



Food Processing of Horticultural Crops

Food processing has a critical role in achieving food and nutrition security. It is required to increase the shelf life of foods and is of utmost importance for perishable commodities like fruits and vegetables to optimize nutrient availability and food quality, and reduce losses and waste. India is the sixth largest food and grocery market in the world and food processing industry contributes 32% to this food market.

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Food processing involves the intentional transformation of any food item from its raw or natural state into a consumable or more durable form. The ultimate objectives include preparing foods for consumption, preservation by slowing or stopping decay to extend shelf life, ensuring safety, and enhancing taste and nutritional profiles. India is the 2nd largest producer of fruits and vegetables in the world with a share of 11.7 and 17.8 per cent, respectively and had a record horticultural production of 355.48 million tonnes in 2022-23. Most

of the horticultural produce like fruits and vegetables are perishable due to short shelf life resulting in huge post-harvest losses. In a study conducted by Indian Council of Agricultural Research-Central Institute of Post-Harvest Engineering and Technology in 2015, 6.7-15.8 per cent of the fruits and 4.5 – 12.4 per cent of vegetables produced in the country are lost due to poor post-harvest handling. National Bank for Agriculture and Rural Development, in its report in 2020, also corroborated this fact that post-harvest handling is responsible for 20-30 per cent of losses, which amounts to Rs. 1,52,000 crores, across various stages, including

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storage, grading, packaging, shipping, and marketing, whether as fresh produce or in processed form. These losses primarily occur in the farmer's field (15-20 per cent), during packaging (15-20 per cent), transportation (30-40 per cent), and marketing (30-40 per cent). Thus, food processing has a critical role in achieving food and nutrition security. Fresh fruits and vegetables contain many vitamins, minerals, dietary fibre, and other nutrients and are an important part of the human diet. The World Health Organization recommends an average daily intake of at least 400 g of fruits and vegetables, significantly reducing the risk of chronic diseases, controlling body weight, and improving intestinal health. Food processing is required to increase the shelf life of foods and is of utmost importance for perishable commodities like fruits and vegetables to optimize nutrient availability and food quality, and reduce losses and waste.

Importance and Scope

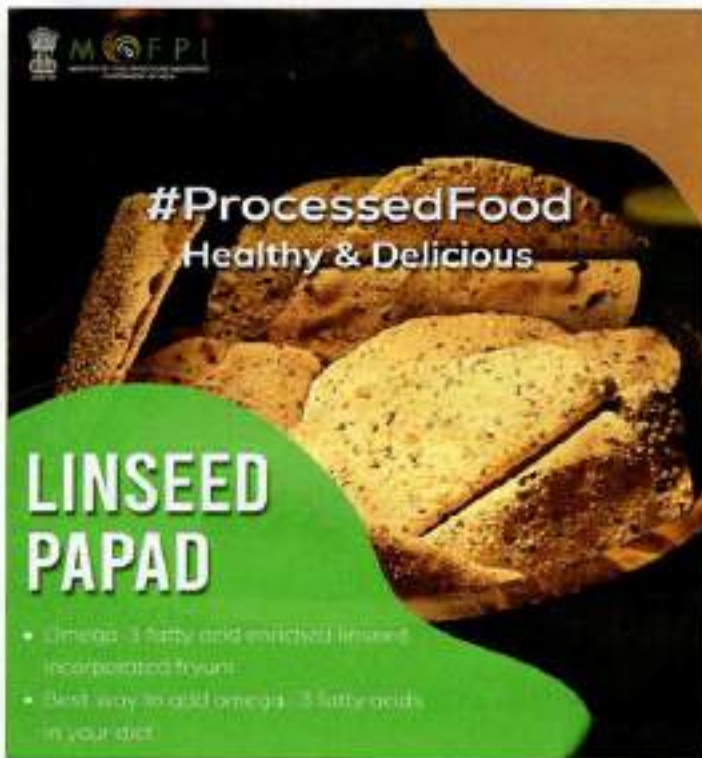
The global market for fruit and vegetable ingredients is estimated at US\$194.1 billion in 2023 and is projected to reach US\$286.8 billion by 2030 and expected to grow from compound annual growth rate (CAGR) of 5.7 per cent from 2023 to 2030. Further, there is an export potential as developed economies import a higher proportion of processed food, comprising about 48 per cent of their total food imports, compared to around 35 per cent for developing economies. The world demand for processed vegetables in the year 2022 was 28.3 million MT by volume and valued at 40 billion USD.



Major importing countries are the USA, Germany, UK, France, Japan, China, Belgium, Netherlands and Italy.

India is the 6th largest food and grocery market in the world and food processing industry contributes 32 per cent to this food market. The market size of the food processing sector in India is estimated to reach US\$1,274 billion in 2027 from US\$866 billion in 2022. Food processing industries also contributes 13 per cent to total export and 6 per cent to the industrial investment. The growing consumption of food is expected to reach US\$1.2 trillion by 2025-26, owing to urbanization and changing consumption patterns. However, food processing levels remain significantly lower in India in comparison to global standards. India currently processes less than 10 per cent of its agricultural output which comprises only around 2 per cent of fruits and vegetables, 6 per cent of poultry, 21 per cent of meat, 23 per cent of marine and 35 per cent of milk. Further, the share of India's high-value and value-added agricultural produce in its agriculture export basket is less than 15 per cent, compared to 25 per cent in the US and 49 per cent in China. The Indian Fruit Juice Market is expected to grow at a robust 7.76 per cent CAGR, reaching a market size of US\$537.172 million in 2030 from US\$369.703 million in 2025. Horticulture industry is one of the big resource and raw material for food processing. This sector constituted 10.54 and 11.57 per cent of Gross Value Added (GVA) in manufacturing and agriculture sector, respectively in





2020-21 which was ₹1.92 lakh crore in 2022-23. Food processing sector had 1.69 per cent share of GVA in the total GVA of the country in 2019-20. Share of processed food export in agri-food export has gone up to 23.4 per cent in 2023-24 from 13.7 per cent in 2014-15. The total FDI received in the food processing sector since April 2000 till March 2022 was US \$11.08 Billion. In 2023-2024, India's agricultural exports including processed food touched USD \$48.9 billion. India stands as one of the largest exporters of cucumber and gherkins globally, exporting 28 per cent by volume and 25 per cent by value of the global demand between 2020-2022. But there is

Achievements
UNDER PRADHAN MANTRI FORMALISATION OF MICRO FOOD PROCESSING ENTERPRISES SCHEME (PMFME)

- A total of **46,643** Loans have been sanctioned under the credit linked subsidy component of the PMFME scheme, since January 2024.
- An amount of **Rs. 254.87 crore** has been sanctioned as seed capital assistance to **71,714** Self Help Group (SHG) members.
- **2** Incubation Centres approved and **11** Incubation Centres have been completed/inaugurated/commissioned during the period providing product development support to grass-root Micro Enterprises.
- **4** proposals of Marketing & Branding have been approved to provide branding support to the micro enterprises

Year End Review 2024

still a noticeable gap between the world's demand and supply from India. India exported processed vegetables worth USD \$526.93 million, equivalent to 409,699 MT in the year 2022. India's major export destinations for processed vegetables include the USA, UK, Germany, Spain, and the Netherlands.

Employment generation has been the significant outcome of the growth of this sector, directly employing about 20.05 lakh people across 40,579 registered food processing factories. Food processing sector is one of the largest employment providers in the organized manufacturing sector with 12.41 per cent employment in the total registered/organized sector as per the report of Annual Survey of Industries (ASI), 2022-23. The Southern region of India dominates the food processing sector with the highest 5348 registered factories in Andhra Pradesh which accounts for about 14.3 per cent of the total units in India, followed by 4764 in Tamil Nadu with share of 12.7 per cent, 3598 in Telangana with share of 9.6 per cent. Punjab has 3200 units with share of 9 per cent followed by Maharashtra having 2509 units with share of 7.0 per cent. Telangana, Tamil Nadu, Andhra Pradesh, Karnataka, and Kerala contribute significantly to the nation's exports accounting for 48 per cent by volume and 41 per cent by value of India's processed fruits, juices, and nuts exports.

New Technologies in Food Processing

Modern technologies are becoming a key element of food processing sector, introducing innovations that not only has potential to increase production efficiency but also shape new standards of food quality and safety. Many of these technologies are green food processing technologies which focus on using renewable resources, reducing waste, and cutting down on energy use. Green techniques such as freeze-drying, high-temperature short-time (HTST) processing, decaffeination, aseptic packaging, and food irradiation are revolutionizing the industry.

Non-Thermal Technologies

Among the new, unconventional food preservation technologies, the non-thermal high-pressure method seems to be promising. These non-thermal treatments reduce microbial load present in the food by destroying the cell membranes and genetic material thereby causing disorganization of catabolic and anabolic activities in the food spoiling microorganisms. All these non-thermal treatments can be employed in single or they can be

NEW TECHNOLOGY IN FOOD PROCESSING INDUSTRIES #2



IRRADIATION

It is the process by which an object is exposed to radiation. An irradiator is a device used to expose an object to radiation, notably gamma radiation, for a variety of purposes.

Uses:

1. Sterilization of pharmaceuticals and other shelf stable foods.
2. Extension of shelf life of various foods to be distributed and stored at refrigerated temperatures, eg. fresh fish, meats, milk, eggs.
3. Inhibition of sprouting in onions and potatoes, and delay in ripening of fruits.

used in a sequential approach or in amalgamation with each other to bring about maximum damage to food spoiling microorganism. These approaches will increase shelf life of food by utilizing energy efficiently for a fleeting time and keeping nutritional, textural, organoleptic qualities of food intact.

High-Pressure Processing (HPP): High-pressure processing (HPP) is a food pasteurization method where food is subjected to elevated pressures (up to 87,000 pounds per square inch, or 6,000 atmospheres, or 600 MPa), at ambient or chilled temperatures, to alter the food's attributes to achieve consumer-desired qualities. The use of high-pressure processing allows us to kill microorganisms that can cause diseases or spoil food. High-pressure processing method has been shown many advantages over the traditional methods as it reduces rennet coagulation time (RCT) and also improve the cheese yield. Cheeses made from milk treated by this method exhibited higher moisture, salt, and total free amino acid content compared to cheeses made from raw or pasteurized milk.

Cold Plasma Technology (CPT): Cold plasma is a recent technical intervention for maintaining food quality and safety. Cold plasma is generated by electric discharges implemented at various levels of pressure in high-moisture foods, as a vacuum boosts liquid conversion to gaseous phase. This novel method also results in microbial inactivation of foods. CPT is gaining prominence in the food processing industry for its

versatile applications in enhancing food safety and extending shelf life.

Pulse Electric Field Technology (PEF): PEF technology is increasingly used in food processing to deactivate microorganisms and enzymes, thereby extending the shelf life of various products without relying on traditional heat treatments. Pulsed electric fields are extensively used for fluid foods like processing of fruit juices, squash, milk etc. The treatment destroys cell membranes of microorganism in treatment time of less than one second. PEF technology has become a global standard for pretreatment before cutting in the production of French fries and chips, due to its numerous process and quality advantages. PEF softens the potato tissues by discharging cell fluid and reducing turgor pressure, effectively replacing the traditional pre-heater. This change reduces water and energy consumption by up to 90 per cent and avoids heating the product.

In other innovative non-thermal technologies, the use of ultrasound can lead to a shortening of the drying time and temperature, thereby improving product quality while preserving health-promoting compounds. Irradiations are usually preferred for the treatment on solid food material. The ionizing radiations used include high speed electrons, high power photons, X-rays which causes damage to the membranes of microbial cells and the disruption in genetic makeup of cells. Non thermal techniques like ultraviolet light treatment are used

NEW TECHNOLOGY IN FOOD PROCESSING INDUSTRIES #9

FREEZE DRYING

Also termed "lyophilization," it is a drying process where the wet product is first frozen to a solid phase and subsequently dried (typically to a final moisture content of 1-3%) by sublimation of the ice under reduced pressure.



PMFME
PM Formalisation of Micro food processing Enterprises Scheme

A SPECIAL INITIATIVE FOR THE DEVELOPMENT OF MICRO FOOD PROCESSING ENTERPRISES.

76 Incubation Centers with an outlay of more than ₹200 crores have been approved.

for treating exterior surfaces of raw fruits, processed food, and packaging material. Cold chain logistics and preservation technologies are essential to cutting down on food waste and prolonging the shelf life of perishables. This holds particularly true for meat, dairy, fruits, and vegetables. In addition, ultraviolet light is also used for treating food processing equipment before and after food processing operations.

Food Fortification

Fortification is the addition of key vitamins and minerals such as Iron, Iodine, Zinc, and Vitamins A & D to various food articles such as rice, wheat, oil, milk, salt, etc. to improve their nutritional content. These nutrients may or may not have been originally present in the food before processing or may have been lost during processing. Various technologies aid this process, such as premixing to ensure even nutrient distribution, extrusion for cereals, spray drying for powdered products, encapsulation that helps protect nutrients, especially in fats and oils. Further, emerging nanotechnology techniques also offers potential for better nutrient absorption. World Health Organization (WHO) has recognized food fortification as a safe and cost-effective public health intervention in prevention, reduction and control of micronutrient deficiencies also known as hidden hunger. Globally, over 100 countries, including India, have implemented national salt iodisation programmes, 85 countries have mandated wheat flour fortification, and 32 countries have

mandatory guidelines for fortification of cooking oil.

Artificial Intelligence (AI)

Among the new strategies for maintaining the quality of fresh vegetables and fruits, AI is a potential technology in food processing. Algorithmic models such as artificial neural networks (ANN), convolutional neural networks (CNN), and support vector machines (SVM) have been developed in combination with image processing to detect and score apples, bananas, mangoes, etc. online. Machine learning is being applied to track quality changes in fruits and vegetables during storage and predict remaining shelf life, and provide timely product information to consumers. In addition, AI has also been introduced into the smart cold chain. AI could monitor and record cold chain environmental parameters in real-time. Based on this information, an algorithm model can be established to evaluate the freshness and maturity of fruits and vegetables in cold-chain transportation.

Automation and Robotics in Food Processing: The food processing sector in India is changing as a result of the use of automation and robots, which improves scalability, accuracy, and efficiency. Robotic fruit, vegetable, and grain grading systems minimize human error and guarantee consistency. Automated packaging machines can meet the growing need for both traditional and intelligent packaging solutions since they are fast and precise. Automation lowers labour costs and boosts throughput in a variety of processes, from pulping and juicing in the beverage industry to mixing dough in bakeries.

Advanced Food Packaging Technologies: Packaging is important for looks also but beyond that packaging is also crucial for food safety, sustainability, and preservation. Smart packaging solutions are gaining popularity because they use sensors to keep an eye on the quality and freshness of products. Indicator packaging is related to the quality of the food, indicating, for example, pH changes, which cause perceptible colour changes when the food is no longer suitable for consumption. Sensor packaging indicates the presence or level of certain substances or physical properties, such as monitoring gases, humidity, microorganisms, or temperature changes. Eco-friendly packaging materials manufactured from biodegradable and recyclable materials are gaining favour in response to the global effort toward minimizing plastic waste.

IoT and Blockchain for Traceability: Transparency and traceability are being improved in the food supply chain through the use of blockchain technology and Internet of Things (IoT) devices. Blockchain enables manufacturing monitoring from farm to fork, guaranteeing product safety and enhancing consumer confidence. Maintaining the authenticity of high-end products and tracking organic produce are two areas where this technology really shines.

Government Initiatives

Government of India has taken various policy and financial initiatives in recent years to strengthen the food processing sector. Central Government has approved the umbrella Central sector scheme, SAMPADA- Scheme for Argo-marine processing and Development of Agro-processing Clusters, subsequently renamed as 'Pradhan Mantri Kisan SAMPADA Yojana (PMKSY) with a total allocation of Rs.6000 crore in 2017. This scheme aims to create modern infrastructure with efficient supply chain management from farm gate to retail outlet for promotion, overall development and growth of Food Processing Industries, through creation of employment opportunities, reducing wastage of agricultural produce, increasing the processing level and enhancing export of the processed foods. Under this scheme, Ministry of Food Processing Industries has approved 41 Mega Food Parks, 399 Cold Chain projects, 76 Agro-processing Clusters, 588 Food Processing Units, 61 Creation of Backward & Forward Linkages Projects

Achievements
UNDER PRADHAN MANTRI KISAN SAMPADA YOJANA (PMKSY)

- **143 projects** have been approved under various component schemes of PMKSY, since January 2024.
- **69 projects** have been operational resulting in processing & preservation capacity of **14.41 Lakh MT**.
- The approved projects, on their operationalization, are expected to leverage investment of **Rs 2303.24 Crore** benefiting about **3.53 lakh farmers** and are expected to result in more than **0.57 lakh** direct/indirect employment.

Year End Review 2024

PMFME
PM Formalisation of Micro food processing Enterprises Scheme

A SPECIAL INITIATIVE FOR THE DEVELOPMENT OF MICRO FOOD PROCESSING ENTERPRISES.

Seed Capital @ **₹40,000/-** per Self Help Group (SHG) member engaged in food processing for working capital and purchase of small tools.

and 52 Operation Green projects. PM Kisan SAMPADA Yojana is expected to leverage investment of Rs. 11,095.93 crore by the year 2025-26. In 2022, a Special Food Processing Fund of Rs. 2,000 crore was set up with National Bank for Agriculture and Rural Development to provide affordable credit for investments in setting up units under Mega Food Parks and Designated Food Parks.

The real challenge in the food processing sector is with the people engaged in food processing in unorganized sector. As per the report on Annual Survey of Unincorporated Sector Enterprises (ASUSE) for the year 2022-23, the unorganized food processing sector in the country comprises nearly 23 lakh food processing enterprises which are unregistered and informal. These units face challenges in access to credit; modern technology and machinery; branding and marketing; and food safety and hygiene. To address this problem, the PM Formalisation of Micro food processing Enterprises (PMFME) scheme was launched with the sole aim to enhance the competitiveness of existing micro-enterprises in the unorganized food processing sector and promote formalization of the sector. The main focus of the scheme was to support Farmer Producer Organizations, Self Help Groups and Producers Cooperatives along their entire value chain. The Scheme is being implemented for a period of five years from 2020-21 to 2024- 25 with an outlay of Rs. 10,000 Crore. The main theme of the Scheme is the One District One Product approach, a part of a broader



**FOR SETTING UP OF
MULTIPRODUCT
FOOD IRRADIATION UNITS**

MINISTRY OF FOOD
PROCESSING INDUSTRIES

**IS PROVIDING
FINANCIAL SUPPORT**

- Grants-in-aid/ subsidy @ 35% of eligible project cost for projects in General Areas
- @50% of eligible project cost for project in Difficult Areas and projects of SC/ST, FPOs and SHGs*

*Subject to a maximum of Rs. 10 crore per project



strategy of concentrated agricultural and industrial development focused on each district, offering an array of fiscal incentives, credit, marketing, and policy support. This scheme is approved for 713 districts in 35 States/UTs with 137 unique products. This sector has the potential to create millions of more jobs, particularly in rural areas, by connecting farmers with processing units and markets, thereby boosting farmer incomes and contributing to rural development.

Another key driver of growth is the Production-Linked Incentive (PLI) scheme, for the period 2021-22 to 2026-27 to create global food champions and improving the visibility of Indian food brands abroad. This scheme has been implemented with an outlay of Rs.10,900 crores and aims to boost domestic manufacturing, promote exports, and generate employment.

In addition, the Central Government has taken many decisions to make fiscal policies favourable to facilitate this sector. New food processing, preservation and packaging units are now qualifying for 100 per cent income tax exemption for the first 5 years of operation and thereafter these units will be charged at the rate of 25-30 per cent. Further, 100 per cent deduction is permitted on capital expenditure for cold chain or warehouse. In addition, loans to food and agro-based processing units and cold chain have been classified under agriculture activities for Priority Sector Lending (PSL). Central Government has also allowed 100 per cent FDI in the food processing sector under the automatic route, facilitating a straightforward and efficient investment process. The food processing sector has also been a magnet for foreign investment, attracting US \$12,955.90 million in FDI equity inflows from April 2000 to September 2024, accounting for 1.83 per cent of the country's total FDI inflows. In another initiative to the food processing sector, government has introduced lower GST slab rates for most of the basic food items. Of all food categories taken together under different chapter heads/subheads, almost 71.7 per cent of the food items fall under the lowest slab of GST, i.e. 0-5 per cent.

Commercial Success Stories

Amul is the leader in food processing in India having reached Rs 80,000 crore (\$10 billion) in 2023-24 from Rs 72,000 crore (\$9 billion) in 2022-23 and have just ventured into the sector of fruit and vegetable processing. PepsiCo is a leading commercial success story in food processing of fruits and vegetables in India with brands like Tropicana and Lay's potato chips. PepsiCo is a world leader in convenience foods

PLIS for developing Global Champions in Food Sector

The Central Sector Scheme - Production Linked Incentive Scheme for Food Processing Industry (PLISFPI) of MoFPI

- Has an outlay of Rs. 10900 crore.
- Will create employment opportunities for nearly 2.5 lakh people by the year 2026-27.
- Food Product Segments covered in the scheme via
 - Ready to Cook/Ready to Eat (RTC/RTE) food including Millet based Products
 - Processed Fruits & Vegetables
 - Marine Products
 - Mozzarella Cheese
 - Innovative/Organic products of SMEs including Free Range Eggs, Poultry Meat, Egg Products





PM FORMALISATION OF MICRO FOOD PROCESSING ENTERPRISES SCHEME (PMFME)

SALIENT FEATURES OF THE SCHEME

- Micro-enterprises to get **Credit-Linked Subsidy @35%** of the total project cost with ceiling of **Rs. 10 lakh** for upgradation of infrastructure and capacity addition
- SHGs to get **Seed Capital** for giving loans to members for working capital and small tools
- On site **Skill Training & Handholding**
- Special focus on **Women Entrepreneurs & Aspirational districts**
- Transition from the **Unorganized** vector to the **Formal** sector

Helpline Number
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and beverages working in 210 countries. PepsiCo in India directly employs more than 5,000 people and indirectly employs another 75,000 for its production and marketing of products across the country. Indian Tobacco Company (ITC) Ltd. is another important company with presence in the fruit and dairy foods with an array of beverages, such as juices like B Natural, Sunfeast and Bingo potato chips offering the goodness of fruit and fibre and milkshakes with real fruit bits in a variety of flavours. Britannia, Dabur India, Mondelez, Tetra Pak, Parle Agro Private Ltd., Tata Consumer Products, Amul, Patanjali Foods and Yu are some of the other leading brands dealing in food processing in India. In addition, Sahyadri Farms in Maharashtra, Sula Vineyards, Sil Food India Pvt. Ltd. in Maharashtra, Suguna Foods in Tamil Nadu, Agro Tech Foods Ltd. in Telangana, MTR Foods in Karnataka, Organic India in Uttar Pradesh, Unibic Foods in Karnataka, McCain in Gujarat, Flex Foods Ltd. in Uttarakhand and Tamil Nadu and Mother Dairy in Delhi are some other big names in food processing industry. In India, Himachal Pradesh being the fruit bowl of the country with strong horticulture annual economy of more than Rs 10000 crore is also emerging as a food processing hub to avoid the post-harvest losses in the tough terrains of the State. Horticultural Produce Marketing and Processing Corporation (HPMC) established in 1974 with the assistance of World Bank is an excellent example of fruit processing in Himachal Pradesh. This Corporation is a success story of 50 years because the vision to establish such an institution was the future outlook of the then Chief Minister of Himachal Pradesh- Dr Y.S. Parmar who visualized the future of Himachal Pradesh in horticulture and food processing. The Corporation has established a new fruit processing plant built at a cost of Rs 100.42 crore at Parala in Shimla district in 2024 and this corporation has

processed a record 2000 metric tons (MT) of apple juice concentrate across its three plants in 2024. In Himachal Pradesh, Cremica Mega Food Park is the first mega food park which has been set up in 52.40 acre of land at a cost of Rs. 107.34 crore with facilities like multi-crop pulping line with bulk aseptic packaging, frozen storage, deep freezing with dry warehouse and other processing facilities. There are some other big food processing units like Himalaya Food Company at Paonta Sahib in Sirmaur district, Shivambu International at Una, Hygeia Fruit and Vegetable Processors Private Limited and Gold Home in Mandi district and Shimla Hills Offerings Pvt Ltd. in Shimla district.

Way Forward

There is a need to make big cluster of food processing by putting research institutions and production houses at a single place to grow in a mutualistic environment. If we have to choose a global success story then Food Valley in Netherlands is a unique example where collaboration between food companies, research institutes, and local agribusinesses has given rise to an industry which is so innovative and important that it is frequently compared to California's Silicon Valley. It is also described as 'the golden triangle', which brings together the key stakeholders in business, government and science. This is a world capital of innovation in food and agriculture, where the whole chain of research is usually covered in-house by more than 6,500 scientists, specialists and experts. Food Valley is a global hotspot for the future of food.

As Food Valley in Netherlands is an excellent example promoting innovations in agriculture and food processing, there is need to further accelerate the momentum of development to make India a major exporting hub of food processing. □