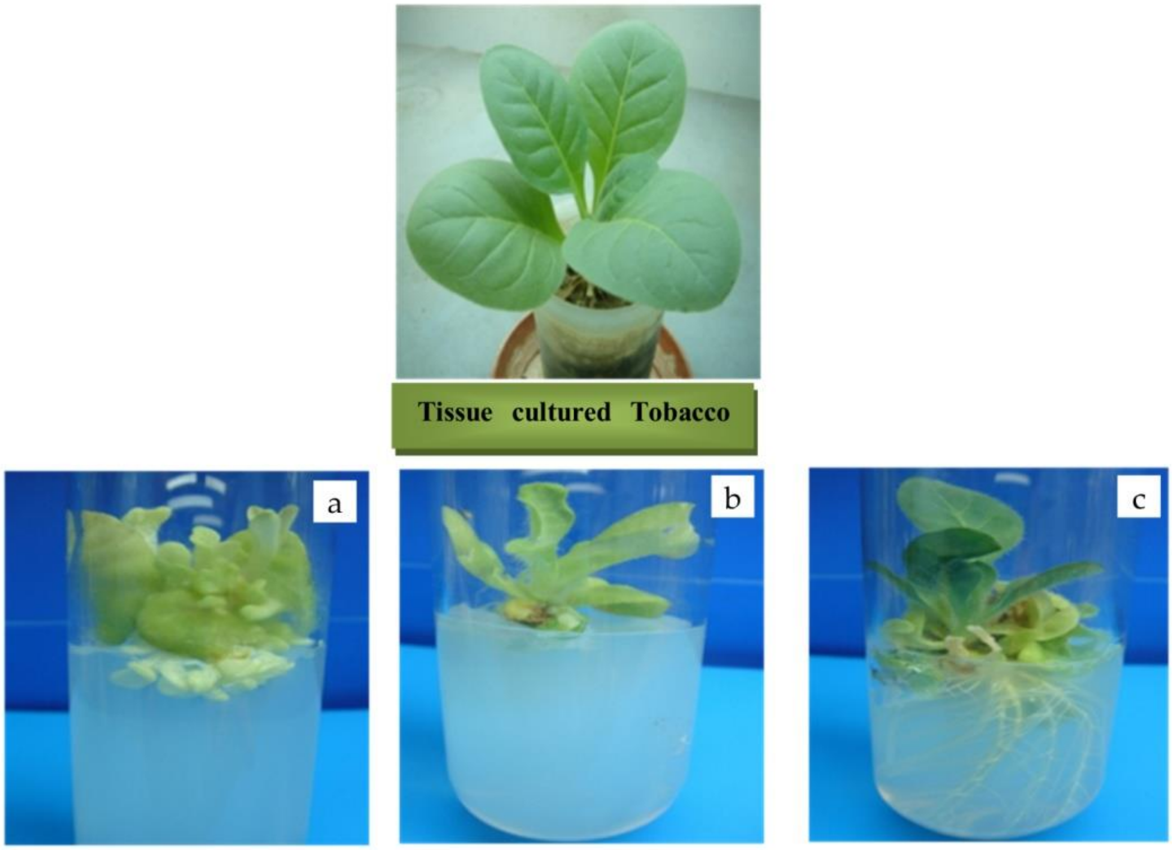
Micropropagation of Orchids (a) callus culture (b) shoot regeneration (c) rooted plantlets

Case study 2

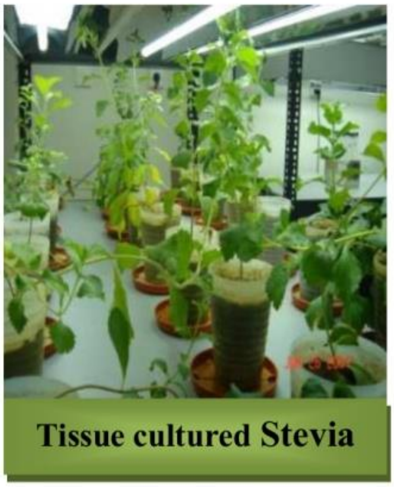
Tissue culture of Tobacco (NicotianatabacumL.)

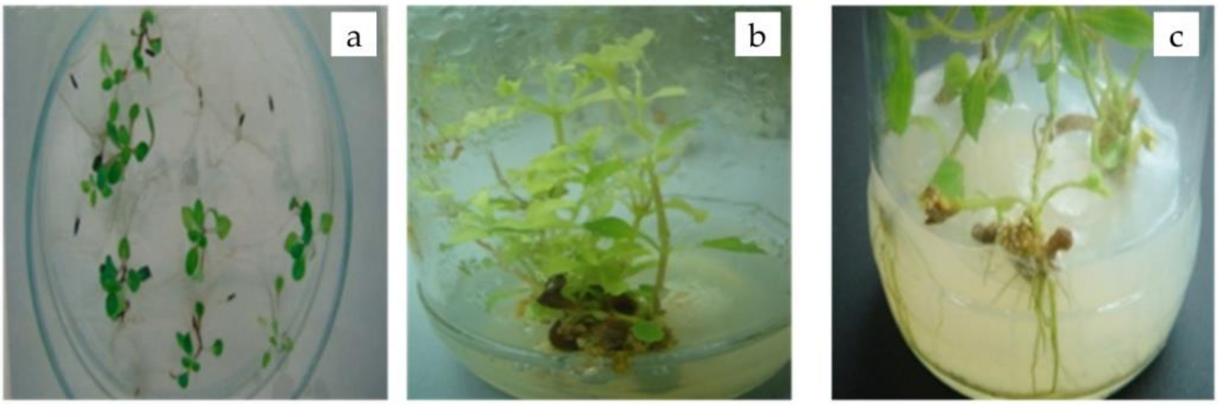
Tobacco is an important crop of Pakistan which covers a large area under cultivation. Being a cash crop grown all over the world, it has a good economic value. Fresh leaves of the plants are processed to obtain an agricultural product that is commercially available in dried, cured and natural forms. Clonal propagation of four important low nicotine content hybrid varieties of tobacco i.e. PGH-01, PGH-02, PGH-04 and PGH-09

was carried out with the special objective of commercialization of tissue cultured plants to the farmers and industry. The mother plants were provided by Pakistan Tobacco Board (PTB). Leaves and meristems were used as explants for the initiation of callus culture. Callus induction and proliferation was carried out on MS medium supplemented with different concentrations of 2,4-D. Excellent growth of callus was obtained at medium containing 1.0 mg/l 2,4-D. Callus was transferred to next medium for shoot regeneration. Efficient numbers of shoots were obtained when culture was shifted to MS medium supplemented with 0.5 mg/l BAP. For root induction different concentrations of IBA and NAA were tested and the result was found best on the same medium supplemented with 2.0 mg/l IBA as shown in Figure 4 a, b, c.



In vitro propagation of Honey Plant (*Stevia rebaudiana*Bertoni) The *in vitro* clonal propagation of *Stevia rebaudiana* was conducted by inoculatingseeds on MS medium [10] and placing under photoperiod of 16 hrs light and 8hrs dark in growth room. The seedlings with four nodes have beendivided into 0.5 cm pieces of nodal segments and used as explants. For shoot multiplication, the nodal explants were inoculated on MS medium supplemented with 3.0% sucrose and 0.5, 1.0, 2.0, 3.0 and 4.0 mg/l of BAP and Kn (Kinetin) alone or in combinations with 0.25 and 0.5 mg/l of IAA. MS medium containing 2.0 mg/l BAP showed the best response to multiple shoot formation,while the highest shoot length (3.73 ± 0.14 cm) per microshoot was observed on MS medium containing 2.0 Kn and 0.25 mg/l IAA after 15 days of inoculation as shown in Figure 5 a, b, c.Excised microshoots were cultured on MS medium supplemented with 0.25, 0.5, 1.0 and 1.5 mg/l of NAA and IBA separately for the root induction. The optimal rooting (81%) was observed on MS medium containing 0.5 mg/l NAA with 2% sucrose within two weeks of culture transfer. The rooted plantlets were acclimatized successfully and transferred to greenhouse under low light intensity. This protocol for ***in vitro*** clonal propagation of ***Stevia rebaudiana*** has been optimized for thelocal environment, as a consequence it will be helpful to establish and cultivate ***Steviarebaudiana*** for commercial scale production in various environmental conditions in Pakistan.**





In vitro propagation of S. rebaudiana (a) seed germination on MS medium (b) shoot multiplication (c) root development.

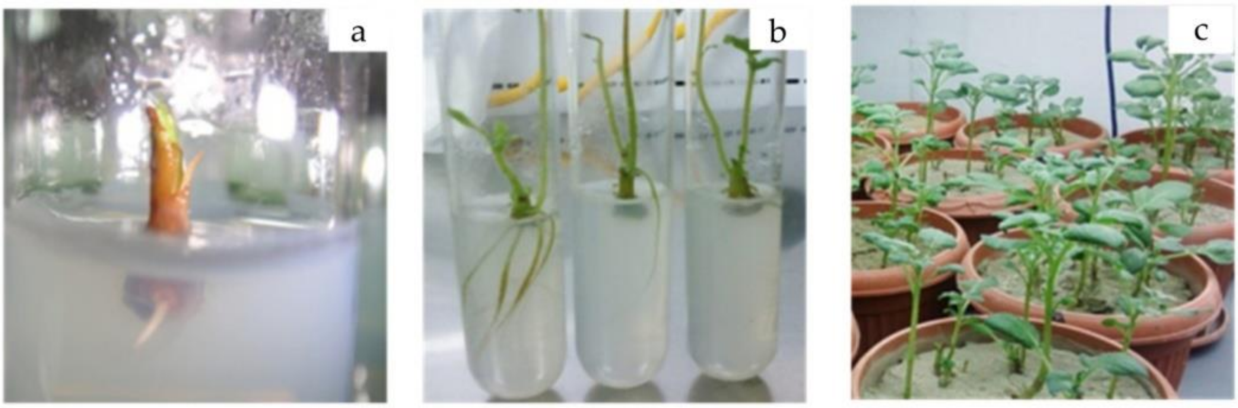
Case study 4

Multiplication and regeneration of Potato (*Solanumtuberosum*L.) from nodal explants

***Solanumtuberosum* L. (potato) is the most important vegetable crop that occupies major area under cultivation in Pakistan. The crop is high yielding, has high nutritive value and gives maximum returns to farmers. Tissue culture is employed as a technique for rapid multiplication of potato plants free from diseases. The research was carried out with the objective of mass multiplication of true-to type**

three potato varieties i.e. Desiree, Diamant and Cardinal. The plant material for this research was provided by Four Brothers Agri Services Pakistan. The Company is working for introduction of high yielding vegetable & crop varieties in Pakistan.

The disease free potato tubers were washed both with detergent and distilled water to remove impurities and allowed to sprouting. Five days old sprouts were used as explants for direct proliferation. The explants were surface sterilized in detergent for 10 minutes, later with 0.1 % mercuric chloride solution for 5 minutes followed by three times washing with sterilized-distilled water. The sprouts were aseptically cut into 10 mm sections containing one node and inoculated in medium. The Espinosa medium plus vitamin B5 supplemented with different concentrations of BAP and GA3 alone and in combinations was utilized. Highest shoot length of shoots was observed in presence of 0.5 mg/l BAP and 0.4 mg/l GA3 with the ability to produce maximum plantlets per explant. For root induction the same medium was used with different concentrations of NAA and IBA. NAA at2.0 mg/l induced the highestroot development. The rooted plantlets were successfully acclimatized and delivered to the company for cultivation.



Tissue culture of Potato (a) nodal segment (b) regenerated shoots and roots (c) tissue culturedpotato

Case study 5

Tissue culture of physic nut (Jatrophacurcas L.)

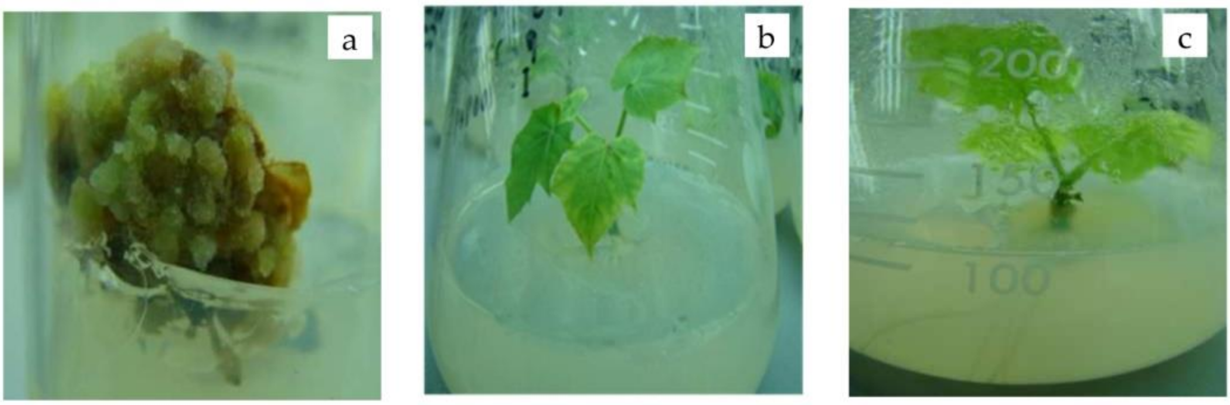
The research studies on Tissue Culture of Jatropha (physic nut) had the objectives to develop protocol for mass propagation of elite trees selected on the bases of higher seed production and oil content.The experimental plant of Jatrophacurcaswas grown in the laboratory under controlled conditions for in vitro studies.

Leaf and apical meristem explants isolated from 7 days old seedling of Jatrophacurcas, were use to induce callus.

Murashige&Skoog (1962) medium supplemented with different growth regulator formulations including 2,4-D and IBA was used. Excellent growth of callus on leaf explants was obtained in medium supplemented with 1.0 mg/L 2, 4-D. Callus produced from leaf explants in all IBA concentrations grew faster during 7 to 30 days of culture and then stabilized at a slow growth rate. While 1.0 mg/L 2,4-D was proved to be most effective in inducing callus on a large scale in short period of time.Callus was soft, friable and white in color.

Apical meristem was used as explant for direct shoot regeneration. Rooting from meristem was effectively achieved on MS supplemented with 1.5, 2.0 and 2.5 mg/l IBA. Root induction with 2.0 mg/l IBA was most effective and the roots also developed secondary roots.

In near future somatic embryogenesis and shoot regeneration from callus will be tested in MS medium supplemented with various concentrations of BA. The regenerated plant will be acclimatized and released for field planting under various climatic and soil conditions for further studies.



Tissue culture of Jatrophacurcas (a) callus of Jatropha (b) shoot regeneration (c) root induction.

Conclusion

Plant tissue culture represents the most promising areas of application at present time and giving an out look into the future. The areas range from micropropagation of ornamental and forest trees, production of pharmaceutically interesting compounds, and plant breeding for improved nutritional value of staple crop plants, including trees to cryopreservation of valuable germplasm. All biotechnological approaches like genetic engineering, haploid induction, or soma clonal variation to improve traits strongly depend on an efficient in-vitro plant regeneration system.

The rapid production of high quality, disease free and uniform planting stock is only possible through micropropagation. New opportunities has been created for producers, farmers and nursery owners for high quality planting materials of fruits, ornamentals, forest tree species and vegetables. Plant production can be carried out throughout the year irrespective of season and weather. However micropropagation technology is expensive as compared to conventional methods of propagation by means of seed, cuttings and grafting etc. Therefore it is essential to adopt measures to reduce cost of production. Low cost production of plants requires cost effective practices and optimal use of equipment to reduce the unit cost of plant production. It can be achieved by improving the process efficiency and better utilization of resources. Bioreactor based plant propagation can increase the speed of multiplication and growth of cultures and reduce space, energy and labor requirements when commencing commercial propagation. However, the use of bioreactors needs special care and handling to avoid contamination of culture which may lead to heavy economic losses. The cost of production may also be reduced by selecting several plants that provide the option for around the year production and allow cost flow and optimal use of equipment and resources. It is also essential to have sufficient mother culture and reduce the number of subcultures to avoid variation and plan the production of plants according to the demand.

Quality control is also very essential to assure high quality plant production and to obtain confidence of the consumers. The selection of explants source, diseases free material, authenticity of variety and elimination of somaclonal variants are some of the most critical parameters for ensuring the quality of the plants.

The in vitro culture has a unique role in sustainable and competitive agriculture and forestry and has been successfully applied in plant breeding for rapid introduction of improved plants.Plant tissue culture has become an integral part of plant breeding. It

can also be used for the production of plants as a source of edible vaccines. There are many useful plant-derived substances which can be produced in tissue cultures.

Since last two decades there have been considerable efforts made in the use of plant cell cultures in bioproduction, bioconversion or biotransformation and biosynthetic studies. The potential commercial production of pharmaceuticals by cell culture techniques depends upon detailed investigations into the biosynthetic sequence. There is great potential of cell culture to be

use in the production of valuable secondary products. Plant tissue culture is a noble approach to obtain these substances in large scale.

Plant cell culture has made great advances. Perhaps the most significant role that plant cell culture has to play in the future will be in its association with transgenic plants. The ability to accelerate the conventional multiplication rate can be of great benefit to many countries where a disease or some climatic disaster wipes out crops. The loss of genetic resources is a common story when germplasm is held in field genebanks. Slow growth in vitro storage and cryopreservation are being proposed as solutions to the problems inherent in field genebanks. If possible, they can be used with field genebanks, thus providing a secure duplicate collection. They are the means by which future generations will be able to have access to genetic resources for simple conventional breeding programmes, or for the more complex genetic transformation work. As such, it has a great role to play in agricultural development and productivity.

Commonly used terms in tissue culture

Adventitious: **development of organs such as buds, leaves, roots, shoots and somatic embryos from shoot and root tissues and callus.**

Agar: **Natural gelling agent made from algae**

Aseptic technique: **procedures used to prevent the introduction of microorganisms such as fungi, bacteria, virusesand phytoplasmas into cell, tissue and organ cultures, and cross contamination of cultures.**

Autoclave: **A machine capable of sterilizing by steam under pressure**

Axenic culture: **a culture without foreign or undesired life forms but may include the deliberate co-culture with different types of cells, tissues or organisms.**

Callus: **an unorganized mass of differentiated plant cells.**

Cell culture: **culture of cells or their maintenance in vitro including the culture of single cells.**

Chemically defined medium: a nutritive solution or substrate for culturing cells in which each component is specified.

Clonal propagation: asexual multiplication of plants from a single individual or explant.

Clones: a group of plants propagated from vegetative parts, which have been derived by repeated propagation from a single individual. Clones are considered to be genetically uniform.

Contamination: infected by unwanted microorganisms in controlled environment

Cryopreservation: ultra-low temperature storage of cells, tissues, embryos and seeds.

Culture: A plant growing in vitro in a sterile environment

Differentiated: cultured cells that maintain all or much of the specialized structure and function typical of the cell type in vivo.

Embryo culture: In vitro culture of isolated mature or immature embryos.

Explant: an excised piece or part of a plant used to initiate a tissue culture.

Ex vitro: Organisms removed from tissue culture and transplanted; generally, plants to soil or potting mixture.

Hormone: Generally, naturally occurring chemicals that strongly affect plant growth

In Vitro: To be grown in glass

In Vivo: To be grown naturally

Laminar Flow Hood: An enclosed work area where the air is cleaned using HEPA filters

Medium: a solid or liquid nutritive solution used for culturing cells

Meristem: a group of undifferentiated cells situated at the tips of shoots, buds and roots, which divide actively and give rise to tissue and organs.

Micropropagation: multiplication of plants from vegetative parts by using tissue culture nutrient medium.

Propagule: a portion of an organism (shoot, leaf, callus, etc.) used for propagation.

Somatic embryos: non-zygotic bipolar embryo-like structures obtained from somatic cells.

Subculture: the aseptic division and transfer of a culture or portion of that culture to a fresh synthetic media.

Tissue culture: in vitro culture of cells, tissues, organs and plants under aseptic conditions on synthetic media.

Totipotency: capacity of plant cells to regenerate whole plants when cultured on appropriate media.

Transgenic: plants that have a piece of foreign DNA

Undifferentiated: cells that have not transformed into specialized tissues.

Abbreviations

BAP 6-benylaminopurine

2,4-D 2,4-dichlorophenoxyacetic acid

EDTA Ethylenediaminetetraacetic acid

EtOH Ethanol

GA3Gibberellic acid

IAA Indole-3-acetic acid

IBA lndole-3-butyric acid

NAA Naphthaleneacetic acid

KN Kinetin

14) SOYA PRODUCTS MANUFACTURING- EXHIBIT 14

List of Soy Products

Soy Milk

Grinding, soaking and straining soybeans creates a mild-tasting liquid known as soy milk. Soy milk is usually a suitable replacement for dairy milk. Vanilla and chocolate soy milk are often sold alongside unflavored soy milk, which are all typically packaged in aseptic containers. A 1-cup serving of soy milk has 104 calories, 6 grams of protein and 3.5 grams of fat, on average. Fortified soy milk is a good source of calcium, iron, vitamin B-12 and vitamin D.

Tofu

Soybean curd -- or tofu -- is created by curdling soy with a coagulant. Tofu, which has minimal flavor, can absorb seasonings and flavorings easily. Firm tofu is dense and useful in stir fries or soups. Soft tofu is mushier and works in place of yogurt in smoothies. A 1/2-cup serving of firm tofu has 88 calories, over 10 grams of protein and 5 grams of fat. Creamy desserts using tofu are common in grocery stores, as are plain blocks of tofu with varying firmness. Most Asian markets carry fresh tofu, which has a smoother texture and flavor.

Soy Sauces

Soy sauce is one of the most common soy products available. This dark brown liquid with a salty taste is made by fermenting soybeans. Shoyu and tamari are common varieties of soy sauce and are typically available in different levels of darkness. A 1-teaspoon serving of tamari has 4 calories and 335 milligrams of sodium. Vegetable, meat and tofu dishes often call for soy sauce, but it is even used in some cookie recipes.

Soybean Oil

According to The United Soybean Board, most margarines, shortenings and salad dressings contain soybean oil. In addition, most of the "vegetable oil" you see in the grocery store is pure soybean oil. The American Heart Association lists soybean oil as a safe fat for maintaining health and longevity. A 1-teaspoon serving of soybean oil has

40 calories, 4.5 grams of fat and less than 1 gram of saturated fat. Soybean oil is mostly flavorless, making it a non-intrusive ingredient in most dishes.

Other Soy Products.

Soybeans are an incredibly versatile ingredient used to make numerous products found around the world. A few examples include whipped

soy topping,

soy cheese,

soy yogurt,

soy nut butter,

soy grits,

soy ice cream,

soy meat alternatives

and soy nuts.

Yuba, which is a thin sheet made from soybeans, is useful for making wraps and soups;

tempeh is a pressed, fermented block of soybeans;

miso is a fermented soybean concoction used in soup;

natto is a sticky, fermented soybean dish.

GLUCOSE PRODUCTION – EXHIBIT- 15

Glucose, also known as dextrose, is a natural sugar that is chemically similar to glucose. If given in adequate doses, dextrose can reduce body protein and nitrogen losses, promote glycogen deposition, and reduce or prevent ketosis. Dextrose is normally metabolized to carbon dioxide and water, so giving someone a dextrose and water solution is a good idea. It is the same as giving away the same amount of free water. Dextrose is easily metabolized and provides calories while also increasing blood glucose levels. If given in adequate doses, dextrose can reduce body protein and nitrogen losses, promote glycogen deposition, and reduce or prevent ketosis.

Since dextrose is normally metabolized to carbon dioxide and water, giving a dextrose and water solution is the same as giving the same amount of free water. Dextrose, a monosaccharide, is rapidly absorbed from the small intestine following oral administration, owing to an active mechanism.

It is used for regulating body fluid and is injected into the human body to stabilize body fluid and restore the human being's fatality as well as the inside body pressure. Electrolyte metabolism and treatment of discarded water, particularly in severe cases. Treatment for acid-base imbalances. In the surgery of an accident victim who has lost blood, volume substitution and replacement are used. Parenteral nutrition for patients who are terminally ill or recovering from surgery. Nasal washes of saline are often used to alleviate some of the effects of the common cold.

Both babies and adults benefit from the solution because it softens and loosens mucus, making it easier to wash out and clear the nasal passages. In this case, "homemade" saline (made by dissolving approximately half a teaspoon of table salt in 8 ounces (approximately 240ml) of clean tap water) may be used. Both babies and adults benefit from the solution because it softens and loosens mucus, making it easier to wash out and clear the nasal passages. In this case, "homemade" saline (made by dissolving approximately half a teaspoon of table salt in 8 ounces (approximately 240ml) of clean tap water) may be used.

In 2019, the global intravenous solutions market was worth US$ 8.5 billion. Fluid resuscitation, routine cleaning, replacement, and redistribution are all common uses for IV solutions and electrolytes. From 2018 to 2025, the market size is projected to grow at a CAGR of 7.1 percent, from USD 86.2 million in 2020 to USD 121.7 million in

2025. As a whole any entrepreneur can venture in this project without risk and earn profit.

Liquid glucose from rice straw

Glucose from corn

Glucose from potato

16) ORGANIC HERBAL CHOCOLATES /CANDIES – EXHIBIT -16

Compound chocolate is a product made from a combination of cocoa, vegetable fat and sweeteners. It is used as a lower-cost alternative to true chocolate, as it uses less-expensive hard vegetable fats such as coconut oil or palm kernel oil in place of the more expensive cocoa butter. It may also be known as "compound coating" or "chocolatey coating" when used as a coating for candy. It is often used in less expensive chocolate bars to replace enrobed chocolate on a product.

Cocoa butter must be tempered to maintain gloss and coating. A chocolatier tempers chocolate by cooling the chocolate mass below its setting point, then rewarming the chocolate to between 31 and 32 °C (88 and 90 °F) for milk chocolate, or between 32 and 33 °C (90 and 91 °F) for semi-sweet chocolate. Compound coatings, however, do not need to be tempered. Instead, they are simply warmed to between 3 and 5 °C (5.4 and 9.0 °F) above the coating's melting point.

MARKET OVERVIEW

The global real and compound chocolate market size was USD 27.09 billion in 2021. The market is projected to grow from USD 29.03 billion in 2022 to USD 42.71 billion by 2029, exhibiting CAGR of 5.67% during the forecast period. The globalism pact of COVID-19 has been unprecedented and staggering, with real and compound chocolate experiencing lower-than-anticipated demand across all regions compared to pre-pandemic levels. Based on our analysis, the global market exhibited a decline of -3.61% in 2020 as compared to 2019.

Real chocolate mainly comprises cocoa mass and cocoa butter, while compound chocolate uses vegetable oil instead of cocoa butter and cocoa powder. Real type of

chocolate is prepared from a nutritious seed, roasted to bring out its favors. However, the efficacy of chocolate (compound type) lies in its technical advantages such as high heat resistance, bloom resistance, and others which make it suitable for consumption in warmer countries and wider application ease.

A rise in the real and compound chocolate market growth could be associated with the rising consumer inclination toward indulgent confectionery products. The demand for innovative chocolate products, ingredients, and premium chocolate confectioneries in emerging and developed economies has witnessed positive growth in recent years. This growth has been attributed to rising consumer expenditure on indulgent confectionery products, especially chocolate confectioneries. This trend has boosted the sales of real and compound chocolate.

The COVID-19 pandemic has heavily affected the food & beverage processing industry. The socio-economic situation has affected the consumption patterns of particular products negatively. Since most countries went under lockdown in 2020 to stop the spread of the virus, the demand for real and compound chocolate in the hospitality sector saw a significant decline. According to the Cocoa Association of Asia (CAA), Asia’s cocoa grindings fell by almost10% in the first half of 2020 as compared to the same period in 2019.During the early stages of the COVID-19 pandemic, cocoa prices fell, and transportation costs rose. The biggest challenge was to collect cocoa from small holder farmers and supply it to cocoa exporters and cocoa processors for chocolate production. Transport restrictions and border closures worsened the situation. As a result, chocolate manufacturers faced raw material supply shortages, thereby ecting their sales. For instance, Barry Callebaut AG, a leading manufacturer of premium chocolate, reported

as lowdown for the first six months of FY-2020 due to the pandemic. The rapid establishment and speedy expansion of online retail, e-commerce, and other distribution channel amidst the COVID19 pandemic have unlocked new opportunities for Manufacturers in the retail sector. They are anticipated to boost the market in forthcoming years.

The chocolate confectionery category is traditionally driven by indulgence, and the sector has experienced a surge in demand for chocolates with better-for-you options over the past few years. The rise in exit Arianism is another factor contributing to the fueling demand for plant-based chocolates. As consume expectations are changing, and they are seeking products beyond dairy allergies and lactose intolerance. At the same time, millennials look for tasty yet “ethical” plant chocolate that are harmless to the planet and animals. Organic chocolate has evolved into the mainstream with the latest trends as chocolatiers and chocolate makers expand their reach. As consumers

are growing more interested inorganic products, it offers various opportunities for confectionery products manufacturers to meet the demands. More organic chocolate variants manufactured by traditional iconic brands and boutiques and independent producers appear on shelves, creating a positive product image among consumers. Retailers are highly aware of

the potential of this label, which has nudged them to develop innovative products. For instance, in March 2021, Puratos USA announced the newest creation in their real Belgian Chocolate portfolio: Belcolade Selection Amber Cacao-Trace. It is an all-natural, clean-labeled, non-GMO and contains no artificial favors.

Confectionery relies on pre miumization in a market that has matured but continuesto grow modestly. In the U.S., the reis particular interesting artisan and gourmet style options, often focusing on the origin of cocoa, its content in the ?nished product, and the use of additional ingredients and favors of great importance. While consumers focus on getting health benefits, the desire to indulge themselves in innovative and flavorful confectioneries mains strong. Taste and texture ere main them a in factor for the consumers in making chocolate confectionery purchasing decisions. Brands continue to innovate with new variations of sweet and savory favors. For instance, Barry Callebautin corporates contrasting creamy and crunchy textures into chocolate products as they strive to create more memorable and engaging sensory experiences for consumers.

Compound type chocolate is a low-cost alternative to original chocolate as it uses inexpensive hard vegetable fats – such as coconut oil and palm kernel oil instead of comparatively expensive cocoa butter. Cocoa butter must be tempered to retain coating and gloss. However, since there is no need to temper the compound type chocolate, this makes the measure to work with and cost effective. In developing countries, such as India and China, where the food service industry is growing due to rising population, the compound chocolate and is witnessing a significant upsurge.

RESTRAINING FACTORS

This market relies on the supply, quality, and cost of raw materials worldwide. The fluctuations in the price and supply of raw materials, such as cocoa, due to crop disease, climate, and labor unavailability can negatively impact the market. Failure to

recover high error shortfalls in availability or quality of raw materials, such as cocoa butter, cocoa powder, sugar, and others, could adversely impact the market. The significant change in regulatory controls, legal systems, and customs in the regions also affects product supply and hampers market growth.

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INTRODUCTION

In the last century, chemical fertilizers were used in agriculture. But slowly chemical fertilizers started displaying their ill-effects such as • polluting water basins • destroying micro-organisms and friendly insects • making the crop more susceptible to the attack of diseases • reducing the soil fertility and thus causing irreparable damage to the overall system.

SOLUTION • Found that biofertilizers can help in increasing the yield without causing the damage associated with chemical fertilizers.

BIOFERTILIZER • It is a large population of a specific or a group of beneficial microorganisms for enhancing the productivity of soil • Either by fixing atmospheric nitrogen or by solubilizing soil phosphorus.

TYPES OF BIOFERTILIZER 1. For Nitrogen Rhizobium for legumes crops Azotobacter/Az spirillum for non-legume crops 2. For Phosphorous Rhizobium, Azotobacter, Az spirillum and Acetobacter

Biocom post • Eco-friendly organic fertilizer • Prepared from the sugar industry waste material. • Consists of nitrogen, phosphate solubilizing bacteria and various useful fungi like decomposing fungi, Trichoderma viridea which protects the plants from various soil borne disease • Increase soil fertility which results to a good quality product to the farmers.

Advantage of biofertilizers

Renewable source of nutrients Sustain soil health Supplement chemical fertilizers. Replace 25-30% chemical fertilizers Increase the grain yields by 10-40%. Decompose plant residues, and stabilize C:N ratio of soil Improve texture, structure and water holding capacity of soil No adverse effect on plant growth and soil fertility.

BIOPESTICIDES

BIOPESTICIDE • Bio pesticides are biochemical pesticides that are naturally occurring substances that control pests by nontoxic mechanisms. • Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. • All the living organism which are cultivated in the laboratory on large scale and are used and exploited experimentally for the control of harmful organism.

■ Consist of a microorganism (e.g., a bacterium, fungus, virus, or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests,

although each separate active ingredient is relatively specific for its target pest. For example, there are fungi that control certain weeds, and other fungi that kill specific insects.

■ Are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce the gene into the plant's own genetic material. 2. Plant pesticides

■ Are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances, such as insect sex pheromones, that interfere with mating, as well as various scented plant extracts that attract insect pests to traps.

• Biopesticides are usually inherently less toxic than conventional pesticides. • Cheap, renewable can be handled safely. • Difficult for insects to develop resistance to these pesticides.

18) SPICE / PROCESSING/ TRADING/ MARKETING - EXHIBIT- 18

Spices which are basically plant products, have a definite role to play in enhancing the taste flavour, relish or piquancy of any food; most of the spices are fragrant, aromatic & pungent. They comprise seeds, barters, rhizome, leaves fruits and other parts of plants, which belong to variegated species and genera since time immemorial, India in renamed to be the wave of spices. Most important spices like black pepper (king of spices) cardamom (queen of spices), ginger, chillis and turmeric, which are produced in India import it great reputation, and these constitute. In the list of spices, clove, nutmeg, cinnamon and cassia are known as tree spices, however, spices like fennel, fenugreek, garlic, onion, coriander, cumin, vanilla, saffron; etc. These spices are not used at a time. For preparation of any dish may be Indian or European, vegetarian or non-vegetarian we use more than one spice. The combination of all the spices but together for the use of one particular dish as known as masala the bulk of the dry matter consists of carbohydrates, proteins, tannins, resins, volatile oil, fixed oil, for pigments, mineral, elements, etc. These constituents differ greatly in their composition and content in different spices. They have varied physical and chemical properties. Due to this reason, the processing method of different spice, differ widely and required individual expertise in operation like curing, drying, cleaning, grading and packing. Uses & Applications There are a large number of dishes used commonly and on special occasions; correspondingly, there may be large variety of masalas (spices) also. However, the purpose or use of spices (a masalas) in dishes is two folds and being the appetizer and the other being taste and appearance. Spices have a definite roll to play in enhancing the taste and flavor of any forces. A dish of spices adds individuality to standardized foods, traditional or modern. In the indigenous system of medicine in

India, spices are used widely. But, till recently, there was a prejudice in many foreign Countries That Spices Are Injurious To Health. Fortunately, This View Has Been Contradicted Recently By Research Workers In India And Abroad. Market Survey India is one of the leading producers, consumers and exporters of spices. The Spices Board, under the umbrella of Ministry of Commerce and Industry, government of India, is the apex body for promoting exports of Indian Spices. Established in 1987, the Board plays an important role as a development agency for Indian spices. Its board-based activities include formulation and important role as a development agency for Indian spices. Its broad-based activities include formulation and implementation of quality improvement system, research and development programmes, imparting education and training to farmers, processors, packers and exporters on post-harvest handling, etc. For promotion of spices, the Spice Board is regularly participating in international food fairs. Assisting exporters in trade fair participation and sending business delegations to identified markets for export development. India is known as the home of spices. No India meal is considered complete without the tangy and delectable flavour of Indian spices, locally known as masala. Indian spices are famous the world over for their high medicinal values. There is no other country in the world that produces as many kinds of spices as India. India grows over 50 different varieties of spices. The total production is around 2.7 million tonnes. Of this, about 0.25 million tonne (8 10 per cent) is exported to more than 150 countries.

SPICES OF INDIA

(SPICES UNDER THE PURVIEW OF THE SPICES BOARD)

English Common Botanical Family Partused

Name Name Name as spice

1. Cardamom (Small)Elettaria cardamomum Maton Zingiberaceae Fruit,Seed

Cardamom (Large) Amomum subulatum Roxb. Zingiberaceae Fruit,Seed

2. Pepper Piper nigrum L. Piperaceae Fruit

3. Chilli,

Bird’s Eye Capsicum frutescens L. Solanaceae Fruit

Capsicum Capsicum annuum L. Solanaceae Fruit

Chilli Capsicum annuum L. Solanaceae Fruit

Paprika Capsicum annuum L. Solanaceae Fruit

4. Ginger Zingiber officinale Rosc. Zingiberaceae Rhizome

5. Turmeric Curcuma longa L. Zingiberaceae Rhizome

6. Coriander Coriandrum sativum L. Apiaceae Leaf & Fruit

7. Cumin Cuminum cyminum L. Apiaceae Fruit

8. Fennel Foeniculum vulgare Mill. Apiaceae Fruit

9. Fenugreek Trigonella foenum-graecum L. Fabaceae Seed

10. Celery Apium graveolens L. Apiaceae LeafFruit,&Stem

11. Aniseed Pimpinella anisum L. Apiaceae Fruit

12. Ajowan Trachyspermum ammi L. Apiaceae Fruit

13. Caraway Carum carvi L. Apiaceae Fruit

14. Dill Anethum graveolens L. Apiaceae Fruit

15. Cinnamon Cinnamomum zeylanicum Breyn Lauraceae Bark

16. Cassia Cinnamomum cassia.Blume Lauraceae Bark

17. Garlic Allium sativum L. Alliaceae Bulb

18. Curry leaf Murraya koenigii(L) Sprengel Rutaceae Leaf

19. Kokam Garcinia indica Choisy Clusiaceae Rind

20. Mint Mentha piperita L. Lamiaceae Leaf

21. Mustard Brassica juncea L.Czern Brassicaceae Seed

22.Parsley Petroselinum crispum Mill. Apiaceae Leaf

23.Pomegranate Punica granatum L. Punicaceae Seed

24.Saffron Crocus sativus L. Iridaceae Stigma

25.Vanilla Vanilla planifolia Andr. Orchidaceae Pod

26.Tejpat Cinnamomum tamala (Buch Ham) Lauraceae Bark&Leaf

Nees & Eberum

27.Pepper Long Piper longum L. Piperaceae Fruit

28.Star Anise Illicium verum Hook. Illiciaceae Fruit

29.Sweet flag Acorus calamus L. Araceae Rhizome

30.Greater Galanga Alpinia galanga Willd. Zingiberaceae Rhizome

31.Horse Radish Armoracia rusticana Gaertn. Brassicaceae Root

32.Caper Capparis spinosa L. Capparidaceae Flower buds

33.Clove Syzygium aromaticum(L)

Merr.& Perry Myrtaceae Unopened

Flower bud

34.Asafoetida Ferula asafoetida L Apiaceae Oleogum resin

from rhizome

and thickened

root

35.Camboge Garcinia cambogia (Gaertn).Desr Clusiaceae Rind

36.Hyssop Hyssopus officinalis L. Lamiaceae Leaf

37.Juniper berry Juniperus communis L. Cupressaceae Berry

38.Bay Leaf Laurus nobilis L. Lauraceae Leaf

39.Lovage Levisticum officinale Koth. Apiaceae Leaf&Stem

40.Marjoram Marjorana hortensis Moench. Lamiaceae Leaf

41.Nutmeg Myristica fragrans Houtt. Myristicaceae Seed

42.Mace Myristica fragrans Houtt. Myristicaceae Aril

43.Basil Ocimum basilicum L. Lamiaceae Leaf

44.Poppy seed Papaver somniferum L. Papaveraceae Seed

45.Allspice Pimenta dioica (L) Merr. Myrtaceae Fruit & Leaf

46.Rosemary Rosmarinus officinalis L. Lamiaceae Leaf

47.Sage Salvia officinalis L. Lamiaceae Leaf

48.Savory Satureja hortensis L. Lamiaceae Leaf

49.Thyme Thymus vulgaris L. Lamiaceae Leaf

50.Oregano Origanum vulgare L. Lamiaceae Leaf

51.Tarragon Artemisia dracunculus L. Asteraceae Leaf

52.Tamarind Tamarindus indica L. Caesalpiniaceae Fruit

Spices

Trading

packaging

processing

manufacturing

farming .

COCA POWDER, COCA PRODUCTION/ PROCESSING--- EXHIBIT- 19

production process of cocoa powder production line:

Cocoa Bean Roasting -- Peeling -- Grinding -- Oil Pressing -- Crushing -- Powder Making Machine -- Powder Packer

Cocoa powder is made from cocoa cake. Baked cocoa beans will first be ground into cocoa butter. Then, the oil is squeezed out of the cocoa mass with a liquid hydraulic press and then the cocoa cake is removed. Cocoa cake will be placed in a powdered machine to obtain the final cocoa powder.

Primary Processing

Raw cocoa is bitter, astringent and devoid of chocolate flavour. The

original taste, flavour and colour of the chocolate are due to interplay of different chemicals developed during processing. Biochemical process for development of chocolate flavour start during fermentation stage and lasts during drying, roasting and conching.

Harvesting of ripe pods

The first harvest takes place after approximately 3 years (hybrid/improved variety) or 4-5 years (traditional variety coming from the nursery) after planting.

The cocoa tree can produce twice a year for more than 30 years.

• Harvest the pods at regular intervals of 10-15days (do not go over 3 weeks)

• Harvest the pods at optimum maturity(when fruits turn three quarters yellow, orange or red depending upon the variety)

• Harvesting is done at the stalk using a machete, pruning shears or sickle.

Avoid damage to flower cushions which will produce new flowers and fruits of subsequent harvests

• Finally transport the pods from the plantation to pod breaking site

Breaking the pods. The pods are broken within 5 days of harvest. Separate the healthy pods from damaged ones to differentiate between the grades. Open the pod with a stick that have no pointed edges so as to extract the beans without damaging them. While breaking the pods remove any defective beans, rachis and cortex debris. During breaking distal portion of the pod gets detached and beans remain conveniently attached to placenta from where they are extracted.

Farm level processing of cocoa

Several factors influence the quality of cocoa beans. The agro techniques adopted, environmental conditions during the development of the pod and the processing technology also contribute significantly to the quality of finished product. As chocolate is sold in a highly competitive market, it is very important to produce good quality beans. Cocoa beans have to be necessarily subjected to an initial process of fermentation and drying before being used for the manufacture of chocolate or other products.

Chocolate flavour is developed by the two processes, fermentation of the beans at the producer's level and roasting of them by the manufacturers.

Fermentation

The beans should be fermented to help produce chocolate flavour, reduce bitterness, loose its viability, remove mucilaginous coating and enable the cotyledons to expand. For proper fermentation there should be sufficient aeration to the beans, provision for drainage of sweating and maintenance of temperature in the system.

Fermentation involves keeping a mass of cocoa beans well insulated so that heat is retained while allowing air to pass through it during the process which lasts 6-7 days. The pulp or mucilage adhering to the beans disappears and the colour of beans which is pale purple or violet changes to light brown. Raw beans are covered by sugary mucilaginous pulp and the beans with pulp around them are 'wet beans. During fermentation the pulp around the bean is lost and a series of biochemical reactions take place in bean which is necessary for imparting chocolate flavour. The beans are subjected to fermentation immediately after the pods are broken.

There are four different methods of fermentation which are as follows

1) Heap method- It involves keeping a mass of not less than 50kg of wet beans over a layer of banana leaves which are spread over few sticks to keep them a little raised over the ground level to facilitate the flow of sweating. The leaves are folded and kept over the heap of beans, the heap is dismantled and the beans are mixed on the 3rd and 5th days. Beans can be taken out for drying on the seventh day.

2) Tray method- **Wooden trays,10 cm deep is divided into a number of sections by means of a wooden partition that will fit into appropriate grooves at required distance. A convenient tray can be of 25cm width and 60 cm length. Wet beans are filled in tray and levelled. Fermentation is completed in four days.**

3) Basket method- **Mini bamboo baskets, closely woven with a diameter of 20cm and 15 cm height are taken for a capacity of 2kg.The baskets are lined with one or two layers of torn banana leaves to facilitate drainage of sweating. Wet beans are then filled in these baskets and kept on raised platform to allow flow of drippings. The beans are to be taken out and stirred well 48 hours and 96 hours after the initial setting. Beans can be taken out for drying on the seventh day.**

4) Box method- **Boxes of different shapes and sizes are used. The bottom of boxes are provided a number of holes at 10cm distance and three such boxes are arranged in a row so that beans can be transferred from one box to the other. The beans are placed in top most box and covered with banana leaves. After two days, the beans should be uncovered and transferred to second box, then to third box after another two days. On the sixth day beans are taken out for drying.**

End of fermentation

The optimal end of fermentation is checked from the end of 5th day.

- **Bean colour changes to brown, becomes plump and filled with reddish brown exudate**
- **Testa becomes loose and gets detached from the cotyledons**
- **Longitudinal halves of cotyledon show bleached apperance in the centre with a brownish ring at the periphery**
- **When 50%of beans show these signs, the lot can be taken out for drying**

Drying

At the end of fermentation, the moisture content of beans is around 60% and this must be reduced to less than 8% before the cocoa can be stored, sold or transported. T he beans are dried naturally or artificially. Natural or solar drying is the simplest, most popular method and takes around 8- 15 days. The beans are often spread out on a bamboo or straw mats placed in the sunlight, on black plastic sheets. Stir them frequently for around 5 days. Sort them to remove defective and damaged beans. Once dry, their average weight is one gram with a moisture content of 7%(approximate). Place them in a dry, sheltered and well aerated spot to protect them from damp rain, humidity to prevent mould development.

Artificial drying usually comes towards the end of natural drying to reduce the drying time. The heat is produced by a wood or gas fired furnace. There must be a system for ventilation and controlling other parameters like temperature as the taste quality of cocoa beans changes above 55 degrees Celsius. Regardless of the drying method used-

• Make sure the product to be dried is properly fermented

• Sort the beans to remove dirt, impurities or any beans that are flat or sprouting

• Follow the correct measurement for the layers to be dried (4-6 cm for natural drying and 5-10 cm for artificial drying)

• Monitor the cocoa beans by regularly taking a sample of few beans towards the end of drying process. Crack them with your hand and split few of them to ensure that beans are dry from both outside and inside

Natural sun drying

Greenhouse drying

Cocoa dryer machine

• Capacity- 1000kg

• Processing time-23hours

• Production capacity- 300kg-1500kg

• Price-2.50lakh/piece

Polishing

During drying the beans are polished to improve their apperance. The beans are polished at a stage where they are hard but not brittle. Polishing also protects the beans from fungal infections during storage.

Cleaning and bagging

After drying and polishing, beans are cleaned of any extraneous matter and are packed in clean, sufficiently strong and properly sewn jute bags.

Grading

Grading is done by a mechanical grader which separate the beans based on their size.

Storage

The great emphasis to achieve optimum quality from harvest to drying must continue during transport and storage. The jute bags containing dried cocoa beans are placed on a pellet to avoid contact with the ground and walls. The storage location must be clean, dry, well aerated and protected from the rodents and humidity to ensure the quality of produce.

Cocoa bean grading machine

• Capacity- 200kg/hour

• **Power- 2.2kw**

• **Price- Rs.75,000-7,50000/-**

Secondary processing

Secondary processing denotes the steps involved in conversion of raw beans into different finished products, the main product being chocolate. The essence of cocoa and chocolate manufacture, lies in the development of flavour by roasting the beans, followed by the extraction of cocoa butter from the nib to produce cocoa powder.

When the cocoa beans arrive in the processing unit, they are cleaned to remove any foreign matter and sorted to separate the small or broken beans. Roasting of cocoa beans Roasting of cocoa beans is one of the important operations in the processing of cocoa and the degree of treatment required being adjusted to the degree of ripeness of the beans concerned. The true purpose of roasting is not only restricted to the loosening of the shells,but also to develop positive flavour as well as the removal of excess moisture and other undesirable volatile matter. It enables to bring down the moisture content to 1.5-2%.

Objectives of roasting

• **Color development**

• **Modification of the structure of the shell so as to permit easier subsequent**

separation

• **Reduction of moisture content**

• **Solubilisation of cocoa starch and chemical changes especially oxidation of some minor constituent of beans**

Most favoured temperature for proper roasting of cocoa beans for chocolate making lies between 120-125-degree Celsius. The discharged beans must be rapidly cooled to prevent over roasting with attendant discoloration and spoilage of flavour. The separation of shell of cocoa beans is necessary as the presence of significant amount of shell in chocolate will affect both colour and flavour and in addition reduces the effectiveness of refining. Cocoa beans are first cracked by passing through rollers or rotating cones, where an air current is used to blow away the lighter shell.

Winnowing

Once the beans are roasted well they should be winnowed or dehulled. Winnowing separates the cocoa nib(the edible and sought after portion)from the outer hull. The cocoa nibs are then processed into chocolate or other cocoa products.

Winnowing is done either manually using a basket that is rounded at one end and open at the other to efficiently toss the beans into air and immediately catch them as they fall back into the basket. As the beans are repeatedly tossed, the brittle shells

break apart and separate from the beans. It is also done with the help of cocoa bean winnower machines.

Cocoa roasting machine

- **Capacity- 50kg/hour**

- **Power consumption-350W**

- **Price- Rs 1.2lakh/piece**

Alkalisation

Cocoa alkalisation is a value-added process in cocoa processing to produce alkalized cocoa mass or powder. It involves treatment of cocoa nibs with a food grade alkali solution (saturated solution of sodium or potassium carbonate) to raise pH, thus producing dark colors and strong flavours. Alkalisation temperature of 80-85-degree Celsius gives the best flavour.

- **Reduces the acidity of natural cocoa (pH is raised from 5.2-5.6 to almost neutral values 6.8-7.5)**

- **Reduces sourness**

- **Increases solubility and dispersibility of cocoa in water**

Cocoa bean winnower

- **Power consumption- 0.5hP**

- **Price- 1.70lakh/unit**

Products of Cocoa

1) Cocoa mass or liquor- The dried beans are cleaned and roasted uniformly to get the desired aroma. The roasted beans are broken and winnowed to get good nibs(cotyledons). When these nibs are ground using a boll mill crusher or grinding machine, cocoa liquor or cocoa mass is obtained. There are two types of cocoa mass-natural mass and alkaline mass.

- **In natural mass production water is added during roasting where as an alkaline solution (potassium carbonate)is added for the alkaline mass**

- **100 kg of cocoa beans produces 80kg of cocoa paste**

Cocoa liquor machine

Price-Rs 1,50000-2,50000/-

2) Cocoa butter- Cocoa butter and cocoa cakes are extracted from pure cocoa mass or paste with the help of a hydraulic press. The cocoa butter obtained is neutralized, hard in consistency, waxy, slightly shiny, pale yellow in color and oily to touch. The cake left

behind at the bottom of the presses after extraction of butter, contains further 20% of butter. This cake is milled and sieved.

3) Cocoa powder- **The solid blocks of compressed cocoa remaining after the extraction of cocoa butter are pulverised into a fine powder called cocoa powder-high fat powder containing 20-25% of fat which is used in drinks and low fat powder containing 10-13% of fat and is used in cakes, biscuits, ice-creams and other chocolate flavoured products.**

Cocoa grinding machine

- **Capacity- 100kg/hour**
- **Price-Rs 2,00000/ unit**

4) Chocolate production

Un-refined local chocolate

Locally , the processing of dried fermented cocoa is largely limited to the production of the local chocolate, commonly called 'Creole Chocolate'.This is basically a crude form of the pure unsweetened (bitter) chocolate,which is used to make a beverage. The production of local chocolate is typically done at the household level using basic utensils. Spices such as cinnamon ,nutmeg, bay keaf are added during or after the grinding process. The mixture is shaped into balls, sticks or blocks. The end product is grated and boiled to make a chocolate beverage.

Chocolate manufacturing processes

a) MixingMixing of ingredients during chocolate manufacture is a fundamental operation employed using time-temperature combinations in a continuous or batch mixers to obtain constant formulation consistency. In batch mixing, chocolate containing cocoa liquor, sugar cocoa butter, milk fat and milk powder is thoroughly mixed normally for 12-15 minutes at 40-50

degree Celsius.

b) RefiningRefining of chocolate is important to the production smooth texture that is desirable in modern chocolate confectionary.Mixtures of sugar and cocoa liquor at an overall fat content of 8-24% are refined using a combination of two-and-five roll refiners.

C) Conching

This process is regarded as the endpoint or final operation in themanufacture of bulk chocolate, whether milk or dark. It is an importantprocess that contributes to the development of viscosity, texture and flavour. Conching is usually carried out by

agitating chocolate at more than 50 degree Celsius for few hours. Making chocolate considered "good" is about forming as many type V crystals as possible as this provides best appearance ,texture and creates the most stable crystals, so the texture and appearance will not degrade with time. To accomplish this temperature is carefully manipulated during the crystallization. To give chocolate a suitable viscosity, additional cocoa butter and lecithin can be added towards the end of conching to thin or liquefy the chocolate prior to tempering.

A conche machine is a surface scraping mixer and agitator that evenly distributes cocoa butter within the chocolate. It promotes flavour development through heat, release of volatiles, acids and oxidation.

d) Tempering- The final process is called tempering. The fats in cocoa butter can crystallize in six different forms. The primary purpose of tempering is to assure that only the best form is present. Two classic ways of manually tempering chocolate are

• Working the molten chocolate on a heat absorbing surface, until thickening indicates the presence of sufficient crystal “seeds" ,the chocolate is then gently warmed to working temperature

• Stirring solid chocolate into molten chocolate to" inoculate" the liquidchocolate with crystals Chocolate tempering machines or temperers with computer controls can be used for producing consistently tempered chocolate. The temper of chocolate can be measured with a chocolate temper meter to ensure accuracy and consistency. A sample cup is filled with the chocolate and placed in the unit which then displays or prints the results.

The uniform sheen and crisp bite of properly processed chocolate are the result of consistently small butter crystals produced by the tempering process. Chocolate processing machine

Price- 75 lakh/unit

Conche machine

• Price- 3,50,000

• Capacity- 40kg/hour

Types of chocolates

a) White chocolate: It is made from cocoa butter, sugar, milk and flavouring such as vanilla.

b) Milk chocolate: It is made from cocoa liquor, cocoa butter, sugar, milk and flavouring

c) Dark chocolate: It is made from cocoa liqour, cocoa butter, sugar and flavourings.

5) Cocoa juice

Wash the harvested pods, then open them with sticks devoid of any sharp edges in order to collect the beans without damaging them. Put the beans in clean containers with small holes. Place a cooking pot under the containers to receive

the cocoa juice. To facilitate the extraction of juice, stir the beans occasionally. After 24 hours, collect the juice, approximately 1 litre of cocoa juice can be obtained from 35kg of fresh beans. Once the juice has been collected, the beans can be taken for the fermentation process. The cocoa juice can be consumed fresh as a non-alcoholic drink or fermented to obtain alcoholic drink Other products from cocoa Processing of cocoa both at primary and secondary levels have a large quantity of waste materials. Research on utilisation of these materials indicates that several useful by-products can be produced from cocoa wastes. The important waste materials are pod husk, sweatings and shell. Animal feed can be made from cocoa pod husks. The husks provide high fibre, low protein and moderate energy feed stuff. Cocoa pod husks can be used as a substitute for corn and wheat bran in feed formulations for chickens, pigs and sheep.

Cocoa bean shells can be used as an organic mulch and soil conditioner for garden. Cocoa sweatings can be used for making jelly or jam. The pectin from sweatings show slow setting characteristics.

Total cost of setting up a cocoa processing plant. The total cost involved in setting up a cocoa processing plant varies from country to country and state to state. On an average it comes around Rs 75,00,000 (including the machineries and other miscellaneous costs)

20) YEAST MANUFACTURING AND CAKE GEL MANUFACTURING – EXHIBIT -20

Cake gels are emulsifiers that are much used for the purpose of baking. Emulsifiers are found in nature and assist in improving food system stability. Cake gels have the best of technical ingredients with desired specifications. It needs to be understood well that cake gels are the best of emulsifiers for cake productions and have the best of function. These emulsifiers exist in white as well as yellow colour.

The abilities of emulsifiers include "foaming" wherein – foam is much produced through agitation making bubbles which have the tendency to burst. When an emulsifier is added, there is need of more aeration to foam. This in turn assists in provision of batter with increased volume and smooth texture. It needs to be well noted that cake gels are easy to use and the instructions of use are well mentioned on the packaging. Using cake gels are indeed cost effective when there is much of mass production.

It needs to be well noted that cake gels are well designed to have a distribution that is uniform throughout the cake. A system needs to be created that keeps emulsifiers in

the form of crystals. Cake gels have a kind of magic at every stage with the best of softening effects. It is important to understand the best of ingredients including water for producers of cake gels. It is important to have the right results and have a baking result that is much consistent.

The key features and benefits of cake gels and emulsifiers need to be understood well and noted at the same time. There needs to be a provision of excellent texture, whippability and volume for cake batters. The emulsifiers are known to decrease the surface tension between fat phase and water. The cake gels ensure stable emulsion and homogenous provision in the end product.

Cake gels are used in making of starch as well as bread emulsifiers. Cake gel is actually a kind of whipping active gel which consists of mono-layers of water. Emulsifiers are di-glycerides and polyglycerol esters and that too related to fatty acids. It needs to be well noted that the monoglycerides are mostly crystalline in alpha form. As mentioned before, cake gels are a kind of emulsifiers used for baking. In nature around, emulsifiers are discovered much having technical elements that give good food quality.

Cake gels are known to improve the strength of the batter as well as gives much consistency. It is very simple to make cake gels and it is important to observe the directions on the packaging. The ingredients of cake gels are maida, vanilla essence, sugar, cocoa powder, tablespoon oil, eggs, salt as well as baking powder. It is price efficient to use cake gels particularly in mass manufacturing. Due to the fact that cake gels are easy to use, they should often be used as emulsifiers. Also, it needs to be noted that cake gels are very simple to make and it is advised that they are often used.

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VANILA CULTIVATION- EXHIBIT -21

Vanilla can be grown indoors, in greenhouses, in pots and even in containers. It can also be grown hydroponically and it produces higher yields when it is grown under the shade or when it is grown individually rather than cultivating it as an intercrop.

It requires high humidity, shade and moderate temperatures and due to this they are cultivated in shaded houses which are fitted with a micro sprinkler to give it the required microclimate. Pollination is important to carry out the fertilisation process and production of fruits, so it is an important factor in the production of Vanilla spice.

Here in this article, we will learn about the Cultivation of Vanilla.

Introduction to Vanilla

Vanilla is derived from Vanilla which means 'little pod' and belongs to the family of Orchidaceous and genus of 'Vanilla '. The plants of Vanilla start to yield after three years of planting the crop and thereafter it continues to produce up to 12 to 14 years. In general, Vanilla crop is not planted as an individual crop but is grown as an intercrop in the fields of 'coconut' and 'areca nut'.

Vanilla essence is mostly used for preparing ice creams, chocolates, bakery products, puddings, pharmaceuticals, liquors and perfumes and its desirable flavour makes it to one of the most common ingredients in the Global Marketplace where it is used as a primary flavour or component for another flavour and also for its desirable aroma qualitie

Vanilla is also used in industries in various forms, and in retail stores or households, it is used as Vanilla beans or as Vanilla extracts.

Varieties of Vanilla

Vanilla has around 50 species but only three are the major species that are currently grown globally and they all are derived from a species that was originally found in Mesoamerica and including the parts of modern day Mexico. They are:

Vanilla planifolia, which is grown in Madagascar Union and other tropical areas along the Indian Ocean. This variety is widely cultivated on a large scale and has more commercial value for its vanillin content.

Vanilla tahitensis, which is grown in the south Pacific.

Vanilla pompona, which is found in the West Indies, Central America and South America.

Health Benefits of Vanilla

Following are some of the health benefits of Vanilla:

It helps in healing burns, wounds, and cuts.

It promotes healthy skin and has anti-aging properties and is good for acne.

It promotes healthy hair.

It helps in treating anxiety and depression.

It helps in weight loss.

It helps in getting relief from nausea.

It provides relief from digestive disorders.

It is good for dental health.

Lavender farming project for beginners

Ideal Conditions for Cultivation of Vanilla

Here we will see some ideal conditions for cultivating Vanilla.

Climate Requirement

Vanilla plants require a warm and humid type of climate with a well distributed annual rainfall of about 150 to 350 cm and temperature range of 25°C to 34°C for optimum growth.

It can be grown above mean sea level of 1400 metres and it prefers 45% shade and grows well under filtered light. Vanilla plants can be cultivated in shade houses or nets fitted with micro sprinklers and foggers in those areas where proper climate is not there.

Soil Requirement

Vanilla crop can be grown in various types of soils from sandy loam to laterites, but it grows well in loose and friable soils with any type of loamy texture and it requires high organic matter content in the soil for better production.

The soil should have a well drainage facility with the lands having a gentle slope and the pH of the soil should range between 6.5 to 7.5.

Vanilla cultivation in Western Ghats is best suited as the soils are rich in organic matter and humus and they also have good drainage facilities. For commercial cultivation of the crop, soil test is essential.

Saffron farming project for beginners.

Land Preparation

The land is prepared by ploughing it a couple of times to bring the soil to a fine tilth stage and to remove any type of weeds that may have been left from the previous

crops. If the soil is not fertile, organic manure is added during the land preparation process.

Vanilla vines require support for growing, so any type of living trees, rock pillars or iron pillars can be arranged for supporting them.

Propagation Methods for Vanilla Farming

The crop is usually propagated from the cuttings of the shoot having 18 to 24 internodes. The cuttings are adjusted depending on the availability of the plant material and the area of the field. However, the cuttings less than 5 to 6 inches or shorter than 60 cm length should be avoided to plant in the main field and for cultivating it in a polybag even 2 nodes of shoot cutting would be enough.

Long cuttings of the shoot start to flower in the second year itself but the short cuttings take three years for flowering. However, long cuttings have slow growth as compared to the shorter ones. Vanilla plants can also be propagated using tissue culture methods.

For propagation the leaves of the 4th to 5th node from the tip is removed and the cutting is kept loosely in a shaded place for 2-3 weeks and when it forms a complete root system then it is transplanted to the field.

Three to four internodes are placed at a shallow trench with the lower end of the cutting with a depth of 3-4 cm and 10 cm wide. The trench is then filled with evacuated soil and the rainy season is considered the best time for this process.

Planting & Spacing of Vanilla plants

Vanilla trees are climbers, so they need support for growing and it grows well in partial shade of low branching trees that have rough bark and small leaves. These supports should be legume so that it can enrich the soil and it can be adjusted so as to make them at a height of 120 to 150 cm.

The best time for Vanilla planting is the month of August and September, when the weather is not too rainy or too dry. The cuttings of the vine are laid on the soil surface and is then covered with a thin layer of about 2-3 cm soil.

The growing tips are gently tied to the support for climbing by the aerial roots and are covered with dry grass or palm fronds or other suitable materials and if the soil is dry water is sprinkled on them for early establishment of these cuttings.

A space of 2.5 to 3 meters is required between the plants and about 2 meters distance between rows and 2 meters distance within the rows, thereby making a population of 1600 to 2000 trees per ha. Vanilla cuttings are planted in rich organic content soil and they are filled in the trenches with the spacing of 8ft and in these trenches 7 feet long support pillars are placed with spacing of 6 feet.

Micro Climate for Vanilla Farming

Green houses and shade nets provide a controlled environment for Vanilla plants, thereby producing more yields and this environment provides them the required humidity, light and temperature which are maintained by the essential components.

Any net that provides 60% of shade can be considered as the shade house. The irrigation and humidity requirements are fulfilled using micro sprinklers with both irrigation and misting or fogging facilities that are installed in the shade net house.

Flowering & Pollination in Vanilla Cultivation

Vanilla plants start to flower from the third year of planting in the month of January and February month but irrigation should be stopped during the month of December and the tips of the vines should be regularly pruned.

Abundant irrigation should be provided for inducing more flowers during this stage. There is an absence of specific pollinating agents so natural self-pollination is not possible, hence artificial pollination is carried out by hand with the help of bamboo splinter, sharpened toothpick or a stiff grass.

The ideal time for pollinating is in the early morning period between 7 a.m. to 12 p.m. and it is preferred to pollinate only the first formed 7-10 flowers on the lower side of the inflorescence.

It is recommended to take 5-6 flowers per inflorescence and not more than 10 to 12 inflorescence per vine for pollination. The pods take 6 weeks to attain full size from fertilisation but 4 to 10 months for reaching full maturity depending upon the climatic conditions.

Intercultural Operations in Vanilla Cultivation

The main intercultural activities in Vanilla farming are:

Mulching – In order to protect the soil from erosion or loss of moisture, mulching is done using dried leaves or coconut leaves or husks and it is also done in order to enrich the soil fertility and weed control.

Manures & Fertilisers – For Vanilla plants, a well composted farmyard manure like cow dung, vermicompost or any organic material such as neem cake is applied. Nitrogen (125 gram) is applied in two split doses in June-July & September-October months. Vermi wash is essential for good growth & yield.

Irrigation – Irrigation is important during the dry & hot summer seasons and also during the first 2 to 3 years of planting. Sprinkler Irrigation is ideal for Vanilla However, you can also opt for micro irrigation or drip irrigation but water stagnation or flooding should be avoided as the crop is sensitive to these conditions.

Trailing – For limited growth of the plants, trailing operation is carried out and about 150-160 cm height is maintained for easy manual pollination. These plants are trailed bh coiling them around the branches of the support pillars or on horizontal support such that the vines should not touch the ground.

Pests & Diseases in Vanilla Cultivation

Some common pests & their control measures are:

Vanilla bug which can be controlled by egg mass at the first nymph stage.

Beetles which can be controlled by collecting and destroying them or by spraying Malathion @0.1%.

Vanilla vine weevil which is controlled by collecting and destroying the weevils during their adult stage.

Caterpillars which can be controlled by destroying them whenever seen.

White grubs which can be controlled by adding Chlorpyrifos @ 0.05% at the base of the soil.

Achatina which can be controlled by destroying them and avoiding such mulch materials that do not decompose easily.

Some of the diseases found in Vanilla plants are:

Root Rot – These are controlled by removing the affected roots, removing the mulch and drenching the soil. Coc (0.2%) @ 3litres per plant can be sprayed on the vines.

Stem Blight – It is controlled by spraying Bordeaux mixture @1%.

Bean Rot – Potassium Phosphonate (0.4%) is used for its control.

Bean shedding – Carbendazim (0.2%) is sprayed at every 2 weeks interval for its control.

Shoot tip rot – Carbendazim (0.2%) is sprayed at every 2 weeks interval for its control.

However, for best solutions you can contact your local horticulture department.

Harvesting of Vanilla plants

The Vanilla beans obtain a full size in six weeks after pollination and take 8 to 11 months for reaching maturity. The plants are ready to harvest between 6 and 9 months after flowering when the parts are dark green and the tip begins to turn yellow.

The beans should be harvested when the distal end turns pale yellow in colour. On an average about 80 to 90 matured beans could make 1 kg of Vanilla.

Fast growing vegetables tips & tricks.

The final product after the harvesting is obtained after these stages:

Curing – Here the beans are dipped in hot water at 63 to 65 °C for 3 to 4 minutes.

Sweating – In this stage, the beans are exposed to sunlight for 2 hours everyday by spreading them on a raised platform for 5 to 6 days.

Drying – The beans are spread on racks in an airy room for about a month.

Conditioning – The dried beans are bundled and covered in butter paper and then kept in wooden boxes for about 3 months.

Yield of Vanilla Plants

The yield of any plant depends upon the soil, climate, irrigation and variety of the crop used. Vanilla plants produce yield as per:

250 grams/plant in the 3rd year

500 grams/plant in the 4th year

750 grams/plant in the 5th year

1000 grams/plant from 6th year upto 15th year.

Marketing of Vanilla

Vanilla is the costliest spice after Saffron. The beans are bought by the pharmaceutical companies and food processing companies in bulk and for growing this crop on a large scale, it is very important to have a good marketing plan.

Vanilla is mostly used in flavouring ice creams and soft drinks. The total production of Vanilla beans is about 3000 tonnes per annum with an international demand of about 19000 tonnes.

HORTICULTURE AND FLORICULTURE AND GREEN HOUSE PROJECTS. - EXHIBIT 22

Horticulture Production Structures

Vegetable Greenhouses

Flower Production

Retail Greenhouse

Industrial Greenhouses

Garden Center Systems

Reforestation Structures

Government Greenhouses

Shade House

Institutional Facilities

Educational Greenhouse

Research & Development

Horticulture Nursery Structures

Seasonal Greenhouses

Agricultural Greenhouses

Aquaculture Growing

Head House

Garden Centers for Horticulture

Hydroponic Greenhouses and Organic Greenhouse are increasing in demand.

Numerous operational systems, equipment, and supplies for efficient operation are available. Diverse and unusual situations are not new to us as we have made installations in the arid deserts of the Middle East, the humid conditions of the tropics, the thin air conditions of Tibet, and the extremely cold climates of northern Canada and Alaska. Be it a greenhouse for growing plants for only rain protection or for use as a restaurant, from institutional growing chambers to ranges over 20 acres, our firm has encountered many challenging applications and met them all.

Greenhouse structures and greenhouse systems

for many uses, crops and all climates of the world and the greenhouse equipment to operate them. Also many greenhouse products, systems and supplies to operate the following types of greenhouses.

Production Greenhouses

Vegetable Greenhouses

Flower Production

Retail Greenhouses

Nursery Structures/Greenhouses

Seasonal Greenhouses

Garden Center Systems

Commercial Greenhouses

Aquaculture Greenhouses

Head Houses

Institutional Greenhouses

Educational Greenhouses

Research & Development Greenhouses, R&D Greenhouses

Industrial Greenhouses

Propagation Greenhouses

Agricultural Greenhouses

Reforestation Greenhouses

Government Greenhouses

Garden Center Greenhouses

MANY STYLES TO SELECT FROM

FOR HORTICULTURE, AGRICULTURE, FORESTRY, ETC.

Ground to Ground Greenhouses

Ridge Frame Greenhouses

Quonset Greenhouses

Quonsetter Greenhouses

Kool House Greenhouses

Expandable Greenhouses

Seasonal Greenhouses

Shade Houses

Shade Open Roof and Insect Protector Greenhouses

Also, look at the many types of Greenhouse Coverings

offered by USGR as well as supplies and equipment:

Poly Houses

Polycarbonate

Covered

Acrylic Systems

Edible oil projects and castor oil and by products- EXHIBIT 23

Edible oils are most often plant-based oils, which are similar, if not the same as those produced by the industrial biotech industry for use as biofuels such as biodiesel, for use in cosmetics, and in other everyday biotech products. Edible oils may be solid or liquid at room temperature.

Market Outlook

The Indian edible oil market is the world's fourth largest after the USA, China and Brazil.

The Indian per capita consumption for edible oil is expected to grow from the current consumption

Demand for edible oil is mainly driven by increase in per capita consumption of the commodity, rising income levels and improvement of living standards. The global edible oil market is anticipated to witness a substantial growth owing to increasing popularity of unrefined, unprocessed, healthy, and organic oil. In the coming years, vegetable oils with low cholesterol, fat, and calories are likely to gain high response due to growing health awareness among people across the world.

The market for edible oil can be segmented on the basis of type, end-users, and geography. In terms of type, the market can be classified into palm oil, canola oil, olive oil, sunflower oil, specialty blended oil, and corn oil. Increasing consumption of fried foods has significantly increased the demand for edible oils. Based on end-users, the marker for edible oil can be divided into food processor, food service, and retail. Improving living standards, changing Dietary habits, and increasing consumer

preference for healthy edible oil supporting the growth of the global edible oil market. The global castor oil and derivatives market demand was 718.5 kilo tons in 2015 and is expected to reach 1,085.2 kilo tons by 2024, growing at a CAGR of 4.7% from 2016 to 2024.The global virgin coconut oil market captured significant revenue in 2016 and is expected to expand at a CAGR of around 11% over the forecast period. Virgin coconut oil is predicted to experience high demand from consumers with higher health

consciousness and as well as aging population. Corn oil market has been segmented on the basis of Edible and non-edible corn oil. Among both of these segments non edible segment is expected to show robust growth over the forecast period. This is supported by the reason that corn oil is highly environmentally friendly product as it has lowest rating for carbon intensity as compared to other biodiesel feed stocks which is driving the segment

growth. Increasing consumption of corn oil as a biodiesel alternative in order to reduce carbon footprint is expected to support the demand of corn oil during the forecast period. Moreover, increasing government regulation especially important in states with low carbon fuels standards such as California is further expected to support the market demand. The Indian olive oil market is projected to expand

at a healthy CAGR through 2025, owing to increasing consumer awareness on the advantages of olive oil for health. Olive oil is considered to be a healthy and nutritional product that contains antioxidants and other medicinal components beneficial for the human heart, liver, and breast.

The global market for olive oil is experiencing a considerable growth owing to the rising consumer awareness about the many benefits of consuming olive oil and strong economic growth. Western lifestyle is being increasingly adopted by the population of developed nations. This is credited to be one of the biggest factors driving the global olive oil market.

Mahua Oil

Mahua is a tropical fruit. It is found in the month of April - July or August - September. It is a fleshy green, yellowish or orange brown when ripe, 2.5 to 5 cm long, 1-4 shining seeds. Its total mass content 70% in seed, two kernels in a seed. 2.5 cm X 1.75 cm, oil content 46% in latatolia and 55% in longitolia which are smaller in size.

Castor Oil & its Derivatives

Castor oil and its derivatives are products of good commercial significance with advancement and new innovation in the field or medicines and allied fields. The demand of these products increasing day by day and their popularity is increasing at a rapid pace.

Turkey Red Oil

Turkey red oil which are also known as sulphonated castor oil in the trade is the oldest textile finishing agent. This oil should contain the minimum of free Sulphur trioxide. Turkey red oil essentially an intimate mixture of pigments, oil varnishes, driers and

frequently waxy or greasy compounds. The ink must possess suitable physical characteristics such as viscosity, length and stock on which it is to be used...

Eucalyptus Oil

Eucalyptus oil is obtained by the distillation of leaves and terminal branch lets of Eucalyptusb globulies (Blue Gum Tree). The oils obtained by the steam distillation of leaves and terminal branches of various species are distinctive incharacter. Australia is the largest producer of eucalyptus oils. About two thirds of the world's supply of medicinal oil and third of industrial oil come from that country.

Coconut Oil from Copra

Coconut oil, also known as coconut butter, is a tropical oil with many applications. It is extracted from copra (derived from Malayalam

word "kopra" which means dried coconut). Coconut oil constitutes seven percent of the total export income of the Philippines, the world's largest exporter of the product.

Vanaspati Ghee

The synthetic fats are known in India by different names such as Vanaspati, Dalda Ghee, and Hydrogenated Oil etc. Perhaps because vanaspati ghee is manufactured with vegetable oils and there is not much change in the components of vegetable oil after it has undergone the process of refining and hydrogenation, the name Vanaspati has been given to this refined oil.

Black Pepper Oil

The trade distinguishes between two principal types of pepper, viz., the black and the white both derived from the same plant piper nigrum L. (fam. Piperaceae), a climbing or trailing vine like shrub native to southern India. Black pepper is the dried whole unripe fruit of this plant. Pepper is one of the most important and oldest spices.

Edible Corn Oil

Edible corn oil is manufactured from maize, wheat and other corn's beaving oil by solvent extraction process. Corn generally contains 3-6% oil in its total constituents. There are several stages required for the production of refined corn oil. In India there are few manufacturers of corn oil even it can be told there is no manufacturer. There is

well oil technologist available in India who can supply the proper technology of corn oil extraction. There is environmental pollution problem arise which can be solved by proper treatment….

Light Liquid Paraffin Oil

Light Liquid Paraffin Oil IP is highly purified mixture of liquid saturated hydrocarbons obtained from petroleum and is highly paraffinic in nature. Light Liquid Paraffin oil is transparent, & free from fluorescence in day light. It is colorless, tasteless, and odorless when cold

Neem Oil

Azadirachta indica (Neem) tree belongs to the Melia ceae family. It is a multipurpose and an evergreen tree, 12'18 m tall, which can grow in almost all kinds of soil including clay, saline alkaline, dry, stony, shallow soils and even on solid having high calcareous soil. It is native to India, Pakistan, Sri Lanka, Burma, Malaya, Indonesia, Japan, and the tropical regions of Australia.

Chili Oil

Chili is an important cash crop in India. Its annual production is 8.4 lakh tones out of which only 10 per cent is being exported to other nations. The primary chemical constituents of chili fruit are (1) color (2) pungency which are chiefly responsible for export demand. The chili colour is being used as a natural colourant in food stuffs in place of synthetic dyes which are harmful.

Olive Oil

The olive is a species of small tree in the family Oleaceae and is of major agricultural importance in the Mediterranean region as the source of olive oil. Olive oil is a fat obtained from the olive (the fruit of Olea europaea; family Oleaceae), a traditional tree crop of the Mediterranean Basin. oil is produced by grinding whole olives and extracting the oil by mechanical or chemical means…

Until recently fats and oils have been in surplus, and considered a relatively low value byproduct. Only recently have energy uses of fats and oils begun to be economically viable. Food value of fats and oils is still far above the energy value of fats and oils. Industrial and technical value of fats and oils is still above the energy value of fats and oils. Animal feeds value of fats and oils tends to remain below the energy value of fats and oils.

With development of new technology oils and fats industry has undergone a number of changes and challenges that have prompted the development of new technologies, and processing techniques. Oils and fats constitute one of the major classes of food products. In fact oils and fats are almost omnipresent in food processing – whether naturally occurring in foods or added as ingredients for functional benefits and, despite the impression given by several sources to the contrary; they remain an essential part of the human diet. However, it is increasingly apparent that both the quantity and the quality of the fat consumed are vital to achieve a balanced diet. They are essential constituents of all forms of plant and animal life. Oils and fats occur naturally in many of our foods, such as dairy products, meats, poultry, and vegetable oil seeds. India is the biggest supplier of greater variety of vegetable oil and still the resources are abundant. The applications of oils are also seen in paints, varnishes and related products. Since the use of oils and fats in our daily life is very noticeable the market demands of these products are splendid.

Special efforts has been made to include all the valuable information about the oils, fats and its derivatives which integrates all aspects of food oils and fats from chemistry to food processing to nutrition. The book includes sources, utilization and classification of oil and fats followed by the next chapter that contain details in physical properties of fat and fatty acids. Exquisite reactions of fat and fatty acids are also included in the later chapter. It also focuses majorly in fractionation of fat and fatty acids, solidification, homogenization and emulsification, extraction of fats and oils from the various sources, detail application in paints, varnishes, and related products is also included. It also provides accessible, concentrated information on the composition, properties, and uses of the oils derived as the major product followed by modifications of these oils that are commercially available by means of refining, bleaching and deodorization unit with detailed manufacturing process, flow diagram and other related information of important oils, fats and their derivatives. Special content on machinery equipment photographs along with supplier details has also been included.

AGRICULTURAL WAREHOUSES WITH AGRI LOGISTICS AND COLD STORAGES PROJECTS- EHIHIBIT 24.

A warehouse describes a facility serving the purpose of storing goods. In ecommerce, warehouses are mainly used to keep items on stock to make sure the short delivery times needed can be fulfilled. Agriculture, which is the backbone of Indian economy contributes to the overall economic growth of the country and determines the standard of life for more than 50% of the Indian population. India holds the second largest agricultural land in the world with approximately 179.9 million hectares under

cultivation. The country has emerged as a major player in agriculture in the global scenario. Warehousing refers to the activities involving storage of goods on a large-scale in a systematic and orderly manner and making them available conveniently when needed. In other words, warehousing means holding or preserving goods in huge quantities from the time of their purchase or production till their actual use or sale. The agricultural warehousing and food processing industries contribute significantly to warehousing. Warehousing plays a very vital role in promoting agriculture marketing, rural banking and financing and ensuring Food Security in the county. It enables the markets to ease the pressure during harvest season and to maintain uninterrupted supply of agricultural commodities during off season. Hence, it solves the problems of glut and scarcity, which are the usual problems in agricultural marketing. Though warehousing is an independent economic activity, yet is closely linked with production, consumption and trade. Warehousing is now seen as an integral part of the supply chain where goods are not only stored for safekeeping, but also where other value processes are implemented, thereby minimizing wastage and costs. India has total agri warehousing capacity of around 91 MMT at present to store and conserve such large quantities with state agencies owning 41% of the capacity and the balance distributed among private entrepreneurs, cooperative societies, farmers, etc. Agricultural warehousing accounts for fifteen percent of the warehousing market in India and is estimated to be worth INR 8,500 crore. Indian logistics market is expected to grow at a CAGR of 12.17% by 2020 driven by the growth in the manufacturing, retail, FMCG and e-commerce sectors. In recent times, the Indian warehousing segment has evolved significantly, resulting in a gradual metamorphosis from the traditional concept of go-downs, which gradually moved to becoming modern formats of warehouses. This demand shall be driven by a combination of growing GDP, maturing industry segments, GST implementation, rising external trade and

share of organized retail. The warehousing sector has seen good growth in past few years due to various reasons. The 'Make in India' campaign ran big throughout the country encouraging enterprises to manufacture their products within India. India's exports have considerably grown, which means the volume of goods being produced locally has increased. This has also propelled the demand for warehouses. The retail business also showed exponential growth because of relaxed FDI norms. This attracted both private and foreign investment. Agricultural warehousing accounts for fifteen percent of the warehousing market in India and is estimated to be worth Rupees 8,500 crore. It is however perceived to be inadequate and unorganized. Warehousing in India has been linked to food security and agricultural growth. Warehousing is now seen as an integral part of the supply chain where goods are not only stored for safekeeping, but also where other value processes are implemented, thereby minimizing wastage and costs. The warehousing market in India is anticipated to grow at a CAGR of ~% from USD ~ billion in FY'2014 to USD ~ billion in FY'2019. This significant growth in warehousing revenue receipts would be due to the major growth in the organized

retail industry, commodity markets, and growth in industrial manufacturing and development.

Cold Storage

India is the largest producer of fruits and second largest producer of vegetables in the world. Cold food storage is the most basic food preservation method. The cold storage facilities now available are mostly for a single commodity like potato, orange, apple, grapes, pomegranates, flowers, etc. which results in poor capacity utilization. A cold storage is a temperature-controlled supply chain network, with storage and distribution activities carried out in a manner such that the temperature of a product is maintained in a specified range, needed to keep it fresh and edible for a much longer period than in normal ambient conditions. This system facilitates long distance transport of various products as well as makes seasonal products available over the entire year. Requirement of cold storage in the next five years may be in excess of 12 lakh tonnes. India has seen a dramatic increase in the production of perishable products including fruits, vegetables, meat, poultry and dairy. It ranks first in global milk production with an annual rate of 138 million tons – and hosts more than 50% of milk product processing. With vegetable production of 280.4 million tons, it ranks second globally and only hosts 6% of total processing. There has also been steady growth in the fish and meat industries due to export potential. Current cold storage capacity in India totals 31.8 million tons. Growth has averaged 3 to 4% over the past 10 years, and 10.5 million tons of space was created in the last seven years. Ownership is mainly in the private sector, with the public and

cooperative sectors only comprising 10% of capacity. The sector's value is estimated at $6.5 billion (USD) and market growth has averaged between 15 to 20%. This pace is expected to be consistent over the next five years. Currently, India has 6,300 cold storage facilities unevenly spread across the country, with an installed capacity of 30.11 million metric ton. These are mostly used for storing potatoes. However, the market is gradually getting organized and focus towards multi-purpose cold storages is rising. More than 50% of the cold storage facilities in India are currently concentrated in Uttar Pradesh and West Bengal. Indian cold storage market is expected to grow at a CAGR of 16.09% by 2020 driven by the growth in the organized retail, Indian fast-food market, food processing industry and ecommerce sectors. Cold storage market in India is expected to be worth US$ 8.57 billion by 2020. The cold storage market in India is highly fragmented with more than 3500 players in the unorganized sector and around 30 players in the organized sector. The global cold storage market size was valued at USD 73.96 billion in 2016. The market has benefitted significantly from the stringent government regulations governing the production and supply of temperature-sensitive products. The industry is poised for unprecedented growth over the forecast period owing to growing organized retail sectors in the emerging economies. The retail sector in emerging economies, such as India and China

are increasingly getting organized. This trend among others is expected to augment the cold storage market demand over the forecast period. Government policies to de-regulate the entry of foreign player has increased the Foreign Direct Investment (FDI) in the organized retail sector. Consumers are increasingly purchasing frozen foods from the organized retail stores. With the increased demand for the chilled and frozen foods and growth of the organized retail sector the demand for the cold storage market is expected to grow over the projected period. The organized retail supports different outlet formats depending on the proximity from residential and consumption cluster and spending power. The offline mode of the organized retailing is categorized into convenience stores, supermarket, and hypermarket based on the product range and surface coverage. The market demand is expected to increase over the forecast period as refrigerated warehouse continue to get automated. The warehouse automation comprises cloud technology, robots, conveyor belts, truck loading automation, and energy management.

Project at a Glance Annexure

ANIMAL FEED – EXHIBIT 25

Our animal feed will be one of the leading third-party Veterinary Feed Supplement manufacturers in India. Animal nutrition focuses on the dietary needs of animals. These dietary needs consist of nutrients, which are the components present in the feed that animals digest and utilize.

As we will be of the leading third-party Animal feed supplement manufacturer companies, our supplements include Aqua Culture Supplements, Poultry Feed Supplements, Cattle feed Supplements, Pet Supplement, Equine Supplement, Swine Supplement & Pet Food.

The utilization of Animal Feed Supplements is for growth repairing and development and to obtain energy is called as nutrition. Nutrients include particular groups of chemical compounds like proteins, fats, carbohydrate, vitamins and minerals which are found in different food stuffs in different amounts.

We will be leading Animal Feed Supplement manufacturer in India. Animals know how to auto-regulate and they stop eating once they feel satisfied. However, if the nutrient content of a feed is very low, the consumed feed will not be enough to meet their requirements and they can suffer from malnutrition, even if fed ad libitum.

Also have a variety of Pets Supplements range & Animal Healthcare Products which make us one of the top leading Pets Supplement Manufacturer. Our product specializes in animal health and nutrition for a variety of different species including dairy, swine, poultry, companion, aquaculture, beef, small ruminants and equine which makes it one

of the top Animal Supplement manufacturers in India. Our product will also your one stop for Premium Poultry Feed Supplement Manufacturer as our products are scientifically formulated to accommodate each animal's unique nutritional needs.

Pet Supplements

We will be leading manufacturer, exporter and supplier of Pet Supplements. We have a wide range of Pet supplements which are used to increase immunity of your pet, improves their digestion, support healthy liver, support their bone health, helps to keep their skin & fur healthy. Product range includes

- Hair care supplements

- Liver tonic

- Heart Care tonic

- Immunity booster tonic

- Calcium supplements for bones

- Protein Powder for pets & more.

Pet Food

We are leading manufacturer, exporter and supplier of Pet food based in India.

We are one of the top listed pet food manufacturing companies in India.

We have different customised packaging available in a variety of delicious flavours for your Fur Baby

We have the following packaging options available.

- Can

- Pouch

- Cup

Poultry Feed Supplement

We will be leading manufacturer, exporter and supplier Poultry Feed Supplements. All poultry birds, whether broilers, layers, or breeders, require a variety of nutrients in their feed to stay healthy and productive. We have a wide range of Supplements for Poultry Nutrition which includes

- Iron Tonic

- Growth Promoters

- Liver tonic

- **Egg Enhancer**
- **Immunity Booster**
- **Feed Enzymes & Probiotics**
- **Feed Toxin Control Supplements.**

Aqua Probiotics Supplement

We will be leading exporter, supplier & Manufacturer of Aquaculture Feed Supplements. Aqua Probiotics are the probiotics for farmed fish and shrimp are beneficial bacteria that are commonly added to aquaculture systems in order to help support health, performance and growth. Support health, performance and growth of aquatic species.

It contains those microorganisms which do not let pathogenic bacteria to grow in tanks and ponds which also reduces the use of antibiotics.

Enhances water quality without water exchange, reduces nitrogenous toxicity in water, high rearing density with low feed wastage, high productivity.

Cattle Probiotics Supplement

We will be leading exporter, supplier & Manufacturer of Cattle Probiotic Supplements. Tested probiotic supplement for cattle to boost their immunity, improves their digestion system and reduces the risk of pathogenic bacteria along with increasing the yield of the products. Probiotics are added in the feed of cattle to enhance the effectiveness of the gut of the animals and improve the digestive system. They are added in very low quantities to increase the digestion of the feed and promote growth.

Poultry Probiotics Supplement

We will be leading exporter, supplier & Poultry Probiotic Manufacturer based in India. It consists of numerous strains of good bacteria which are beneficial for not only poultry but also for humans. The one of the most important benefits of using probiotic mixed feed is that they prevent the growth of pathogenic bacteria and develop immunity from within the body of poultry birds which means there is no requirement of using the antibiotic and antimicrobial agents and improve immune system along with meat quality

Millets projects. - EXHIBIT 26

1. Introduction

Traditionally fermented foods and beverages obtained from millet or millet mixed with other cereals (corn and sorghum) include koko (millet porridge), fura, mangishi, jandh, uji, burukutu, kunuzaki, ogi, and bushera. Unfermented millet-based products include dambu, masvusvu, and roti

Millet is a cereal grain that belongs to the Poaceae family, commonly known as the grass family (1). It's widely consumed in developing countries throughout Africa and Asia. While it may look like a seed, millet's nutritional profile is similar to that of sorghum and other cereals. It is rich in minerals like calcium, copper, iron, magnesium, phosphorus, potassium, and selenium as well as essential vitamins like folate, pantothenic acid, niacin, riboflavin, and Vitamins B6, C, E, and K. Many of the most powerful health benefits millet has to offer are related to its fiber content.

Millet Based Cookie

Cookie is a small flat, baked product, commonly called biscuit. Cookie usually prepared from wheat flour, eggs, sugar and fat, sometimes toppings with raisins, oats or chocolate chips. Generally,

wheat is one of the cereals used extensively throughout the world for the preparation of cookie. But cookie from non-wheat cereals like rice, jowar, maize or millet is uncommon. Recently, millets are gaining importance because they can offer several nutraceuticals, and also being rich in protein, minerals and vitamins. Its protein has a beneficial influence on the metabolism of cholesterol. Cereal or millet cookie is made from a fine flour of millet with leavening and shortenings. There exists, however considerable potential for large scale manufacture and marketing of shelf-stable product utilizing underutilized grains like proso or foxtail millet as the demand for ready-to-eat convenience food products has been steadily increasing, consequent to industrialization.

2. Market Demand

The global millet consumption expected to witness positive movement during the forecast period. India, Niger, and China are the largest producers of millet in the world, accounting for more than 55% of global production. For many years, India was the world's major producer of millet. However, in recent years, millet production has increased dramatically in Africa. The global millet production was estimated at 27.8 million tons. India is the largest global producer with a 41.0% global market share. In the last two decades, the importance of millet as food staples, particularly in India, has been declining due to various factors, including rising incomes, growing urbanization, and government policies. More than 50% of the millet production is currently finding its way into alternative uses as opposed to its consumption only as a staple. Due to COVID-19 issues in across the world the demand of nutrition based foods are having good demand, thus the millet based food industry will shine significantly.

3. Energy Conservation:

General precautions for saving electricity are followed by the unit by providing energy meter. These products are low energy consumption. Thus, considerable energy could be saved during manufacturing activities

THERE ARE 154 VARITIES

Sorghum-43

Pearl Millet -52

Little Millet-11

Proso Millet-4

Kodo Millet-4

Finger Millet-28

Foxtail Millet-8

Barnyard Millet-4

The Millet Revival Project is our modest attempt to demystify cooking with millets, and learn the impact that it has on our ecology. This initiative aims to facilitate the gradual incorporation of millets into our diets, as well as create a space for meaningful engagement so that we can tap into the resilience of millets while also rediscovering its taste.

The Millet Revival Project 2023 is our modest attempt to demystify cooking with millets, and relearn the impact that it has on our ecology. This initiative aims to facilitate gradual incorporation of millets into our diets, as well as create a space for meaningful conversation and engagement so that we can tap into the resilience of millets while also rediscovering its taste.

We hope to help you learn more about each millet, figure out different ways of cooking them, and also look into your own culinary heritage (are there any millet recipes in your family?). That's not all. In a world that is grappling with the climate crisis, it is crucial for us to consider and incorporate sustainable food choices in our lives.

Millets are resilient in numerous ways—they require less water, will grow in high and low altitudes, and are more tolerant of heat—which makes them ideal to grow, and also include them in a future in which no one goes hungry. Millets are better for you, better for the farmer and soil, and better for our planet!

The Purpose

The Millet Revival Project, led by The Locavore in association with the Rainmatter Foundation, sets out to —

Bring more millets onto people's plates in delicious and balanced ways, and help consumers understand what this means for their bodies, the farmers who grow it, and the environment around them.

Study and document the diversity of millets across different regions in India, and the impact that growing and consuming it has on our planet.

Create a digital repository that makes it easy for people to find those working in the millet space: information regarding consumer brands, farmers, restaurants, and experts.

Millet Revival Project: First Phase, Jan-May 2023

So, how will we put these objectives into action? Here's our plan for the 1st phase of this extensive project, and it takes many shapes and forms:

1. Millet Cooking Lab

Profiling millets across India, this virtual kitchen lab will create a collection of millet-based recipes which are creative and interesting but also easy to cook. The recipes will also be tested to observe how different millets react to a variety of cooking methods. But the main idea of the lab? To encourage people to incorporate millets into their meals, in interesting and delicious ways.

2. Millet Climate & Policy Lab

Can eating millets impact our climate? Our team of researchers and volunteers will facilitate and promote a nuanced understanding of how millets—known to be climate-smart—can help tackle the climate crisis.

3. Millet Resource Bank

Want to find out about all the work in India around millets? Our open-access repository lists and gathers details from various efforts across India focussed on promoting, distributing, and making millets more accessible. This evolving bank will include producers, consumer brands, environmental organisations, restaurants, and anyone who is doing significant work in the millet space.

Know anyone who is doing amazing work to promote millets, and isn't already featured in our bank? Contribute by filling out this Millet Resource Bank form.

4. Millet Stories

Examining the past, present and future of millets, The Locavore will publish stories that explore the various aspects of this hardy grain—its history in India, our culinary knowledge of it, experiences from those who grow and advocate it, and its ties to our environment and the ongoing climate crisis. These will be features, interviews, photo essays, recipes, and more.

5. Events, Online Workshops, and Conversations With Experts

We're keen that the knowledge that we acquire through the project, especially through our labs, is passed on to others as well. Our online workshops will be designed to demystify cooking with millets, and yes, there will be demonstrations by expert chefs!

Since the project also looks at the larger context in which millet is placed, our Beyond the Plate sessions with millet experts will address its various other aspects like its impact on the climate, history in India, and farmer livelihoods. In the past, Beyond the Plate has dealt with themes like identity, caste, mental health, and seafood sustainability.

The Locavore is kicking things off with what promises to be an exciting Millet Meetup in Mumbai in March. Register to attend this event by signing up via this Millet Meetup form. Only limited seats are available, so sign up quickly!

6. Collaborations with the F&B Industry

MIXED MILLET DOSA AT PREMS GRAAMA BHOJANAM, CHENNAI

Restaurants, hotels and other F&B outlets hold a lot of power when it comes to shaping people's perceptions and choices. In the case of millets, we see so much potential if consumers are able to taste these in an atmosphere that inspires curiosity and adventure. Not to forget, when millets are presented to them in tasty and memorable ways. We're looking to collaborate with dynamic restaurants and chefs who not only enjoy creative challenges, but are also interested in bringing millets into their kitchens.

If you are a restaurant, cafe or F&B outlet in India that already incorporates millets on your menu, we'd love to add you to our repository. You just have to fill this Millet Resource Bank form!

Future Phases of the Millet Revival Project and What Else to Expect

In subsequent phases of this project later this year, we're also planning a bunch of other fun engagements like putting together an extensive Indian Millet Cookbook, collaborating with a microbrewery to highlight millets through beers, and hosting a larger Millet Festival event later this year!

27) Ethanol projects- EXHIBIT 27

Production of biofuels from renewable feedstocks has captured considerable scientific attention since they could be used to supply energy and alternative fuels. Bioethanol is one of the most interesting biofuels due to its positive impact on the environment. Currently, it is mostly produced from sugar- and starch-containing raw materials. However, various available types of lignocellulosic biomass such as agricultural and forestry residues, and herbaceous energy crops could serve as feedstocks for the production of bioethanol, energy, heat and value-added chemicals. Lignocellulose is a complex mixture of carbohydrates that needs an efficient pretreatment to make accessible pathways to enzymes for the production of fermentable sugars, which after hydrolysis are fermented into ethanol. Despite technical and economic difficulties, renewable lignocellulosic raw materials represent low-cost feedstocks that do not compete with the food and feed chain, thereby stimulating the sustainability. Different bioprocess operational modes were developed for bioethanol production from renewable raw materials. Furthermore, alternative bioethanol separation and purification processes have also been intensively developed. This paper deals with recent trends in the bioethanol production as a fuel from different renewable raw materials as well as with its separation and purification processes.

Biorefinery and Bioethanol Production

Fossil resources are still primary energy and chemical sources; around 75% is used for heat and energy production, about 20% as fuel, and just a few percent for the production of chemicals and materials. Natural regeneration of fossil resources through the carbon cycle is significantly slower than their current rate of exploitation. A small number of countries possess the major reserves of fossil fuels, which additionally increases unsustainability of their production. Furthermore, increased greenhouse gas emission arises from fossil fuel combustion and land-use change as a result of human activities, and consequently results in an acceleration of the global warming crisis. In most developed countries, governments stimulate the use of renewable energies and resources with following major goals:

- **(i) to secure access to energy,**
- **(ii) to mitigate climate changes,**
- **(iii) to develop/maintain agricultural activities and**
- **(iv) to ensure food safety. Affordable energy, climate change and social stability, as the three pillars of sustainability, are directly related to the above-mentioned major goals. Current situation of global warming and all fossil-based problems could be successfully altered by replacing fossil with renewable resources, which are more uniformly distributed and cause fewer environmental and social concerns.**

During the last decades of the 20th century, there was an enormous interest in the production and usage of liquid biofuels (biodiesel or bioethanol) as promising substitutes for fossil fuels. Biofuels manufactured from plant-based biomass represent renewable energy resources. The use of this feedstock would reduce fossil fuel consumption and consequently the negative impact on the environment. Development of biorefinery aims to fulfil the sustainability criteria for biofuel production. Biorefinery is an integrative and multifunctional concept that uses biomass for the sustainable production of different intermediates and products as well as the complete possible use of all feedstock components. The concept includes selective transformation of the different molecules available in the biomass into biofuels, but also into pharmaceuticals, pulp, paper, polymers and other chemicals, as well as food or cattle feed. A wide range of technologies are able to separate biomass resources into their building blocks, like carbohydrates, proteins, fats, etc.. The plant that produces lignocellulose-containing raw materials could be a good example of biorefinery concept where cellulose and hemicellulose produce simple (fermentable) sugars and lignin produces target compounds (e.g. polymers, resins, pesticides, levulinic acid and other materials). Recently, there have been considerable efforts to improve selectivity and efficiency of lignin depolymerization and upgrading processes for the target compound production. The catalytic hydrodeoxygenation process is the most promising way for target compound production from lignin.

In general, the biorefinery process usually comprises the following stages: pretreatment and preparation of biomass, separation of biomass components and subsequent conversion and product purification steps. There are two basic approaches for biorefinery concept implementation: bottom-up and top-down. Bottom-up biorefinery approach is characterized by the spreading of current biomass processing facilities (the production of only one or a few products) into a biorefinery with the aim to obtain an enlarged range of products and/or an increase of usable biomass fractions through the connection to additional technologies. An example of bottom-up biorefinery is the wheat and corn starch biorefinery (Lestrem, France) that starts as a simple starch factory. It gradually expanded the number of products, like starch derivatives and starch modifications, chemicals and fermentation products. A corn starch biorefinery in the USA (Decatur, Illinois) and wood lignocellulosic biorefineries in Austria (Lenzing) and Norway (Sarpsborg) also use bottom-up approach.

The new top-down approach is a highly integrated system established for the use of various biomass fractions and generation of different products for the market (zero-waste generation). The objective is to obtain the complete use of biomass (e.g. wood lignocellulose, grain and straw from cereals or green grasses). An example of top-down approach is Austrian Green Biorefinery. It uses green grass silage as feedstock

for the production of biobased products like proteins, lactic acid, fibres and biogas from the remaining biomass. Furthermore, green grass juice and silage juice (complex nitrogen and phosphate sources) served as cultivation medium constituents for growth and polyhydroxyalkanoate production by Wautersia eutropha. Top-down biorefineries are still at the research and development stages and their demonstration plants are mainly based in the USA, Europe and some other industrialized countries.

However, both biorefinery concepts still need a lot of engagement to fulfil all requirements for production of high- -quality biofuels, value-added chemicals or other products, mainly in terms of the optimisation and upgrading of existing conversion processes, development of new processes and products with justified costs, and the industrial scale-up of existing ideas.

Bioethanol, as an alternative to the fossil fuels, is mainly produced by yeast fermentation from different feedstocks. It is a high octane number fuel and its physicochemical features are considerably different compared to the gasoline.

Bioethanol serves mostly in the transport sector as a constituent of mixture with gasoline or as octane increaser (ethyl tertiary butyl ether (ETBE), consisting of 45% per volume bioethanol and 55% per volume of isobutylene). Many countries use ETBE instead of methyl tertiary butyl ether (MTBE), which serves for octane number increase, but it is prohibited in the USA and Canada due to cancerous emissions. Bioethanol is mixed with gasoline at the volume fractions of 5, 10 and 85% (fuel names E5-E85). A total of 85% bioethanol by volume can only be used in flexible fuel vehicles (FFV), while mixtures of 5 and 10% by volume can be used without any engine modifications. However, problems related to the use of bioethanol are: corrosive effect on fuel injector and electric fuel pump (bioethanol is hygroscopic in nature), engine startup problem in cold weather conditions (pure ethanol is hard to vaporize) and the tribological effect on lubricant properties and engine performance. Bioethanol inside lubricant significantly reduces the properties and performance of engine oil. It is miscible with water, but immiscible with oil. Therefore, bioethanol has high potential for emulsion formation (bioethanol-water-oil mixture), which causes serious engine failures. There are different methods to improve the performance of engines (e.g. laser texturing, coatings, mass reduction of engine parts and lubricant composition) and extend their lifetime through the friction and wear reduction. The use of synthetic oil is one possibility to solve the above-mentioned issues.

Data for 2016 show that the global bioethanol production was 100.2 billion litres. Annual bioethanol production is constantly increasing, and the prediction of worldwide bioethanol production and its consumption is an increase to nearly 134.5 billion litres by 2024.

Raw Materials and Their Pretreatment for Bioethanol Production

Different types of biomass have a potential as raw materials for bioethanol production. Because of their chemical composition, i.e. carbohydrate sources, they mostly form three groups: (i) sugar-containing raw materials: sugar beet, sugarcane, molasses, whey, sweet sorghum, (ii) starch-containing feedstocks: grains such as corn, wheat, root crops such as cassava, and (iii) lignocellulosic biomass: straw, agricultural waste, crop and wood residues. However, these sugar- and starch-containing feedstocks (first generation) compete with their use as food or feed, thus influencing their supply. Therefore, lignocellulosic biomass (second generation) represents an alternative feedstock for bioethanol production due to its low cost, availability, wide distribution and it is not competitive with food and feed crops.

Raw materials that contain sugar

Sugar cane and beet are the most important sugar-producing plants in the world. Two-thirds of the world sugar production are from sugar cane and one-third is from sugar beet. They can be easily hydrolysed by the enzyme invertase, which is synthesed by most Saccharomyces species. Therefore, the pretreatment is not required for bioethanol production from the feedstocks containing sugar (sucrose), which makes this bioprocess more feasible than from feedstocks containing starch. Sugar crops need only a milling process for the extraction of sugars to fermentation medium, and here ethanol can be produced directly from juice or molasses.

Sugar cane as a raw material for bioethanol production provides certain advantages, since it is a semi-perennial crop that does not require many agricultural operations that are usually needed for raw crop processing, and its biomass is used for heat and electricity. Sugar cane is less expensive than other raw materials used for bioethanol production due to easier processing and higher productivity. However, many efforts still aim at the improvement of bioethanol production from sugarcane. This includes development of new sugar cane varieties with higher sugar contents and resistance to diseases, larger yield per hectare and greater longevity.

In Europe, sugar production is mainly based on the use of sugar beet as raw material. Raw, thin and thick juice, as intermediate formed during sugar beet processing, as well as high purity crystal sugar, could be converted into bioethanol and/or bio-based products. Raw sugar beet cossettes are also suitable substrates for bioethanol production. The use of sugar processing intermediates determines bioprocess configuration, their microbiological stability and transport properties. Sugar syrup and granulated sugar can serve as substrates for bioethanol production during the whole

year. Futhermore, they can also serve as precursors for different chemical intermediates or final products (e.g. surfactants; 8).

Molasses, a main byproduct of the sugar industry, serves mostly as a substrate for yeast, bioethanol and biochemical production, but it can also be suitable for feedstuff production. Total residual sugars in molasses can amount to 50–60% (m/V), of which about 60% is sucrose, which makes this substrate suitable for large-scale bioethanol production. Sugar cane and beet molasses are byproducts of the manufacture or refining of sucrose from sugar cane and beet. Cane molasses contains not less than 46% of total sugars and sugar beet molasses not less than 48% (m/V). Molasses is also a byproduct in the production of dried citrus pulp, with not less than 45% (m/V) total sugars. Glucose manufacture from starch (corn or grain sorghum; enzymes or acids are used for starch hydrolysis) also yields molasses. Starch molasses contains about 43% (m/V) reducing sugars and 73% (m/V) total solids.

Another sugar-containing material that can be used for bioethanol production is whey, a byproduct of cheese manufacture, containing around 4.9% (m/V) lactose. Due to the relatively low sugar content, a bioethanol plant of modest size requires a sizeable whey volume. The feasibility of a new bioethanol plant depends on the cost of whey permeate as feedstock as well as the final bioethanol price that is closely related to the production technology and bioprocess performance.

Raw materials that contain starch

Grain crops (e.g. corn, barley, wheat or grain sorghum) and root/tubular crops (e.g. cassava, potato, sweet potato, Jerusalem artichoke, cactus or arrowroot) contain large quantities of starch. Isolated native starch from different sources can be used for further conversion into bio-based products and/or the bioethanol production. The residue from starch isolation contains proteins and fibre, which has a great potential for application in food and feed production. The biggest corn starch production is in the USA and it represents more than 80% of the worldwide market. In the USA, corn is a source of over 95% of bioethanol production and the rest is produced from barley, wheat, whey and beverage residues. The grain sorghum cultivating regions in the USA show an increasing interest in bioethanol production from this crop. Furthermore, the economic viability of bioethanol production from cassava in Thailand was also under investigation. Cassava tubers contain nearly 80% by mass starch and below 1.5% by mass proteins. Pretreatment of cassava tubers for bioethanol production includes following operations: cleaning, peeling, chipping and drying. After that, the dried cassava chips are used for bioethanol production.

Starch is a mixture of linear (amylose) and branched (amylopectin) polyglucans. The crucial enzyme for starch hydrolysis is α-amylase, active on α-1,4, but not on α-1,6 linkages in amylopectin. For bioethanol production from starch-containing feedstocks, it is necessary to perform the starch hydrolysis (mostly by α-amylase and glucoamylase) into glucose syrup, which can be converted into ethanol by yeast Saccharomyces cerevisiae. This step is an additional cost compared to the bioethanol production from sugar-containing feedstocks. Bacterium Bacillus licheniformis and genetically modified strains of bacterium Escherichia coli and Bacillus subtilis produce α-amylase, while moulds Aspergillus niger and Rhizopus sp. produce glucoamylases.

Under anaerobic conditions, yeast S. cerevisiae metabolizes glucose into ethanol. The maximum conversion efficiency of glucose into ethanol is 51% by mass. However, the yeast also uses glucose for cell growth and synthesis of other metabolic products, thus reducing the maximum conversion efficiency. In practice, 40 to 48% by mass of glucose is actually converted into ethanol.

In comparison to ethanol production from sugar-containing raw materials, ethanol obtained from starch improves enzyme application and yeast strains with high ethanol tolerance.

Microalgae are a potential renewable source of biomass for biofuel production because they are capable of converting CO2 into lipids and polysaccharides. Therefore, industrial CO2 could be collected and used for cultivation of microalgae as part of strategy for reduction of CO2 emission in atmosphere. Microalgae can accumulate starch as a reserve polysaccharide, which can be used for bioethanol production (third generation) after pretreatment process. Furthermore, residual biomass (containing organic matter and minerals) after bioethanol production can serve as biofertilizer. Thus, it is obvious that the use of biorefinery concept can considerably improve bioethanol production from microalgae.

Raw materials that contain lignocellulose

Production of bioethanol from the raw materials that contain lignocellulose is attractive and sustainable because lignocellulosic biomass is renewable and non-competitive with food crops. Furthermore, the use of bioethanol obtained from lignocellulosic biomass is related to the considerable reduction of greenhouse gas emission. Lignocellulosic biomass is almost equally distributed on the Earth, compared to the fossil resources, which provides security of supply by using domestic energy sources. It can be obtained from different residues or directly harvested from forest and its price is usually lower than of sugar- or starch-containing feedstocks, which

require full agricultural breeding approach. Raw materials that contain lignocellulose for bioethanol production form six main groups: crop residues (cane and sweet sorghum bagasse, corn stover, different straw types, rice hulls, olive stones and pulp), hardwood (aspen, poplar), softwood (pine, spruce), cellulose wastes (e.g. waste paper and recycled paper sludge), herbaceous biomass (alfalfa hay, switchgrass and other types of grasses) and municipal solid wastes.

The average lignocellulosic biomass contains 43% cellulose, 27% lignin, 20% hemicellulose and 10% other components. Compositional variety of lignocellulosic biomass could be an advantage (availability of more products than obtained in petroleum refineries, and a broader range of feedstocks), but also a disadvantage (need for a large range of technologies). Such heterogeneous structure of lignocellulosic biomass requires more complex chemical processes than uniform and consistent raw materials needed in chemical industry. Furthermore, harvesting of lignocellulosic crops is usually not possible throughout the whole year, which makes it more difficult for biomass suppliers. Therefore, this problem has to be solved by biomass stabilization in order to be available for long-term storage, and to ensure continuous work of biorefinery throughout the year.

The hydrolysis of lignocellulosic biomass to monomeric sugars is necessary before microorganisms can metabolize them. Acids, alkalines or enzymes usually perform this process. Physicochemical, structural and compositional factors can considerably slow down this process. Therefore, alkaline pretreatment step is usually necessary to obtain conditions for an efficient enzymatic hydrolysis. In the pretreatment, reduction of polymerization degree and crystallinity index, disruption of the lignin-carbohydrate linkages, removal of lignin and hemicelluloses and increase of material porosity have to occur in order to insure the efficient enzymatic hydrolysis of lignocellulosic biomass. The choice of pretreatment depends on the nature of the raw material and the formation of byproducts during the selected pretreatment, and its choice has a large impact on all subsequent stages in the bioethanol production.

Harsh conditions used during pretreatments lead to the synthesis of toxic compounds, like furans (2-furaldehyde (furfural) and 5-hydroxymethylfurfural (HMF)), carboxylic acids (acetic, formic and levulinic acids) and phenolic compounds (aldehydes, ketones, p-coumaric and ferulic acids). Because these compounds are potential yeast inhibitors, following strategies (to reduce their impact on the bioprocess performance) were proposed: (i) removal of inhibitors by solvent extraction, ion exchange, overliming, usage of zeolites, or enzyme laccase, (ii) use of yeast strains very tolerant to inhibitors, and (iii) selection of effective pretreatment that causes minimal sugar degradation and formation of inhibitors. Most detoxification methods only partially remove inhibitors, but they also contribute to the sugar loss, which additionally enlarges the final process

costs. Recently, lignite served as adsorbent for detoxification of spurce sawdust hydrolyzates in the production of polyhydroxyalkanoates (PHA) by Burkholderia cepacia and Burkholderia sacchari. The use of lignite instead of activated carbon in detoxification is less efficient in the removal of inhibitors, but has a greater positive impact on the bacterial growth and PHA yield. Furthermore, lignite is a considerably cheaper adsorbent than activated carbon, which can improve bioprocess economic feasibility. Lignite used in detoxification can partially compensate for fermentation heat and energy demands.

Pretreatment methods could be basically divided in four main groups (physical, chemical, physicochemical and biological), where not all of the given methods are fully feasible for application on industrial scale.

Physical pretreatment of raw materials that contain lignocellulose

Physical (mechanical) pretreatment includes milling (e.g. two-roll milling, ball or hammer milling and colloid or vibroenergy milling), irradiation (gamma ray, electron beam, microwave) and other (e.g. hydrothermal, expansion, extrusion or pyrolysis) methods. After physical pretreatments, the reduction in particle size and crystallinity of lignocellulosic biomass has an impact on the increase of specific surface area and reduction of the degree of polymerization. However, the particle size has to be optimized (very small particles are not desirable) because of high energy consumption during milling and negative impact on the pretreatment. Many of the mentioned size-reduction physical methods are not economically feasible due to the very high energy demands. Extrusion is a new and prospective physical pretreatment for biomass conversion into fermentable sugars. The capacity to ensure high shear rate, rapid heat transfer and effective mixing are the main extruder advantages. Yoo et al. employed extrusion as pretreatment for conversion of soybean hulls to fermentable sugars, and compared it with two traditional pretreatments using dilute acid (1% by mass H2SO4) and alkali (1% by mass NaOH). Under optimal conditions the authors revealed the highest cellulose to glucose conversion of 95% by mass.

Chemical pretreatment of raw materials that contain lignocellulose

Chemical pretreatments include acid (sulfuric, hydrochloric, phosphoric or nitric acid), alkali (sodium or potassium hydroxide, ammonia or ammonium sulfite), or gas treatment (chlorine dioxide, nitrogen dioxide or sulfur dioxide) as well as addition of oxidizing agents (oxygen, ozone, hydrogen peroxide), ionic liquids (imidazolium-based ionic liquids) and organosolv (methanol, ethanol, acetone, glycerol, ethylene glycol, etc.).

The main goal of employing acid pretreatment is to solubilize the hemicellulose, making the cellulose more accessible to enzymes. Acid pretreatments use concentrated or diluted acids. However, concentrated acids (H_2SO_4 or HCl) are good hydrolysis agents with corrosive and hazardous characteristics. The main disadvantage of acid hydrolysis is formation of inhibitors, since released fermentable sugars can be decomposed into furfural (from pentoses) and HMF (from hexoses). These compounds are yeast cell growth inhibitors which have negative impact on the bioethanol production efficiency (e.g. reduced yeast growth, ethanol yield and productivity).

For alkaline pretreatment of lignocellulosic raw materials, NaOH, KOH, $Ca(OH)_2$ and NH_4OH are used most often. In this pretreatment lower temperature and pressure than in the other pretreatment methods are applied. Alkaline pretreatment increases cellulose digestibility and it is more effective for lignin solubilisation. However, high cost of alkalis is one of the major drawbacks. In a study of Cheng et al., both $Ca(OH)_2$ pretreatment (at 95 °C) and NaOH pretreatment (at 55 °C) significantly improved delignification of rice straw. Ozonolysis reduces lignin content (hemicellulose is slightly affected, while cellulose is not), and does not produce toxic residues, but larger ozone demands makes this method very expensive. Wheat and rye straw, cotton straw, bagasse and poplar, sugarcane bagasse and straw have been pretreated by ozone in order to examine the features of this pretreatment method.

The use of ionic liquids (ILs), salts usually composed of large organic cations and small inorganic anions, as solvents for lignocellulosic feedstocks pretreatment has also been intensively studied. ILs have a capacity to break the extensive hydrogen bonds in the polysaccharides and to stimulate their solubilization. They are characterized by thermal and chemical stability, nonflammability, wide liquid temperature range and good solvation features for various materials. ILs are known as "green" solvents due to the fact that during their use toxic or explosive gases are not formed. During ILs pretreatment of switchgrass, significant increase of the enzymatic saccharification of xylan (63% xylose yield in 24 h) and cellulose (96% glucose yield in 24 h) was observed. Combined method that uses ILs and ammonia was examined for rice straw pretreatment. Obtained results show that 82% of the cellulose from rice straw was recovered with 97% of the glucose conversion, significantly higher than the individual ammonia or ILs treatments. Pretreatment of wheat straw by using IL ([emim][CH_3COO]) resulted in high purity cellulose and hemicellulose fractions as well as 87% pure lignin.

The organosolv is based on the use of organic or aqueous solvents (e.g. ethanol, methanol, acetone and ethylene glycol) to extract lignin and to ensure more accessible cellulose. In this pretreatment solvents are mixed with water in various portions, added to the biomass and heated (100–250 °C). However, solvents need to be drained from

the reactor, evaporated, condensed and recycled, which makes the pretreatment costs relatively high. Organosolv extraction of sugarcane bagasse under optimized conditions (30% by volume ethanol at 195 °C for 60 min) results in the production of 29.1% by mass of fermentable sugars. Sun and Chen studied the organosolv (glycerol-based) pretreatment of wheat straw. Under optimized conditions (liquid-solid ratio of 20 g/g at 220 °C for 3 h) 70% by mass hemicelluloses and 65% by mass lignin were removed from the lignocellulose-containing raw materials.

Physicochemical pretreatment of raw materials that contain lignocellulose

Physicochemical pretreatments include wet oxidation, explosion (steam explosion, ammonia fibre explosion, CO2 explosion, SO2 explosion), microwave, ultrasound and liquid hot water pretreatment. The steam explosion consists in the treatment of ground biomass with high-pressure saturated steam and then the pressure is quickly released, which causes an explosive decompression of biomass. It usually starts at 160–260 °C (corresponding pressure of 0.69–4.83 MPa) for a short time (several seconds to a few minutes) before the biomass is exposed to atmospheric pressure. During this pretreatment hemicellulose and lignin are degraded. This pretreatment is cost effective, but it also destroys a portion of the xylan fraction. During steam explosion incomplete disruption of lignin-carbohydrate matrix and generation of microbial inhibitors also occurred. Sugar cane bagasse was treated by steam explosion at 200, 215 and 230 °C for 5 min in the simultaneous saccharification and fermentation process of bioethanol production. The optimum pretreatment conditions (215 °C for 5 min) resulted in a total glucose yield of 86.8% by mass. Ammonia fibre explosion (AFEX) is an important pretreatment that utilizes physical (high temperature and pressure) and chemical (ammonia) processes to achieve effective feedstock hydrolysis. AFEX increases the surface accessibility for hydrolysis, promotes cellulose decrystallization and partial hemicellulose depolymerization and reduces lignin recalcitrance in the treated feedstock. However, this process is not efficient for biomass with high lignin content. Lau et al. studied AFEX pretreatment and enzymatic hydrolysis of empty palm fruit bunch fibre (EPFBF), obtained from palm processing industry. The optimal conditions were: 135 °C, 45 min residence time, water to dry biomass loading of 1:1 (g/g), and ammonia to dry biomass loading of 1:1 (g/g), giving yield of 90% by mass of the total reducing sugars after 72 h of enzymatic hydrolysis.

Supercritical fluids are gaseous substances compressed at temperatures above their critical point to a liquid-like density. Water, carbon dioxide and ammonia are the most often used substances in supercritical form. Supercritical CO2 mostly serves as an extraction solvent because it is nontoxic, noninflammable, inexpensive, and readily available, and it does not cause formation of inhibitory compounds. In supercritical CO2 explosion, the explosive release of CO2 pressure disrupts the cellulose and

hemicellulose fractions, and consequently increases the accessible surface area of the substrate for enzymes. For the sugar cane bagasse pretreatment, supercritical CO2 and ultrasound served to improve the efficiency of enzymatic hydrolysis. In the pretreatment with only supercritical CO2 the amount of fermentable sugar increased 2.8 times compared to the untreated sugar cane bagasse and consequently the efficiency of enzymatic hydrolysis was 74.2% by mass. The combined ultrasound and supercritical CO2 pretreatment increased the amount of fermentable sugars after enzymatic hydrolysis by 16% by mass compared to the pretreatment with only ultrasound. These results lead to conclusion that the combined ultrasound and supercritical CO2 pretreatment is an efficient and prospective alternative for pretreatment of lignocellulose-containing raw materials at relatively low temperatures without the use of hazardous solvents.

Sulfite pretreatment to overcome recalcitrance of lignocellulose (SPORL; 82-85) is an efficient approach in the pretreatment of woody biomass (both hardwoods and softwoods). SPORL is efficient at 160–190 °C for 10–30 min. The sulfite addition increases the medium pH value, which consequently results in the synthesis of lower quantities of fermentation inhibitors. The partial sulfonation of lignin by sulfite ensures wood softening, which considerably reduces energy demand for pretreatment. Comparison between acid-catalyzed steam explosion and SPORL shows that SPORL energy efficiency is about 30-fold higher. Enzymatic hydrolysis of softwood substrates pretreated by SPORL with enzyme loading of 15 FPU/g cellulose was approx. 95% by mass within only 48 h.

Microwaves also have application in the pretreatment of lignocellulose-containing raw materials. Many investigations have pointed out that microwaves cause localized heating of feedstock leading to disruption of lignocellulose structure, making cellulose and hemicellulose more accessible for enzymatic hydrolysis. Su et al. studied the effects of microwave treatment on the Taiwan sorghum liquor waste. Results of this research indicate that reducing sugar yield was considerably higher than of the untreated waste.

Ultrasonic treatment of solutions has a potential use as an alternative technology, and it has been used for the extraction of cellulose, hemicellulose and lignin. Ultrasonic waves create pressure differences (cavitation) within a solution for the enhancement of physical and chemical processes. Bussemaker and Zhang extensively wrote about the effect of ultrasound on the lignocellulosic biomass as pretreatment for biorefinery applications.

Biological pretreatment of raw materials that contain lignocellulose

In comparison to most of other pretreatments used, biological pretreatments are considered as environmentally friendly processes, since they do not employ chemicals, energy input is relatively low, there are no corrosion-related problems, no waste stream, and production of inhibitors is on the lowest level. In these pretreatments, microorganisms like brown, white and soft rot fungi degrade lignin and hemicellulose, but they are not effective in cellulose disruption. However, the rate of lignocellulose hydrolysis in biological processes is very low. The pretreatment of corn stover, wheat and soybean straw, switchgrass and hardwood by Ceriporiopsis subvermispora was studied by Wan and Li . After an 18-day pretreatment, C. subvermispora was capable of delignifying corn stover, switchgrass and hardwood by using enzymes manganese peroxidase and laccase. In this enzymatic hydrolysis, glucose yields were 56.50, 37.15 and 24.21% by mass, respectively, which is 2- to 3-fold higher than those observed with the untreated feedstocks. A further increase of glucose yield (by 10–30% by mass) was obtained when fungal pretreatment time was prolonged to 35 days. On the contrary, fungal pretreatment did not increase cellulose digestibility from wheat and soybean straw.

Biological pretreatment also includes the use of enzymes for hydrolysis of raw lignocellulosic materials. The overall bioprocess efficiency depends on the rate of lignocellulosic feedstock hydrolysis into fermentable sugars. Cellulases perform enzymatic hydrolysis of cellulose, so that yeasts or bacteria can then ferment the obtained reducing sugars into ethanol. In the hydrolysis of cellulose at least three major groups of cellulases take part: endoglucanases (attack regions of low crystallinity in the cellulose fibre creating free chain ends), exoglucanases (cellobiohydrolases; degrade the molecule further by removing cellobiose units from the free chain ends) and β-glucosidases (hydrolyze cellobiose to produce glucose). Enzymatic hydrolysis can be actually divided into two stages: primary and secondary. Primary hydrolysis stage involves the action of endoglucanases and exoglucanases on the surface of solid substrate, resulting in the release of oligosacharides (up to 6 glucose units in chain) into liquid phase. Secondary hydrolysis stage includes further hydrolysis of oligosacharides to cellobiose (by cellobiohydrolase) and glucose (by β-glucosidases).

The accessibility of cellulose to enzymatic hydrolysis depends on the xylan removal from lignocellulose by using xylanases. Xylan does not have the tightly packed crystalline structure like cellulose and therefore it is more susceptible to enzymatic hydrolysis. The complete hydrolysis of xylan requires the cooperative action of the following enzymes: endo-1,4-β-xylanase, β-xylosidase, α-arabinofuranosidase and α-glucuronidase. Esterases act upon the ester linkages between xylose units of the xylan and acetic acid (acetyl xylan esterase) or between arabinose side chain residues and

phenolic acids such as ferulic acid (ferulic acid esterase) and p-coumaric acid (p-coumaric acid esterase; 44). Several species of bacteria and fungi are able to produce cellulases and hemicellulases. Among these microorganisms, Trichoderma reesei was mentioned as the most efficient cellulose-hydrolysing organism.

Lignin is closely bound to cellulose and therefore it is not accessible for cellulases. The main characteristic of lignin degradation is the action of peroxidases where lignin peroxidase (also called ligninase) and manganese peroxidase (also called Mn-dependent peroxidase) are the two major enzymes. These enzymes were discovered in Phanerochaete chrysosporium and they are called true ligninases because of their high redox potential. Lignin peroxidase oxidizes nonphenolic lignin substructures (by taking out one electron) and produces cation radicals, which are further chemically degraded.

Laccase (benzenediol oxygen oxidoreductase) also takes part in the lignin degradation which is synthesized by the broad variety of white rot fungi. It has a capacity for complete lignin hydrolysis alone or in combination with other peroxidases. Laccases catalyze the oxidation of phenolic units in lignin (consequently molecular oxygen is reduced to water) as well as phenolic substances and aromatic amines to radicals. Phenolic substances (strictly related to lignin or lignin derivatives) as well as nonlignin substances and extracts from different resources stimulate lacasse synthesis.

Enzymatic hydrolysis is highly specific and it occurrs in milder reaction conditions (e.g. pH=5 and temperature below 50 °C) with lower energy consumption and environmental impact than the acid hydrolysis of lignocellulose. It also gives high glucose yield with low byproduct formation, which is favourable for further use of hydrolysate in fermentation. Enzymatic hydrolysis does not cause the corrosion problems. The final product of enzymatic hydrolysis (glucose) inhibits the enzyme activity and therefore it has to be removed immediately after formation to reduce its impact on the hydrolysis kinetics. Different approaches have been examined to reduce the glucose inhibition by hydrolysis such as the use of high enzyme concentrations, the addition of β-glucosidases during hydrolysis, and sugar removal during hydrolysis by ultrafiltration or simultaneous saccharification and fermentation (SSF; 38,96). Substrate concentration has a crucial impact on the initial rate and the yield of cellulose enzymatic hydrolysis. Increase of low substrate concentration increases yield and hydrolysis rate. Although cellulase price has been reduced more than a 10-fold in the last decades, it still represents more than 20% of bioethanol production costs from lignocellulosic feedstocks. Since cellulases remain active after hydrolysis, their recycling could be useful and economically feasible approach. Therefore, various methods for enzyme recycling (e.g. sedimentation followed by ultrafiltration or microcentrifugation, cation exchange chromatography, readsorption and immobilization) have been studied.

Bioethanol Production from Raw Materials That Contain Sugar

The most employed microorganism for bioethanol production from sugar-containing feedstocks is Saccharomyces cerevisiae due to its capacity to degrade sucrose into hexoses (glucose and fructose). The cells of S. cerevisiae require small amounts of oxygen for fatty acid and sterol synthesis during bioethanol production, so aeration is an important bioprocess parameter. S. cerevisiae does not tolerate higher sugar and salt concentrations in the medium or higher temperatures. Cane molasses media have the highest osmolarity as a consequence of medium sugar and salt concentrations, which negatively affects ethanol synthesis. Numerous studies have searched for S. cerevisiae strains with higher salt and temperature tolerance. Yeast Schizosaccharomyces pombe is also used in bioethanol production since it tolerates high osmotic pressures (high salt concentrations) and high solid content. In bioethanol production the possibility of using other microorganisms such as Zymomonas mobilis, Klebsiella oxytoca, Escherichia coli, Thermoanaerobacter ethanolicus, Pichia stipitis, Candida shehatae, Mucor indicus, etc. was also investigated. However, adequate alternative to S. cerevisiae still has not been found.

The Melle-Boinot process is the typical process for bioethanol production in batch fermentation. It consists in broth preparation (pH adjustment, 14–22% by mass) and sterilization followed by yeast fermentation. Fermented broth goes through the centrifugal separation, whereas the liquid part of the broth moves on to ethanol separation stage (usually distillation) and the yeast is recycled for the next fermentation in order to achieve higher cell concentrations.

Fed-batch process requires low initial substrate concentrations and yeast cells are separated from the broth which is then distilled. After bioreactor and broth preparation processes, separated yeast cells are usually used for a new fed-batch process of bioethanol production. This approach is the most common industrial technology in Brazil for bioethanol production because it can achieve the highest bioprocess volumetric productivity. In this bioprocess operational mode, the optimization of feeding process plays a critical role for increasing ethanol yield and productivity.

In the repeated (or multiple) batch fermentation, the use of flocculating yeast strain plays the key role. After initial batch process is finished, the yeast cells settle down (flocculate) on the bottom of the bioreactor and the clarified broth is removed. Subsequently, an equal amount of fresh broth is added to the bioreactor for the next batch, resulting in high cell concentrations and reduced ethanol inhibition. These

batches can be repeated until the activity and viability of yeast cells is lost (due to the accumulation of yeast inhibitory compounds in broth) and consequently fresh inoculum has to be prepared for system reinoculation.

Continuous bioethanol production systems usually consist of a cascade of continuous bioreactors in which ethanol inhibition is reduced. This hypothesis is based on the fact that ethanol synthesized in the first bioreactor is easily transported to the next bioreactors and consequently ethanol inhibition is diminished. Another possibility to enhance bioprocess productivity is the continuous ethanol removal from broth during the bioprocess by using vacuum or membrane systems, but this increases capital costs. In continuous systems of bioethanol production increasing air supply can improve yeast cell viability, yield and concentration. Comparison between continuous and batch bioprocesses for bioethanol production shows following advantages of continuous bioprocesess: reduced costs of bioreactor constructions, lower plant maintenance and operation costs, better bioprocess control and higher productivities.

Most of bioethanol production plants in Brazil are still employing the fed-batch operational mode because of its practical advantages on industrial scale. However, 30% of industrial facilities for bioethanol production in Brazil are using continuous bioprocess systems due to their advantages related to the higher yeast cell concentrations. Immobilization, recovery and recycling of yeast cells, or control of yeast growth can increase the yeast cell density .

The concentration of immobilized cells in continuous bioprocesses for bioethanol production is relatively high, and at higher dilution rates bioprocess can be easily controlled, which consequently results in higher bioprocess productivities. Immobilization methods can be divided into following groups: (i) reversible (or irreversible) attachment to solid surfaces, (ii) entrapment in porous matrices (e.g. gelatine, agar, calcium alginate, κ-carrageenan, chitosan and polyacrylamide), (iii) mechanical separation behind a barrier (e.g. microporous membrane filters or microcapsules), and (iv) self-aggregation of the cells by flocculation.

Yeast cell immobilization by surface adsorption is often more efficient than entrapment or mechanical separation methods. Studies of yeast cell immobilization by the surface adsorption have shown that yeast cell growth is not significantly affected, although some yeast cells can be washed out of the system. The self-flocculating yeast cells showed similar bioethanol production efficiency as observed by the yeast cells immobilized on supporting materials. Furthermore, the supporting material is not used and consequently the bioprocess is simpler and economically competitive compared to the yeast cell immobilized on the supporting materials. The yeast flocs

can be washed out from the bioreactor under controlled conditions in order to maintain the yeast concentration inside the bioreactor at constant level. Sedimentation or centrifugation can be used for yeast recovery after wash-out from bioreactor. The use of centrifugation requires higher capital investment and energy consumption costs. However, separated yeast cells can recirculate and be used in further bioethanol production cycle, and consequently bioethanol production costs are reduced.

Following bioreactor configurations were developed for the bioethanol production with self-flocculating yeast strains: air-lift bioreactors, single- or two-stage packed column bioreactors, column bioreactors coupled with or without settlers, a CO2 suspended bed fermenter with baffle plates inside and separation tanks outside or only with a separation tank for CO2 separation and recycling to suspend the yeast flocs.

In the last decades, very high gravity (VHG) bioethanol production technology has become attractive due to the considerable energy savings. The VHG technology needs relatively high substrate (270 g/L of dissolved solids or more) and final bioethanol concentration (15% by volume or more) in the broth. Increase of bioethanol broth concentration results in significant reduction of energy consumption for distillation and the amount of waste stillage. Therefore, this production technology is promising for industrial bioethanol production.

Bioethanol Production from Raw Materials that Contain Starch

There are two major processes for bioethanol production from corn starch: dry-grind (67%) and wet mill process (33%), both using yeasts (Saccharomyces cerevisiae, Saccharomyces pastorianus, Schizosaccaharomyces pombe and Kluyveromyces sp.) that are capable of metabolizing starch hydrolysates. Dry milling is often used for bioethanol production in the USA due to its lower capital and operating costs. In this process, the whole corn is milled (hammer or roller mill) and mixed with water to obtain a mash. The mash is cooked in a jet cooker at 80–90 °C for 15–20 min. During jet cooking α-amylase (relatively small amounts) is added in order to support liquefaction. Additional α-amylase is added during secondary liquefaction, which occurs for 90 min at 95 °C. After that, the mash is cooled to 60 °C and mixed with the glucoamylase to hydrolyse the starch into sugars which can be further metabolized to ethanol by yeast. Saccharification and fermentation often occur simultaneously (simultaneous saccharification and fermentation, SSF), thus reducing the enzyme levels and yeast cell inhibition by ethanol or substrates to minimum. The bioprocess usually takes place at pH=4.8–5.0 and 30 °C for 48 h. The fermented broth is then distilled to produce a 95% by volume ethanol. Dehydration of the 95% by volume ethanol requires molecular sieves in order to obtain 99.5% by volume ethanol. Centrifugation of fermentation residues (whole stillage) yields wet cake, which has to be dried to obtain distiller's

dried grains (DDG). Thin stillage is the liquid portion from centrifugation that has to be evaporated to obtain syrup. The syrup is then blended with DDG to form distiller's dried grains with solubles (DDGS). The residual part of the thin stillage is often recycled as process water.

A few modifications of dry-grind process have been introduced in order to recover corn germ or both germ and fibre before fermentation. Wet milling process produces various value-added co-products (e.g. fibre, germ, starch and gluten) before fermentation, which makes this process more economically feasible and energy efficient.

Wet milling process needs clean, steeped and degermed corn in order to obtain the germ for corn oil extraction. After that, corn is defibrated to obtain fibers, and gluten and starch are also separated. The following steps in the bioethanol production are the same as in dry-grind process: saccharification, fermentation, distillation and ethanol dehydration. Ethanol yield per kg of corn in the dry-grind process is 0.3235 and in the wet mill process 0.2919.

Among SSF and SHF (separated hydrolysis and fermentation) processes that are usually used for bioethanol production from starch-containing raw materials, the technology that incorporates the yeast propagation (from active dry yeasts) in the bioreactor during initial saccharification is also applied for bioethanol production. This technology is called simultaneous saccharification, yeast propagation and fermentation (SSYPF; 103).

Bioethanol Production from Raw Materials that Contain Lignocellulose

There has been enormous research in the biorefining area to convert lignocellulosic raw materials into fermentable sugars. Despite huge interest and adequate progress in the lignocellulosic bioethanol research and development, many challenges still need to be solved.

The most often used steps in the bioethanol production from lignocellulose-containing raw materials are: (i) pretreatment of cellulose and hemicellulose to become more accessible in the subsequent steps, (ii) acid or enzymatic hydrolysis of polysaccharides into simple sugars, (iii) microbial fermentation of the simple sugars (hexoses and pentoses) to ethanol, and (iv) separation and concentration of ethanol.

Previous section described in detail pretreatment of lignocellulosic raw materials for their use in the bioethanol production. Therefore, in this section our focus will be on the fermentation process of lignocellulosic hydrolysates. Different microorganisms are used for fermentation of glucose to ethanol, most frequently Saccharomyces cerevisiae. It is able to metabolize mono- and disaccharides (e.g. glucose, fructose, maltose and sucrose), but not pentoses (e.g. xylose and arabinose). Furthermore, S. cerevisiae is not capable of direct assimilation of cellulose and hemicellulose. The recombinant DNA technology or the pentose-fermenting microorganisms (e.g. Pichia stipitis, Pachysolen tannophilus and Candida shehatae) are used to overcome this disadvantage. These pentose-fermenting microorganisms have at least five times lower ethanol production rate than the ethanol production from glucose by S. cerevisiae. Moreover, oxygen and ethanol tolerance of these microorganisms are also 2–4 times lower. S. cerevisiae has been engineered with arabinose-metabolizing genes from yeasts such as Candida aurigiensis. Therefore, lately there have been many efforts to obtain an ideal microorganism that will be able to produce ethanol directly from any carbohydrate.

Furthermore, ethanol-producing bacteria have also attracted attention since their growth rate is substantially higher than that of the S. cerevisiae. Z. mobilis produces ethanol from glucose via the Entner-Doudoroff pathway in conjunction with the enzymes pyruvate decarboxylase and alcohol dehydrogenase. It is capable of producing ethanol with efficiency up to 97% of theoretical maximum, while S. cerevisiae with efficiency around 90 to 93%. However, the use of Z. mobilis is not feasible for the industrial bioethanol production because its fermentation pathways are oriented only to glucose, fructose and sucrose. Another disadvantage of the use of this bacterium is the levan formation observed during its fermentation of sugar cane syrup and other sucrose-based media. Levan is a polysaccharide that considerably increases the broth viscosity. Z. mobilis is also capable of reducing fructose into sorbitol, which additionally decreases the conversion efficiency of sucrose to ethanol.

On the contrary, the Gram-negative strain Zymobacter palmae is an anaerobe with a potential to metabolize hexoses, α-linked di- and trisaccharides, and sugar alcohols (fructose, galactose, glucose, mannose, maltose, melibiose, sucrose, raffinose, mannitol and sorbitol). Z. palmae produces approx. 2 mol of ethanol per mol of glucose without accumulation of byproducts, and also shows productivity similar to that of Z. mobilis.

The filamentous fungus Fusarium oxysporum is known for its ability to produce ethanol, but conversion rate is low and it produces significant acetic acid amounts as a byproduct. Other species, such as Neurospora, Monilia, Paecilomyces, Fusarium and Neocallimastix, have also been reported as ethanol-producing fungus.

In the integrated bioprocess systems, the hydrolysis and fermentation usually function as separate hydrolysis and fermentation (SHF) or simultaneous saccharification and fermentation (SSF). New integrated bioprocesses such as simultaneous saccharification and cofermentation (SSCF) and consolidated bioprocessing (CBP) have recently emerged.

SHF hydrolyzes pretreated lignocellulosic feedstock to glucose and subsequently ferments it to ethanol in separate bioreactors. After pretreatment of lignocellulosic raw materials, solid phase is separated from liquid phase, which mostly contains pentose sugars and some hexoses. After pretreatment with dilute acid, residual solid phase contains mainly lignin and cellulose. Cellulose is then hydrolyzed by the addition of cellulolytic enzymes. In SHF both hydrolysis and fermentation take place at their optimal temperatures (50 °C for hydrolysis and 28–32 °C for yeast fermentation). Suitable microorganisms perform the fermentation of hexoses and pentoses separately. The need for separate fermentations is because pentose-utilizing microorganisms metabolize pentoses and hexoses slower than microorganisms that only assimilate hexoses. Moreover, these microorganisms are also more sensitive to ethanol and inhibitors. The accumulation of released sugars (mainly glucose and cellobiose) during enzymatic hydrolysis inhibits the cellulase activity. The inhibitory effect of cellobiose on cellulase is considerably higher than of glucose. At relatively low cellobiose concentrations (up to 6 g/L), cellulase activity is reduced by 60% compared to the production without cellobiose. Microbial contaminations are also a problem in the SHF because of relatively long incubation period during hydrolysis. Main contamination sources are hydrolytic enzymes, but sterilization on industrial scale is very demanding.

During SSF, hydrolysis and fermentation take place in a single bioreactor. Therefore, released sugars from the enzymatic hydrolysis are immediately used by the microorganism. Under these conditions, relatively low sugar concentrations are present in the broth and consequently cellulase inhibition by the released sugars is reduced. The optimal temperature for SSF (around 38 °C) is a compromise between the optimal hydrolysis (45–50 °C) and fermentation (30 °C) temperatures. Further improvement of SSF can be achieved through selection of enhanced enzymes and yeast strains. SSF most often uses T. reesei and S. cerevisiae. In order to use the fermentation temperature closer to the optimal hydrolysis temperature, thermotolerant yeasts and bacteria have been studied. According to literature, Kluyveromyces marxianus and K. fragilis have the highest ethanol productivity at 42 °C, when K. marxianus has an ethanol yield of 0.5 g/g cellulose in 78 h using Solka Floc® 200 (International Fiber Corporation, North Tonawanda, NY, USA) as substrate.

The main SSF advantages are: (i) increase of hydrolysis rate through the reduction of cellulase inhibition by released sugars, (ii) lower enzyme demand, (iii) higher bioethanol yield, (iv) lower requirement for sterile conditions, (v) shorter bioprocess time, and (vi) cost reductions by elimination of expensive separation processes and equipment.

Main SSF disadvantages are incompatible temperatures of hydrolysis and fermentation, microbial ethanol tolerance and ethanol inhibition of enzymes. The incomplete substrate hydrolysis causes close association of yeast and adsorbed cellulases with fermentation residue, which prevents the recirculation of higher yeast cell concentrations required for successful bioethanol production in the next fermentation. Under these conditions, yeast cells mostly utilize sugars released from cellulose hydrolysis for growth, but not for ethanol synthesis. SSF is the operational mode of choice in many pilot-scale studies of bioethanol production despite the above-mentioned drawbacks.

The inclusion of the pentose fermentation in the SSF is another promising integration alternative, and this process is called simultaneous saccharification and cofermentation (SSCF). In this mode, both producing microorganisms have to be compatible in terms of optimal pH and temperature. Furthermore, the development of microbial strains able to grow at elevated temperatures may significantly improve techno-economic indicators of SSCF. SSCF is more economically feasible, but technically much different. By cofermentation of pentoses and hexoses in one bioreactor capital costs, but also the possibility of contamination are reduced. In a study of Yadav et al., coculture of S. cerevisiae and P. stipites resulted in conversion of both hexoses and pentoses in the hydrolysate with higher ethanol yields than the bioprocess with S. cerevisiae monoculture. Sornvoraweat et al. also reported that coculture of S. cerevisiae and Candida tropicalis produced higher ethanol quantities than the S. cerevisiae monoculture by using acid hydrolysate of cassava peels. As an alternative of this configuration, Olsson and Hahn-Hägerdal suggested a system including the isomerization of xylose and the fermentation with S. cerevisiae in a simultaneous process. In this bioprocess, glucose isomerase converts xylose into xylulose, which is subsequently utilized by yeast cells and therefore the cofermentation of lignocellulose-containing raw materials was improved. However, high byproduct (CO2 and xylitol) synthesis, poor enzyme stability, incompatible pH and temperature, and the reversibility of the enzyme transformation are the main drawbacks of this bioprocess.

Another integration approach for the conversion of lignocellulose-containing raw materials into bioethanol is the consolidated bioprocessing (CBP; 103). In this approach, cellulase production and fermentation require only one microorganism. Therefore, cellulase production, cellulose hydrolysis and fermentation are performed

in a single step. Actually, the concept of CBP involves four biological reactions in one step: the production of enzymes (cellulases and hemicellulases), carbohydrate hydrolysis into sugars, fermentation of hexoses (glucose, mannose and galactose), and fermentation of pentoses (xylose and arabinose). The CBP has the following advantages compared to the other integrated systems for bioethanol production: the enzymatic and fermentation systems are completely compatible and therefore costs of bioethanol production are reduced, capital and operation investments are not required and part of the substrate is not spent for cellulase production. In CBP, usually Clostridium thermocellum is used for enzyme production, cellulose hydrolysis and glucose fermentation, where C. thermosaccharolyticum coferments pentoses (obtained from hemicellulose) into ethanol. The CBP system with C. thermosaccharolyticum shows 31% higher substrate conversion than the CBP system with Trichoderma reesei and S. cerevisiae. However, the main problems of this CBP system are still not adequately solved such as: ethanol yield reduction due to the formation of acetic and other organic acid salts (e.g. lactate) and low ethanol tolerance by Clostridia. Although CBP is interesting from economic point of view, until now, an effective microorganism that exhibits all required features has still not been found. However, genetic engineering could improve the properties of microorganisms that are already being applied in the ethanol fermentation. Microorganisms with high cellulase activity need to have enhanced fermentation properties, and contrary, microorganisms with satisfactory fermentation properties need to have cellulolytic and/or hemicellulolytic activity. For example, improved recombinant strain of C. thermocellum produces 60 g/L of ethanol. Also, the use of genetic engineering improved cellulolytic activity of highly productive recombinant strains of bacteria E. coli, K. oxytoca and Z. mobilis, and yeast S. cerevisiae. Sakamoto et al. constructed a recombinant Saccharomyces cerevisiae that is able to hydrolize hemicellu- loses with endoxylanase from T. reesei, β-xylosidase from Aspergillus oryzae, and β-glucosidase from Aspergillus aculeatus, as well as to assimilate xylose through the expression of xylose reductase and xylitol dehydrogenase from P. stipitis and xylulokinase from S. cerevisiae. This recombinant strain successfully produces bioethanol from rice straw hydrolysate, without requiring the addition of sugar-hydrolyzing enzymes or detoxication. Authors confirmed that such cell surface-engineered strain can be highly effective in consolidating bioethanol production from hemicellulosic raw materials.

Moreover, Ishola et al. developed and evaluated a novel method of lignocellulosic bioethanol production, simultaneous saccharification, filtration and fermentation (SSFF). SSFF is an integrated bioprocess that allows simultaneous enzymatic hydrolysis of lignocellulosic biomass, filtration of sugars from hydrolysis and filtrate fermentation with yeast Saccharomyces cerevisiae. In SSFF, pretreated lignocellulose-containing raw material is enzymatically hydrolyzed in a bioreactor, while the suspension is continuously pumped through a cross-flow membrane. The retentate goes back to the bioreactor for hydrolysis and purified sugar-rich filtrate is continuously added to the bioreactor for fermentation. The membrane (module made of polyethylene with a

polypropylene housing used in a cross-flow microfiltration) was able to filter pretreated spruce slurry up to 14.4% per mass suspended solids, without clogging and it worked continuously for 28 days. The flocculating strain of S. cerevisiae was succesfully reused for 5 different batches of SSFF, and its cultivations resulted in an ethanol yield of up to 85.0% of the theoretical yield. Ishola et al. also used SSFF system for simultaneous glucose and xylose uptake by genetically modified yeast strain S. cerevisiae (T0936) with the ability to ferment xylose in the bioethanol production from pretreated wheat straw (xylose-rich lignocellulose-containing raw material). In this SSFF ethanol yield was 90% of the theoretical yield.

Bioethanol Separation and Purification

Two energy-demanding separation steps are necessary to obtain purified ethanol (95.63% by mass) from binary azeotrope ethanol-water. The first step is a standard distillation that concentrates ethanol up to the level of 92.4–94% by mass. The cyclic distillation for ethanol purification is an energy-efficient alternative that is characterised by relatively low investments. The second step involves ethanol dehydration to obtain an anhydrous ethanol (ethanol concentrations above the azeotropic composition). Several well known methods serve that purpose, such as pressure-swing distillation, extractive distillation (with liquid solvent, dissolved salt, their mixture, ionic liquids, hyperbranched polymers), azeotropic distillation and combination of these methods. The distillation residue is called vinasse and it could be an environmental problem because 1 L of ethanol generates around 15 L of vinasse.

In the next paragraphs we will discuss innovative techniques. In order to reduce energy consumption of conventional distillation, membrane techniques have gained attention as an alternative because of a number of advantages that make them attractive for the separation of liquid mixtures. They have high separation efficiency, energy and operating costs are relatively low, they produce no waste streams, and they can be used in the separation of temperature-sensitive materials. Among the available membrane techniques, pervaporation is quite attractive due to its simplicity, low energy-demands and the absence of extra chemicals; besides, the vacuum part of the process consumes the majority of energy. It uses a non-porous membrane which separates the mixture as a result of molecular interactions between the feed components and the membrane. The transport of molecules through the membrane generally involves three steps: (i) molecules from the feed are selectively adsorbed into the membrane, (ii) diffusion of the adsorbed molecules across the membrane, and (iii) desorption of the molecules into the gas phase on the permeate side. Polymeric membranes which can be used in the ethanol separation from the fermentation broth include polydimethylsiloxane (the most commonly used because of its good selectivity and stability) and poly-1-(trimethylsilyl)-1-propyne membranes, polyether block amide membranes, other modified polymeric membranes, porous polypropylene and

polytetrafluoroethylene membranes. Besides the above mentioned, inorganic hydrophobic zeolite membranes can also be used. Furthermore, two types of hydrophobic zein (monolayer and composite) membranes were also studied for ethanol separation.

Pervaporation can be carried out in parallel to the fermentation. This is promising system for in situ extraction of ethanol, which is harmless to the working microorganism. Therefore, low ethanol medium concentrations can prevent ethanol inhibition, and consequently the bioprocess can run continuously. Before the pervaporation unit, a microfiltration/ultrafiltration module has to be installed for biomass removal to prevent deterioration of the pervaporation membrane. This integrated system was used in the study of ethanol separation from aqueous solution and fermented sorghum juice. Cost analysis of the separation from the fermented juice showed it is higher than in some other methods, therefore it is necessary to optimize the procedure.

The silicalite-1/polydimethylsiloxane/polyvinylidene fluoride hybrid composite membrane was used for the in situ extraction of ethanol during the fermentation of sorghum juice in a fed-batch and a continuous bioprocess. The results of this study show that the integration of bioprocess considerably improves the bioprocess productivity and ethanol separation efficiency. The nanocomposite membrane made of polyamides with integrated carbon nanotubes was also used for ethanol separation. The results show that the membrane is most effective when used for the separation of mixtures with an ethanol content of more than 50% by mass. The temperature of the mixture also plays a significant role; at higher temperatures, there is an increase in the permeate flux, but the separation factor decreases.

Liquid-liquid extraction is another attractive method for ethanol separation from fermentation broth. The process involves the direct contact of a water-insoluble solvent with the broth in the bioreactor or in an externally located extraction vessel. During the contact, ethanol diffuses from the broth and is dissolved in the solvent, after which it needs to be isolated from the solvent with distillation or re-extraction using acid or base solutions. The selected solvent must meet some criteria, such as satisfactory extraction efficiency, chemical stability, water insolubility, must not form foam or emulsion, must be nontoxic, environmentally friendly and affordable. The most attractive solvents are ketones, esters and alcohols due to their low reactivity and high distribution coefficients (ketones 0.13–0.79, alcohols 0.53–1.30 and esters 0.24–0.59). Most of the interesting solvents were discarded because of their toxicity to the working microorganisms. The toxicity problem could be solved by using natural organic compounds, such as fatty acids, β-alcohols and carboxylic acids. Therefore, several fatty acids as solvents for ethanol extraction from water were examined. Valeric

acid, a low-molecular-mass fatty acid, extracted the highest amount of ethanol, but alongside, it extracted water and it is partly soluble in it. The same was reported for other low-molecular mass fatty acids. Oleic acid is insoluble in water, but it extracted a small quantity of ethanol. Octanoic and nonanoic acid proved to be the best; however, nonanoic acid was the most suitable solvent because of its minimal evaporation during flash distillation, which resulted in a gaseous mixture with 69.5% ethanol. This method requires 38% less energy for the same amount of ethanol than fractional distillation.

The efficiency of ethanol extraction using vegetable oils, such as coconut, olive, safflower and castor oil, and their derivatives, alcohols and esters was also examined. These oils were compared with the following esters: methyl laurate, methyl oleate, methyl linoleate, and methyl ricinoleate, and alcohols: lauryl (1-dodecanol), oleyl and ricinoleyl. Out of these compounds, castor oil, ricinoleyl alcohol and methyl ricinoleate showed higher ethanol distribution coefficients with similar or slightly lower separation factors than other compounds used in this study. It is interesting that ricinoleyl alcohol has a 50% higher distribution coefficient than oleyl alcohol, the most commonly used alcohol in ethanol extraction from fermentation broth. The use of higher β-branched alcohols, and their analogues in the form of carboxylic acids was also studied. The results showed that the C14-C20 β-branched alcohols have a narrow range of distribution coefficients (0.2–0.3), but a wide value range of separation factors, which reflects the influence of the position of hydroxyl groups and branching. Due to the low distribution coefficient values, the use of such alcohols is not recommended, but due to their non-toxicity and low solubility in the raffinate, as compared with shorter chain alcohols, it is possible to select and define the conditions of their application. Comparing the results of that study with the results obtained for carboxylic acids (C8-C18), it is obvious that acids have higher separation factors, and lower distribution coefficient values. Although it is preferable to use acids with shorter chains with higher distribution coefficients, their solubility in water and toxicity on the working micoorganisms prevents it. It is therefore advisable to use C16-C18 fatty acids as they are less soluble in the raffinate, are non-toxic and non-inhibitory.

Gas stripping is another alternative to distillation for the extraction of volatile components, such as ethanol, from fermentation broth. The process is relatively simple, does not require expensive equipment, fermentation culture is not harmed, it does not remove nutrients from the broth, it reduces product inhibition and it can be used for in situ separation of the desired product. In this method, inert gas is sparged through the broth. By passing through the broth, it collects volatile components. The most suitable gas is CO_2, as it is one of the fermentation products, but other gases (N_2 or H_2) and air can also be used. After passing through the bioreactor, the outflow is cooled in a condenser in order to condensate the desired products. Besides condensation, other methods can also be used, such as membrane separation and extraction. The gas is then recycled by going through another cycle of stripping. In

most cases, the alcohol-rich condensate must pass through at least one purification step to remove excess water. Research results show that by using gas stripping, higher ethanol yield and productivity can be achieved.

Several studies of ethanol separation by gas stripping from fermentation broth during continuous bioprocess we- re conducted. These studies examined the effect of ethanol concentration on working microorganism and bioprocess productivity. The pilot plant consisted of a 14-litre bioreactor and a 10-cm column, and the bioprocess was continuously run for over 100 days. The feed contained 560 g/L glucose and 100 g/L corn steep water. CO_2 produced by fermentation was used as the stripping gas. The productivity of the process varied between 14 and 17 g/(L·h). In a similar study, a pilot plant with a fermentor of 30 L was run for 185 days. The yield was slightly lower than the maximum theoretically possible (0.50 g/g), which resulted in an average bioprocess productivity of 7.5–12.6 g/(L·h). In both studies growth inhibition occurred when the broth ethanol concentration was higher than 65 g/L. Chen et al. compared ethanol production from sorghum with or without gas stripping. Fermentation with gas (CO_2) stripping proved to be a better choice for ethanol production, because the yield was 0.227 g/g with a stripping efficiency of 77.5%. Temperature is one of the most important parameters in the fermentation and stripping processes. With the increase in temperature, stripping efficiency increases. The highest ethanol extraction efficiency of 96.4% was at 75 °C, but this temperature has a negative effect on microorganism growth, and increases the energy costs. It is therefore necessary to adjust the stripping temperature to the microorganism, or use heat-resistant microorganisms while keeping in mind that fermentation temperature should not be higher than 40 °C. It was also observed that the gas bubble size has an influence on the efficiency of stripping. By reducing the bubble size from 0.4 cm to 0.05 cm, an increase of 30% in efficiency was observed. Ponce et al. assessed an integrated fermentation stripping system for ethanol production. In that research, 58% of total ethanol in the broth was continuously withdrawn from the bioreactor. Although the removal of ethanol was not complete, the percentage that was removed was sufficient for ethanol concentration to drop below the inhibitory values. Lower condensation temperatures have a negative impact on the ethanol concentration in the condensate. The most interesting temperatures are in the range of –2 to –5 °C because at these temperatures a significant amount of ethanol was obtained. As for the gas flow, it was concluded that higher flow rates encourage better ethanol separation from the system and therefore increase the overall bioprocess efficiency.

Adsorption is a separation technique in which molecules of gas or solution components are adsorbed on the solid surface (adsorbent). The adsorbent is a stable crystalline solid having negligible or no solubility in water or alcohol. Substances are adsorbed onto it depending on their physical and chemical properties. Generally, larger particles are more easily adsorbed due to their low diffusivity. Adsorbents are

usually located in column devices. Unlike systems with gaseous or liquid extractants, the solid adsorbent does not move through the system. Therefore, adsorption involves two phases, the loading phase (adsorption) and the discharge phase (desorption). Similar to liquid extractants, a solid adsorbent has a specific selectivity and sorption distribution coefficients for water and ethanol. The most studied class of alcohol-selective adsorbents are hydrophobic zeolites, in particular zeolites with a ZSM-5 structure and various silicon and aluminium ratios. The most important zeolite of this type is silicalite-1, which does not contain aluminium. Other adsorbents that have been studied are polymeric resins, polyvinylpyridine, activated carbon and activated carbon molecular sieves. Studies conducted with silicalite-1 showed that water and ethanol compete for sorption sites on the adsorbent. When pure water was used, silicalite-1 adsorbed 40 mg/g water, whereas when a mixture containing ethanol and water was used, there was a decrease in the adsorption of water. At 5% by mass ethanol, about 85 to 100 mg/g ethanol was adsorbed onto the surface, and only about 20 mg/g water, which is equal to a separation factor of 76.

For ethanol recovery from fermentation broth, silicalite-1, ZSM-5 and activated carbon molecular sieves (CMS-5A) were also examined as adsorbents. ZSM-5 adsorbed 0.068 g/g ethanol, silicalite-1 0.084 g/g and CMS-5A 0.126 g/g. Silicalite and ZSM-5 did not adsorb measurable quantities of glucose, fructose and glycerol, while CMS-5A adsorbed 0.011 g/g glucose, 0.010 g/g fructose, and 0.014 g/g glycerol. The measurement of ethanol adsorption from broth showed that it decreased only slightly, while there was a notable reduction in sugar and glycerol adsorption. In a recent study, activated carbon as an adsorbent for ethanol separation from fermentation broth was studied. They used two separation modes; in the first activated carbon was added directly into the broth, while in the second it was placed in an external container through which the broth circulated at specific time intervals. The second method proved to be much more efficient with final ethanol concentration of 51 g/L.

The new adsorption process that uses activated molecular sieving carbon (MSC) was also studied. The pore diameter of the sieves was around the size of an ethanol molecule. Experiments were conducted using five different MSCs, which were compared with two hydrophobic zeolites, and one hydrophilic zeolite adsorber. The total pore adsorption capacity of the MSCs was 0.2 mL/g. The most promising adsorbent was MSC4A, which, after adsorption and desorption at temperatures higher than 100 °C, helped to obtain a mixture with 96% by volume ethanol.

On the basis of previous discussion, it is obvious that the majority of studies still use two-component ethanol and water solutions, without taking into account other substances present in the fermentation broth. It is therefore necessary to conduct further research in order to check the influence of other components on adsorption, or

to investigate other methods that can be coupled with adsorption to facilitate the separation and purification of ethanol. Some of the methods that can be used with adsorption are ozonation or gas stripping .

Conclusions

Based on the presented data, it is obvious that bioethanol can be an alternative solution for the current fuel issue. There has been significant progress in renewable biomass pretreatment, cellulase production and cofermentation of sugars (pentose and hexose) as well as bioethanol separation and purification in recent decades, but bioethanol (based on the production costs) is still not competitive (exception can be only bioethanol production from sugar cane in Brazil) to the fossil fuels. The biggest challenge remains how to reduce the production cost of bioethanol. Therefore, the biorefinery concept is needed to utilize renewable feedstocks more comprehensively and to manufacture more value-added coproducts (e.g. bio-based materials from the lignin) that would reduce the cost of bioethanol production. This will make bioethanol more economically competitive than the fossil fuels.

Subsequent to opening up of alternate route i.e. Second Generation (2G) route for ethanol production, Public Sector Oil Marketing Companies under the administrative control of Ministry of Petroleum and Natural Gas are in the process of setting up 12, 2G bio-refineries with an investment of Rs.14,000 crore.

In order to encourage setting up of second generation bio-fuels plants, Government has launched as scheme namely i.e. "Pradhan Mantri JI-VAN (JaivIndhan-VatavaranAnukoolfasalawasheshNivaran) Yojana" for providing financial support to integrated bio-ethanol projects, using lignocellulosic biomass and other renewable feedstock. In this scheme, financial support to twelve Integrated Bio ethanol Projects using lignocellulosic biomass & other renewable feedstock with total financial outlay of Rs 1969.50 crore for the period 2018-19 to 2023-24 will be provided along with support to ten demo projects for 2G technology.

Rice products. - EXHIBIT 28

Value-Added Processing of Rice and Rice By-Products. Rice Processing and Products made from Rice

Rice is the most important cereal food crop of India, occupying one-fourth of the gross cropped area of the country. As the basic food crop, rice is cultivated comfortably in

hot and humid climate. In the country, the crop is mainly grown as a Kharif crop in rainfed areas that receive heavy annual rainfall.

India is the second largest rice producer in the world after China, with 21% of the global production share. The rice production has increased by 3.5 times in the last 60 years. The country's productivity is higher than Thailand and Pakistan at 2.2tons/ha. Major Rice producing states in India are West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Odisha, and Bihar. India has been the top exporter in global rice trade, accounting for 25% of the export in the last four years. Indian rice caters to the Middle East and Africa for non-Basmati, and the EU and the US for Basmati variety.

Rice and rice-based products derived from rice grain and rice flour include parboiled rice; quick-cooking rice and ready-to-eat convenience foods; rice flours; rice starch; cakes and puddings; baked breads and crackers; breakfast cereals and expanded rice products; extrusion-cooked and puffed-rice snacks; noodles, paper, and pasta; baby/weaning foods; fermented foods and beverages; pet foods; and bran products.

Value addition also enhances the profitability of rice production. A wide range of product development like processed and canned, ready-to-eat products, vitamin, iron or calcium enriched flaked or puffed rice, flavoured rice, starch extraction from broken rice and so on are nowadays getting popular. Value-added products from organic rice and therapeutic value medicinal rice varieties have good niche in domestic and export markets.

Rice is one of the most common staple foods that people usually consume around the world. By-products from the rice milling process have high amounts of nutrients when compared to white rice itself. Rice straw, rice hull, broken rice, rice germ, rice bran, rice bran oil and wax are the by-products from the rice industry. These by-products usually have basic applications in their original form, but now can be used as raw materials for different value-added research or in food applications with functional properties.

Rice by-products not only contain various types of functional components, but also contain dietary fiber. The fiber can be mostly found in rice hull and the types of fiber present include cellulose, hemicellulose, lignin and hydrated silica. Because of the high fiber content in rice hull and rice bran, they are used as ingredients by the bakery industries to increase the fiber content and improve the nutrition of bakery products.

Following are few Business Ideas for Startup:

Rice Cultivation

Rice is the leading food crop in the developing world in terms of total world production. It represents the staple food for almost two-thirds of the world's population. Rice provides 21% of global human per capita energy and 15% of per capita protein. However, the world's stocks of stored rice grain have been falling in negative correlation to each year's consumption levels which now exceeds actual annual production. Rice is generally considered a semi-aquatic annual grass plant, which can be grown under a broad range of climatic conditions. Read more

Rice Milling Unit

Rice (Oryza sativa L.) is one of the leading food crops of the world, and is produced in all the continents. Rice was an important food even before the dawn of written history. One centre of origin of cultivated rice is thought to have been in South East Asia. That is in eastern India. Indo- China and Southern China, Another probably was in Africa. Rice is one of the most important food grains. It is used in almost all homes as eatables. It has good filling capacity as a food grains. Rice is one of the leading food crops of the world. Read more

Rice Mill (Parboiled Rice)

Parboiled rice, popularly known as "ushna" rice in boiled form. India contributes about one-third of the world acreage under rice. Rice is available in over 5000 varieties, of which Izong rice of Assam occupies a important position on account of its superfine grains, pleasant, fine cooking quality, sweet taste, soft texture. This article reviews the quality and traits of Izong rice, particularly the verities grown in different parts of Assam and North Eastern Region. Parboiling is preliminary to hulling in which the rough paddy is first soaked, then steamed and dried before removing the hulls. Read more

Rice Powder, Puttu and Wheat Powder

Wheat flour is a powder made from the grinding of wheat used for human consumption. More wheat flour is produced than any other flour. Wheat varieties are called "soft" or "weak" if gluten content is low, and are called "hard" or "strong" if they have high gluten content. Hard flour, or bread flour, is high in gluten, with 12% to 14% gluten content, and has elastic toughness that holds its shape well once baked.

Rice flour (also rice powder) is a form of flour made from finely milled rice. It is distinct from rice starch, which is usually produced by steeping rice in lye. Read more

Rice Bran Oil

Rice bran is the main source of rice oil. The majority of available bran continues to be used for animal feeds without being extracted for the oil. Rice oil, also called rice bran oil, has been used extensively in Asian countries. Rice oil is a minor constituent of rough rice when compared with the carbohydrate and protein content. Two major classes of lipids are present: those internal within the endosperm and those associated with the bran. The internal lipids contribute to the nutritional, functional, and sensory qualities of rice. Read more

Rice Beer

Rice beer is an alcoholic drink generally made from rice. Those who consume moderate amounts of beer (one to two a day at the most) have a 30-40% lower rate of coronary heart disease compared to those who do not drink. Beer contains a similar number of polyphenols (antioxidants) as red wine and 4-5 times as many polyphenols as white wine. Alcohol has also been attributed of its ability to increase the amount of good cholesterol (HDL) into the bloodstream as well as help to decrease blood clots. Read more

Rice Flakes

Rice flakes are tasty flakes that are created using rice grains. The process for creating rice flakes involves parboiling the rice, then flattening the grains to product a solid flake. There are a number of rice flake recipes used in Asian cuisine. Often in western countries, rice flakes are used to create cereals and different types of snacks. Once the rice is tender, the cooked grains are rolled, then flattened. The thickness of the flattened rice will depend on the amount of pressure that is applied. Read more

Rice Bran Based Solvent Extraction Plant

Rice has been and continues to be the largest source of human nutrition. Rice bran is a by-product of the rice milling process. Rice bran is the most important source of edible oil among the unconventional sources. Rice bran is the brown coating around the white starchy rice kernel, which is obtained by dehusking paddy and polishing the rice. While white rice holds little nutritional value, the bran that is removed contains 65 percent of the rice kernel’s nutrients and boasts a bounty of healthful benefits. Read more

Rice Mill, Rice Bran Oil with Captive Power Plant (integrated Unit)

Paddy is the most important and extensively grown food crop in the World. Rice grain (Oryza sativa) along with hulls/husk is known as paddy. Paddy seed contains a rough, hard and woody outer covering, called husk which make paddy as such inedible. It is the staple food of more than 60 percent of the world population. The rice which is obtained after milling is called raw rice. Nearly 60% of the total rice produced in India is subjected to parboiling. Parboiling is a hydrothermal treatment of paddy followed by drying before milling for the production of milled parboiled rice. Read more

Fructose Syrup from Broken Rice (HFS 90%)

Glucose syrup is a popular substitute for sugar. It is more commonly referred to as corn syrup because its main ingredient is usually cornstarch. From a strictly chemical perspective, glucose syrup is the proper term for any liquid starch consisting of carbohydrates. In addition to cornstarch, it can be made from any form of starch, including wheat, rice or potatoes. Because of its successful and easy bonding with dry or solid substances, this syrup is the preferred sweetener for candy, chewing gum, jams, jellies and canned fruit. Read more

Puffed Rice (Muri)

Puffed Rice is a commonly consumed commodity as a pastime snack. It can be used in combination with nuts such as groundnut or roasted and salted cashews; with fried gram; with Jaggery and coconut gratings, or dusted with salt and spices after enrobing with oil. Since the product is easily digested and assimilated, it finds a wide acceptance among a cross section of the households. It is a versatile product with an excellent market potential. Today the snack food is one of the most important areas of the food industry. Read more

Liquid Glucose from Broken Rice

Liquid Glucose is usually manufactured by subjecting starch to high temperature in the presence of acid. However, Liquid Glucose of same Dextrose Equivalent can be manufactured by enzymatic conversion but the spectrum of saccharides will differ and so also the properties, in comparison to acid converted Liquid Glucose. Liquid Glucose is an aqueous solution of nutritive saccharide obtained by starch hydrolysis, by using Corn and Rice as raw material, which is purified and concentrated to required solids. Read more

Parboiled Rice Mill with Rice & Corn Flakes

The term parboiling covers the operation to which the paddy is subjected before milling. Water and heat are the two main elements in the process. After steeping followed by heating, which involves the action of steam. The rice must be dried milling and storage. Corn flakes are used mainly as break-fast food along with milk. They are also used for making any delicious food by cooking. It contains carbohydrates, protein and starch. Read more

Rice Flakes from Broken Rice (Used in Beer Industry)

Rice flakes are tasty flakes that are created using rice grains. Rice Flakes are used as breakfast food and are famous by the names like poha/chiwda when cooked as breakfast meal. Rice flakes can be consumed with milk as cereal. Wide application of Rice Flakes is in the application of beer industry to produce beer. Rice flakes can also be mixed with other dried grain flakes to create a tasty breakfast cereal. Rice flakes from broken rice used in beer industries, which is cheap convenient and is an innovated concept. Read more.

Rice Processing

Rice grain consists of many components, Thus, there is a need for rice grains to undergo several processing steps before they can be consumed by humans. Rice processing covers the operations from harvest to the production of graded and polished white rice. From the rice harvesting process, residue-to-product-ratios values for rice straw ranging from 0.41 to 3.96 were produced for every kilogram of harvested paddy.

The rice milling process involves cleaning, hulling and post-hulling processing (whitening, polishing and grading), which combined will produce several rice by-products, The percentage of rice by-products is dependent upon several factors, such as the milling rate and type of rice. An ideal milling process will yield 20% husk, 8-12% bran depending on the milling degree and 68-72% milled rice or white rice, depending on the variety .

Nutritional Values of Rice By-products

Rice by-products actually had higher amount of nutrients when compared to the polished rice. the proximate composition and major minerals of several rice by-products. Rice bran, which is derived from the outer layer of the rice grain, is composed of an aleurone layer of the rice kernel, with some proportion of the endosperm and germ accounting for approximately 10% of the weight of the rice grain. This part is composed of both lipophilic antioxidants (tocopherols, tocotrienols

and γ-oryzanol) and phenolics. These substances protect against chronic diseases of the cardiovascular system and help to quench the free radicals and anticancer effects .

Rice germ is also known as the embryo or reproductive parts, which germinate and grow into plants . The content of vitamin E in rice germ is 5 times higher than that in rice bran. The major vitamin E component in rice germ is α-tocopherol, which is the most active form of vitamin E, whereas for rice bran, the major vitamin E component is γ-tocopherol. In addition to these, rice germ also contains a substantial concentration of vitamins (B1, B2 and B6), fibre and neurotransmitter γ– aminobutyric acid (GABA), which is believed to have many beneficial health effects, such as lowering the blood pressure, improving cognition and lowering blood glucose levels. The level of γ-oryzanol in rice germ, however, was 5 times lower than the level in rice bran . This is in accordance with Butsat and Siriamornpun , who also reported that the bran has the highest oryzanol content compared to other parts of rice.

The components of dietary fibre in rice by-products include cellulose, hemicellulose, pectins, hydrocolloids and lignin. These can be classified into two types, depends on their solubility in water. The structural or matrix fibres, such as lignins, cellulose and some hemicelluloses, are insoluble, while the natural gel-forming fibres (pectins, gums, mucilages and the remainder of the hemicelluloses) are soluble. Generally, soluble fibre forms a gelatin-like substance in the intestine and increases the water content in the stool. It has also been demonstrated to possess the ability to decrease the blood cholesterol and sugar after meals in diabetics . Insoluble fibre plays a key role in adding bulk or softening stool, which helps to reduce constipation and haemorrhoids and is also effective in creating a feeling of fullness.

The fibres found in rice husks are mainly lignin, hemicellulose, cellulose and hydrated silica . These components are similar to those in ground rice husk made from defatted concentrated rice bran . They are not digested by human pancreatic or brush border enzymes and therefore are not expected to be fully absorbed. However, their consumption does help to control blood glucose levels and lipid concentrations by enhancing the viscosity of the gastrointestinal contents.

Antioxidant Properties of Rice By-products

Antioxidants play an important role in preventing damage to the cellular components caused by chemical reactions involving free radicals. The outer layers of plants, including their peels, shells and husks, can protect the seeds from oxidative damage due to the large amounts of strong antioxidants present, such as flavonoids, hydro cinnamic acid derivatives, isovitexin, phytic acid, anisole, vanillin and syringaldehyde . They are good sources of natural antioxidants. However, these by-products, such as rice husk, are mostly wasted and are usually used as a feedstock due to their low digestibility, peculiar size, low bulk density, high ash/silica contents and abrasive characteristics .

Rice husk contains an antioxidant defence system, including polyphenolic compounds, to protect the inner materials from oxidative stress . Phenolic compounds from

methanol extracts of rice husks have been shown to exert high antioxidant activities against scavengers of singlet oxygen and to inhibit high hydrogen peroxideinduced damage to DNA in human lymphocytes. These data are also supported by the findings of Kim et al , who showed that Nokmi rice husk extracts have effective antioxidant activities.

Numerous primary nutraceutical compounds extracted from rice bran also contain high levels of phytochemicals, which exert antioxidant activities [55]. These phytochemicals are α, β, γ, δ-tocopherol, tocotrienols (vitamin E) and γ-oryzanol. Vitamin E protects the cell membrane by preventing the oxidation of unsaturated fatty acids and by scavenging free radicals. Gamma-oryzanol, however, has been shown to have higher antioxidant activity than tocopherols or tocotrienols.

In addition to the rice husk and rice bran, the study by Moongngrm et al. also showed that rice germ contains highest amounts of α-tocopherol and γ–tocopherol, further supporting the earlier finding by Yu et al. Rice germ has also been demonstrated to have the strongest antioxidant activity, compared to rice bran (containing a bran layer and rice germ) and the rice bran layer (without the germ) [62]. The rice germ extract exhibited electron-donating abilities and hence may play a key role in radical chain terminators by transforming the reactive free radical species into more stable, non-reactive products. For brewer's rice, data from Tan et al. showed that the content of phenolics, vitamin E and γ-oryzanol was significantly lower than in rice bran. It is expected, as indicated by Zhou et al. [65], that the phenolic acids and γ-oryzanol contents of rice are chiefly concentrated in the bran; brewer's rice mostly consists of broken rice, with only small percentage of rice bran and rice germ.

Anti-cancer Effect of Rice By-products

The consumption of whole grains has been reported to protect against colorectal cancer in human interventions. The chemo preventive properties of whole grain consumption have been attributed both to fibres and to other phytochemicals that are mostly present in the bran layer. several previous findings on the effect of rice by-products on cancer. Water-soluble rice bran hemicelluloses prevent against 1,2-dimethylhydrazine (DMH)- induced colonic tumours in rats. Rice germ prevents azoxymethane (AOM)-induced colonic aberrant crypt foci (ACF), a preneoplastic lesion in colon cancer, as well as tumours in rats.

Rice bran inhibits the growth of human colon cancer cells, and rice bran consumption reduces the number of intestinal adenomas in APCMin mice, an animal model of human familial adenomatous polyposis (FAP) [86]. Finally, DMH- and AOM-induced preneoplastic lesions are inhibited by rice bran-derived sphingolipids in the colons of rats . Several phenolic compounds have been recognised in the ethyl acetate extracts of rice bran, such as caffeic acid, cycloartenyl ferulate, ferulic acid, methoxycinnamic acid, p-coumaric acid, protocatechuic acid, sinapic acid, tricin and vanillic acid.

Some of these phenolic compounds have been reported to inhibit the growth of human breast and colon cancer cells . There is no evidence to indicate that rice husk is

carcinogenic or mutagenic. Nevertheless, rice husk has shown anticarcinogenic and antimutagenic activities in vitro and in vivo. The in vitro study of water extract from brewer's rice by Tan et al. also demonstrated the cytotoxic effects of the extract against ovary cancer (Caov-3) and colon cancer (HT-29) cell lines with IC50 36.67 μg/ml and 38.33 μg/ml respectively .

Anti-cancer Mechanism by Rice By-products

Dietary fibre

Epidemiological data has suggested that the consumption of dietary fibre, especially the mixture of soluble and insoluble fibres, is inversely associated with the risk of cancers, such as colon cancer [88,89]. Therefore, the presence of dietary fibre in high amounts in rice byproducts might partly explain its effects on the reduction of cancer. The dietary fibre in rice bran that ferments slowly may exert its protective effects through the physical dilution of the contents of the gut through its potential for dilution and faecal bulking capacity .

This property may shorten the transit time, hence leading to alterations in the mutagenicity of the intestinal contents, altered mucosal cytokinetics and subsequent effects in the excretion of putative carcinogens . It has also been suggested that the production of butyrate from these fibres could protect against the initial stages of colon carcinogenesis . Butyrate, as suggested, is able to arrest the growth of neoplastic colonocytes and inhibit the preneoplastic hyperproliferation induced by the several tumour initiators and promoters . This type of fibre also has been suggested to be paramount to carcinogenesis by changing from propionate to butyrate, as observed in animals fed hydrolysed guar .

Phytic acid

Phytic acid (inositol hexaphosphate, IP6), which is a component of rice bran, most cereals, nuts, oilseeds and legumes, has been shown to reduce the incidence of carcinogen-induced large bowel cancer [96] and to inhibit the growth of transplanted tumours ; further, it has been shown to have cytotoxic effects against hepatocellular cell lines (HEPG2) . The modifying effects of phytic acid on carcinogenesis have been investigated in several studies .

The phytic acid in rice bran is a negatively charged molecule that is able to bind proteins and starch. Thus, it contributes to the reduction of absorption and increases faecal bulk. Several other mechanisms by which the phytic acid exerts its anti-cancer and chemo preventive properties include gene alteration, cell cycle inhibition, increased natural killer cell activity and antioxidant function. Phytic acid enacts effects at the genetic level by affecting signal transduction pathways, cell cycle regulatory genes and tumour suppressor genes. Hence, phytic acid may cause greater differentiation among malignant cells and complete reversions to normal phenotypes . Phytic acid has also been demonstrated to block phosphatidyl inositol-3-kinase (PI-3

K) through its activity and has been found to influence the activity of neoplastic cell transformation in a dose dependent manner .

Furthermore, several colon cancer studies have supported the ability of phytic acid to favourably influence colon morphology by increasing both cell apoptosis and differentiation. These data show that phytic acid may affect the cell cycle by decreasing the S phase of mitosis and arresting cells in the G0/G1 phase, thereby enacting an anti-proliferative effect on tumour cells. Phytic acid can be absorbed by cells rapidly (in vitro and in vivo) and metabolised to cause phosphates and inositol levels to become lower. The conversion of phytic acid to its lower forms, IP1-5, by dephosphorylation may contribute to phytic acid's anti-cancer properties. Hence, IP3 plays a major role in cellular signal transduction and intracellular function .

Tricin

Tricin is an O-methylated flavone, a type of flavonoid that can be found in rice bran, and it has been shown to inhibit colon cancer cell growth. Cai et al. reported that feeding on a diet containing 0.2% tricin decreased the size and number of intestinal adenomas formed in ApcMin/+ mice through the inhibition of cyclooxygenase (COX)-2 . Tricin consumption decreased PGE2 levels in the murine plasma and reduced the number of adenomas, particularly in the proximal small intestine. In addition to these properties, tricin has also long been credited for health beneficial effects due to its antioxidant potential, which can inhibit lipoperoxidation, and its sparing effect on vitamin E in erythrocyte membrane .

Vitamin E

Various studies have shown the effects of tocotrienol as an anticancer agent. For example, rice bran-derived tocotrienol inhibited tumour cell-induced angiogenesis in the mouse dorsal air sac (DOS) assa and could promote tumour necrosis factor-related apoptosis-inducing ligand (TRAIL) through the up regulation of death receptors in leukemic, kidney and pancreatic cells .

Oryzanol

A study by Kim et al. suggested that γ-oryzanol in rice bran inhibits tumour growth in tumour-bearing mice by the induction of natural killer (NK) activity, the activation of macrophages and the inhibition of angiogenesis (reduction of vascular endothelial growth factor VEGF, cyclooxygenase-2 COX-2 and 5-lipoxygenases 5-LOX).

Hypocholesterolaemic Effects of Rice By-products

Numerous data on the hypocholesterolaemic effects of rice bran have been produced, especially regarding the oil. Studies have been conducted on rats , rabbits , hamsters , monkeys and humans . In addition to those preliminary studies, other research has shown that there is a significant effect of these rice branderived products on improving the lipid profile . However, black rice bran extracts reduce the progression of dietary cholesterolinduced atherosclerotic plaque development and cholesterol

plasma levels in rabbits while decreasing the levels of serum triglycerides and total cholesterol in mice .

Some components of rice bran oil that is mainly responsible for the cholesterol-lowering effects in rice bran oil's unsaponifiable fraction (4.2%) include tocols (tocopherols and tocotrienols), β-sitosterol, γ-oryzanol and unsaturated fatty acids .

Cholesterol-lowering Properties

Gamma-oryzanol

Gamma-oryzanol, is present at 13 to 20 times (w/w) higher content in rice bran compared to total tocopherols and tocotrienols [133] and has been shown to decrease animal serum-cholesterol levels and antiinflammatory activities while inhibiting cholesterol oxidation in vitro .

The effects of γ-oryzanol on biliary secretion and faecal excretion of cholesterol, phospholipids and bile acid were investigated in male albino rats. Bile flow and composition did not cause any changes by feeding gamma-oryzanol at 0.5% level with the control diet. However, the bile flow and total bile acid output were increased by 12% and 18%, respectively. An earlier study by Seetharamaiah et al. showed that there is a significant increase in the faecal excretion of cholesterol (28%) and bile acids (29%) after feeding gamma-oryzanol with a high cholesterol diet, while cholesterol absorption was lowered by 20%.

Gamma-oryzanol's anti hyper cholesterol a emic effect also might be due to the sterol moiety, which is split off from the part of the ferulic acid in the small intestine by cholesterol esterase. Sakamoto et al. reported that gamma-oryzanol and cycloartenol ferulate have an anti-hyperlipidaemic action and identified that intravenous administration creates more remarkable effects than oral administration due to a direct inhibition of the lipid metabolism. Furthermore, ferulic acid that has been absorbed and metabolised demonstrated an intrinsic hypolipidemic effect in several studies . Another suggestion from Makynen et al. was that the hypocholesterolaemia activity of γ-oryzanol is due in part to the impaired apical uptake of cholesterol into enterocytes and perhaps a decrease in HMG-CoA reductase activity.

Phytosterols

There are three groups of phytosterols that are usually found in the crude rice bran oil. These include 4, 4′-dimethylsterols (1.2%), 4-monomethyl-sterols (0.4%) and 4-desmethylsterols (1.8%) [141]. Several mechanisms by which plant sterols affect the concentration of cholesterol in the body, such as the formation of non-absorbable complexes with cholesterol, alterations of the size and/or stability of the micelles, interferences with the cholesterol esterification in the mucosal cell and interactions with the protein receptors that are required in the absorption of cholesterol .

In addition, the cholesterol-lowering effects of the rice bran oil could also be due to the bile acids and total plasma cholesterol complexes in the intestinal lumen (anion

exchange resin-like action) . This hypothesis has been confirmed by a study conducted by Shinomiya et al. . Another study by Wang and Ng on human subjects also reported the anti-hypercholesterolaemic effects of phytosterol.

Vitamin E

Corn, wheat and soybeans contain major tocopherols, while barley, oats, palm, commercial rice bran and rice bran oil contain up to 70% tocotrienols . The hypocholesterolaemia activity of vitamin E in rice bran oil has been clearly shown in several animal species and in humans . There are several mechanisms that demonstrate how vitamin E can lower cholesterol levels. This includes the role of vitamin E as an antioxidant that inhibits the oxidation of cholesterol [61] and the activity of liver enzyme, 3-hydroxy-3- methylglutaryl-coenzyme A reductase (HMG-CoA-R) , which is critical in the cholesterol synthesis rate .

Vitamin E also increased the controlled degradation of the reductase protein and decreased the efficiency of the translation of HMG-CoA-R messenger RNA. By inhibiting the activity of HMG-CoA-R, the serum total and LDL cholesterol could be reduced; hence, the levels of cholesterol will be lowered. Data from a study by Cicero and Derosa also showed that tocotrienols act as a main mediator of the antihypercholesterolaemic effect in rice bran oil.

Hypoglycaemic Effect of Rice By-products

The effects of rice by-products on the reduction of diabetic risk have been shown by many studies. The diabetes mellitus Type 2 subjects fed with rice bran water-soluble and rice bran fibre concentrates plus AHA Step-1 diet had decreased glycosylated haemoglobin levels (15% and 11%) and fasting glucose (33% and 22%), respectively . The levels of serum insulin were also increased (4%) in both types of diabetes.

The properties of the rice by-products that might contribute to this effect include tocotrienol, γ-oryzanol and fibre. The tocotrienol-rich fraction from palm oil and rice bran oil has been reported to lower the blood glucose levels of patients and preclinical animal models. Siddiqui et al. outlined the fact that treatment with the palm oil tocotrienol rich fraction and the rice bran oil-tocotrienol rich fraction in hyperglycaemia induced nephropathy in Type 1 diabetic rats, significantly improving the glycaemic status and renal functions of the rats.

A study by Fang et al. further showed that δ-tocotrienol within the tocotrienol-rich fraction functioned as a peroxisome proliferator activated receptor (PPAR) modulator and may improve the utilisation of whole-body glucose and insulin sensitivity in diabetic Db/Db mice by selectively regulating its PPAR target genes. Gamma-oryzanol that is present in high amount of rice bran also tends to increase the insulin sensitivity in rats with streptozotocin-/nicotinamide-induced type 2 diabetes. Its activity as a potent antioxidant can suppress the reactive oxygen species generated under a high blood glucose concentration. The high fibre content in rice by-products could also slow down the absorption of the glucose, while the colonic fermentation products of fibre may also enhance glucose utilisation .

In addition to tocotrienol, fibre and γ-oryzanol, the phenolic acid fraction of rice bran also may be beneficial for the treatment of type 2 diabetes mellitus because it regulates blood glucose levels by elevating glucokinase activity and the production of glycogen in the liver. Furthermore, GABA also might be beneficial in the reducing the risk of diabetes due to it potentiation of insulin secretion from the pancreas.

Applications in Food Products

Currently, people are concerned about personal health and nutrition. Rice bran is highly nutritious and thus is used as a food additive. The primarily use of rice bran as an additive in food is due to its high fibre content, which mildly promotes stool regularity. From a marketing view point, the most commonly available rice bran-derived product is the oil. Rice bran oil has an impressive nutritional quality that makes it suitable for nutraceutical products.

It also has the potential to be used as an additive to improve the storage stability in food due to its antioxidant's properties. Rice bran oil has industrial potential, especially in the preparation of snack food due to the great stability of frying, whereas rice bran fibre can be used as both a nutritional and functional ingredient. Chicken coated with stabilised rice bran fibre tends to absorb less fat during frying, and the small amount of fat present naturally in rice bran fibre can act as a carrier of flavours.

The nutritional and functional properties of rice bran are suitable for baked products, namely cookies, muffins, breads, crackers, pastries and pancakes. The addition of rice bran into the wheat flour further increased the protein, lysine and dietary fibre contents in bread and cookies. The colour, flavour, protein extractability and solubility of bran, as well as other properties, such as water and fat absorption, emulsifying and foaming capacity, have demonstrated improvements that further enlighten us on the potential use of bran in foods. Due to its naturally occurring enzymatic activity (lipases) and subsequent hydrolytic rancidity, rice bran needs to be stabilised to control these undesirable reactions.

The process also destroys the fungi, bacteria and insect infestations, hence enhancing the shelf life of rice bran. The stabilised rice bran was successfully incorporated in up to 20% of the production of yeast bread because the hygroscopicity of the rice bran may improve its moisture retention in the baked products, while its ability to foam improved the air incorporation and leavening processes. Defatted rice bran can be used to substitute for up to 10 to 20% of the wheat flour used for making cookies without adversely affecting the quality. Biscuits prepared with broken rice powder were highly acceptable in terms of taste and feel in the mouth .

Beside oil, rice bran also has a 10-15% protein content, consisting of 37% water-soluble, 31% salt-soluble, 2% alcohol-soluble and 27% alkali-soluble storage proteins. Rice bran proteins have been found to be of high quality and application in food and

pharmaceutical industries. Its unique properties, hypo allergenicity and anticancer effects make it a superior cereal protein with a wide range of possible applications. However, as of now, commercial rice bran protein is still unavailable on the market.

Rice husks can be formulated and optimised to meet the particle sizes. Its use is technically feasible for about 5% in dry mix applications and about 35% as an adsorbent in liquids . Furthermore, brewer's rice can also be utilised as a brewing adjunct. The brewing industry favours the use of adjuncts because of economic reasons. Shortages of barley and malt and demographic growth will lead to a substantial increase in the use of brewing adjuncts.

Conclusions

Rice straw, rice husk, rice bran, rice germ and broken rice are the main rice by-products in the rice industry. Rice by-products may serve as important sources of raw material that could be used as ingredients of functional food and nutraceuticals. They have great potential to be converted into human food to improve food security in the country.

PLANT BASED OMEGA-3- EXHIBIT 29

What Are Omega-3 Fatty Acids? Explained in Simple Terms

Omega-3 fatty acids are a group of three important types of fat: ALA, DHA, and EPA. Getting enough of each type may help keep your retinas, brain, and other parts of your body in healthy function.

Omega-3 fatty acids are important fats that you must get from your diet.

However, most people don't know what they are.

What are omega-3s?

Omega-3s are a family of essential fatty acids that play important roles in your body and may provide a number of health benefits (1Trusted Source, 2Trusted Source).

As your body cannot produce them on its own, you must get them from your diet.

The three most important types are ALA (alpha-linolenic acid), DHA (docosahexaenoic acid), and EPA (eicosapentaenoic acid). ALA is mainly found in plants, while DHA and EPA occur mostly in animal foods and algae.

Common foods that are high in omega-3 fatty acids include fatty fish, fish oils, flax seeds, chia seeds, flaxseed oil, and walnuts.

For people who do not eat much of these foods, an omega-3 supplement, such as fish oil or algal oil, is often recommended.

The 3 types of omega-3

There are three main types of omega-3 fatty acids — ALA, DHA, and EPA.

ALA

Alpha-linolenic acid (ALA) is the most common omega-3 fatty acid in your diet (3Trusted Source).

Your body mainly uses it for energy, but it can also be converted into the biologically active forms of omega-3, EPA and DHA.

However, this conversion process is inefficient. Only a small percentage of ALA is converted into the active forms (4Trusted Source, 5Trusted Source, 6Trusted Source).

ALA is found in foods like flax seeds, flaxseed oil, canola oil, chia seeds, walnuts, hemp seeds, and soybeans.

EPA

Eicosapentaenoic acid (EPA) is mostly found in animal products, such as fatty fish and fish oil. However, some microalgae also contain EPA.

It has several functions in your body. Part of it can be converted into DHA.

DHA

Docosahexaenoic acid (DHA) is the most important omega-3 fatty acid in your body.

It's a key structural component of your brain, the retina of your eyes, and numerous other body parts (7Trusted Source).

Like EPA, it occurs mainly in animal products like fatty fish and fish oil. Meat, eggs, and dairy from grass-fed animals also tend to contain significant amounts.

Vegetarians and vegans often lack DHA and should take microalgae supplements to make sure they get enough of this omega-3 (8Trusted Source, 9Trusted Source).

The omega-6 to omega-3 ratio

Omega-6 fatty acids also have important roles in your body similar to those of omega-3s.

Both are used to produce signaling molecules called eicosanoids, which have various roles related to inflammation and blood clotting (10Trusted Source).

Yet, omega-3s are anti-inflammatory, and scientists hypothesize that eating too much omega-6 counteracts these beneficial effects.

In the Western diet, omega-6 intake is very high compared to that of omega-3s, so the ratio is currently skewed far towards the omega-6 side (11).

Maintaining a balance between these two fats — often termed the omega-6 to omega-3 ratio — may be important for optimal health.

Although insufficient evidence exists to show that omega-6 is harmful, most health professionals agree that getting enough omega-3 is important for health (12Trusted Source).

Omega-3 and -6 fats are used to produce important signaling molecules called eicosanoids. Balancing your intake of these fatty acids is considered important for optimal health.

What omega-3 fatty acids do

Omega-3 fatty acids, particularly DHA, are vital for your brain and retinas (7Trusted Source).

It is particularly important for pregnant and breastfeeding women to get enough DHA, as it can affect the health and intelligence of the baby (13Trusted Source).

Additionally, sufficient omega-3 intake can have powerful health benefits for adults. This is especially true of the longer-chain forms, EPA and DHA.

omega-3 fatty acids can protect against all sorts of illnesses, including breast cancer, depression, ADHD, and various inflammatory diseases (14Trusted Source, 15Trusted Source, 16Trusted Source, 17Trusted Source).

If you don't eat fish or other food sources of omega-3s, consider taking supplements. These are both cheap and effective.

Omega-3 fatty acids play several important roles in your body. They have anti-inflammatory effects and are an essential component of your brain and eyes.

Omega-3 fatty acids are a family of polyunsaturated fats associated with several health benefits. High intake is linked to a reduced risk of inflammatory diseases and depression.

Rich natural sources of omega-3, although few, include fish oil, fatty fish, flaxseed oil, and walnuts.

As omega-3 intake is low in Western countries, most health professionals recommend omega-3 supplements for people who don't get adequate amounts in their diet.

Omega-3 fatty acids have many health benefits. The best way to reap them is by eating fatty fish at least twice per week, but if you don't eat fatty fish often, you should consider taking a supplement.

It's important to make sure your supplement contains enough eicosatetraenoic acid (EPA) and docosahexaenoic acid (DHA). These are the most useful types of omega-3 fats, and they are found in fatty fish and algae.

You can also get omega-3 from seeds and nuts, like flax seeds and walnuts. These foods contain alpha-linolenic acid (ALA), a small part of which can be converted into EPA and DHA in your body (1Trusted Source).

Official omega-3 dosage guidelines

Various mainstream health organizations have released their own expert opinions, but they vary considerably.

Overall, most of these organizations recommend a minimum of 250–500 mg combined EPA and DHA each day for healthy adults. This can be obtained from about 8 ounces of fatty fish per week (2Trusted Source, 3Trusted Source, 4Trusted Source, 5Trusted Source).

However, higher amounts are often recommended for certain health conditions.

The recommended dietary allowance (RDA) for alpha-linolenic acid is 1.6 grams per day for men and 1.1 grams per day for women (6).

To date, there is no official recommended daily allowance for EPA and DHA. However, most health organizations agree that 250–500 mg of combined EPA and DHA is enough for adults to maintain their overall health.

Omega-3 for specific health conditions

The following health conditions have been shown to respond to omega-3 supplements.

Heart disease

One study followed 11,000 people who took an 850-mg dose of combined EPA and DHA every day for 3.5 years. They experienced a 25% reduction in heart attacks and a 45% reduction in sudden death (7Trusted Source).

The American Heart Association (AHA) recommends that people with coronary heart disease or heart failure take omega-3 supplements containing EPA and DHA daily. More research is needed to establish the ideal dose, but most studies have used about 1,000 mg per day. For people with high triglycerides, the AHA recommends a dose of 4,000 mg per day (8Trusted Source, 9Trusted Source, 10Trusted Source).

However, some large studies have not supported the use of omega-3 supplements to reduce the risk of heart disease. This topic is still being investigated (11Trusted Source, 12Trusted Source).

Overall, evidence is stronger for the benefits of omega-3 supplements in people with a history of heart disease rather than generally healthy people (13Trusted Source).

Depression and anxiety

Studies suggest that high doses of omega-3, ranging from 200–2,200 mg per day, can reduce symptoms of depression and anxiety (14, 15Trusted Source, 16Trusted Source).

In cases of mood and mental disorders, a supplement with higher amounts of EPA is more likely to have a beneficial effect than one with higher DHA.

However, some research suggests that omega-3 supplements had little or no effect in preventing depression or anxiety symptoms. More research is needed (17Trusted Source).

Cancer

A high intake of fish and omega-3 fatty acids has been linked to a reduced risk of breast, prostate, and colon cancers (18Trusted Source, 19Trusted Source).

However, correlation doesn't equal causation. Controlled studies need to confirm whether your intake of omega-3 fatty acids affects your cancer risk.

Omega-3 fatty acids may relieve several health conditions. An effective dosage ranges from 200–4,000 mg.

Omega-3 for children and pregnant people

Research shows that omega-3 fatty acids, especially DHA, are vital before, during, and after pregnancy (20Trusted Source, 21Trusted Source, 22Trusted Source, 23Trusted Source).

Nearly all official guidelines recommend adding 8–12 ounces of fish or shellfish per week during pregnancy and nursing, or an extra 200–300 mg of DHA per day (24, 25Trusted Source, 26Trusted Source).

The FDA suggests 2 servings of fish or seafood per week for children. Serving size depends on age (25Trusted Source):

1 ounce at ages 1–3

2 ounces at ages 4–7

3 ounces at ages 8–10

4 ounces at age 11 and up

Additionally, the FDA also recommends low-mercury seafood options for children and pregnant people (25Trusted Source).

An additional 200–300 mg of DHA is recommended during pregnancy and nursing. The recommended serving for children depends on their age.

Omega-6 intake may affect your omega-3 needs

The typical Western diet contains around 10 times more omega-6s than omega-3s. These omega-6 fatty acids come mainly from refined vegetable oils that are added to processed food (27Trusted Source, 28Trusted Source).

Many experts believe that the optimal omega-6 to omega-3 ratio is closer to 2:1 (29).

Omega-6s and omega-3s compete for the same enzymes, which convert the fatty acids into their biologically active forms (30Trusted Source, 31Trusted Source).

Therefore, if you wish to improve your omega-3 status, you should not only be sure to get enough omega-3 from your diet and supplements but also consider reducing your intake of vegetable oils high in omega-6.

Your body may function best with balanced amounts of omega-6 and omega-3.

The FDA and the European Food Safety Authority (EFSA) claim that omega-3 supplements containing EPA and DHA are safe if doses don't exceed 5,000 mg per day (13Trusted Source, 32Trusted Source, 33).

These cautions are in place for several reasons. For one, omega-3s can cause blood thinning or excessive bleeding in some people.

For this reason, many organizations encourage people who are planning surgery to stop taking omega-3 supplements 1–2 weeks beforehand.

The second reason is due to vitamin A. This vitamin can be toxic in high amounts, and some omega-3 supplements, such as cod liver oil, are high in it.

Finally, taking more than 5,000 mg of omega-3s has never been shown to provide any added benefits, so the risk is not worth taking.

SUMMARY

Taking up to 5,000 mg of omega-3 per day appears to be safe, although such a high intake is likely not necessary for most people.

Omega-3 supplement doses

Omega-3 supplements, including fish oil, contain the long-chain omega-3 fatty acids EPA and DHA.

It's important to read the label of your omega-3 supplement to figure out how much EPA and DHA it contains.

These amounts vary, and the labels can be confusing. For example, a product may provide 1,000 mg of fish oil, but its levels of these two fats could be much lower.

Depending on the concentration of EPA and DHA in a dose, you may need to take as many as eight capsules to reach the recommended amount.

The 7 Best Plant Sources of Omega-3 Fatty Acids

Omega-3 fatty acids are important fats that provide many health benefits.

Studies have found that they may reduce inflammation, decrease blood triglycerides, and even reduce the risk of dementia (1Trusted Source, 2Trusted Source, 3Trusted Source).

The most well-known sources of omega-3 fatty acids are fish oil and fatty fish such as salmon, trout, and tuna.

This can make it challenging for vegans, vegetarians, or even those who simply dislike fish to meet their omega-3 fatty acid needs.

Of the three main types of omega-3 fatty acids, plant foods typically contain only alpha-linolenic acid (ALA).

ALA is not as active in the body and must be converted to two other forms of omega-3 fatty acids — eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) — to bestow the same health benefits (4Trusted Source).

Unfortunately, your body's ability to convert ALA is limited. Only about 5% of ALA is converted to EPA, while less than 0.5% is converted to DHA (5Trusted Source).

Thus, if you don't supplement with fish oil or get EPA or DHA from your diet, it's important to eat plenty of ALA-rich foods to meet your omega-3 needs.

Additionally, keep in mind your omega-6 to omega-3 ratio, as a diet low in omega-3s but high in omega-6s can increase inflammation and your risk of disease (6Trusted Source).

Here are 7 of the best plant sources of omega-3 fatty acids.

Helen Rushbrook/Stocksy

1. Chia seeds

Chia seeds are known for their many health benefits, providing a hefty dose of fiber and protein in each serving.

They're also a great plant-based source of ALA omega-3 fatty acids.

Studies have found that, thanks to their omega-3, fiber, and protein, chia seeds could decrease the risk of chronic disease when consumed as part of a healthy diet.

One study in people with metabolic syndrome found that consuming a diet with chia seeds, nopal, soy protein, and oats decreased participants' blood triglycerides, glucose intolerance, and inflammatory markers (7Trusted Source).

A 2007 animal study also found that eating chia seeds decreased blood triglycerides and increased both HDL (good) cholesterol and omega-3 levels in the blood (8Trusted Source).

However, more human research needs to be conducted before a definitive conclusion can be made.

The current daily recommended intake of ALA for adults over age 19 is 1,100 mg for women and 1,600 mg for men (9Trusted Source).

Just 1 ounce (28 grams) of chia seeds far exceeds your daily recommended intake of omega-3 fatty acids, delivering a whopping 5,000 mg (10Trusted Source).

You can boost your chia seed intake by whipping up a nutritious chia pudding or sprinkling chia seeds on top of salads, yogurts, or smoothies.

Ground chia seeds can also be used as a vegan substitute for eggs. Combine 1 tablespoon (7 grams) with 3 tablespoons of water to replace 1 egg in recipes.

One ounce (28 grams) of chia seeds provides 5,000 mg of ALA omega-3 fatty acids, or 312–454% of the recommended daily intake.

2. Brussels sprouts

In addition to their high content of vitamin K, vitamin C, and fiber, Brussels sprouts are an excellent source of omega-3 fatty acids.

Because cruciferous vegetables like Brussels sprouts are so rich in omega-3 fatty acids and other nutrients, they have been linked to many health benefits.

In fact, one study found that an increased intake of cruciferous vegetables is associated with an almost 16% lower risk of heart disease (11Trusted Source).

A half-cup (44 grams) of raw Brussels sprouts contains about 44 mg of ALA (12Trusted Source).

Meanwhile, cooked Brussels sprouts contain three times as much, providing 135 mg of omega-3 fatty acids in each half-cup (78-gram) serving (13Trusted Source).

Whether they're roasted, steamed, blanched, or stir-fried, Brussels sprouts make a healthy and delicious accompaniment to any meal.

Each half-cup (44-gram) serving of cooked Brussels sprouts contains 44 mg of ALA, or up to 4% of the daily recommended intake.

3. Algal oil

Algal oil, a type of oil derived from algae, stands out as one of the few vegan sources of both EPA and DHA (14Trusted Source).

Some studies have even found that it's comparable to seafood in regard to its nutritional availability of EPA and DHA.

One study compared algal oil capsules to cooked salmon and found that both were well tolerated and equivalent in terms of absorption (15Trusted Source).

Though research is limited, animal studies show that the DHA from algal oil is especially beneficial to health.

In fact, a recent animal study found that supplementing mice with a DHA algal oil compound led to an improvement in memory (16Trusted Source).

However, more human studies are needed to determine the extent of its health benefits.

Most commonly available in softgel form, algal oil supplements typically provide 400–500 mg of combined DHA and EPA. Generally, it is recommended to get 300–900 mg of combined DHA and EPA per day (17Trusted Source).

Algal oil supplements are easy to find in most pharmacies. Liquid forms can also be added to drinks or smoothies for a dose of healthy fats.

Depending on the supplement, algal oil provides 400–500 mg of DHA and EPA, fulfilling 44–167% of the daily recommended intake.

4. Hemp seed

In addition to protein, magnesium, iron, and zinc, hemp seeds consist of about 30% oil and contain a good amount of omega-3s (18Trusted Source, 19).

Studies have found that the omega-3s found in hemp seeds could benefit heart health. They may do this by preventing the formation of blood clots and helping the heart recover after a heart attack (20).

Three tablespoons (30 grams) of hemp seeds contain approximately 2,600 mg of ALA (18Trusted Source).

Sprinkle hemp seeds on top of yogurt or mix them into a smoothie to add a bit of crunch and boost the omega-3 content of your snack.

Also, homemade hemp seed granola bars can be a simple way to combine hemp seeds with other healthy ingredients such as flaxseeds and pack in extra omega-3s.

Hemp seed oil, which is made by pressing hemp seeds, can also be consumed to provide a concentrated dose of omega-3 fatty acids.

Three tablespoons (30 grams) of hemp seeds contain 3,000 mg of ALA omega-3 fatty acids, or 162–236% of the daily recommended intake.

5. Walnuts

Walnuts are loaded with healthy fats and ALA omega-3 fatty acids. In fact, walnuts are composed of about 65% fat by weight (21Trusted Source).

Several animal studies have found that walnuts could help improve brain health as a result of their omega-3 content.

Studies in both humans and animals have found that eating walnuts is associated with improvements in cognitive performance and memory (22Trusted Source).

Another animal study showed that walnuts caused significant improvements in memory, learning, motor development, and anxiety in mice with Alzheimer's disease (23Trusted Source).

More research is still needed in this area since animal studies cannot be applied to humans.

Just one serving of walnuts can fulfill an entire day's requirements of omega-3 fatty acids, with a single ounce (28 grams) providing 2,570 mg (24Trusted Source).

Add walnuts to your homemade granola or cereal, sprinkle them on top of yogurt, or simply snack on a handful to increase your ALA intake.

One ounce (28 grams) of walnuts contains 2,570 mg of ALA omega-3 fatty acids, or 160–233% of the daily recommended intake.

6. Flaxseed

Flaxseed is a nutritional powerhouse, providing a good amount of fiber, protein, magnesium, and manganese in each serving.

It's also an excellent source of omega-3s.

Several studies have demonstrated the heart-healthy benefits of flaxseed, largely thanks to its omega-3 fatty acid content.

Both flaxseed and flaxseed oil have been shown to reduce cholesterol in multiple studies (25Trusted Source, 26Trusted Source, 27Trusted Source).

Another study found that flaxseed could help significantly lower blood pressure, particularly in people with high blood pressure (28Trusted Source)

One tablespoon (10 grams) of whole flaxseed contains 2,350 mg of ALA omega-3 fatty acids, surpassing the daily recommended amount (29Trusted Source).

Flaxseed is easy to incorporate into your diet and can be a staple ingredient in vegan baking.

Whisk together 1 tablespoon (7 grams) of flaxseed meal with 2.5 tablespoons of water to use it as a handy substitute for 1 egg in baked goods.

With a mild yet slightly nutty flavor, flaxseed also makes the perfect addition to cereal, oatmeal, soups, or salads.

One tablespoon (10 grams) of flaxseed contains 2,350 mg of ALA omega-3 fatty acids, or 146–213% of the daily recommended intake.

7. Perilla oil

This oil, derived from perilla seeds, is often used in Korean cuisine as a condiment and cooking oil.

In addition to being a versatile and flavorful ingredient, it's a good source of omega-3 fatty acids.

In one study in 20 elderly participants, researchers replaced soybean oil with perilla oil and found that it caused ALA levels in the blood to double. In the long term, it also led to an increase in EPA and DHA blood levels (30Trusted Source).

Perilla oil is very rich in omega-3 fatty acids, with ALA making up an estimated 64% of this seed oil (31Trusted Source).

Each tablespoon (14 grams) contains nearly 9,000 mg of ALA omega-3 fatty acids.

To maximize its health benefits, perilla oil should be used as a flavor enhancer or dressing, rather than a cooking oil. This is because oils high in polyunsaturated fats can oxidize with heat, forming harmful free radicals that contribute to disease (32Trusted Source).

Perilla oil is also available in capsule form for an easy and convenient way to increase your omega-3 intake.

Each tablespoon (14 grams) of perilla oil contains 9,000 mg of ALA omega-3 fatty acids, or 563–818% of the daily recommended intake.

Chia Seeds : Nutrition Facts and Health Benefits

Chia seeds contain large amounts of fiber and omega-3 fatty acids, plenty of protein, and many essential minerals and antioxidants. They may help improve digestive health, lower blood pressure, and improve blood sugar control.

Chia seeds are the tiny black seeds of the chia plant (Salvia hispanica).

Native to Mexico and Guatemala, they were a staple food for the ancient Aztecs and Mayans. In fact, "chia" is the ancient Mayan word for "strength" (1).

Chia seeds are small, flat, and oval-shaped with a shiny and smooth temperature. Their color ranges from white to brown or black (2).

These seeds are highly versatile. They can be soaked and added to porridge, made into pudding, used in baked goods, or simply sprinkled on top of salads or yogurt.

Because of their ability to absorb liquid and form a gel, they can also be used to thicken sauces or as an egg replacement (3Trusted Source, 4Trusted Source).

Chia seeds contain 138 calories per ounce (28 grams).

By weight, they are 6% water, 46% carbohydrates (of which 83% is fiber), 34% fat, and 19% protein.

The nutrients in 3.5 ounces (100 grams) of chia seeds are (5Trusted Source):

Calories: 486

Water: 6%

Protein: 16.5 grams

Carbs: 42.1 grams

Sugar: 0 grams

Fiber: 34.4 grams

Fat: 30.7 grams

Saturated: 3.33 grams

Monounsaturated: 2.31 grams

Polyunsaturated: 23.67 grams

Omega-3: 17.83 grams

Omega-6: 5.84 grams

Trans: 0.14 grams

Notably, chia seeds are also free of gluten.

Carbs and fiber

More than 80% of the carb content of chia seeds is in the form of fiber.

A single ounce (28 grams) of chia seeds boasts 11 grams of fiber, which is a significant portion of the Reference Daily Intake (RDI) for women and men — 25 and 38 grams per day, respectively (6Trusted Source).

Chia seeds contain both insoluble and soluble fiber. (7Trusted Source).

Chia fiber may also be fermented in your gut, promoting the formation of short-chain fatty acids (SCFAs) and improving colon health (6Trusted Source, 8Trusted Source).

Fat

One of the unique characteristics of chia seeds is their high content of heart-healthy omega-3 fatty acids.

About 75% of the fats in chia seeds consist of the omega-3 alpha-linolenic acid (ALA), while about 20% consist of omega-6 fatty acids (9, 10, 11).

In fact, chia seeds are the best known plant-based source of omega-3 fatty acids — even better than flaxseed (12, 13Trusted Source).

Some scientists believe that a high intake of omega-3s relative to omega-6s reduces inflammation in your body (14Trusted Source).

Because they're a great source of omega-3 fatty acids, chia seeds promote a lower omega-6 to omega-3 ratio.

A low ratio is associated with a lower risk of various chronic conditions — such as heart disease, cancer, and inflammatory diseases — and a lower risk of premature death (15Trusted Source, 16Trusted Source).

However, gram for gram, the omega-3 fatty acids in chia seeds are not nearly as potent as those found in fish or fish oil (EPA and DHA).

The ALA found in chia needs to be converted into the active forms (EPA and DHA) before your body can use it, and this process is often inefficient (17Trusted Source, 18Trusted Source, 19Trusted Source, 20Trusted Source, 21Trusted Source).

Protein

Chia seeds contain 19% protein — a similar amount to other seeds but more than most cereals and grains (1, 10, 22, 23).

High protein intake is associated with increased fullness after meals and reduced food intake (24Trusted Source, 25Trusted Source).

Notably, these seeds offer all nine essential amino acids and are thus a high-quality plant-based protein. However, they are not recommended as the sole protein source for children (26, 27Trusted Source).

Chia seeds are packed with fiber and among the best plant-based sources of omega-3 fatty acids, which have numerous health benefits. They're also loaded with quality protein.

Vitamins and minerals

Chia seeds provide high amounts of many minerals but are a poor source of vitamins.

The most abundant minerals are:

Manganese. Whole grains and seeds are rich in manganese, which is essential for metabolism, growth, and development (28Trusted Source).

Phosphorus. Usually found in protein-rich foods, phosphorus contributes to bone health and tissue maintenance (29Trusted Source).

Copper. A mineral often lacking in the modern diet, copper is important for heart health (30Trusted Source).

Selenium. An important antioxidant, selenium is involved in many processes in your body (31Trusted Source).

Iron. As a component of hemoglobin in red blood cells, iron is involved in the transport of oxygen throughout your body. It may be poorly absorbed from chia seeds due to their phytic acid content.

Magnesium. Often lacking in the Western diet, magnesium plays important roles in many bodily processes (32Trusted Source).

Calcium. The most abundant mineral in your body, calcium is essential for bones, muscles, and nerves (33Trusted Source).

The absorption of some minerals, such as iron and zinc, may be reduced because of the phytic acid content of chia seeds.

Chia seeds are an excellent source of many essential minerals but a poor source of vitamins. They are high in manganese, phosphorus, copper, selenium, iron, magnesium, and calcium.

Other plant compounds

Chia seeds contain a number of beneficial plant compounds, including (9, 11, 34Trusted Source):

Chlorogenic acid. This antioxidant may lower blood pressure (35Trusted Source, 36Trusted Source).

Caffeic acid. This substance is abundant in many plant foods and may help fight inflammation in your body (37Trusted Source).

Quercetin. This powerful antioxidant may reduce your risk of heart disease, osteoporosis, and certain forms of cancer (38Trusted Source, 39Trusted Source, 40Trusted Source).

Kaempferol. This antioxidant has been associated with a decreased risk of cancer and other chronic diseases (41Trusted Source, 42Trusted Source).

Clean, dry chia seeds have an extended shelf life, as their antioxidants protect their fats from damage (1, 43).

Chia seeds contain many powerful antioxidants that may reduce your risk of chronic illnesses such as heart disease and cancer.

Health benefits of chia seeds

Chia seeds have become increasingly popular in recent years because of their high nutritional value and alleged health benefits.

Their main health benefits are listed below.

Increased blood levels of omega-3

Omega-3 fatty acids are incredibly important for your body and brain, and chia seeds are an excellent source of the omega-3 ALA.

However, ALA needs to be converted into the active forms, such as EPA, before your body can use it.

Studies in humans and animals have shown that chia seeds may raise blood levels of ALA up to 138% and EPA up to 39% (21Trusted Source, 44Trusted Source, 45Trusted Source, 46Trusted Source, 47Trusted Source).

Improved blood sugar control

Having healthy blood sugar levels is crucial for optimal health.

Animal studies demonstrate that chia seeds reduce insulin resistance and improve blood sugar control, which are important risk factors for metabolic syndrome, type 2 diabetes, and heart disease (48Trusted Source, 49Trusted Source, 50Trusted Source, 51Trusted Source).

Human studies show that bread made with chia seeds causes a reduced blood sugar response compared with more traditional breads (52Trusted Source, 53Trusted Source).

Lower blood pressure

High blood pressure is a major risk factor for chronic diseases such as heart disease

Chia seeds and chia flour have both been found to lower blood pressure in people who already have elevated levels (54Trusted Source, 55Trusted Source).

Increased fiber intake

Most people don't consume enough fiber (56Trusted Source).

High fiber intake is linked to improved gut health and a lower risk of numerous diseases (57Trusted Source, 58Trusted Source).

A single ounce (28 grams) of chia seeds provides 9.75 grams of fiber, which is 25% and 39% of the RDI for men and women, respectively (5Trusted Source).

Due to their extraordinary water-absorbing capacity, chia seeds increase the volume of foods in your digestive tract, leading to increased fullness and decreased food intake.

Chia seeds have numerous benefits, including lower blood pressure, improved blood sugar control, and higher fiber and omega-3 levels.

Adverse effects and individual concerns

Chia seeds are generally considered safe to eat, and few to no adverse effects have been reported from consuming them (59Trusted Source).

However, to avoid possible digestive side effects, drink plenty of water when eating them — especially if they have not been presoaked.

Phytic acid content

Like all seeds, chia seeds contain phytic acid.

Phytic acid is a plant compound that binds with minerals, such as iron and zinc, and inhibits their uptake from foods (60Trusted Source).

Blood-thinning effect

Large doses of omega-3 fats, such as those from fish oils, may have blood-thinning effects (61Trusted Source).

If you're taking blood-thinning medications, consult with your doctor before incorporating large amounts of chia seeds into your diet. Omega-3 fatty acids may affect the activity of your medication (62Trusted Source, 63Trusted Source).

SUMMARY

Chia seeds generally do not cause any adverse effects. However, they may have blood-thinning effects in large doses, and they contain a plant compound that can reduce mineral absorption.

Chia seeds are very rich in fiber, antioxidants, minerals, and heart-healthy omega-3 fatty acids.

They have been linked to improvement in risk factors for heart disease and diabetes, as well as benefits for digestion and gut health.

Chia seeds are very easy to incorporate into a healthy diet.

Our experts continually monitor the health and wellness space, and we update our articles when new information becomes available.

7 Enticing Health Benefits of Chia Seeds

Chia seeds contain antioxidants, minerals, fiber, and omega-3 fatty acids. These nutrients play a role in supporting multiple body functions and systems.

The nutrients in chia seeds may promote heart health, support strong bones, and improve blood sugar management (1Trusted Source).

What's more, chia seeds are versatile and can be used in many recipes. Personally, I embrace their gel-like consistency by mixing them with liquid and making chia pudding.

Here are 7 health benefits of chia seeds, all supported by science.

1. Highly nutritious

Chia seeds are tiny black or white seeds from the plant Salvia hispanica L. They're believed to be native to Central America (1Trusted Source).

Historically, Aztec and Mayan civilizations used the seeds in their diets, as well as for medicinal purposes, religious rituals, and cosmetics. Today, people all over the world enjoy chia seeds (2Trusted Source).

Ancient civilizations viewed chia seeds as highly nutritious — a belief that's backed by modern science. In fact, just 1 ounce (28 grams or 2 tablespoons) of chia seeds contains (3Trusted Source):

calories: 138

protein: 4.7 grams

fat: 8.7 grams

alpha-linolenic acid (ALA): 5 grams

carbs: 11.9 grams

fiber: 9.8 grams

calcium: 14% of the Daily Value (DV)

iron: 12% of the DV

magnesium: 23% of the DV

phosphorus: 20% of the DV

zinc: 12% of the DV

vitamin B1 (thiamine): 15% of the DV

vitamin B3 (niacin): 16% of the DV

This nutritional profile is particularly impressive considering that it's for just a single serving of about two tablespoons.

Despite their tiny size, chia seeds are highly nutritious. They're packed with fiber, protein, omega-3 fatty acids, and various micronutrients.

Pixel Stories/Stocksy United

2. Loaded with antioxidants

Chia seeds are also an excellent source of antioxidants (1Trusted Source, 4Trusted Source).

Antioxidants not only protect the sensitive fats in chia seeds from going rancid but also benefit human health by neutralizing reactive molecules known as free radicals, which can damage cell compounds if they build up in your body (1Trusted Source).

For example, free radical damage contributes to aging and diseases like cancer (5Trusted Source, 6Trusted Source).

The specific antioxidants in chia seeds include chlorogenic acid, caffeic acid, myricetin, quercetin, and kaempferol. These may all have protective effects on your heart and liver, as well as anticancer properties (1Trusted Source).

For example, chlorogenic acid may help lower blood pressure, while caffeic acid has anti-inflammatory effects (7Trusted Source, 8Trusted Source).

Chia seeds are high in antioxidants. These compounds help protect the seed's delicate fats while also offering health benefits to humans.

3. May support weight loss

The fiber and protein in chia seeds may benefit those trying to lose weight.

One ounce (28 grams) of chia seeds has close to 10 grams of dietary fiber. That means they're a whopping 35% fiber by weight (3Trusted Source, 9Trusted Source, 10Trusted Source).

Although research on this topic is mixed, some studies suggest that eating fiber may play a role in preventing overweight and obesity (11).

Additionally, the protein in chia seeds could help reduce appetite and food intake.

One study in 24 participants found that eating 0.33 ounces (7 grams) or 0.5 ounces (14 grams) of chia seeds mixed with yogurt for breakfast increased feelings of fullness and reduced food intake in the short term compared with eating chia-free yogurt (12Trusted Source).

Even so, studies examining the effectiveness of chia seeds for weight loss have observed mixed results.

In an older study from 2009 involving 90 people with overweight, consuming 50 grams of chia seed supplements per day for 12 weeks did not affect body weight or health markers like blood pressure and inflammation markers (13Trusted Source).

In contrast, a 6-month study involving 77 people with overweight or obesity and type 2 diabetes eating a reduced-calorie diet found that those who took chia seeds daily experienced significantly greater weight loss than those who received a placebo (14Trusted Source).

Though adding chia seeds to your diet is unlikely to cause weight loss on its own, it may be a useful addition to a balanced, nutritious diet if you're trying to lose weight.

Chia seeds are high in protein and fiber, both of which have been shown to aid weight loss. However, studies on chia seeds and weight loss have provided mixed results.

4. May lower your risk of heart disease

Given that chia seeds are high in fiber and omega-3s, consuming them may reduce your risk of heart disease.

Soluble fiber, the kind primarily found in chia seeds, can help lower total and LDL (bad) cholesterol in your blood. In turn, this can reduce your risk of heart disease (15Trusted Source).

Consuming ALA, the omega-3 fatty acid in chia seeds, has also been linked to decreased heart disease risk (16Trusted Source).

Still, studies specifically examining the connection between chia seeds and heart health have had inconclusive results.

Some rat studies have shown that chia seeds can lower certain heart disease risk factors, including high triglyceride and oxidative stress levels (17, 18).

A few human studies found that chia seed supplements significantly reduced blood pressure in people with hypertension, or high blood pressure, which is a strong risk factor for heart disease (19Trusted Source, 20Trusted Source).

Overall, chia seeds may benefit heart health, but more research is needed.

Chia seeds may reduce the risk of heart disease, likely due to the fiber and ALA they contain. However, more human research is needed.

5. Contain many important bone nutrients

Chia seeds are high in several nutrients that are important for bone health, including:

calcium

phosphorus

magnesium

Many observational studies suggest that getting enough of these nutrients is important for maintaining good bone mineral density, an indicator of bone strength (21Trusted Source, 22Trusted Source).

In addition, ALA in chia seeds may play a role in bone health. Observational studies have found that consuming this nutrient could also be associated with increased bone mineral density (23Trusted Source).

Therefore, it's possible that regularly eating chia seeds could help keep your bones strong.

One animal study found that rats who received chia seeds daily for about 13 months had increased bone mineral content compared with a control group. The authors concluded that ALA may have contributed to this benefit (24Trusted Source).

However, besides animal studies, a limited number of studies have explored this topic, specifically. Ultimately, more human research is needed.

Chia seeds are high in calcium, magnesium, phosphorus, and ALA. All of these nutrients have been linked to improved bone mineral density.

6. May reduce blood sugar levels

Consuming chia seeds may help with blood sugar regulation, possibly due to their fiber content and other beneficial compounds.

People with diabetes may experience high blood sugar levels. Consistently high fasting blood sugar levels are associated with an increased risk of several complications, including heart disease (25Trusted Source).

Promisingly, animal studies have found that chia seeds may improve insulin sensitivity. This might help stabilize blood sugar levels after meals (26, 1Trusted Source).

Research in humans is sparse, but some older studies have shown promising results.

In particular, older research from 2010 and 2013 suggests that eating bread containing chia seeds helps lower post-meal rises in blood sugar among healthy adults, compared with eating bread without chia seeds (27Trusted Source, 28Trusted Source).

Nevertheless, more research is needed to learn more about the connection between these nutritious seeds and blood sugar regulation.

Animal studies suggest that chia seeds may help with blood sugar management, but more human research is needed.

7. Easy to incorporate into your diet

Chia seeds are incredibly easy to incorporate into your diet. They taste rather bland, so you can add them to pretty much anything.

You don't need to grind, cook, or otherwise prepare them, making them a handy addition to recipes.

They can be eaten raw, soaked in juice, or added to oatmeal, pudding, smoothies, and baked goods. You can also sprinkle them on top of cereal, yogurt, vegetables, or rice dishes. Plus, they work wonders in homemade fritters as a binding agent.

Given their ability to absorb water and fat, you can use them to thicken sauces and as an egg substitute. They can also be mixed with water and turned into a gel.

The seeds appear to be well tolerated. Still, if you're not used to eating a lot of fiber, you might experience digestive side effects like bloating or diarrhea if you eat too many seeds in one sitting.

A common dosage recommendation is 0.7 ounces (20 grams or about 1.5 tablespoons) of chia seeds twice per day. Remember to drink plenty of water to prevent any digestive side effects.

Chia seeds are easy to prepare and often used as an egg substitute and added to oatmeal or smoothies.

Chia seeds are not only rich in minerals, omega-3 fat, antioxidants, and fiber but also easy to prepare.

Studies suggest that they have various health benefits, ranging from weight loss to a reduced risk of heart disease. However, more research involving humans is needed before any firm conclusions can be made.

If you want to reap the possible benefits of chia seeds, consider incorporating them into your diet. They're a great addition to smoothies, oatmeal, yogurt, baked goods, and more.

Chia Farming: If you want to earn twice the cost then grow Chia

Chia crop is neither affected by disease-pests nor is there any possibility of spoilage.

Chia, or Mexican chia, is an oilseed crop. It is relatively new to Indian farmers, but its popularity is growing rapidly, as according to agricultural experts, the yield from chia cultivation can fetch more than double the cost in the market. That is, Chia is a great option for making better profits in farming. Rich in nutrients, chia is an extremely low-maintenance crop. Chia crop remains free from diseases and pests. There is no possible damage to its crop, so Chia farmers do not have to worry about loss in cultivation.

Chia is a major commercial crop in Mexico and Guatemala in South America. Spreading from the mountainous areas, its cultivation was also established in Australia, Bolivia, Colombia, Peru, and Argentina. In India, scientific cultivation is being done in Madhya Pradesh, Andhra Pradesh, Gujarat, Karnataka, Rajasthan, and Haryana. Chia oil's growing popularity is due to its high levels of polyunsaturated fatty acids. For this reason, the trend of using it mixed with traditional edible oils is increasing rapidly. Chia belongs to the family of Tulsi (Lamiaceae), which is why the properties of Tulsi are also found in it.

Scientific Cultivation of Chia

Chia can be grown easily in moderately fertile and well-drained soil. Chia has the ability to tolerate acidic soil to a great extent. But its yield decreases in more saline and alkaline soils. Sandy loam soil is most suitable for a good yield of Chia. Progressive farmers in central and south Indian states also cultivate chia seeds for export. It is better to do organic farming of Chia for good nutritional production.

Chia Sowing Time

The research of the Agricultural Research Center of Mandore affiliated with Jodhpur Agricultural University has proved that the best time to sow Chia in the Indian climate is from the 5th to the 25th of October. At the time of sowing, the temperature of 25 to 30 degrees Celsius is most suitable for good germination of chia seeds. Although Chia is very sensitive to cold, it likes the coolness of December and January. This season, flowers come in chia, and filling grains in earrings starts.

A deep plowing is sufficient to prepare the field before sowing chia. After this, harrowing should be done and paving should be done. Good quality seeds should be used for sowing. If Chia seeds are not available with your nearest seed seller, then you should contact the nearest Krishi Vikas Kendra (KVK).

Sowing of Chia: **Chia can be sown with seed drill or sowing machine. Since chia seeds are so small, some adjustments may need to be made to the seed drill equipment. Chia**

seed can be mixed with roasted millet at the rate of 3 to 7 ratio to ensure the desired seed rate for sowing. At the time of sowing, row to row distance of 30 to 45 cm and plant to plant distance of 30 cm should be kept.

Seed Quantity: **On accurate sowing with a standard seed drill at a fixed distance, only 500 grams of seed is sufficient in one hectare. But usually 2 to 2.5 kg of seed is used for sowing Chia in one hectare. Spacing may need to be improved as chia plants grow in the field after germination. Two weeks after sowing the plants are thinned at a distance of 30 cm.**

Use of Manure in Chia Cultivation

It is very beneficial to give 10-15 tonnes of well decomposed cow dung manure per hectare to get good nutrition and good yield of Chia crop. In light soils, giving 20-30 kg Nitrogen, 20-25 kg Phosphorous and 15-20 kg Potash per hectare at the time of sowing is beneficial for the required growth of plants. If required, 10 kg Nitrogen per hectare can also be given 30-45 days after sowing.

Chia Crop Irrigation

Chia must have sufficient soil moisture at the time of sowing for the seeds to germinate. The number of irrigations will depend on the type of soil and the ambient temperature. Generally, 4-5 irrigations are required after sowing in sandy or sandy loam soil. But when Chia crop is about to ripen, its sensitivity to moisture increases a lot, so do not irrigate during that period.

Chia plant can grow up to 1 meter tall. Its leaves are 1.5 to 3 inches long and 1 to 2 inches wide. Small flowers of 3-4 mm size of white or purple color bloom in it. They have the property of self pollination. Its oval and black, brown and black-white spots are in color and their diameter is 1 to 2 mm.

Weed and Pest Control

Chia itself is a powerful crop. It doesn’t care much about weeds. Nevertheless, the management of weeds in the early stages of plant development is of great benefit. Plowing with tractor drawn hoeing or hand hoe 25-30 days after sowing can control the weed. Chia plants are not a problem with pests and diseases. But many times when the crop is about to ripen, an outbreak of ants has been seen on its earrings. To prevent this, a line of insecticide powder can be made around the field.

Chia must be protected from Frost

The effect of frost has been observed on Chia crop. Chia is sensitive to the cold of December and January. This causes its tender leaves and emerging earrings to turn black. The filling of seeds in the crop and the yield are affected by the effect of frost. That's why the soil temperature should be maintained comfortable by doing light surface irrigation of the field in frost prone season.

Harvesting, Threshing, Yielding and Storage

Chia crop ripens in 120-130 days. Then all its leaves fall off and only earrings remain on the stem. In developed countries it is harvested by machines like other small seed crops like berseem and rizka, but in India the crop is harvested with sickles or sickles. In threshing, seeds are separated by pressing/crushing the Chia ears with wooden sticks.

Chia threshing is also done with little addition to a standard thresher using a small screen. By cultivating Chia with the above general production method, a yield of 6 to 8 quintals per hectare can be obtained. Cleaned and dried seeds can be kept in normal barn or godown for 3-4 months.

Chia seeds contain 15 to 25 percent protein, 30 to 33 percent fat, 26 to 41 percent carbohydrate, 18 to 30 percent high dietary fiber, and many minerals, vitamins, and antioxidants. Its oil is rich in polyunsaturated fatty acids such as omega-3 and omega-6. Chia oil contains up to 67 percent alpha linolenic fatty acid. This is the highest among all oils.

Chia is cultivated for the oil obtained from its seeds, as it is added to traditional edible oils to enhance its nutritional value. For weight loss, it should be consumed only with the advice of a doctor. Chia is also eaten sprouted or raw. In many countries such as the United States, Canada, Chile, Australia, New Zealand, and Mexico, chia is eaten with cookies, snacks, bars, cakes, yogurt, and fruit juices.

35 Fun Ways to Eat Chia Seeds

We include products we think are useful for our readers. If you buy through links on this page, we may earn a small commission Here's our process. You can add chia seeds to baked goods, drinks like smoothies, and other recipes to add extra nutrients to your diet.

Chia seeds are tiny but extremely nutritious. Just 2 tablespoons (30 grams) contain 10 grams of fiber, 5 grams of protein, and 138 calories (1Trusted Source). They're a great source of omega-3 fatty acids and some minerals essential for bone health, including calcium, phosphorus, and magnesium. Chia seeds are also flavorless, making them easy to add to many foods and recipes.

Here are 35 fun ways to eat chia seeds.

1. Chia water

One of the simplest ways to include chia seeds in your diet is to add them to water. To make chia water, soak 1/4 cup (40 grams) of chia seeds in 4 cups (1 liter) of water for 20–30 minutes. To give your drink some flavor, you can add chopped fruit or squeeze in a lemon, lime, or orange.

2. Juice-soaked chia

Water isn't the only liquid you can soak these seeds in. Add 1/4 cup (40 grams) of chia seeds to 4 cups (1 liter) of fruit juice and soak for 30 minutes to make a drink that's full of fiber and minerals.

This recipe gives you several servings of juice. Just make sure to keep your intake moderate, as fruit juice contains lots of sugar.

3. Chia pudding

You can make chia pudding as you would chia water. For a thicker, pudding-like texture, add more seeds and let the mixture soak longer. You can make this treat with juice or milk, including flavourings like vanilla and cocoa. Chia pudding makes a delicious dish that can be eaten for breakfast or as a dessert. If you don't like the seeds' texture, try blending it to give it a smoother finish.

4. Chia in smoothies

If you want to make your smoothie even more nutritious, consider adding chia seeds. You can use chia in almost any smoothie by soaking them to make a gel before adding.

5. Raw chia toppings

Although many people prefer to soak chia seeds, you can eat them raw, too. Try grinding and sprinkling them on your smoothie or oatmeal.

6. Chia cereal

To try something a little different for breakfast, you could swap your usual cereal for chia cereal. To make it, soak the seeds overnight in milk (or a milk substitute like almond milk) and top with nuts, fruit, or spices like cinnamon. You can also use mashed banana and vanilla extract to make a delicious morning treat.

7. Chia truffles

If you’re often in a hurry, you can use chia seeds to make a great on-the-go snack. For a quick and easy no-bake snack, try chia truffles that combine dates, cocoa, and oats.

8. In a stir-fry

You can also add chia seeds to savory dishes like stir-fries. Just add a tablespoon (15 grams) of seeds and mix.

9. Added to a salad

Chia seeds can be sprinkled on your salad to give it some texture and a healthy boost. Simply mix them in and add your favorite salad vegetables.

10. In salad dressing

You can also add chia seeds to your salad dressing. Commercially prepared salad dressings are often loaded with sugar. Making your own dressing can be a much healthier alternative.

11. Baked in bread

It’s possible to add chia seeds to many recipes, including bread. For example, you can try a homemade buckwheat bread that’s healthy and flavourful.

12. As a crispy crumb coating for meat or fish

Another fun way to use chia seeds is as a coating for meat or fish. Ground into a fine powder, the seeds can be mixed with your usual breadcrumb coating or used to substitute it altogether, depending on your preference.

13. Baked in cakes

Cakes are usually high in fat and sugar. However, chia seeds can help improve their nutritional profiles. Adding them to your cake mix will boost the fiber, protein, and omega-3 content.

14. Mixed with other grains

If you don’t like the gooey texture of soaked chia seeds, you can mix them with other grains. You don’t need a fancy recipe. Simply stir 1 tablespoon (15 grams) of seeds into a cup (180 grams) of rice or quinoa.

15. In breakfast bars

Breakfast bars can be very high in sugar. In fact, some contain as much sugar as a candy bar. However, making your own with chia is quite easy. Just be sure to cut back on the sugar content.

16. In pancakes

If you like this fluffy breakfast food, you could try adding chia seeds to your pancake mix.

17. In jam

Chia seeds can absorb 10 times their dry weight in water, which makes them a great substitute for pectin in jam. Pectin is quite bitter, so substituting pectin with chia seeds means that your jam won't need a lot of added sugar to make it taste sweet. Better yet, chia jam is much easier to make than traditional jam. Try adding blueberries and honey — and skipping the refined sugar.

18. Baked in cookies

If you love cookies, chia seeds can give your cookie recipe a nutritional boost. Both oatmeal and chocolate chip cookies are good options.

19. Chia protein bars

Like breakfast bars, many commercially prepared protein bars can be high in refined sugar and taste more like a candy bar than a healthy snack. Homemade chia-based protein bars are a healthy alternative to prepackaged ones.

20. In soup or gravy

Chia seeds can be a great replacement for flour when thickening stews or gravies. Simply soak the seeds to form a gel and mix it in to add thickness.

21. As an egg substitute

If you avoid eggs, keep in mind that chia seeds make a fantastic substitute in recipes. To substitute for 1 egg, soak 1 tablespoon (15 grams) of chia seeds in 3 tablespoons (45 ml) of water.

22. Added to dips

Chia seeds are a versatile ingredient and easily mixed into any dip. You can add them into homemade dip recipes or stir them into your favourite store-bought version.

23. Baked in homemade muffins

Muffins are often eaten for breakfast or dessert, depending on their ingredients. Notably, chia seeds can be added to both savory and sweet versions of this baked good.

24. In oatmeal

Adding chia seeds to oatmeal requires very little effort. Simply prepare your oatmeal and stir in 1 tablespoon (15 grams) of whole or ground seeds.

25. In yogurt

Chia seeds can make a great yogurt topping. If you like a bit of texture, sprinkle them on top whole. If you want to avoid the crunch, mix in ground seeds.

26. To make crackers

Adding seeds to crackers isn't a new idea. In fact, many crackers contain seeds to give them extra texture and crunch. Adding chia seeds to your crackers is a good way to include them in your diet.

27. As a thickener for homemade burgers and meatballs

If you use eggs or breadcrumbs to bind and thicken meatballs and burgers, you could try chia seeds instead. Use 2 tablespoons (30 grams) of seeds per pound (455 grams) of meat in your usual meatball recipe.

28. As a homemade energy gel

Athletes looking for a homemade alternative to commercially produced energy gels could consider using chia. You can buy chia gels online or make your own.

29. Added to tea

Adding chia seeds to drinks is an easy way to include them in your diet. Add 1 teaspoon (5 grams) into your tea and let them soak for a short time. They may float at first but should eventually sink.

30. To make tortillas

Soft tortillas can be eaten with a variety of fillings and are a delicious way to enjoy chia seeds. You can make your own or purchase them pre-made.

31. In ice cream or ice cream pops

Chia seeds can also be added to your favorite treats, such as ice cream. You can blend and freeze chia puddings to make a smooth ice cream or freeze them on sticks for a dairy-free alternative.

32. To make a pizza base

Chia seeds can be used to make a high-fiber, slightly crunchy pizza crust. Simply make a chia-based dough and add your toppings.

33. To make falafel

Falafel with chia can be especially enjoyable for vegans and vegetarians. You can combine them with a variety of vegetables for flavor.

34. In homemade granola

Making granola is simple. You can use any mixture of seeds, nuts, and oats you like. If you don't have time to make your own, plenty of commercial granolas include chia.

35. In homemade lemonade

Another interesting way to consume chia seeds is in homemade lemonade. Soak 1.5 tablespoons (20 grams) of seeds in 2 cups (480 ml) of cold water for a half hour. Then add the juice from 1 lemon and a sweetener of your choice. You can also experiment with adding extra flavors like cucumber and watermelon.

We will enter into this omega 3 concentrate projects from chia seed -farming and processing.

ARTIFICIAL INTELLIGENCE IN AGRICULTURE – EXHIBIT- 30

Technology

How Artificial Intelligence Can Be Used in Agriculture

What is the role of artificial intelligence in solving the global food crisis and other agricultural problems? To what extent can artificial intelligence be utilized to alleviate the global issue of food inequality? In this article, we'll explore how AI is being used in agriculture, from predicting crop yields to improving soil health, and how it can pave the way for a more sustainable and food-secure future.

March 14, 2023

What is the role of artificial intelligence in solving the global food crisis and other agricultural problems? To what extent can artificial intelligence be utilized to alleviate the global issue of food inequality?

Despite producing enough food to feed the world's population, nearly one billion people still suffer from hunger and malnutrition because of food wastage, climate change, and other factors. Moreover, with the global population projected to reach 9.7 billion by 2050, the pressure is mounting on the agricultural industry to produce more food while using fewer resources and reducing its environmental impact.

Fortunately, the integration of artificial intelligence (AI) in agriculture has the potential to transform food systems and help address the global food crisis. By analyzing data from various sources, AI can help farmers make data-driven decisions, optimize resource usage, and reduce environmental impact. For example, the World Economic Forum has reported that AI integration in agriculture could bring about a 60% decrease in pesticide usage and a 50% reduction in water usage.

In India, a country with one of the most prominent Agtech startups, enhancing 15 agriculture datasets, such as soil health records, crop yields, weather, remote sensing, warehousing, land records, agriculture markets, and pest images, could lead to a $65 billion opportunity, according to research conducted by NASSCOM and McKinsey.

In this article, we'll explore how AI is being used in agriculture, from predicting crop yields to improving soil health, and how it can pave the way for a more sustainable and food-secure future.

Use of Artificial Intelligence in Agriculture

There are many approaches to leveraging AI to enhance efficiency and productivity in agriculture. We've gathered a few examples to illustrate some of them.

Analyzing market demand

Analyzing market demand is a crucial aspect of modern agriculture. AI can help farmers select the best crop to grow or sell. Descartes Labs is a New Mexico-based company that offers an AI-powered platform to help farmers evaluate market demand. The company develops machine learning algorithms to analyze satellite imagery and weather data, providing valuable insights on optimal planting times and the best crops to grow. By analyzing data patterns, Descartes Labs can predict the market demand for specific crops and help farmers maximize their profits.

Managing risk

Through forecasting and predictive analytics, farmers can minimize the risk of crop failures. For example, Intello Labs is a startup company in India that uses artificial intelligence (AI) to help farmers analyze the quality of their produce and reduce food loss.

The company develops software application products that use AI and computer vision algorithms to analyze fruits and vegetables and provide insights on quality, ripeness, and size. These AI tools can also detect defects and diseases in crops, enabling farmers to take preventive measures before the crops are affected.

Breeding seeds

By collecting data on plant growth, AI can help produce crops that are less prone to disease and better adapted to weather conditions. With the help of AI, scientists can identify the best-performing plant varieties and crossbreed them to create even better hybrids.

Yes, the process of creating hybrids has been used in the agricultural industry for many years. However, gathering genomic information of seeds through AI technologies like that of Seed-X can help to speed up the process and increase the likelihood of success.

Monitoring soil health

AI systems can conduct chemical soil analyses and estimate missing nutrients accurately. One example is AI-powered hardware and software built by Agrocares, a Dutch agritech company.

One of their products, Nutrient Scanner, collects data from soil samples and provides farmers with accurate estimates of missing nutrients and overall soil status. This allows farmers to adjust their fertilizer application and irrigation practices to ensure optimal crop growth and reduce environmental impact.

In addition to this, AgroCares provides farmers with customized recommendations for soil management, helping them to maintain the health of their soil in the long term.

Protecting crops

AI can monitor the state of plants to spot and predict diseases, identify and remove weeds, and recommend effective treatment of pests. For example, a precision agriculture startup called Taranis uses computer vision and machine learning to analyze high-resolution images of crops, providing plant insights to identify signs of stress or disease. Their AI-powered technologies can detect and classify diseases and

pests with high accuracy. It can also suggest the most effective treatment for pests, reducing the need for broad-spectrum insecticides that can harm beneficial insects and lead to pesticide resistance.

Observing crop maturity

Estimating crop growth and maturity is a tedious and challenging task for farmers, but AI can handle the job quickly and precisely. Through AI-powered hardware such as sensors and image recognition tools, farmers can detect and track crop changes to obtain accurate predictions on when crops will reach optimal maturity. Studies have found that using AI to predict the maturity of crops resulted in a higher accuracy rate than the accuracy rate achieved by human observers. This increased accuracy can bring significant cost savings and higher profits for farmers.

Soil monitoring

Integrating sensors and AI systems enables farmers to accurately monitor how much water and nutrients are available in the soil. Using sensors in soil monitoring could involve deploying devices that measure various parameters like soil moisture, temperature, pH levels, and nutrient content. These sensors send information back to AI systems which then analyze it and provide instructions to farmers on how best to manage their crops based on what they find out about the soil conditions.

For example, the AI system might identify areas of the field where the soil is too dry or too moist and provide recommendations on when and how much water to apply to optimize crop growth. Similarly, the system might detect nutrient deficiencies in the soil and provide advice on the suitable types and amounts of fertilizer to use to improve yields.

Insect and plant disease detection

Farmers can use AI-powered systems to detect insects and plant diseases more quickly than humans. For example, an AI-powered system could detect an infestation of aphids on a crop of strawberries, send the data back to the farmer's mobile phone, and then suggest what action should be taken next. If a pesticide application is needed, the system could even automate it through a connected sprayer.

Intelligent spraying

Weed or pest control can be automated with AI technologies. With the help of computer vision, weeding robotics is said to be remarkably precise, resulting in a 90% reduction in pesticide usage. Based on data analytics, these tools can calculate how much pesticide is needed for each field based on data about its history, soil status, or crop type.

Blue River Technology has disrupted traditional weed control methods with its flagship product, the "See and Spray" machine. Using computer vision and machine learning, the device can distinguish between crops and weeds and then apply herbicide only where needed. This can be cost-effective.

Chatbots for farmers

Chatbots can be used as an interface between farmers and their customers or distributors. Farmers can use these conversational agents to answer questions about products or services offered, order supplies, and check inventory levels.

Chatbots are also useful for managing databases of information about crops and soil conditions. They act like virtual farm assistants for executing farm tasks. Chatbots like Microsoft's FarmVibes.Bot provides farmers with personalized advice and recommendations based on data. The platform uses natural language processing and machine learning algorithms to understand farmers' queries and provide real-time insights on weather, market prices, and other agricultural information. It's currently being used by over half a million sub-Saharan African farmers.

The Future of AI in Agriculture

Artificial Intelligence (AI) in agriculture is poised to grow significantly in the coming years, as it has the potential to revolutionize the sector by improving crop yields, reducing waste, and increasing efficiency. According to a report by MarketsandMarkets, the AI in agriculture market is predicted to experience explosive growth, with the market size expected to grow from $2.35 billion in 2020 to $10.83 billion by 2025 at a Compound Annual Growth Rate (CAGR) of 35.6% during the forecast period.

Collecting and analyzing large amounts of data is among the most notable advantages of AI in agriculture for farmers. This will lead to more informed decision-making and improved crop yields, essential for addressing the global food security challenge.

Farmers can also use AI to monitor soil conditions, crop growth, and climate changes. As a result, they will be able to detect diseases early and take the necessary preventive measures before a crop is destroyed. AI will also continue to aid in forecasting weather changes, allowing farmers to plan their activities better and to take advantage of the optimal planting season.

Furthermore, AI can also help to reduce waste and resource usage. For example, farmers can use AI to optimize the amount of fertilizer and water used on their crops,

leading to a more sustainable and environmentally friendly practice. This optimization will reduce the risk of soil and water contamination, which is an increasing concern today.

While the benefits of AI in agriculture are numerous, the reality is that most farmers worldwide, particularly smallholder farmers, lack the necessary resources to implement these technologies. Smallholder farmers typically have limited access to technical training, which makes it difficult for them to operate AI systems effectively. Many also lack the financial resources needed to purchase the equipment and software required for AI-based farming.

The adoption of AI in agriculture must be inclusive, considering the needs and limitations of smallholder farmers, who make up a significant portion of the global agricultural workforce. Initiatives that provide access to training and funding for smallholder farmers to implement AI-based farming practices can help bridge the divide. With this, farmers at all levels can benefit from emerging technologies that the world needs to secure our food system's future.

Based mostly in rural areas, smallholder farmers might not have access to experts who can deliver helpful advice to aid modern farming practices. At MAHASAMVIT, we are happy to be part of a growing movement that is helping to bring more transparency and education to smallholder farmers through AI-powered advice.

OUR FUTURE AI-powered apps, can provide targeted advice to farmers at scale. They're already helping farmers achieve more sustainable and productive farms.