Recent Advances in Processing of Fruits and Vegetables

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ON

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FOREWORD

The country has made tremendous progress in food production, currently estimated to a record 305.44 million tonnes. Production of Horticulture crops is estimated at a record 326.58 million tones and accounts for 12% of world's fruit and 13% of vegetable production. Fruits and vegetables are highly perishable and have a very short shelf-life, resulting in huge post harvest loss during different handling and marketing operations. Further, qualitative losses like loss in edibility, nutritional quality, calorific value and consumer acceptability of fresh produce are much more difficult to assess than quantitative losses.

Presently, Food Processing Sector has been identified as a priority sector under "MAKE IN INDIA", programme of Hon'ble Prime Minister of India. With a view to attract investment to this sector, Ministry of Food Processing Industry has been implementing a number of schemes to strengthen the existing infrastructure for promoting the FPIs in the country with major emphasis on ensuring quality of processed products by adopting 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). These initiatives would enable processing industries to prepare themselves to cope-up with global competition, enhance product acceptance by importing countries and keep the industry technologically abreast of international best practices.

Establishing Mega Food Parks with efficiently knitted with advanced storage technologies and logistics will prove to be a boon to young and vibrant entrepreneurs to set up their Food Processing Units in "plug and play model". Further, Govt. of India ((GOI) has launched Pradhan Mantri Kisan SAMPADA Yojana (Scheme for Agro- Marine Processing and Development of Agro- Processing Clusters) which is considered a most comprehensive package for creation of modern infrastructure with efficient supply chain management from farm gate to retail outlet. An efficient food processing sector embedded with high powered research and cutting edge technologies greatly helps in the reduction of food wastage, improves value addition, promotes crop diversification, ensures better return to the farmers, promotes employment and export.

Keeping the above bright prospects of Processing and Value addition in view, a National Webinar "Recent Advances in Processing of Fruits and Vegetables" was organized on November 11, 2020. I appreciate the effort of authors to bring out a compendium dealing the various aspects of Processing and Value addition in fruits and vegetables.

(Arvind Kumar)

Preface

India has witnessed increase in horticulture production over the last few years. Significant progress has been made in area expansion, better varieties and recent scientific advances resulting in higher production. Over the last decade, the area under horticulture grew by 2.6% per annum and annual production increased by 4.8%. Apart from nutritional benefits, the production of fruits and vegetables improves the economy of a country as these are very good source of income and employment. The country has potential to grow all types of temperate, subtropical and tropical fruits and vegetables because of varied agro-climatic diversity. The losses are estimated to the extent of 20 -30 per cent due to lack of proper harvesting, processing and storage facilities.

The aim of doubling the farmer's income cannot fulfilled without the efficient postharvest management of agri-horti crops. As per the latest, estimate not only horticultural production but also agricultural production is at a record high. On the other hand processing and value addition of horticultural crops is still very less, while there is a tremendous scope of processing and government is also emphasizing to give a fillip in this sector. Processing and value addition not only help in minimizing the waste but it will also create ample employment in this sector. Therefore, this webinar going to address different problems and prospective to minimize wastage and making today's farmer *atamnirbhar* by combining traditional practices with recent technologies developed in fruits and vegetable processing, National Webinar on "Recent Advances in Processing of Fruits and Vegetables" was organized on November 11, 2020.

The compendium entitled "Recent Advances in Processing of Fruits and Vegetables" has been edited and complied as per the addresses by eminent speakers during the webinar. We are will sure this compendium apart from serving the need of the entrepreneurs will serve the purpose of SHGs engaged in processing sectors, extension workers, students and progressive grower who are actively involved in production of fruits and vegetables and want to move a step forward for processing and value addition of their produce.

(Authors)

Content

Chapter – 1

Innovation in Postharvest Technology for the Maintenance of Quality of Fruits and Vegetables

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At present, agriculture and allied sector contributes 25.49% of GDP in India. Total cropped area in India is 197.05 million hectares contributing a total food grain production of 292 million tonnes. Horticulture crops cover over 20.7 million hectares of area, which is approximately 11.25% of the total gross cropped area of the country and contributes 18-20% of the gross value of India's agricultural output. India is the world's second largest fruit and vegetable producing country accounting for 97.97 million tons of fruit and 183.17 million tons of vegetables (Recent estimate). The country produces 41% of world mangoes, 23% banana, 24% cashew nut, 36% green peas, 10% onion and 30% cauliflower and accounts for 12% of world fruit and 13% of vegetable production. Fruits and vegetables are highly perishable and have very short shelf-life. During different handling and marketing operations, there is huge post harvest loss of agriculture produce. Qualitative losses like loss in edibility, nutritional quality, calorific value and consumer acceptability of fresh produce are much more difficult to assess than are quantitative losses. Quantitative post-harvest losses in India estimated by different committees ranged between 25-33% depending upon the crop. According to national level study conducted under AICRP on PHT, ICAR, the post-harvest losses during different farm handling operations like harvesting, sorting, grading and packing accounts for about 13%, during farm storage about 6% and during storage at godown, wholesale and retail level about 12% of the produce goes waste. The food processing industry ranks fifth in size in the country and employs 16 lakh workers which is 19% of the country's industrial labour. It accounts for 14% of the total industrial output with 18% of industrial GDP and 6.3% of countries GDP. 100 per cent FDI under the Government route for retail trading, including through e-commerce, is permitted in respect of food products manufactured and/or produced in India. The Central Institute of Post-Harvest Engineering and Technology had estimated the value of food waste at almost Rs 100,000 crore. The government has approved 42 mega food parks, recently and a third of which are already in operation. In parallel, 274 cold chain projects have been announced. 129 of them are already functional. The **Pradhan Mantri Kisan Sampada Yojana** has been launched to modernise processing facilities and check agro-wastage. Programmes such as **MUDRA and Start-up India** are promoting small-scale enterprises, sometimes in the very household of a small farmer. These are adding value to food produce and giving a push to food processing at the micro-level. Such initiatives can only be successful if

the food processing industry – Big Food as it is called – becomes a facilitator and user.

Fresh fruit and vegetables (FFV) are a major source of essential vitamins and minerals, such as vitamin A, vitamin C and potassium, needed for human wellbeing. They are, however, perishable living products that require coordinated activity by growers, storage operators, processors and retailers to maintain quality and reduce food loss and waste (Lipinski et al., 2013). The extent of coordination can vary greatly from loose in the case of local food supplies to complex for global supply chains. The Food and Agriculture Organization estimated that 32% (weight basis) of all food produced in the world was lost or wasted. When converted into calories, global losses represent approximately 24% of all food produced. Reducing the loss and waste of FFVs is important because these foods provide essential nutrients and represent sources of domestic and international revenue.

Fresh produce attributes (appearance, texture, flavour and nutritional value) have been traditional quality criteria, but increasingly safety (chemical, toxicological and microbial) and traceability are important for all the role players along the supply chain, from the farm to consumers (Artés et al., 2009). Fresh produce is often eaten raw or after minimal processing and food pathogen contamination can present risk of outbreaks of foodborne illnesses. *Listeria monocytogenes, Salmonella enteritidis phage* and *Escherichia coli* O157:H7 and O104:H4 are major pathogens contributing to outbreaks of foodborne illness with fresh produce as vectors for these pathogens (Mahajan et al., 2014). Owing to multiple uncertainties along the supply chain, microbial contamination leading to spoilage and postharvest losses can occur at any of the stages in the continuum from farm to consumer (Olaimat and Holley, 2012). Therefore, postharvest treatments are essential to minimize microbial spoilage and reduce the risk of pathogen contamination for FFV.

New postharvest technologies to prevent postharvest losses

New cooling systems and temperature control

The major effect of low temperature applications between harvest and produce end use is a reduction in metabolism and implicitly a delay in quality loss and senescence. Beneficial effects of pre-cooling on produce shelf life are more pronounced in highly perishable products. In order to help maintain a higher product quality and longer shelf life starting at the harvesting site, the most advantageous systems are the mobile forced air-cooling tunnels and crates. These systems provide a shorter delivery time to market and decrease on-site production costs. With regards to the greening of the cold chain systems, sustaining their capabilities becomes increasingly challenging as populations grow and new technologies emerge. New warehousing and transportation technologies can reduce greenhouse gas emissions, improve air quality, and replace environmentally-destructive refrigerants with benign alternatives. A recent technology using liquid nitrogen engines is being considered as a “quick-fix” solution to air pollution caused by refrigerated transport by allowing produce suppliers to create a zero-emissions fleet. As a by-product of the industrial gas sector, the infrastructure allowing to provide liquid nitrogen is already in place and it is described as cheaper than traditional fuel. Meanwhile, vehicle emission technologies are emerging to address transport refrigeration units (TRUs). Battery-electric TRUs are already available, as are eutectic plates that store cold in a salt solution (similar in principle to a beer cooler cold pack), both of which are quiet and, with fewer moving parts require lower maintenance.

Reducing fresh produce waste through sustainable packaging

Major supermarket chains are already leading the way by encouraging their suppliers to use bio-based packaging materials and this trend is likely to grow: future bio-based food packaging materials are likely to be blends of polymers and bio-nanocomposites, in order to achieve the desired barrier and mechanical properties demanded by the food industry (Mahajan *et al*., 2014). Producing biodegradable plastics using renewable biomass that ends up in biodegradation infrastructures like composting facilities is ecologically sound and promotes sustainability. The improvement in polymer technologies and the use of smart additives (sensors, time temperature indicators. etc. will confer the same performance to bio-based packaging as conventional packaging, with the added value of compostability. Bio-based packaging is compatible with new, innovative technologies such as the e+Remover Technology for ethylene adsorption.

Table 1. Strategies for efficiently achieving a sustainable development

– Minimise the number of packaging layers through the optimal combination of primary, secondary and transport packaging.
– Eliminate unnecessary packaging, for example replace the plastic on blister packs with a simple tie.
– Reduce unnecessary void space.
– Reduce the thickness of packaging.
– Increase the amount of product per package to reduce the packaging/product ratio.
– Use bulk packaging for distribution of industrial products.
– Concentrate the products that can be concentrated.
– Eliminate the use of glues in folded carton board by using tab closures.

Ethylene Controlling Technologies

Physical treatments

(a) Heat treatment

Heat treatment has been studied as an alternative to chemical treatments for harvested FFV. Treatments include hot water dip (HWD), saturated water vapour heat, hot dry air and hot water rinse (HWR) with brushing. Beneficial effects of these heat treatments are linked (i) through changes in physiological processes such as a reduction in chilling injury and delay of ripening processes by heat inactivation of degradative enzymes, (ii) by killing of critical insect contaminations, and (iii) by controlling the onset of fungal decay. Heat treatments can be of short- (up to 1 h) or long-term duration (up to 4 days). Heat treatments have been applied to firm potatoes, tomatoes, carrots and strawberries; to preserve the colour of asparagus, broccoli, green beans, kiwi fruits, celery and lettuce; to prevent development of overripe flavours in cantaloupe and other melons; and to generally add to the longevity of grapes, plums, bean sprouts and peaches, among others.

It has been demonstrated that heat shock by using hot water washing at temperatures ranging from 37 to 55°C for a duration of 30 s to 3 min can improve the postharvest quality of spinach, rocket leaves, apples and mandarin fruit (Fallik, 2004). A clear mode of action of any water treatment is to wash-off the spores from the fruit surface.

Hot water is a better vector of energy than air and has provided comparable reductions in fungal decay. Blue mould on grapefruit caused by *Penicillium* sp. has been controlled by dipping fruit in hot water for 2 min at 50°C. Improvements in the quality of bell pepper, apples, melons, sweet corn, kumquat and grapefruit have been reported with cold water cleaning in combination with brushing and a short HWR (Hong et al., 2014; Maxin et al., 2012). Hot water treatments also influence the structure and composition of epicuticular waxes. Covering of cracks and wounds and the formation of anti-fungal substances in the wax after heating are thought to be possible modes of action (Lurie, 1998).

It is suggested that the combination of *Bacillus amyloliquefaciens* HF-01, sodium bicarbonate and hot water could be a promising method for the control of postharvest decay on citrus while maintaining fruit quality after harvest. To date, commercial applications of heat treatments are limited. Heat treatment provides an alternative to fungicide applications, and in Germany HWD has been used in the storage of organic apples (Schirra *et al*., 2000). Treatment of fruit after a few days of cold storage or immediately after the opening of a long-term controlled atmosphere (CA) storage room provides new options for prolonging their subsequent storage life, although acceptance of this technology by fruit growers has been hampered by high-energy costs and also the need for added labour at the peak work period during harvest time.

(b) Edible coating

Edible coatings are thin layers of external coatings applied to the surface of fresh produce to enhance the waxy cuticle or as replacements for natural barriers where the produce cuticle has been removed (Dhall, 2013). The application of edible coatings on fresh produce provides a partial barrier to the movement of moisture on the surface of fresh produce, thereby minimizing moisture loss during postharvest storage; a gas barrier, thereby establishing a modified atmosphere around the product, which slows down respiration, senescence and enzymatic oxidation and preserves colour and texture; helps to retain volatile compounds contributing to produce a natural aroma and restrict foreign odours; maintains fresh produce structural integrity, and protects against mechanical damages; and serves as carriers of functional or active compounds, such as nutraceuticals, flavouring and colouring agents, antioxidants and antimicrobials, that will maintain/improve product quality and safety (GoI *et al*., 2013).

Table 2. Edible coating(s) used on fresh/fresh-cut fruit and vegetables

Coating material	**Purpose of coating**
guar gum; pea/potato starch ± potassium sorbate	antimicrobial
candelilla wax-based	antimicrobial; antioxidant; quality
Shellac ± Aloe vera gel	keeping quality
soy protein; carboxymethyl cellulose	antioxidant; H_2O barrier
chitosan; zein	antioxidant; H_2O barrier
beeswax; coconut and sunflower oil	antimicrobial; antioxidant; quality
chitosan; methyl cellulose	antimicrobial; antioxidant; $O_2/CO_2/H_2O$ barrier
Aloe vera gel	overall quality
whey protein; rice bran oil	H_2O barrier; overall quality
alginate and gellan based	$O_2/CO_2/H_2O$ barrier

Edible coatings are composed of hydrophobic groups, such as lipid-based waxes; hydrocolloid/hydrophilic groups, such as polysaccharide or protein-based materials; or an integration of both groups in order to improve the functionality of the coating. Within the last decade, there has been a considerable amount of research and innovations focused on the development of edible coatings from natural or synthetic sources in order to control physiological and pathological challenges of fresh produce (table 2). Several edible coatings including chitosan, *Aloe vera*, polyvinyl acetate, mineral oils, cellulose and protein based have shown desirable attributes on fresh produce with good barrier properties, without residual odour or taste and efficient antimicrobial activity (Mohebbi et al., 2012). However, more research is required to enhance moisture barrier properties of hydrophilic edible coatings, improve coating adhesion and durability during storage. To maximize the benefits of edible coatings for fresh produce, it is important to understand the effect of storage conditions on the desired functions and the adverse effect on fresh produce quality. The main limitation for the application of edible coating at the industrial level is the cost of scaling up research concepts or investment for new installation of film production and coating equipment, the lack of edible materials with desired physical and functional properties as well as the challenges of regulatory status for the different coating materials. Furthermore, process parameters, such as the method of coating and the amount of additives, can affect the film barrier properties and overall quality of the food product. One of the commercial coating products is Natureseal, which maintains colour, texture and shelf life of a number of fresh-cut fruits e.g. apples, pears, carrots, celery, etc., has recorded a good success. However, further research development is required to investigate the influence of edible coatings on individual cultivars of fresh-cuts in order to understand the variation in shelf life.

(c) Irradiation

Irradiation exposes food to radiant energy from γ rays and e-beam (high-energy electrons) that penetrate objects and break molecular bonds, including the DNA of living organisms. Ionizing radiation from cobalt-60 or caesium-137, or machine generated electron beams are used as a source of irradiation for extending shelf life of fresh produce (Ferrier, 2010). By inhibiting cellular reproduction, irradiation can neutralize pest and food safety problems. The effect depends on the doses, measured in kilograys (kGy). Low doses of irradiation (less than 1 kGy) only disrupt cellular activity enough to inhibit sprouting of tubers, bulbs and roots and delay senescence. Medium doses (1–10 kGy) reduce microbial loads while high doses (more than 10 kGy) kill a broad spectrum of fungi and bacteria spp. and pests. Most medium- and high-level doses are not appropriate for fresh produce because they can cause sensory defects (visual, texture and flavour) and/or accelerated senescence due to the irreparable damage to DNA and proteins. Irradiation presents an effective postharvest treatment for destroying bacteria, moulds and yeasts, which cause food spoilage, and also control insect and parasite infestation resulting in reduced storage losses, extended shelf life and improved parasitological and microbiological safety of foods. Irradiation has been commercialized for control of potato and onion sprouting, and strawberry decay. Low-dose γ-irradiation on mango (0.3–0.7 kGy) resulted in delay in ripening and extension of shelf life by a minimum of 3–4 days. Recently, it is reported an irradiation dose of 1 kGy to be the only effective dose in which enhanced shelf life was achieved without any deterioration of various quality attributes of litchi fruit.

While much of the focus of irradiation use on FFV has been for extending shelf life and reducing decay, it has been known for many decades that irradiation is effective

at killing, sterilizing or preventing further development of a wide variety of insect pests of quarantine importance on perishable FFV (Hassenberg et al., 2012). Despite some misconceptions, exposing food to irradiation does not make the food itself radioactive. The irradiation process produces very little chemical change in food and does not change the nutritional value of food. Extensive research and testing has demonstrated that irradiated food is safe and wholesome.

Chemical treatments

(a) Antimicrobial and anti-browning agents

Over the past decade, the increasing number of reported outbreaks of foodborne illnesses has heightened the concern of regulatory agencies, producers and the consumers about the microbial safety of FFV. Outbreaks have been associated with vegetables such as cabbage, celery, cucumber, leeks, watercress, lettuce and sprouts. Antimicrobial and anti-browning agents offer the possibility to maintain safety and can be grouped into chemical- and natural/bio-based agents. Chemical-based agents include chlorine-based solutions, peroxyacetic acid (PAA), organic acids, hydrogen peroxide (H2O2) and electrolysed water (Baskaran et al., 2013). A chlorine-based solution such as NaClO has been one of the commonly used disinfectants for fresh produce, owing to its very potent oxidizing properties and cost effectiveness. However, its efficacy as an antimicrobial agent is dependent on the levels of chlorine and at high levels may cause taste and odour defects on treated products. Additionally, chlorine-based compounds have been reported to have limited effectiveness in the reductions of microbial load on fresh produce (Rodgers et al., 2004). Surfactants, detergents and solvents, alone or coupled with physical manipulation such as brushing, may be used to reduce hydrophobic nature of the waxy cuticle or remove part of the wax to increase exposure of microorganisms to chlorine. However, chlorine has been associated with the possible formation of carcinogenic chlorinated compounds and this may lead to new regulatory restrictions in the EU.

PAA is a very strong oxidizing agent, with no harmful by-products (Landfeld et al., 2010). PAA has been reported to be effective in controlling E. coli O157:H7 and L. monocytogenes on apples, strawberries, lettuce and cantaloupe. A 5 log reduction in Enterobacter sakazakii was reported for lettuce when treated with PAA. It is also reported that decontamination treatment of fresh-cut carrot with PAA reduced the initial load of aerobic mesophilic bacteria by about 4 log units and yeasts and moulds by 3.5 log units and no further microbial growth was observed during storage.

H_2O_2 possesses a bactericidal, sporicidal and inhibitory ability, owing to its property as an oxidant and being able to generate other cytotoxic oxidizing species, such as hydroxyl radicals. Treatment with H_2O_2 can extend the shelf life and reduce natural and pathogenic microbial populations in melons, oranges, apples, prunes, tomatoes, whole grapes and fresh-cut produce (Cengiz and Certel, 2013). However, H_2O_2 treatment requires a long duration of application and can cause injury on some produce. Also, it is accepted as a generally recognized as safe for some food applications but not yet approved as an antimicrobial agent. However, in a recent study found that the newly developed H_2O_2-based sanitizers provoked a significant increase in the respiration rate and the electrolyte leakage of fresh-cut iceberg lettuce compared with tap water washing.

Organic acid, ascorbic acid and calcium-based solutions have been applied largely to

slow down enzymatic and non-enzymatic browning, deterioration of texture and microbial growth on fresh produce. Treatment of fresh-cut melon dipped in 0.52 mM citric acid for 30 s prior to modified atmosphere packaging (MAP) maintained microbial safety and prevented translucency and discoloration.

(b) Nitric oxide

Nitric oxide (NO) is a highly reactive free radical gas and acts as a multifunctional signalling molecule in various plant physiological processes, such as fruit ripening and senescence of FFV. Endogenous NO concentrations decrease with maturation and senescence in FFV, thereby offering an opportunity for modulation of their levels with exogenous application to exert the opposite effects (Kim et al., 2006). Optimum NO levels delay the climacteric phase of many tropical fruits, prolong the postharvest storage life by impeding ripening and senescence, suppress biosynthesis of ethylene, reduce ethylene production and, consequently, delay in fruit ripening. NO gas is applied as a fumigant or released from compounds such as sodium nitroprusside, S-nitrosothiols and also diazeniumdiolates used as a dipping treatment. Reduced ethylene production during ripening in NO-fumigated fruit has been claimed owing to binding of NO with 1-aminocyclopropane-1-carboxylic acid (ACC) and ACC oxidase to form a stable ternary complex, thus limiting ethylene production. Other mechanism of NO action include the inhibition of ethylene biosynthesis, cross-communication with other phytohormones, regulation of gene expression and amelioration of oxidative postharvest stress. Successful application of NO has been reported for apple, banana, kiwifruit, mango, peach, pear, plum, strawberry, tomato, papaya, loquat, Chinese winter jujube fruit and Chinese bayberry. NO treatments reduce the rate of respiration, water loss and inhibit browning, as well as reducing the incidence of postharvest diseases.

(c) Sulfur dioxide

Sulfur dioxide (SO_2) is widely used on table grapes to prevent decay during storage, by either initial fumigation of fruit from the field followed by weekly fumigation of storage rooms or slow release from in-package pads containing sodium metabisulfite. SO_2 technology has also been tested for control of postharvest decay on other fruits such as litchi, fig, banana, lemon or apple (Mahajan et al., 2014). It is reported that SO_2 fumigation followed by CA storage ($3\%O_2$+6 or $12\%SO_2$) is a promising postharvest strategy for fresh blueberries to reduce decay, extend market life and maintain high nutritional value. SO_2 is an effective and practical technology for reducing the risk of blueberry grey mould decay during storage and it could be used for the export market. There are disadvantages to SO_2 use; the SO_2 concentration necessary to inhibit fungal growth may induce injuries in grape fruits and stems, and sulfite residues pose a health risk for some individuals, as well as firming of the texture of some fruit species (pomaces), incomplete de-sulphiting and incomplete re-colouring of red fruits. Nevertheless, SO_2 treatment is a widespread process because of its advantages of universal antiseptic action and economic application.

Gaseous treatments

(a) Ozone

Recent research and commercial applications have verified that ozone can replace traditional sanitizing agents. Ozone is a very pungent, naturally occurring gas with strong highly reactive oxidizing properties. Ozone is reported to have 1.5 times the oxidizing potential of chlorine and 3000 times the potential of hypochlorous acid

(Horvitz and Cantalejo, 2014). Contact times for antimicrobial action are typically four to five times less than that for chlorine. Ozone rapidly attacks bacterial cell walls and is more effective than chlorine against the thick-walled spores of plant pathogens and animal parasites, at practical and safe concentrations The fruit exposed to 2.5 ppm ozone had higher levels of total soluble solids, ascorbic acid content, β-carotene content, lycopene content, and antioxidant activity and also reduced weight loss at day 10 compared with untreated fruit. The sensory attributes of papaya of ozone-treated fruit was also superior in sweetness and overall acceptability endorsing ozone as a non-thermal and safe food preservation technique for FFV. Ozone can be employed in cold storage, washing system or process water sterilization. Irradiation and washing with ozonated water slightly reduced respiration in white asparagus spears, but increased spear tissue toughness. However, neither washing the asparagus spears with ozonated water (3 or 4.5 ppm) nor treating them with radiation (1 kJ m^{-2}) systematically and significantly affected their microbial loads during storage (Carrasco and Urrestarazu, 2010). Some commercial use has occurred with commodities such as apples, cherries, carrots, garlic, kiwi, onions, peaches, plums, potatoes and table grapes. However, ozone does not penetrate natural openings or wounds efficiently. Additional research is needed to define the potential and limits of the effective use of ozone for postharvest treatments for the quality and safety of FFV.

(b) Ethylene

Endogenous ethylene production and its exogenous application exhibit both beneficial and deleterious effects on horticultural fresh produce. Beneficial effects of exogenously applied ethylene includes triggering ripening, improving fruit colour and quality in some crops, such as bananas and avocados, kiwifruit, persimmon, tomato, mangoes, de-greening of citrus fruit (Janssen et al., 2014). The deleterious effects of ethylene in postharvest phase horticultural commodities has also been documented, such as shorter storage life, promotion of senescence, fruit softening, discoloration (browning) and russet spotting in lettuce, yellowing of leafy vegetables and cucumbers and increased susceptibility of FFV to decay. Therefore, ethylene management plays a pivotal role in maintaining postharvest life and quality of climacteric and non-climacteric horticultural produce. Most commercial strategies for maintaining horticultural commodities involve storing at low temperatures, blocking ethylene biosynthesis and its action, minimizing exposure produce to ethylene during ripening, harvest, storage and transport by controlling temperature and atmospheric gas composition. Newly developed ethylene measurement devices will enable to detect critical concentrations during storage and transportation.

Beneficial effects of ethylene biosynthesis inhibitors such as aminoethoxy-vinylglycine alone on postharvest quality have been demonstrated in apples and stone fruits and in combination with controlled atmosphere (CA) storage. Treating FFV with inhibitors of ethylene action, such as 1-methylcyclopropene (1-MCP) or NO alone or in combination with MAP or CA storage, also impedes ethylene production and action consequently extends storage life and maintains quality of FFV.

(c) 1-Methylcyclopropene

The discovery and patenting of cyclopropenes as inhibitors of ethylene perception represents a major breakthrough in controlling ethylene responses of horticultural products. The process of discovery of the effects of cyclopropenes, and their proposed method of action, has been described. Of the cyclopropenes, 1-MCP proved to be

extremely active, but unstable in the liquid phase. However, 1-MCP can be complexed with α-cyclodextrin to maintain its stability; this development represented a major step towards its commercialization as it was then possible to release 1-MCP from the complex to expose to the horticultural products. Regulatory approval for use of 1-MCP has been obtained in more than 50 countries, and approval for use of the technology continues to occur around the world. 1-MCP is registered for use on a wide variety of FFV including apple, avocado, banana, broccoli, cucumber, date, kiwifruit, mango, melon, nectarine, papaya, peach, pear, pepper, persimmon, pineapple, plantain, plum, squash and tomato. 1-MCP affects many ripening and senescence processes, including pigment changes, softening and cell wall metabolism, flavour and aroma, and nutritional properties, but to varying degrees in both non-climacteric and climacteric products. While aqueous 1-MCP shows similar responses as those treated with gaseous 1-MCP, ripening actors such as activity of cell wall-associated enzymes, e.g. lycopene, antioxidant and volatiles of avocado, are delayed but recover to reach levels similar to those of untreated fruit. The range of responses reflects the enormous diversity of these crops in terms of both inherent diversity and morphological derivation.

(d) Controlled atmosphere storage

CA storage refers to the monitoring and adjustment of the CO_2 and O_2 levels within gas tight stores at optimum storage temperature. Thus, the atmosphere is controlled rather than established passively as in the case of MAP, though the effects of altered atmospheres on metabolism of FFV are essentially the same. In most cases, the concentrations of CO_2 are higher and those of O_2 are lower, optimum concentrations depending on the specific product and the purpose of the CA storage conditions. Reduced O_2 and elevated CO_2 levels affect both primary (glycolysis, fermentation and aerobic respiration) and secondary (e.g. processes involved in ethylene production and action, pigments, phenolics and volatiles) metabolism (Tahir et al., 2009).

Each FFV has an optimal range of O_2 and CO_2 for maintaining quality and extending shelf life, and these can differ for whole and fresh-cut products of the same fruit or vegetable. The beneficial effects of CA include:

- retardation of senescence and associated biochemical and physiological changes, e.g. slowing down rates of respiration, ethylene production and softening;
- reduction in sensitivity to ethylene action at O_2 levels less than 8% and/or CO_2 levels more than 1%;
- alleviation of certain physiological disorders, e.g. chilling injury of avocado and superficial scald of apples and pears;
- direct or indirect effect on postharvest pathogens (bacteria and fungi) and consequently decay incidence and severity e.g. CO_2 at 10–15% inhibits development of Botrytis rot on strawberries and cherries; and
- low O_2 (less than 1%) and/or elevated CO_2 (40–60%) can be a useful tool for insect control in some fresh and dried fruits, flowers and vegetables; and dried nuts and grains.

The detrimental effects of CA include:

- initiation and/or aggravation of certain physiological disorders, such as internal browning in apples and pears, brown stain of lettuce and chilling injury of some commodities;
- irregular ripening of fruits, such as banana, mango, pear and tomato, can result from exposure to O_2 levels below 2% and/or CO_2 levels above 5% for more than one month;
- development of off-flavours and off-odours at very low O_2 concentrations (as a result of anaerobic respiration) and very high CO_2 levels (as a result of fermentative metabolism); and
- increased susceptibility to decay when the fruit is physiologically injured by insufficient O_2 or too-high CO_2 concentrations.

Use of CA technology is limited to relatively few FFV, the major crop being apples. Other FFV include cabbages, sweet onions, kiwifruits, avocados, persimmons, pomegranates, nuts and dried fruits, and vegetables. Atmospheric modification during long-distance transport is used on apples, asparagus, avocados, bananas, broccoli, cranberries, cherries, figs, kiwifruits, mangos, melons, nectarines, peaches, pears, plums and strawberries. Limited use of CA for many FFV is related to the high levels of capital investment required for high-quality storage rooms and the maintenance and monitoring of atmospheres; therefore, fruit volumes must be high enough to fill rooms, and extended storage periods are needed to make investments economical. For shipping containers, limitations include maintaining container identity for those with equipment. Specific CA storage technologies that are used are a function of the FFV, growing region and size of the industry. Where used, static systems are still used for the majority of FFV CA storage, ranging from simple controlled ventilation systems to conventional CA (more than 2 kPa O_2). The use of low O_2 (LO) and ultra low O_2 (ULO) CA storage, where O_2 levels are as low as 1.5–2.0 and 0.8–1.2 kPa, respectively, is increasingly becoming common.

(e) Modified atmosphere packaging

MAP generally involves the packaging of a whole or fresh-cut product in plastic film bags, and can be either passive or active. In passive MAP, the equilibrium concentrations of O_2 and CO_2 are a function of the product weight and its respiration rate, which is affected by temperature and the surface area, perforations, thickness and permeability to gases of films used in packaging. In active MAP, the desired atmosphere is introduced in the package headspace before heat sealing, but the final atmosphere will eventually be a function of the same factors that affect passive MAP (Caleb et al., 2013). Correct equilibrium atmosphere can delay respiration, senescence, and slow down the rate of deterioration, thereby extending product storage life. More recently, active MAP also includes technologies to adsorb substances, such as O_2, ethylene, moisture, CO_2, flavours/odours, and release substances such as CO_2, antimicrobial agents, antioxidants and flavours.

An extensive number of models have been developed to predict respiration rates of

FFV under MAP conditions. Behind the software is an extensive database on product respiration rate, optimum temperature, optimum ranges of O_2 and CO_2 and gas permeability of packaging materials commonly used in MAP. The software is based on a series of mathematical algorithms to simulate the evolution of internal gas composition in the packaging as a result of food respiration and mass transfer through the packaging material and, when used in a reverse manner, to identify the window of gas permeability that satisfy food requirements, size and number of micro-perforations, if needed.

Current MAP design considers the respiration rate of product as the only important parameter for deciding target gas barrier properties required to achieve an equilibrium-modified atmosphere. However, besides in-package gas composition it is also important to take into consideration the in-package level of humidity, in order to avoid condensation and/or mould and bacterial development in MAP systems. It is well known that the in-package humidity is influenced by respiration and transpiration of the fresh produce as well as the water vapour permeability of the packaging material. However, most polymeric materials (polyethylene, polypropylene or polyvinyl chloride) used in MAP have lower water vapour permeability relative to transpiration rates of fresh produce; therefore, most water molecules evaporated from the produce do not escape through the film and remain within the package, enhancing the water vapour pressure in the package microenvironment. Under these near-saturation conditions, even minor temperature fluctuation may result in condensation inside the package resulting in produce sliminess and enhancement of microbial growth and decay of produce. Therefore, the major challenge of modified atmosphere and humidity packaging (MAHP) is finding a solution for creating optimal atmosphere and reducing the risk of water condensation in the package while still maintaining produce weight loss as low as possible (Warriner et al., 2009).

Emerging technologies

Plasma is an emerging technique for decontaminating FFV. Plasma is composed of ionized gas molecules, which have been dissociated via an energy input. Depending on the mode of particles activation and the excitation energy, they can generate high or low temperatures, referred to as thermal or cold plasma, respectively. Cold plasma at atmospheric pressure can be generated by transforming argon gas into plasma at radio frequency of 27 MHz or by electric discharge between two electrodes separated by dielectric barriers. Three basic mechanisms have been suggested for the inactivation microbial spores in plasma environments, including the erosion of microbial spore surface atom by atom through adsorption of reactive free radicals ‘etching’; direct destruction of DNA via UV irradiation and volatilization of compounds from the spore surface by UV photons through intrinsic photo-desorption (Mahajan *et al*., 2014). The optimal operating conditions of cold gas plasma treatment about 15 min treatment time was required to achieve 2.72, 1.76 and 0.94 log-reductions in viable cells of S. enteric sv. *Typhimurium* on lettuce, strawberry surfaces and potato tissue, respectively. Fresh corn salad leaves showed that the plasma treatment at 20 W for 1 min successfully inactivated *E. coli* by 4 log-cycles. However, more research is required for a complete understanding of the role of microbial cell structure, physiology and stress resistance mechanisms involved in plasma resistance. Also, the effect of plasma treatment on food enzymes and postharvest quality

attributes of FFV requires more detailed study. Safety of gases, consumer perception and the translation of laboratory scale to large commercial scale, also requires further investigation.

Conclusion and future prospects

A wide range of physical and chemical treatments exist to maintain and extend shelf life FFV. Specific treatments may only be applicable to certain types of product and spoilage conditions and the effectiveness of existing treatments on emerging quality issues need to be assessed. Postharvest treatments, such as CA and MAP, in combination with appropriate temperature control are the basis for maintaining physical, nutritional and sensory attributes, and by reducing decay incidence. These can be supplemented by chlorine, SO2, irradiation, hot water, hot air, antimicrobial agents and edible coatings as appropriate for the specific product. Newer technologies include ULO and postharvest technologies based on ethylene oxidation, inhibitors of ethylene action and modulators of ripening, such as NO. Research on these technologies is continuing on a range of FFV, including climacteric and non-climacteric types. Research with DCA represents a new era where the technology is applied in a dynamic fashion, recognizing that the metabolism of the product changes in response to the applied storage conditions. To date, use of this technology is limited but the introduction of nanotechnology to the postharvest arena may open new opportunities. For example, the development of nanocomposite packaging materials with tuneable architecture can act as a smart carrier/controlled release system for 1-MCP, NO or antimicrobial agents. Future research in development of delivery systems will not only improve efficacy of postharvest systems but may also address the safety issues.

References

1. Artés F, Gómez P, Aguayo E, Escalona V, Artés-Hernández F. 2009. Sustainable sanitation techniques for keeping quality and safety of fresh-cut. Postharvest Biol. Technol. 51, 287–296.
2. Baskaran SA, Upadhyay A, Kollanoor-Johny A, Upadhyaya I, Mooyottu S, Amalaradjou MAR, Schreiber D, Venkitanarayanan K. 2013. Efficacy of plant-derived antimicrobials as antimicrobial wash treatments for reducing enterohemorrhagic Escherichia coli O157:H7 on apples. J. Food Sci. 78, 1399 (10.1111/1750-3841.12174)
3. Caleb OJ, Mahajan PV, Al-Said FA, Opara UL. 2013. Modified atmosphere packaging technology of fresh and fresh-cut produce and the microbial consequences: a review. Food Bioprocess Technol. 6, 303–329.
4. Carrasco G, Urrestarazu M. 2010. Green chemistry in protected horticulture: the use of peroxyacetic acid as a sustainable strategy. Int. J. Mol. Sci. 11, 1999–2009.
5. Cengiz MF, Certel M. 2013. Effects of chlorine, hydrogen peroxide, and ozone on the reduction of mancozeb residues on tomatoes. Turk. J. Agric. For. 38, 1–6.
6. Dhall RK. 2013. Advances in edible coatings for fresh fruits and vegetables: a review. Crit. Rev. Food Sci. Nutr. 53, 435–450.

7. Fallik E. 2004. Pre-storage hot water treatments (immersion, rinsing and brushing). Postharvest Biol. Technol. 32, 125–134.
8. Farkas J. 2014. Food technologies: food irradiation. Encycl. Food Safety 3, 178–186.
9. Ferrier P. 2010. Irradiation as a quarantine treatment. Food Policy 35, 548–555.
10. Gol NB, Patel PR, Rao TVR. 2013. Improvement of quality and shelf life of strawberries with edible coatings enriched with chitosan. Postharvest Biol. Technol. 85, 185–195.
11. Hassenberg K, Huyskens-Keil S, Herpich WB. 2012. Impact of postharvest UV-C and ozone treatments on microbiological properties of white asparagus (*Asparagus officinalis* L.). J. Appl. Bot. Food Qual. 85, 174–181.
12. Hong P, Hao W, Luo J, Chen S, Hu M, Zhong G. 2014. Combination of hot water, Bacillus amyloliquefaciens HF-01 and sodium bicarbonate treatments to control postharvest decay of mandarin fruit. Postharvest Biol. Technol. 88, 96–102.
13. Horvitz S, Cantalejo MJ. 2014. Application of ozone for the postharvest treatment of fruits and vegetables. Crit. Rev. Food Sci. Nutr. 54, 312–339.
14. Janssen S, Schmitt K, Blanke M, Wöllenstein ML, Bauersfeld J, Lang W. 2014. Ethylene detection in fruit supply chains. Phil. Trans. R. Soc. A 372, 20130311
15. Kim H, Ryu J, Beuchat L. 2006. Survival of Enterobacter sakazakii on fresh produce as affected by temperature, and effectiveness of sanitizers for its elimination. Int. J. Food Microbiol. 111, 134–143.
16. Landfeld A, Erban V, KováŘíková E, Houška M, Kýhos K, Pruchová J, Novotná P. 2010. Decontamination of cut carrot by persteril® agent based on the action of peroxyacetic acid. Czech J. Food Sci. 28, 564–571
17. Lipinski B, Hanson C, Lomax J, Kitinoja L, Waite R, Searchinger T. 2013. Reducing Food Loss and Waste. Working Paper, Installment 2 of Creating a Sustainable Food Future. Washington, DC, USA.
18. Lurie S. 1998. Postharvest heat treatments. Postharvest Biol. Technol. 14, 257–269.
19. Mahajan PV, Caleb OJ, Singh Z, Watkins CB, Geyer M. 2014. Postharvest treatments of fresh produce. Philos Trans A Math Phys Eng Sci. 20130309. doi: 10.1098/rsta.2013.0309.
20. Maxin P, Weber RWS, Pedersen H, Williams M. 2012. Control of a wide range of storage rots in naturally infected apples by hot-water dipping and rinsing. Postharvest Biol. Technol. 70, 25–31.
21. Mohebbi M, Ansarifar E, Hasanpour N, Amiryousefi MR. 2012. Suitability of Aloe vera and gum tragacanth as edible coatings for extending the shelf life of button mushroom. Food Bioprocess Technol. 5, 3193–3202.
22. Olaimat AN, Holley RA. 2012. Factors influencing the microbial safety of fresh produce: a review. Food Microbiol. 32, 1–19.
23. Rodgers S, Cash J, Siddiq M, Ryser E. 2004. A comparison of different chemical sanitizers for inactivating Escherichia coli O157:H7 and Listeria monocytogenes

in solution and on apples, lettuce, strawberries, and cantaloupe. J. Food Prot. 67, 721–731.

24. Schirra M, D'Hallewin G, Ben-Yehoshua S, Fallik E. 2000. Host–pathogen interactions modulated by heat treatment. Postharvest Biol. Technol. 21, 71–85.
25. Tahir II, Johansson E, Olsson ME. 2009. Improvement of apple quality and storability by a combination of heat treatment and controlled atmosphere storage. HortScience 44, 1648–1654.
26. Warriner K, Huber A, Namvar A, Fan W, Dunfield K. 2009. Recent advances in the microbial safety of fresh fruits and vegetables. Adv. Food Nutr. Res. 57, 155–208.

Chapter – 2

Boosting Immunity Through Processed Enriched Products

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Health and well-being are important factors of a modern lifestyle. The health conditions of individuals and households have economic significance for both developing and developed countries. Additionally, an aging population is considered a significant challenge in the coming decades for the fast growing population countries. Worldwide chronic diseases are increasing as leading causes of death every year, with scientific evidence linking these chronic diseases to diet. These diet-related chronic diseases include obesity, diabetes, cardiovascular diseases (CVDs), and certain cancers. Obesity is associated with various health problems including CVD, type 2 diabetes mellitus, and musculoskeletal disorders such as osteoarthritis, work disability and respiratory disorders. According to a 2016 report from the Organization for Economic Co-operation and Development/European Union (OECD/ European Unions, 16% of adults in the EU member states were obese in 2004, an increase from 11% in 2000. Moreover, overweight or obese children have a higher risk of poor health in adulthood. Therefore, a strong immune system is more important for healthy and well-being. A strong immune system releases antibodies that fight off viruses, bacteria's and foreign bodies that are responsible for disease or infection. As coronavirus (Covid-19) has impacted communities around the world, many people have wondered whether there are steps they can take to stay healthy. Everyday preventive measures- such as hand washing, avoiding contact with sick individuals, managing stress, eating healthy foods, and good hygiene- can go a long way in reducing your risk of viruses, bacteria, and pathogens.

Immunity

Resistence acquired by a host towards injury caused by microorganisms and their products. "Protection against the infectious diseases only one of the consequences of the immune response, which entirely is concerned with the reaction of the body against any foreign antigen". There are three types of immunity in humans called innate, adaptive and passive:

Innate Immunity:

We are all born with some level of immunity to invaders. Human immune systems, similarly to those of many animals, will attack foreign invenders from day one. This innate immunity includes the external barrier of our body- the first line of defense against pathogens-such as the skin and mucous membranes of the throat and gut. This response is more general and non-specific. If the pathoogen manages to dodge the innate immune system, adaptive or acquired immunity kicks in.

Adaptive (acequired) Immunity

This protect from pathogens develops as we go through life. As we are exposed to

diseases or get vaccinated, we built up a library of antibodies to different pathogens. This is sometimes reffered to as immunological memory because our immune system remembers previous enemies.

Passive Immunity

This type of immunity is "borrowed" from another source, but it does not last indefinitely. For instance, a baby receives antibodies from the mother through the placenta before birth and in brest milk following birh. This passive immunity protects the baby from some infections during the early years of their life.

Immunization

Immunization introduces antigens or weakened pathogens to a person in such a way that the individual does not become sick but still produces antibodies. Because the body saves copies of the antibodies, it is protected if the threat should reappear later in life.

In addition, however, there is evidence that nutrition and other lifestyle measures influence immune strength and susceptibility to infectious diseases. Wheather these measures do or do not influence susceptibility to COVID-19 or its clinical course is not yet known. However, there is every reason to put what we do know about foods and immune defenses to use.

Diet

The best way to strengthen your immune sysytem is by incorporating specific foods in your daily diet. Several reports suggest a healthy diet should include a good mix of fruits, vegetables, legumes, pulses, milk etc., Also, some amount of salts, sodium, potassium and sugars which are naturally present in fruit juice, honey etc. So, select those type of food in your daily diet which can incorporate all those things togather.

Selection of food (high vitamins and low fat)

Eating a low-fat, plant-based diet may help give the immune system a boost. The immune system relies on white blood cells that produce antibodies to combat bacteria, viruses, and other invaders. Vegetarians have been shown to have more effective white blood cells when compared to nonvegetarians, due to a high intake of vitamins and low intake of fat (Malter *et al.*, 1989). Eating a low-fat diet may also be protective. Studies have shown that limiting dietary fat helps strengthen immune defenses. Research also shows that oil may impair white blood cell function and that high-fat diets may alter the gut microbiota that aid in immunity (Rinninella *et al.*, 2019).

Now a day's obesity has a big problem, which is totally based on the food habit. Obesity is associated with various health problems including CVD, type 2 diabetes mellitus, musculoskeletal disorders such as osteoarthritis, work disability and respiratory disorders. At presently as per the WHO report 672 million people are sufering problems due to obesity in the world as well as 1.3 billion people from over weight due to uneven lifestyle and food habit, and these people are having weak immune system.

Maintaining a healthy weight can also benefit the immune system. Obesity has been linked to increased risk for influenza and other infections such as pneumonia (Alwarawrah *et al.,* 2018). Plant-based diets are effective for weight loss, because they are rich in fiber, which helps fill you up, without adding extra calories. Fiber can

also lower BMI, which is linked to improved immunity (Haddad *et al.,* 1999). A plant-based diet has also been shown to reduce inflammatory biomarkers (Eichelmann *et al.,* 2016).

Vitamins, Minerals, and Antioxidants

Carotenoids, anthocyanins, flavonoids, and other phenolic compounds in fruits and vegetables may prevent and counter many common diseases such as high blood pressure, diabetes, cancer, vision loss, heart disease, and several intestinal disorders. The link between fruit and vegetable consumption and a lower risk of mortality has been increasing. Cardiovascular mortality may notably decrease with high consumption of fruit and vegetables. It was also noticed that not only the elderly and chronic disease sufferers, but also smokers and alcohol drinkers were in the high-risk patient group during the Covid-19 pandemic. Thus, eating vegetables is suggested together with sporting activities to boost the immune system. Studies have shown that fruits and vegetables provide nutrients- like β-carotene (Cantaloup, apricot, carrot, bathua leaves, colocasia leaves, beet leaves, elephant foot yam leaves, sweet potato, spinach, kale, winter squash), vitamin C (Cherry, guava, kiwi fruit, strawberries, oranges, papaya, drumstick leaves, coriander leaves, chilli, broccoli, tomato, kale), vitamin B-2 (Bael, papaya, litchi, almond, avocado, spinach, fenugreek) and vitamin E (Almond, avocado, papaya, olive, spinach, broccoli, kale, asparagus, tomato, sweet potato) that can boost immune function. Because many vegetables, fruits, and other plant-based foods are also rich in antioxidants, they help reduce oxidative stress (Barnard *et al.,* 2019).

β-Carotene: β-carotene is a powerful antioxidant that can reduce inflammation and boost immune function by increasing disease-fighting cells in the body. Excellent sources include sweet potatoes, carrots, and green leafy vegetables.

Vitamins C and E: Vitamins C and E are antioxidants that help to destroy free radicals and support the body's natural immune response. Sources of vitamin C include red peppers, oranges, strawberries, broccoli, mangoes, lemons, and other fruits and vegetables. Vitamin E sources include nuts, seeds, spinach, and broccoli.

Vitamin D

Research shows vitamin D supplementation may reduce the risk for viral infections, including respiratory tract infections, by reducing production of proinflammatory compounds in the body. Increased vitamin D in the blood has been linked to prevention of other chronic diseases including tuberculosis, hepatitis, and cardiovascular disease. Food sources of vitamin D include fortified cereals and plant-based milks and supplements (Grant *et al.,* 2020). Apart from this several mineral nutriotion which are a good source in fruits and vegetables may also enhances the immunity. Such as zinc is a mineral that can help boost white blood cells, which defend against invaders. Sources include nuts, pumpkin seeds, sesame seeds, beans, and lentils.

Citrus Foods

The superstar when it comes to Vitamin C loaded food. Vitamin C might not fight the illness, but it helps build up your immune system as it aids in the increase of white blood cells. Foods rich in Vitamin C play a vital role in fighting infections. Your body does not produce or store it, hence, you need to consume it daily to boost your immunity *e.g.* Orange, lemon, lime, grapefruit, mosambi,mandarin, tangerine, galgal (citron), pomelo etc.

Turmeric

The vibrant colour of turmeric comes from the natural compound Curcumin which is also a great source of anti-inflammatory compounds. Adding turmeric in your diet helps boost immune cell activity and fight against anti-inflammatory issues. Indian cuisine is known for its use of turmeric in most curries. Including turmeric in them helps your resolve to fight infections.

Curd (Yoghurt)

Curd and yoghurt contain probiotics which are live active bacterias living in our gut and intestinal tract. These healthy bacterias help keep the intestinal tract free from germs which cause diseases. Try and eat plain yoghurt rather than the sugar-filled or flavoured ones. Instead, you can add fruits and honey to sweeten the curd. They are also rich in Vitamin D which enhances the regulation of the immune system.

Black pepper

Black pepper is known for its anti-inflammatory properties, it also discourages intestinal gas. Black pepper helps in regulating sweat as it warms the body upon consuming it thereby releasing toxins from your body. It acts as an antioxidant and anti-bacterial agent in enhancing your immune system.

Tulsi

Tulsi is known as the Indian basil which has several properties which offer relief from asthma, respiratory illnesses, fever and lung disorders. You can add it to your tea or just simply add it to your drinking water. Tulsi is known to kill germs and its aroma helps in elevating your mental health as well.

Green Vegetables

Green and leafy vegetables such as spinach, broccoli, and kale are a great source of your daily vitamin intake. Broccoli is packed with vitamins A, C and E, making it one of the best foods to boost your immune system. Spinach contains Vitamin C and is also packed with antioxidants, increasing your ability to fight the infection. Tomatoes have a high concentration of Vitamin C making it an incredible source to fight against infections. Vitamin C is known to strengthen your body's t-cells and phagocytes, which are two main components of the immune system. Any reduction in these two components can weaken your immune system.

Sleep

Our bodies need sleep to rest and recharge. Without a sufficient amount of sleep, we increase our risk for developing serious health problems—like heart disease, Alzheimer's disease, and obesity. Inadequate sleep has also been linked to suppressed immune function. One study found that those who sleep fewer than five hours per night are more likely to have recently suffered a recent cold compared with those who sleep more.Try adding healthful fruits, vegetables, grains, and beans in the daily diet.

Boost your immune system through these products:

Aonla processed products: Chyawanprash, Triphala, Candy, Preserve, Juice, Shreds, Laddu, Burfi etc.

Bael processed products: Sherbat, Preserve, candy, Squash etc.

Karonda processed products: Candy, Tutti-fruti, Preserve etc.

Fig processed products: Chips, Burfy, Powder etc.

Beetroot processed products: Halwa, Natural colour, Lassi etc.

Cauliflower processed products: Pickle, Chips, Flakes etc.

Carrot processed products: Halwa, Preserve, Canned, Dehydrated, Juice etc.

Apart from this there are several fruits and vegetables processed products are prepared to enriched the immunity power.

Aonla Chyawanprash:

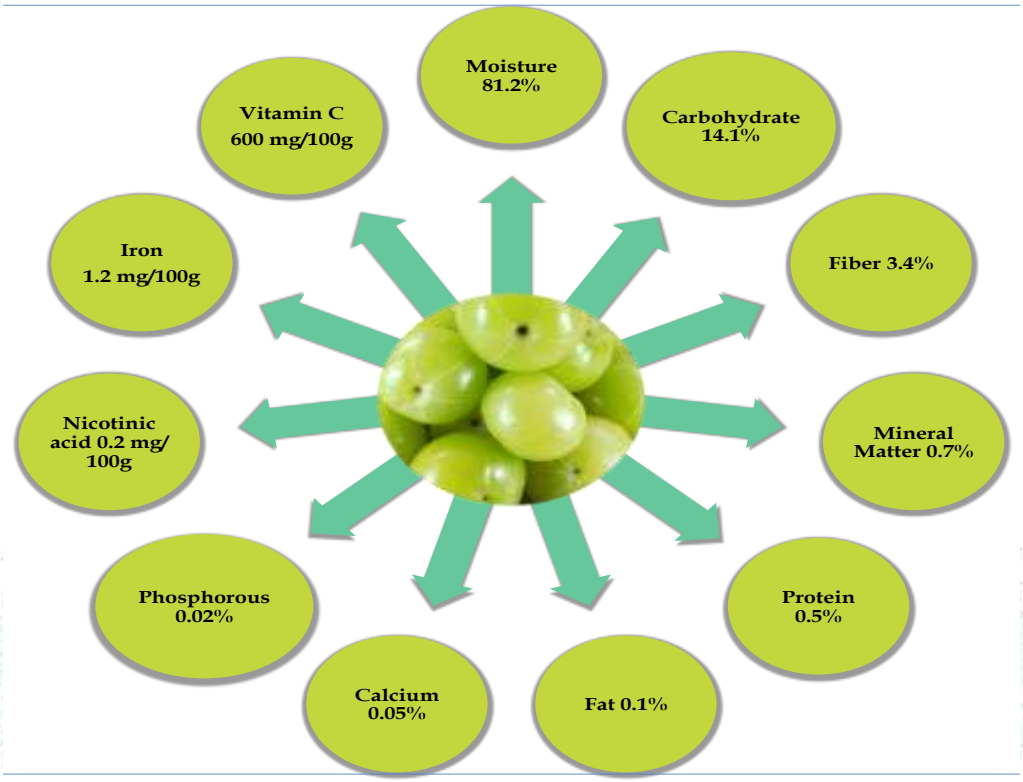
Chyawanprash is an herb based formulation and health supplement that can be taken by people, from literally any age group. Both men and women can benefit from taking Chyawanprash regularly. It tastes sweet, sour and a tad spicy, and looks like fruit jam to an extent. It is sticky and has a brownish-black hue. Chyawanprash also known, as chyavanprasha, chyavanprash, chyavanaprasam, chyawanprash rasayana (the word "*rasayana*" means tonic). Chyawanprash comprise two lexes, "*Chyawan* and *Prasha*". The word *Chyawan* is the name of a sage, and symbolizes 'degenerative changes'. *Prasha* denotes a drug or foodstuff that is suitable for consumption. The story starts off with the sage, who was quite old in the beginning. Then, however, he regained his youthfulness and vitality with the use of this herbal tonic. *Charak Samhita*[8] is an ancient Ayurvedic book written by Charak in the 4th century B.C. that includes the formula for this herbal preparation. In it, it claims that Chyawanprash is the best and most effective of all herbal tonics available to mankind. In Ayurveda, Chyawanprash it's classified under the category Rasayana, which aims at maintaining physique, vigour and vitality, while delaying the aging process and reserves of life force (*ojas*) Shastri, 1996.

It can be consumed in all seasons, as it contains ingredients, which are weather friendly nullifying the unpleasant effects due to extreme environmental and climatic conditions. Chyawanprash is made in amalaki (Indian gooseberry) base, which is the most useful rasayana for maintaining homeostasis. Aonla fruit paste, the major ingredient of Chyawanprash is the richest source of vitamin C. Vitamin C present in Aonla does not get deteriorated on heat exposure during preparation of Chyawanprash (Bhandari, 1938). Chyawanprash is an admixture of at least five tastes such as sweet, sour, bitter, pungent and astringent, due to presence of Aonla paste. People around the world now use Chyawanprash, for its anti-stress and anti-ageing properties. It has been found to be effective as an immunity booster, vitalizer and a comprehensive general tonic. It is extremely effective in preventing gastric problems, common cold and cough, when taken regularly.

Major ingredients used for the preparation of Chyawanprash

Sl. No.	Ingredients	Quantity	Sl. No.	Ingredients	Quantity
1	Aonla pulp	1 kg	14	Ashwagandha	10 g
2	Gur/Sugar	1.5 kg	15	Satavari	10 g
3	Desi Ghee	100 g	16	Bala	5 g
4	Linseed oil	10 g	17	Jeevanti	5 g
5	Javitri	10 g	18	Pushakarmul	5 g
6	Jaiphal	10 g	19	Agarkashta	5 g
7	Clove	10 g	20	Haritaki	5 g
8	Small cardamom	10 g	21	Guruchi	5 g
9	Black pepper	10 g	22	Nilkamal	5 g
10	Large cardamom	10 g	23	Dasmul	4 g

11	Dried ginger	10 g	24	Abharakbhasm	1 g
12	Small pipali	10 g	25	Muktasuktipishtibhasm	1 g
13	Banslochan	10 g			



(Fig. 1. Nutritional composition of Aonla**)**

Liquid Materials (Dravya Samagri): Shatawari, Bala, Jeevanti, Pushakarmul, Agarkashta, Haritki, Guruchi, Nilkamal, Abharakbhasm, Muktasuktipishtibhasm etc.

Dry Materials (Sukhi Samagri): Javitri, Jaiphal, Clove, Small cardamom, Large cardamom, Black pepper, Dried ginger, Small pipli, Banshlochan, Ashwagandha etc.

Apart from these two different types of materials another third major important component is fresh Aonla fruit pulp. The selection of Aonla fruit is based on the nutra-ceutical value as well as their quality.

Selection of fruits (mature)
⇓
Washing (running tap water) & sorting
⇓
Add 5 lit. of water in a deep pan and boil it, and mixed the liquid materials
⇓
Add Aonla fruits in in muslin cloth and deep in the pan during boiling (at low flame)
⇓
Remove the muslin cloth when fruits/pieces become loose (loosening of pulp)
⇓
Remove the seeds from fruits and collect the pulp
⇓
Boil continue with mix up of liquid materials till the total volume becomes 1 to 1.5 litre
⇓
Strain it and keep it Jar
⇓

Wash the Iron pan (Kadahi)

⇓

Add 100 g of Desi Ghee and heat it

⇓

Add Aonla pulp and heat it with low flame

⇓

Mix the *Gur* or *Sugar* when brownish

⇓

Continuous heating with low flame and stirring

⇓

Add dry materials one by one and mix it when it becomes consistent

⇓

Bright appearance and high consistency indicates, its ready

⇓

Stop cooking and cool it

⇓

Filled in bottles

⇓

Stored at ambient condition (cool and dry place)

Technological flow-chart for Aonla Chyawanprash

Fig. Major ingredients used for Chyawanprash preparation

Health benefits:

❖ Presence of high Vitamin C and good contains of antioxidants helps to boost the

immunity.

- ❖ Enhances the digestive system, mineral absorption, efficiency of liver, fertility, better skin tone, hair, nail growth and improves memory.
- ❖ Acts as antioxidant (Anti-ageing), support the heart and strength the muscles.
- ❖ Prevents seasonal infections, urinary infections, respiratory disorders and support the hearts.
- ❖ Aids in purifying blood, assist in coping up stresses, reduce cholesterol.

Aonla Preserve:

Aonla preserve is an extremely popular traditional product, which is also known as Amla Murabba in India. It has the beneficial effect of purifying blood and also helps in reducing the cholesterol level and improving eyesight. Preserve are prepared from matured, whole or in large pieces of fruit, in which sugar are impregnated till it becomes tender and transparent. Minimum fruit portion in preserve should be 55%. Pricking (piercing) is done in Aonla to remove its astringency and to allow the syrup to go inside the fruits. Aonla preserve which treated from alum were found best as compare to water, salt, lime and ethephon, and Total Soluble Solids, Total Sugar, Reducing Sugar, Acidity were found increasing in order while, ascorbic acid and organoleptic value were found decreasing in order during storage of Aonla preserve has been reported by several scientist. Aonla fruits treated with salt solution in 2-4 per cent for three hrs and then blanched in boiling alum solution for 4 min. during preserve preparation.

Sl. No.	Ingredients	Quantity	Sl. No.	Ingredients	Quantity
1	Aonla (pulp)	1 kg	4	Water	1 ltr
2	Alum	20 g	5	Citric acid	1.5 g
3	Salt	20 g			

Aonla Candy

Fruit candies are becoming more and more popular because of high acceptability, minimum volume, higher nutritionally value and longer storage life. These have additional advantage of being least thrust provoking and ready to eat snacks. A fruit or fruit pieces impregnated with sugar, removed drained and dried is called as candied fruit or fruit candy. It should have maximum 75 % of total soluble solids. For the preparation of Aonla candy, mature fruits are washed, pricked and dipped in 2 per cent salt solution for 24 hours. Then fruits are washed and dipped in 2 per cent alum solution for 24 hours. The fruit are thoroughly washed and blanched in boiling water for 5 minutes, and keep it in pieces, then steeped in 50 ^{O}Brix syrup solutions for 24 hours. The next day steeping is done in 60 ^{O}Brix for 24 hours. Again steeping is done in 70 ^{O}Brix for 72 hours. Excess syrup is drained. The fruit are dried to 15 per cent moisture content and coated with powdered sugar/pectin and packed in polythene pouches (400 gauge).

General considerations

Prick with fork, needle or gooseberry pricker.

Steep in 2 % salt solution for 24 hrs to remove astringency

Wash and dip in 2 % alum solution for 24 hours then wash thoroughly

Blanch until soft but segments do not break or crack.

Cooking of amla directly in syrup causes shrinking of fruit and reduces absorption of sugar.

Therefore, the fruit should be blanched first to make it soft enough to absorb water, before steeping in syrup.

Fruits may be cooked in syrup by two processes as given below:

1) Rapid process

Amla are cooked in low sugar syrup. Boiling is continued with gentle heating until the syrup becomes sufficiently thick.

Rapid boiling should, however be avoided as it makes the fruit tough, especially when heating is done in a large shallow pan with only a small quantity of syrup.

The final concentration of sugar should not be less than 68 %, which corresponds to a boiling point of 106 ^{O}C.

This is a simple and cheap process but the flavor and colour of the product are lost considerably during boiling.

2) Slow process

The amla is blanched until it becomes soft.

- Sugar, equal to the weight of fruit, is then added to the fruit in alternate layers and the mixture allowed to stand for 24 hrs.
- During this period, the amla gives out water and the sugar goes into solution, resulting in a syrup containing 37-38 % TSS.
- Next day, the syrup is boiled after removal of amla to raise its strength to about 60 % TSS.
- A small quantity of citric acid (1 to 1.5 g/ kg sugar) is also added to invert a portion of the cane sugar and thus prevent crystallization.
- The whole mass is then boiled for 4-5 min. and kept for 24 hrs.
- On the third day, the strength of syrup is raised to about 65 % TSS by boiling.
- The fruit is then left in the syrup for a day.
- Finally, the strength of the syrup is raised to 70 % TSS and the amla are left in it for a week.

The preserve is now ready and is packed in containers. This method is usually practiced.

Mature fruit

↓

Washing with clean water

↓

Blanching in 2 % solution for 10 min

↓

Separation of the fruits

↓

Steeping in 50 % syrup solution for 24 hrs.

↓

Steeping in 60 % syrup solution for 24 hrs.

↓

Steeping in 70 % syrup solution + Cardamom/ginger powder for 3 days

↓

Draining of excess syrup

↓

Drying of segments (Cabinet drier) up to 75 % TSS

↓

Wrapping with powdered sugar Mixing pieces with fried spices

↓

Packing

↓

Storage

Technological flow-chart for processing of Preserve and Candy

Health benefits:

- Prevents formation of gall bladder stones, ulcer, constipation, jaundice, lice, greying of hair
- Anti-ageing and anti-inflammatory
- Digestive
- Good source of minerals
- Relief from knee or joint pain
- Helps in pregnancy
- Keeps a check on high cholesterol level
- Fights against heart diseases
- Increases diuretic and metabolic activity
- Reduces blood sugar
- High in digestive fiber
- Improves eyesight
- Purifies blood, strengthens bones and cools the body
- Protects your liver and reduces the risk of cancer

	
Preserve	**Candy**

Bael preserve and Candy

Bael (*Aegle marmelos* Corr.) belongs to family Rutaceae and it is commonly known as Bengal quince, Stone apple, Maredo, Indian quince, golden apple in English, holy fruit, bel, belwa, Sriphal in Hindi in India. Inside this, there is soft yellow or orange coloured mucilaginous pulp with numerous seeds. Bael fruit contains 28-39 per cent total soluble solids, 19-21 per cent carbohydrates, 11-17 per cent sugar, 1 per cent protein, 0.2 per cent fat and 7-21 mg/100g vitamin C. In addition, it is rich in vitamin A (186 IU/100g pulp); volatile oils and marmelosines. Its food value is 88 calories/100g. Bael is considered to be one of the richest sources of riboflavin and provides lots of minerals and vitamins to diet.

Sl. No.	Ingredients	Quantity	Sl. No.	Ingredients	Quantity
1	Bael (pulp)	1 kg	4	Water	1 ltr
2	Alum	20 g	5	Citric acid	1.5 g
3	Salt	20 g			

Candy

Fruit candies are becoming more and more popular because of high acceptability, minimum volume, higher nutritionally value and longer storage life. These have additional advantage of being least thrust provoking and ready to eat snacks. A fruit impregnated with sugar, removed drained and dried is called as candied fruit or fruit candy. It should have maximum 75 % of total soluble solids. For the preparation of Bael candy, mature fruits are washed, pricked and dipped in 2 per cent salt solution for 24 hours. Then fruits are washed and dipped in 2 per cent alum solution for 24 hours. The fruit are thoroughly washed and blanched in boiling water for 5 minutes and steeped in 50 ^{O}Brix syrup solutions for 24 hours. The next day steeping is done in 60 ^{O}Brix for 24 hours. Again steeping is done in 70 ^{O}Brix for 72 hours. Excess syrup is drained. The fruit are dried to 15 per cent moisture content and coated with powdered sugar/pectin and Packed in

polythene pouches (400 gauge). Technological flow chart for the preparation of Bael preserve and candy will be similar to Aonla preserve and candy, cutting in small pieces (with the help of hacksaw) will be done in place of piercing in bael preserve and candy.

Health benefits:

- ❖ Control dysentery, diarrhoea, griping pain in the loins and constipation, gas, and colic, spure, scurvy
- ❖ Highly rich in antioxidant properties such as riboflavin (Vitamin B12), Vitamin A, tannin etc. Digestive
- ❖ Good source of minerals
- ❖ Relief from knee or joint pain
- ❖ Helps in pregnancy, treat of peptic ulcer, prevent diabetes, treat arthritis and gout
- ❖ Prevents the risk of cancer
- ❖ Keeps a check on high cholesterol level

	
Preserve	**Candy**

Dry Fig (Anthocyanin rich):

Figs are highly perishable, which limits storage for long periods, and in order to expand the potential markets, most of the production is used for drying. Figs are climacteric fruits and are slightly sensitive to ethylene action on stimulating softening and decay severity, especially if kept at 5 ^{O}C or higher temperatures (Gozlekci *et al.*, 2008). The most important cause of deterioration is the incidence of microbial molds and rots that take advantage of the easily damaged epidermis and the high content of sugar in figs. The use of SO2 can be a potential tool to control postharvest rots and, therefore, increase the market life of fresh figs (Cantin *et al.*, 2011).

Drying has many advantages for food quality with decreasing water activity, reducing microbiological activity and minimizing physical and chemical changes (Mujic *et al.,* 2014). Drying is by far the most popular and effective way of processing/preservation of figs known from prehistoric times (Kislev, 2006). Important advantages of this method are its low cost and the fact that the obtained product does not depend on refrigeration (Seylam and Olmez, 1999). Dried figs comprise about 90% of the world production (Bolin *et al.,* 1983). Dried figs are distinguished by high nutritional value and possess functional food properties (Vinson, 1999). Pre drying treatments may include blanching in boiling water (normally for 1 minute) and/or Sulphuring (*i.e.* treatment with sulphur dioxide). These methods, however, are not easily compatible with the traditional technique of sun drying, but they are often practiced before solar or mechanical dehydration. The treatments accelerate dehydration, control browning of the drying fruit, and may improve its texture and reduce infestation (Cawade and Waskar, 2005; Piga *et al.,* 2004).

Technological flow-chart for processing of Anthocyanin rich dry fig

Fresh fully ripe fruit

↓

Sorting & Washing

↓

Cutting into halves

↓

Oven drying at 60 ± 2 ^{O}C for 8 hours

↓

Packing in polyethylene packets

↓

Storage (at cool and dry place)

Health benefits:

- ❖ High content of antioxidants and good retention of ascorbic acid
- ❖ High in fibre and easy to store
- ❖ Regulates blood pressure, treats piles, diabetes, heart attacks, applied in hormonal balance and prevents constipation.
- ❖ Improve digestion
- ❖ Prevents hypertension, heart diseases and preventing cancer
- ❖ Preventing heart disease
- ❖ Helps loosing weight and strengthens your bones
- ❖ Cures from iron deficiencies and improves reproductive health

Fresh Fruits

Cutting into halves

After drying

Karonda tutti-frutti

Karonda is a very hardy, drought tolerant plant that thrives well in a wide range of soil and it belongs to family Apocynaceae. Fruits are astringent and sour in taste as well as the richest sources of iron, calcium, phosphorus, essential vitamins and minerals (Gopalan *et al.*, 1993). The mature fruits are used for preparation of number of products such as chutney, pickles and sauces whereas ripe fruit for jam jelly and candy. "A fruit/vegetable impregnated with sugar as above and subsequently drained and dried is called a candied product". A candied product is covered with a thin transparent layer/coating of sugar is called a glazed product. When a candied product is coated with sugar crystal either by rolling it in finely powdered sugar or by allowing sugar crystals to deposit on it, is called crystallized product. Karonda tuti-fruti is a candied product made under standardized conditions and having good shelf life when packed and stored suitably.

Technological flow-chart for processing of Karonda tutti-frutti

Health benefits:

- Due to precursor of iron used for anemia patient.
- It has rich source of vitamin C, which helps with growth and repair of tissues.
- Fruit is known to keep the liver healthy, by stopping its excessive secretion of bile.
- It also acts as an analgesic, comforts the body during diarrhea, keeps the heart healthy, reduces inflammation, helps fight cold and cough, bloodpurifying, regulate blood pressure, and helps the constipation.

Karonda fruits

Fruit pieces

Tutti-Frutti

Conclusion:

Eating of fresh fruits and vegetables as well as their nutritionally rich processed enriched products will be more helpful to improve the immunity power in the human health. These are the precursors of Vitamins, minerals, antioxidants etc. By seeing the present situation it's most important that every one must be healthy and good immunity as because it protects our body not only from disease but also acts as anti-ageing. Above discuss processed enriched products will be more helpful to boost the immunity.

References

1. Malter, M., Schriever, G. and Eilber, U. (1989). Natural killer cells, vitamins, and other blood components of vegetarian and omnivorous men. *Nutr Cancer*. 12:271-278;
2. Rinninella, E., Cintoni, M., Raoul, P., Lopetuso, L. R., Scaldaferri, F., Pulcini, G., Miggiano, G. A. D., Gasbarrini, A. and Mele, M. C. (2019). Food components and dietary habits: keys for a healthy gut microbiota composition. *Nutrients*. 11(10): 2393.
3. Alwarawrah, Y., Kiernan, K. and MacIver, N. J. (2018). Changes in nutritional status impact immune cell metabolism and function. *Front Immunol*. 9:1055-1069.
4. Haddad, E. H., Berk, L. S., Kettering, J. D., Hubbard, R. W. and Peters, W. R. (1999). Dietary intake and biochemical, hematologic, and immune status of vegans compared with nonvegetarians. *Am J Clin Nutr*. 70(3 Suppl):586S-593S.
5. Eichelmann, F., Schwingshackl, L., Fedirko, V. and Aleksandrova, K. (2016). Effect of plant-based diets on obesity-related inflammatory profiles: a systematic review and meta-analysis of intervention trials. *Obes Rev*. 17:1067-1079.
6. Barnard, N. D., Goldman, D. M., Loomis, J. F., Kahleova, H., Levin, S. M., Neabore, S. and Batts, T. C. (2019). Plant-based diets for cardiovascular safety and performance in endurance sports. *Nutrients*. 11(1): 130.
7. Grant, W. B., Lahore, H., McDonnell, S. L., Baggerly, C. A., French, C. B., Alinao, J. L. and Bhattao, H. P. (2020). Evidence that vitamin D supplementation could reduce risk of influenza and COVID-19 infections and deaths. *Nutrients.* 12(4):988.
8. Shastri, A. D. (1996)Bhaishjya-Ratnawali, (ChaukhambhaSanskrit Bhawan, Varanasi): 286.
9. Bhandari, C. R. (1938).Vanoshadhi-Chandrodaya, Vol I (GyanMandirBhanpura): 112.
10. Gozlekci, S., Erkan, M., Karaşahin, I. and Şahin, G. (2008). Effect of 1- Methyl

Cyclo Propene (1-MCP) on fig (*Ficuscarica* cv. Bardakci) storage. *Acta Horticulture*. 798: 325-330.
11. Cantin, C. M., Palou, L., Bremer, V., Michailides, T. J. and Crisosto, C. H. (2011). Evaluation of the use of sulphur dioxide to reduce postharvest losses on dark and green figs. *Postharvest Biology and Technology*. 59: 150-158.
12. Mujic, I., Kralj, M. B., Jokic, S., Jug, T., Subaric, D., Vidovic, S. et al. (2014). Characterization of volatiles in dried white varieties figs (*Ficuscarica* L.). *Journal of Food Science and Technology*. 51(9): 1837-1846.
13. Kislev, M. E., Hartmann, A. and Bar-Yosef, O. (2006). Early domesticated fig in the Jordan Valley. Science. 312:1372-1374.
14. Seylam, A. and Olmez, H. K. (1999). GAP (South-east Anatolia Project) and drying with solar energy. (In Turkish). Tarm ye KoyisleriBakanlgDergisi. 126: 55-57.
15. Bolin, H. R., Huxsoll, C. C., Jackson, R, and Ng, K. C. (1983). Effect of osmotic agents and concentration on fruit quality. *Journal of Food Science*. 48(1): 202-205.
16. Vinson, J. A. (1999). The functional food properties of fig. *Cereal Foods World*. 44: 82-87.
17. Cawade, M. H. and Waskar, D. F. (2005). Effect of different varieties and pre-treatments on yield and quality of dried fig fruits. *Indian Journal of Agriculture Research*. 39: 138-141.
18. Piga, A., Pinna, I., Ozer, K. B., Agahbio, M. and Aksoy, U. (2004). Hot air dehydration of figs (*Ficuscarica* L.): drying kinetics and quality loss. *International Journal of Food Science and Technology*. 39: 793-799.
19. Gopalan, C, Rama Sastri, B. R. and Balasubramanian, S. C. (2009). Nutritive Value of Indian Foods, 12th Edition. ICMR-National Institute of Nutrition, Hyderabad.

Chapter – 3

Recent Innovation in Value Addition of Horticultural Crops

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Despite huge production of horticultural crops, India processes only about 2.2 % of the total production. A considerable amount of fruits and vegetables produced are lost due to improper post harvest management and lack of appropriate processing technologies. Out of the total production of about 270 million tonnes of fruits and vegetables in the country, only 1 million tonne value added processed products are produced. About 20% of the produce worth crores is wasted every year. Value addition for a product can be in terms of economic gain, time and money saving in preparation, quantity and quality improvement or modification of raw ingredients for specific desirable characteristics. With increased incomes, urbanization and changing eating habits, the demand for value added processed foods has increased manifold. In our efforts to diversify our products and to meet the market requirements, there is an increased need to add value to our products in order to fetch better prices.

About 60 per cent of the consumers live in the rural sector, the processed food is transported back to where it was produced at much higher prices and after incurring substantial losses. Had the produce been processed in the production catchment, the consumers there would have accessed the processed food at lower prices, post harvest losses would have been avoided and more employment would have been created in the rural areas. Rural folk can play an important role in post harvest management right from harvesting and can salvage a large part of the loss. It will also help in higher availability of this dietary material, which comes under protective foods at lesser cost and improve the nutritional status of vast population of our country. If the rural women and younger generation are trained in some of the simple and low cost, energy efficient techniques for proper management of fresh fruits and vegetables at farm level, it will help in reduction of losses, better returns to the growers and reasonable price to the consumers both for fresh and processed products.

1. Status of processing Industry

In India, less than 3 per cent of fruits and vegetables produced are commercially processed as against 65 per cent in the US, 70 per cent in Brazil, 78 per cent in the Phillipines, 80 per cent in South Africa and 83 per cent in Malaysia. The value addition is only 7 per cent in India as against 23 per cent in China and 88 per cent in UK.

Table 1: Extent of post-harvest losses (estimates) in horticultural crops

S. No.	Crops	Quantity (Mt.)	Loss (%)	S. No.	Crops	Quantity (Mt.)	Loss (%)
1	Fruits	55.00	20	**4**	Tuber Crops	32.19	20
2	Vegetables	95.00	25	**5**	Spice & Condiment	3.02	12
3	Floriculture	-	40				

Bundelkhand region have a geographical area of about 7 .0 million ha comprising the 13 district of Uttar Pradesh and Madhya Pradesh together. In Bundelkhand ,*ber* , *aonla* ,*bael*, *lemon* and guava and papaya are leading fruit crops accounting for over 70% of the area under fruit . The main vegetables grown in this region include tomato, pea ,potatoes, , cucurbits, carrots, radish and onions. The main spices grown are garlic, fenugreek, coriander and turmeric (Tikamgarh) while the major flowers grown are marigold, tuberose and gladiolus (Sagar). The integrated strategy includes

- Cluster based and demand-driven farming
- Integration of food processing infrastructure from farm to market and
- Promoting a dynamic food processing industry that could result in high growth of the processed food sector

This can be achieved by augmenting the level of processing of perishables from 6 to 20 per cent, value addition from 20 to 35 per by 2025. Advances in processing technologies of perishable crops will help to curb the post harvest losses and result in giving a boost to the food processing industry to accomplish the goal. In this region, there are very few fruit and vegetable processing centers at present (5 units - personal communications).

2. Technologies developed

Most of the fruits and vegetables produced in India are still consumed fresh except for a very small quantity going for the manufacture of various products such as pickles, tomato ketchup, jams, dried and fried potato and raw banana and fruit drinks. With changing dietary pattern, demand of fresh and processed fruits and vegetables in domestic market has increased. To meet the challenge, fruit and vegetable production has increased many fold in the last few decades. There has been unprecedented increase in export of some fruits like mango, walnut and grapes in the last few years.

Table 2. Processed products from vegetables

S. No.	Vegetables	Existing Products	Newer Products
1	Bitter gourd	Dehydrated	Juice
2	Carrot	Juices, dehydrated	Colour extraction, osmotically dried shreds
3	Cauliflower	Dehydrated	Minimally processed
4	Chili	Chutneys, pickle, dehydrated	Puree, essential oil
5	Cucumber	Slices, whole in brine solution	Pickled
6	Mushroom	Canned, dehydrated, ketchup, pickle	Phytochemicals
7	Okra	Minimally processed, dehydrated	Coated and battered
8	Onion, garlic	Dehydrated, paste	Ready-to-use gravy base
9	Shelled beans and peas	In brine, frozen, canned	Protein isolates
10	Tomato	Juice, puree/concentrate	Ready-to-use gravy base, lycopene extraction
11	Potato	Chips, starch	Alcohol

The production of frozen peas, garlic and ginger paste, tomato puree, mango pulp etc. has been taken up in a big way only recently in India. Some of the popular processed or value added products in the country, dried onions and garlic powder, ginger and garlic paste, jams of mixed fruits, pineapple and strawberry; juice and concentrates of apple, pineapple, orange and litchi, squashes of litchi, canned pineapple, canned beans, frozen beans, cauliflower and okra; pickles of mango, lime, chilies and mixed fruits and vegetables; tomato ketchup and puree; mango fruit drink and nectar, chili sauce, mango chutney etc. In addition to offering a higher return, value added products can open new markets, create recognition for a farm and expand the market season. The processing centres in the region can take up diversification of the processing line to develop newer products listed as under.

Table 3. Existing and newer products from fruits

S. No.	Fruits	Existing Products	New Products
1	Aonla	Preserve, pickle	Juice and concentrate, osmo-dried segments, powder, salted segment preserve
2	Bael	Pulp	Preserve, juice, canned
3	Citrus	Canned slices, pickle, squash, extraction of citric acid, essential oil from peels	Limonene extraction, flavours
4	Grape	Raisins, juice, wine	Canned grapes, concentrate
5	Guava	Jelly, juice, nectar	Pulp, concentrate, bars, powder
6	Mandarin	Blended juice	Debittered juice, concentrates
7	Mango (Green)	Pickle, chutney, dried slices, powder	Drink, juice concentrate
8	Mango (Ripe)	Canned slices, pulp, juices, nectar jam, bar	Frozen slice, mango powder, concentrate, wine, vinegar,IQF
9	Papaya (raw)	Tutti-fruitty	Papain/pectin, IQF

The value added products from flowers include dry flowers and pot pourri, essential oils, flavours and fragrances, pharmaceutical and neutraceutical products, pigments and natural dyes, gulkand, rose water and insecticidal and nematicidal compounds. Spices are processed for essential oils, oleoresins, natural colours and spice extracts. Mushrooms are being processed into fresh, dried and pickled forms. There are several villages in Tikamgarh devoted to spices cultivation and processing.

Table 4. High value products from horticultural crops

Crop	Value added products
Chrysanthemum	Knock down effect on Lepidoptera insects, bouquets
Marigold	Essential oil and oleoresins for perfumery, aggarbattis, repellent for flies and mosquitoes, natural colorants to be used as dyes, poultry feed, pharmaceuticals, herbal products, bouquets, loose flowers
Rose	Food flavor, lotions, eye washes, tobacco flavouring, gulkand, herbal products, dried flower arrangements, bouquets

Tuberose	High grade perfumes, lotions
Crop	**Value added products**
Fenugreek	Ayurvedic medicines, health products
Garlic	Oleoresins, prebiotics, medicinal compounds, beauty products
Ginger	Oleoresin, medicines
Turmeric	Curcumin (natural colour), ayurvedic medicine

It is recommended to use suitable processing variety for particular type of processed fruit and vegetable product to maintain uniformity in quality. The following table shows a few recommended varieties of fruits and vegetables for use in specific product type.

Table 5. Processable varieties of horticultural crops

Crop	Processable Variety	Processed product
Fruits		
Mango	Alphonso, Arka Puneet, Arka Anmol, Amrapali	Canned juice
	Totapari, Arka Aruna	Osmotic dehydration
	Alphonso, Amrapali	Canned pulp
	Ramkela	Pickle
Guava	Red fleshed exotic guava-7-12-EC-147036, Allahabad safeda	RTS beverage
	Sardar, Apple colour, Chittidar	Jelly
Citrus	Nagpur santra, Khasi mandarin	Canning
	Kinnow, Coorg mandarin	Juice
	Kagzi lime, Eureka, Kagzi kalan, Nepali round	Pickle
Pomegranate	Amlidana, Basein seedless	Anardana
	Papershel, Kandhari	Squash
Aonla	Banarsi aonla	Murabba/ preserve
	Krishna	Candy
	Kanchan	Pickle
Vegetables		
Tomato	Pusa Gaurav, Pusa Uphar, Pusa Hybrid 2	Sauce, ketchup, chutney
Onion	Pusa White Flat, Pusa White Round	Dehydrated, flakes
Carrot	Pusa Meghali, Nantes, Pusa Yamdagini	Dehydrated, shreds, pickles
Paprika	KT-PL-19	Oleoresin, powder
Amaranth	Pusa Lal Chaulai	Pigments for natural dyes, food additives
Beet root	Detroit Dark Red	Pigments for natural dyes and food additives
Methi	Pusa Kasuri	Dehydrated
Ash gourd	Pusa Shakti, Pusa Ujwal	Candy sweet
Bitter gourd	Pusa Vishesh, Pusa Hybrid 1	Dehydrated, pickle
Pumpkin	Pusa Vikas	Sauce
Pea	Arkel, Pusa Pragati	Frozen, Canned

Crop	Processable Variety	Processed product
Fruits		
Mango	Alphonso, Arka Puneet, Arka Anmol, Amrapali	Canned juice
	Totapari, Arka Aruna	Osmotic dehydration
	Alphonso, Amrapali	Canned pulp
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Guava	Red fleshed exotic guava-7-12-EC-147036, Allahabad safeda	RTS beverage
	Sardar, Apple colour, Chittidar	Jelly
Citrus	Nagpur santra, Khasi mandarin	Canning
	Kinnow, Coorg mandarin	Juice
	Kagzi lime, Eureka, Kagzi kalan, Nepali round	Pickle
Pomegranate	Amlidana, Basein seedless	Anardana
	Papershel, Kandhari	Squash
Aonla	Banarsi aonla	Murabba/ preserve
	Krishna	Candy
	Kanchan	Pickle
Vegetables		
Cauliflower	Pusa Snowball Kt-1, Pusa Snowball Kt-25	Dehydrated, pickle, frozen curds

2.1. Cluster approach for processing /value addition of major horticultural

2.2. *Ber* processing

Being a hardy crop, *Ber* is extensively grown across the Bundelkhand. Area under *ber* cultivation in the region had already reached up to desirable level on which small scale processing units can sustain. The major varieties grown in this region are Banarasi, Umran, Kaithali, Gola and Seb . Cultivars like Umran, Gola and Seb have high potential of value addition in the form of candy, leather and bar. Ber has high level of rafinose and other pectinase substances, which make its juice extraction a difficult task. Nowadays, enzyme-assisted juice extraction technology is commercially used for “difficult to juice extraction” fruit crops. The state governments can take the advantage of this prevalent popular fruit crop in selected growing clusters by setting up integrated ber processing units.

2.3. Aonla and bael processing

The Bundelkhand region enjoys semi-arid climate, which is congenial for aonla cultivation. The area under aonla and bael cultivation is further expected to rise in near future due to scarcity of water and poor soil health. The major aonla growing districts are Lalitpur, Jhansi, Hamirpur Datia, Sagar and Damoh. With the help of state government and SHGs, the farmers /small entrepreneurs can be encouraged for setting up aonla juice, powder, and preserve-making small-scale industries.

2.4. Pea processing

Bundelkhand is leading pea-producing region of UP-MP and has potential to increase its production in future. Major pea production in the region comes from the growers of the Jhansi, Hamirpur, Jalaun, and Lalitpur districts. However, when there is a peak production, farmers face distress sale. Green pea shelling, freezing and

processing and training facilities may be developed in and around Jhansi and Banda districts.

2.5. Value addition in Baby corn

Baby corn is the ear of maize (*Zay mays* L.) plant harvested young, especially when the silk have either not emerged or just emerged and no fertilization has taken place depending on the cultivar grown. The dehusked young ears of baby corn can be consumed as a vegetable, whose delicate sweet flavour and crispiness are much in demand. Baby corn can be grown near Jhansi, Gwalior and Bhopal. Cobs of baby corn being highly perishable requires enhancement of shelf life for its storage and utilization as food. The State Governments can further promote the crop through R & D intervention.

3. Infrastructure development

New technologies in post-harvest infrastructure also need to be adopted. Pre-cooling and post harvest chilling facilities play a very important role in processing of perishable goods. The state governments can set-up Mega Food Park and herbal centers which is aimed at bringing together all players in the value chain so as to minimize wastages and facilitate better inventory management and production planning. Functions like sorting, grading and packaging along with irradiation, use of renewable energy sources from rural areas; food incubation-cum-development will take place in these food parks.

4. Marketing and export

Integrated supply chain of fruits and vegetables helps to make horticulture market driven rather than an area driven activity. It helps to shrink the long supply chain through which the produce passes through to a shorter chain by reducing the number of intermediaries and avoids multiple handling. The alleviation in the price of the commodity from farm gate to consumer level is as high as 60-75% Farmers get only about 25 to 30% of the consumer price because of the several intermediaries, wastages and cost of logistics. With an efficient integrated supply chain these costs can be reduced significantly and both farmers and consumers stand to gain. Thus there is a shift from unorganized retail to organized retail in the country.

To attract the investment in the food processing and value addition sector, the state Government should increase the number of industries to increase value addition, establish cold chain system, should promote primary/minimal processing at rural level to generate self employment and should collaborate with research and development institutes in the wake of the quality consciousness of the consumers.

5. SWOT analysis

5.1. Strengths

The strength of the food processing industry for the region lies in:

- The abundance of some indigenous fruits and vegetables in the area
- The availability of large pool of technocrats and of the research and development Centers (Central and State Agricultural Universities and ICAR research institutes)
- The capability of design, development and construction of process plant machinery matching international standards

5.2. Weaknesses

- Poor availability of suitable processing variety of raw materials
- Poor and inadequate rural infrastructure especially feeder access roads, power/electricity, telecommunication and market facilities in major urban centers
- Lack of post harvest handling facilities
- Lack of trained manpower
- Lack of cool chain system for proper management of highly perishable crops
- Strict food safety, traceability and good agricultural practice requirements as stipulated in the certification requirements
- Inadequate access to new varieties of crops, information on market demands and other market information
- Lack or poor dissemination of local and external market information
- Increasing competition from imports in to the local market
- Inadequate research, ineffective extension messages and delivery system and adoption
- Inadequate infrastructure for implementation of quality standards in the local market

5.3. Opportunities

- The opportunities available for these processed horticultural products are:
- The pre-prepared meals based on Indian cuisines for large Asian ethnic population including working middle class couples is big opportunity for domestic as well as export market
- Dried and processed products are growing in demand owing to shelf-stability and ready-to-use nature
- Fruit and vegetable based functional foods are becoming popular
- Nutraceuticals derived from indigenous horticultural produce is gaining popularity
- Trend for addition of natural colours and flavours from the fruits, vegetables and flowers is on the rise
- Essences and flavours from indigenous spices are being used for aromatherapy

5.4. Threats

The major threat to food processing industry is expected from the goods by the neighboring countries such as China, Thailand, Indonesia and Philippines who have a distinct price advantage and stringent processing quality norms. In addition, staggered bulk supply of raw materials is also one of the bottlenecks in sustainable growth of processing industry.

6. Future strategies

The horticulture industry has major contribution for improving food security, enhancing rural employment, alleviating poverty and export-promotion. Increased urbanization, improved standards of living, and the convenience needs of dual income families poised to major market potentialities in the food processing and marketing sectors. To compete with the changing market scenario and to strengthen our global position, the following strategies should be adopted:

- There is need for concerted government efforts to improve feeder roads and put up modern improved facilities in the urban wholesale markets through encouraging private sector participation, improve electricity distribution network to major production areas and make it more reliable
- New innovations in eco-friendly, cost effective technologies should be made towards value addition of horticultural crops using under-exploited raw materials such as *bael*, *ber* and *jamun*. Processing opportunities exist for osmotic dehydration, ready to serve/eat vegetables, mushroom processing, health drinks, snack foods and fortified products.
- Processing of horticultural crops can be done at farm level for better utilization of waste as animal feed, biogas or as compost, thereby reducing pollution load in the cities
- Adopting a holistic approach to food quality and safety by meeting various ISO standards and following FSSAI and HACCP guidelines that encompasses the whole food chain- from farm to plate. It is essential to prepare products meeting international standards not only from export point of view but also for domestic consumption.
- Investment for modernizing the processing plants must be encouraged.
- Inter-linkages between research and development sector and processing/packaging sector have to be well developed to attain a global initiative **"**From Quantity to Quality**"**.

The main issues to be addressed are minimization of post harvest handling losses, value addition, by-product utilization and promotion of export through public-private partnership. Our ultimate aim should be convergence of technologies and emergence of products or processes, by interfacing and networking of various stakeholders.

Suggested References

1. APEDA, Annual Administrative Report 2018-2019
2. Ministry of Food Processing and Industries, Schemes 2020

Chapter – 4

Postharvest Handling and Value Addition of Vegetable Crops

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In the global scenario, vegetables play a significant role in nutritional and food security. Recently, farmers have shifted the traditional cereal crops to vegetable farming due to high yield, short duration, intensive cropping system, high income and employment generation. Vegetable production is increasing faster than the population and consequently increasing the market surplus and more pressure on post-harvest technologies for vegetables. Further, inadequate storage, transport, handling and processing has led to unacceptable level of wastage and value loss. The magnitude of these losses is 6-18% in fruits and vegetables. Value addition is the easiest way to reduce these losses.

Under Indian scenario, vegetable processing is restricted mainly pickles, chutneys, preserves and candies at cottage level on small scale with processing capacities of 250 tons/per annum as against the same level of processing in one day by Multi National Companies. Furthermore, there has been gross negligence on quality of processed vegetables in terms of hygiene due to employment of many unskilled labors in fruits and vegetable processing operations. However, value addition in fruits and vegetable sector is expected to increase from 8 to 20% by 2025. Fruits and vegetable processing sector is very important as it ensures employment to large section of unemployed youths along with it prevents the huge post-harvest losses to meet the nutritional and food security of the growing population. In view of migration of rural population to urban areas, the demand of processed vegetables is increasing. Due to change in life styles, changing demography at work place and reduced time available for cooking, the demands for high quality processed vegetables are increasing. The demand for ready-to-eat, easy-to-cook vegetables is increasing. Processed vegetables are very popular as it saves time, labour and having extended shelf life. In this context, low cost vegetable processing and value addition is very important to minimize huge post-harvest losses to a greater extent for nutritional security of large section of population.

Low cost processing technologies of vegetables with good aesthetic values are very important to cater the demand of urban population. Consumers can be attracted to these low cost processing technologies for serving the needs of offseason vegetables. Furthermore, consumers in cities have very little time to cook vegetables daily and cater the nutritional and sensory perception of vegetables. The demand of convenience form of vegetables in form of easy-to-cook, ready-to-eat vegetables would increase with time. Keeping the above view the following techniques may be used for the value addition of vegetables:

Shellac coating for increasing the shelf life of vegetables

Shellac resin is secreted by the insect (*Laccifer lacca*) found in India. Shellac being composed of aleuritic and shelloic acids, is compatible with waxes and gives coated products a high glossy appearance. This compound is permitted as an indirect food additive but is nevertheless commonly used in coatings for fresh fruits and candies where the coated surface is consumed. It is absolutely safe for coating in fresh fruits and vegetables (Kore et al., 2017).

Shellac coating of Capsicum (*Capsicum annum* L.)

Nutritional and Health benefits

- Rich sources of vitamin C, vitamin A, antioxidant flavonoid such as lutein, zea-xanthin and cryto-xanthin
- Antibacterial, anti-carcinogenic, analgesic and anti-diabetic properties
- Reduction of triglycerides cholesterol level after regular consumption

De-waxed and bleached Shellac (1g)

⇓

Addition of 20 ml of 0.2% sodium hydroxide

⇓

Heat treatment and addition of 0.6% ammonia in hot condition

⇓

Addition of 3% polyvinyl alcohol with 1% tri ethanol amine

⇓

Cooling to room temperature and addition of 0.5% sodium alginate

⇓

Coating on the surface of capsicum with the help of sponge or spraying followed by surface drying and storage at 10 ^{O}C

Flow diagram for shellac coating in Capsicum

Usage: Capsicum is washed thoroughly in running water before consumption

Quality attributes

- Shelf life extension of 30-35 days after storage at 10 ^{O}C
- Decrease in ascorbic acid content from 102 mg/100g to 70 mg/100g after 35 days of storage at 10 ^{O}C
- Decrease in green colour in terms of a value from -12.1 to - 8.1 after 35 days of storage at 10 ^{O}C
- Decrease in hardness in terms of force 4.02 N to 2.8 N during storage
- Overall sensory acceptability score of 7.5 on 9 – point Hedonic scale

Shellac coating of Pointed gourd (*Trichosanthes dioica*)

Nutritional and Health benefits

- Rich sources of carbohydrates, vitamin A, vitamin C, vitamin B1, vitamin B6, etc.
- Good sources of minerals such as calcium, phosphorus, potassium,

magnesium, sulphur and chlorine, etc.

- Good for skin and hair growth
- Acts as blood purifier and skin texture clarifier
- Helpful in reducing gastrointestinal diseases, role in salivary tubule activation and aids in anorexia

Shellac coating of Capsicum (*Capsicum annum* L.)

De-waxed and bleached Shellac (1g)

⇓

Addition of 20 ml of 0.2% sodium hydroxide

⇓

Heat treatment and addition of 0.6% ammonia in hot condition

⇓

Addition of 3% polyvinyl alcohol with 1% tri ethanol amine

⇓

Cooling to room temperature and addition of 0.5% sodium alginate

⇓

Coating on the surface of pointed gourd with the help of sponge or spraying followed by surface drying and storage at 10 ^{O}C

Flow diagram for shellac coating in Pointed gourd

Usage: Pointed gourd is washed thoroughly in running water before consumption.

Quality attributes

- Shelf life extension of 15 days after storage at 10 ^{O}C
- Increase in physiological loss in weight to 8.5% after 15 days of storage at 10 ^{O}C
- Increase in total soluble solids from 3.85% to 5.8% after 15 days of storage at

10 ^{O}C

- Decrease in ascorbic acid (40-44%) after 15 days of storage at 10 ^{O}C

Shellac coating of Pointed gourd (*Trichosanthes dioica*)

Shellac coating of Eggplant (*Solanum melongena* L.)

Nutritional and Health benefits

- Rich sources of various vitamins such as vitamin B1, vitamin B2, vitamin B6, vitamin C and fairly balanced amount of minerals
- Fairly rich sources of bioactive compounds such as phenolics and flavonoids
- Suppress the development of blood vessels required for tumor growth metastasis
- Significant reduction of inflammation after regular consumption

De-waxed and bleached Shellac (1g)

⇓

Addition of 20 ml of 0.2% sodium hydroxide

⇓

Heat treatment and addition of 0.6% ammonia in hot condition

⇓

Addition of 3% polyvinyl alcohol with 1% tri-ethanol amine

⇓

Cooling to room temperature and addition of 0.5% sodium alginate

⇓

Coating on the surface of eggplant with the help of sponge or spraying followed by surface drying and storage at room temperature (20-22 ^{O}C)

Flow diagram for shellac coating in Eggplant

Usage: Eggplant is washed thoroughly in running water before consumption.

Quality attributes

- Shelf life extension of 7 days at ambient storage temperature (20-22 ^{O}C)

- Increase in physiological loss in weight from 6.0 – 25.7% after 7 days of storage
- Increase in total solids from 8.5-11.9% during storage
- Decrease in red colour intensity in terms of a value from 13.9 to 10.3 during storage
- Decrease in texture from 89.24 N to 55.7N during storage
- Decrease in antioxidant activity from 389.7 to 182.8 µM gallic acid/g

Shellac coating of Eggplant (*Solanum melongena* L.)

Shellac coating of Carrot (*Daucus carota*)

Nutritional and Health benefits

- Rich sources of β-carotene, vitamin B complex especially folic, thiamine, pantothenic acid, etc.
- Fairly good sources of minerals such as calcium, magnesium, phosphorus, zinc, manganese, selenium, iron, etc.
- Rich sources of antioxidant poly acetylene antioxidant such as lutein, zeaxanthin and falcarinol responsible for destruction of precancerous cells in tumors.

De-waxed and bleached Shellac (1g)

⇓

Addition of 20 ml of 0.2% sodium hydroxide

⇓

Heat treatment and addition of 0.6% ammonia in hot condition

⇓

Addition of 3% polyvinyl alcohol with 1% tri-ethanol amine

⇓

Cooling to room temperature and addition of 0.5% sodium alginate

⇓

Coating on the surface of carrot with the help of sponge or spraying followed by surface drying and storage at 10 ^{O}C

Flow diagram for shellac coating in Carrot

Usage: Carrot is washed thoroughly in running water before consumption.

Quality attributes

- Overall sensory acceptability score of 7.5 on 9-point Hedonic scale after 20 days of storage at 10 ^{O}C
- Physiological loss in weight increased from 2.64% to 14.8% during storage
- Total solids increased from 9.67% to 12.4% during storage
- Red colour in terms of a value increased from 4.38 to 6.67 during storage
- Antioxidant activity in terms of FRAP decreased from 7.18 to 5.96 µM/g

Shellac coating of Carrot

Steeping preservation of vegetables with hurdle technology

The retention of sensory and nutritional quality in vegetables is the biggest challenge to the processors for the benefit of consumers. It all depends on the application of safer food additives in judicious manner. The combined safer additives act as hurdles to inhibit the growth of microorganisms and prevent the biochemical reactions leading to breakdown of vegetable constituents such as carbohydrates, proteins and vitamins. The most important hurdles used in vegetable preservation are temperature, water activity, acidity, redox potential, preservatives and competitive microorganisms. The hurdles in vegetables can be kept at optimal range, considering the safety and quality and thus affecting the total quality of foods. A certain set of hurdles is inherent for each stable and safe vegetable, which differs in quality and intensity depending on the particular product. But in any case, the hurdles must keep the normal population of microorganisms in the vegetable under control. The microorganisms present in vegetable should not be able to overcome the hurdles present during storage of the product otherwise the vegetable will spoil or even cause food poisoning.

Basic preservation methods imply putting microorganisms in a hostile environment, in order to inhibit their growth or shorten their survival or cause their death. The feasible responses of microorganisms to this hostile environment determine whether they may grow or die. Recent advances have been made by considering the homeostasis, metabolic exhaustion and stress reactions of microorganisms in relation to hurdle technology, as well as by introducing the novel concept of multi-target preservation for a gentle but most effective preservation of

hurdle technology foods.

Multi-target preservation refers to ambitious goal for a gentle and most effective preservation of foods. It has been reported that that different hurdles in a food might not have an additive effect on microbial stability, but they could act synergistically. A synergistic effect could be achieved if the hurdles in a food hit at the same time different targets such as cell membrane, DNA, enzyme systems, pH, aw, Eh etc. within the microbial cells and thus disturb the homeostasis of the microorganisms present in several respects. The repair of homeostasis as well as the activation of stress shock proteins becomes more difficult. It is anticipated that the targets in microorganisms of different preservative factors for foods should be elucidated and the hurdles may be grouped in classes according to their targets. A mild and effective preservation of foods is effective if the preservation methods are based on intelligent selection and combination of hurdles taken from different target classes. The synergistic approach is probably not only valid for traditional food preservation procedures but as well for modern processes such as food irradiation, ultra high pressure, pulsed technologies. Multi-target effect is effective in controlling the highly contagious diseases such as tuberculosis and AIDS.

The use of antimicrobials is a common practice for preservation of foods. The incorporation of antimicrobial in a food recipe reflects towards inhibition of spoilage and pathogenic microorganisms, which results in the compositional modification of food. The majority of consumers are demanding the natural antimicrobials such as bacteriocins, which inhibit the microbial growth.

Bacteriocins are proteinaceous compounds consisting of peptides and amino acids with antimicrobial activity and are synthesized by the ribosomes of the microbial cells. Over the decades, numerous bacteriocins produced by lactic acid bacteria (*Lactobacillus*, *Lactococcus*, *Enterococcus*, *Pediococcus* and *Carnobacterium*) have been isolated and characterized as nisin, lactococcins, sakacins, curvaticins, carnobacteriocins, pediocins, etc. Bacteriocins gained increased attention because of their potential application as natural antimicrobials in foods to substitute or decrease the addition of other chemical preservatives, which are considered hazardous. Among the bacteriocins, nisin is very popular additive in variety of food products such as milk and milk products, fruits and vegetables products and meat based products to control gram-positive bacteria.

Steeping preservation of Cauliflower (*Brassica oleracia* var botrytis)

Nutritional and Health benefits

- Rich sources of vitamin C, vitamin K, vitamin E, vitamin A, folate and dietary fibre
- Protection against lung, prostate, breast and chemically induced cancers in cruciferous vegetables rich in glucosinolates
- Rich sources of manganese, phosphorus and magnesium

Cauliflower

⇓

Sorting, washing and cutting of stalk

⇓

Cauliflower pieces (3-4 cm)

⇓

Blanching in boiling water for 30 sec in muslin cloth

⇓

Steeping into 3.5% sodium chloride solution, 1.1% acetic acid, 350 ppm sulphur dioxide

⇓

Storage of cauliflower in glass bottles with steeping solution for 8-10 months at 25-30 ^{O}C

Flow diagram for steeping preservation of cauliflower

-Usage: Steeped cauliflower is washed in water and it is used for pickle or curry preparation (Singh et al., 2015).

Quality attributes

- Overall acceptability score of 8.0 on 9-point Hedonic scale after 8 months of storage
- Maximum decrease in pH of curd pieces from pH 6.3 to 3.68 after 15 days of storage in steeped cauliflower samples with 4% sodium chloride, 1% acetic acid and 350 ppm sulphur dioxide
- Maximum decrease in hardness value of curd pieces (15.20N-10.12N) during 120 days of storage with steeped solution of 6% sodium chloride, 2% acetic acid and 350 ppm sulphur dioxide
- Decrease in extent of browning, ascorbic acid and total carotenoids content in steeped cauliflower samples of 2-6% sodium chloride, 1-2% acetic acid and 350 ppm sulphur dioxide, respectively during storage

Steeping preservation of Cauliflower (*Brassica oleracia* var botrytis)

Steeping preservation of Carrot (*Daucus carota*)

Nutritional and Health benefits

- Major source of □-carotene providing 17% of the total vitamin A consumption along with rich sources of vitamin C, vitamin K, thiamine, riboflavin, pyridoxine and folates

- Good sources of lipophilic antioxidants like lycopene and lutein
- Significant role in controlling diabetes due to low glycaemic index
- Cholesterol lowering effect due to increased level of dietary fibre

Carrot
⇓
Washing and trimming
⇓
Slicing/cutting
⇓
Steeping into 25% sugar solution, 0.4% citric acid, 400 ppm benzoic acid and 400 ppm sulphur dioxide
⇓
Storage of carrot slices in glass bottles with steeping solution for 6-8 months at 25-30 ^{O}C

Flow diagram for steeping preservation of carrot

Usage: Steeped carrot is washed in water and it is consumed for salad or for the preparation of carrot based halwa

Quality attributes

- Overall acceptability score of 8.02 on 9-point Hedonic scale after 6 months of storage at ambient temperature
- Reduction of reducing sugar, total carotenoids and ascorbic acid to the level of 30 26.45%, 44-48% and 48–58%, respectively during storage
- Suitable for carrot based halwa even after 6 months of ambient storage

Steeping preservation of Carrot (*Daucus carota*)

Steeping preservation of Pointed gourd (*Trichosanthes dioica*)

Nutritional and Health benefits

- Most nutritive cucurbit vegetable in Indian market during summer and rainy season
- Rich sources of protein and vitamin A content
- Significant effect in lowering blood sugar, serum triglycerides, cardio-tonic and anthelmintic properties
- Easily digestible and diuretic nature

Pointed gourd

⇓

Washing

⇓

Blanching in boiling water for 15 sec

⇓

Steeping into 2.5% sodium chloride solution, 1.0% acetic acid and 350 ppm sulphur dioxide

⇓

Storage of pointed gourd fruits in glass bottles with steeping solution for 3-4 months at 25-30 ^{O}C

Flow diagram for steeping preservation of pointed gourd

Usage: Steeped pointed gourd is washed in water and it is used for pickle or curry preparation.

Quality attributes

- Overall acceptability score of 7.0 on 9-point Hedonic scale after 4 months of storage
- Maximum decrease in pH from 6.94 to 3.84 after 4 months of storage
- Maximum decrease in green colour in terms of a value (-9.94 to -6.67) after 4 months of storage

Steeping preservation of Pointed gourd (*Trichosanthes dioica*)

Steeping preservation of French beans (*Phaseolus vulgaris*)

Nutritional and Health benefits

- Low in calories (31 calories per 100 g), rich sources of dietary fibre, excellent balance of essential amino acids and rich source of dietary fibre
- Good sources of vitamin A and health promoting flavonoid polyphenolic antioxidants such as lutein, zea xanthin and β-carotene in good amounts
- Rich sources of pyridoxine (vitamin B6), thiamine and vitamin C

- Presence of good amounts of minerals like iron, calcium, magnesium, manganese and potassium essential for body metabolism

French bean

⇓

Removal of stalk and washing

⇓

Cutting into 4-4.5 cm long length pieces

⇓

Blanching of French bean pieces in boiling water containing 0.1% magnesium oxide followed by steeping into 1% sodium sulphite solution for 10 min

⇓

Steeping in 2.0 - 2.5% sodium chloride solution, 0.25–0.3% acetic acid, 350 ppm benzoic acid and 350 ppm sulphur dioxide

⇓

Storage of French bean in glass bottles with steeping solution for 2-3 months at 25-30 ^{O}C

Flow diagram for steeping preservation of French bean

Usage: Steeped French bean is washed in water and it is used for pickle or curry preparation.

Quality attributes

- Decrease in pH from 6.3 to 4.8 during storage
- Decrease in green colour in terms of a value from -3.2 to -2.4 during storage
- Decrease in hardness value from 4.3N to 2.8N during storage

Steeping preservation of French beans (*Phaseolus vulgaris*)

Steeping preservation of Bitter gourd (*Momordica charantia*) slices

Nutritional and Health benefits

- Excellent remedy for diabetic patients due to hypo-glycaemic effect
- Ideal treatment for blood disorders due to blood purifying properties
- Effective treatment for preventing constipation, secretion of more bile juice from liver and strengthening immune system
- Remedy for skin diseases, psoriasis, skin infections such as eczema, stimulation of energy and stamina in people suffering from chronic fatigue
- Rich sources of mineral such as calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper and manganese
- Potential sources of vitamins such as vitamin A, vitamin C, thiamine, riboflavin, niacin, vitamin B6, folate, pantothenic acid, etc.

Bitter gourd

⇓

Sorting, washing and cutting of stalk

⇓

Cutting into thin slices of 0.25-0.3 cm

⇓

Blanching in boiling water for 15-20 sec containing 0.1% magnesium oxide followed by steeping into 1% sodium sulphite solution for 10 min

⇓

Steeping into 2.5% sodium chloride solution, 1% acetic acid, 350 ppm sulphur dioxide and 350 ppm benzoic acid

⇓

Storage of bitter gourd slices in glass bottles with steeping solution for 4-5 months at 25-30 ^{O}C

Flow diagram for steeping preservation of bitter gourd slices

Usage: Steeped bitter gourd slices is washed in water and it is used for pickle or curry preparation.

Quality attributes

- Good sensory overall acceptability score of 7.5 on 9-point Hedonic scale after 5 months of ambient storage
- Decrease in ascorbic acid to 18-20 mg/100g after storage
- Decrease in hardness value of bitter gourd slices from 3.8N -1.5N after storage
- Decrease in green colour in terms of a value from -5.5 to -3.5 after storage

Steeping preservation of Bitter gourd (*Momordica charantia*) slices

Steeping preservation of Onion (*Allium cepa*) with hurdle concept

Nutritional and Health attributes

- Excellent sources of vitamin C, flavonoids and phytochemicals thus encouraging immune system
- Acts as powerful anticarcinogenic compounds due to presence of quercetin, against cancer cells of breast, colon, prostate, ovarian and lung tumors
- Soluble dietary fibre, oligofructose as probiotic effect in increasing bacterial population in intestine
- Regulation of blood sugar due to chromium in onion

Onion bulb

⇓

Peeling

⇓

Washing

⇓

Steeping of onion bulb in 2% sodium chloride solution, acetic acid steeping (pH 2.5-2.75), 300 ppm sulphur dioxide for 7 days followed by heat treatment at 100 ^{O}C for 3-5 min

⇓

Storage of onion bulb in steeping solution for 60-75 days at ambient storage (25-30 ^{O}C)

Flow diagram for steeping preservation of onion

Usage: Steeped onion after washing is preferred as salad in food

Quality attributes

- Significant reduction in microbial load (98-99%) after acetic acid steeping (pH 2.5 2.75) and 2% sodium chloride solution
- Overall acceptability score of 7.5-8.0 on 9-point Hedonic scale after 75 days of ambient storage
- Reduction in D value (1.58 min-1.0 min) in onion bulb at pH 2.5-2.75 after 2% sodium chloride steeping solution, 300 ppm sulphur dioxide and heat treatment at 100 ^{O}C for 3 min

Steeping preservation of Onion (*Allium cepa*) with hurdle concept

Preservation of Onion (*Allium cepa*) paste with hurdle concept

Nutritional and Health benefits

- Improvement in immunity response due to presence of phytochemicals in onion
- Presence of high chromium level in regulating blood sugar
- Reduction of inflammation and heart infections due to regular consumption of onion
- Production of high-density lipoprotein due to regular intake of fresh onions in diet
- Significant effect on prevention of cancer due to quercetin

Onion bulb

⇓

Peeling

⇓

Washing

⇓

Making paste with addition of little quantity of water in laboratory grinder

⇓

Addition of 2% table salt, adjustment of pH 2.75 with 50% acetic acid and addition of 375 ppm sulphur dioxide

⇓

Heat treatment of onion paste at 100o C for 3-5 min

⇓

Storage of onion paste for 60 days at ambient storage temperature (25-30 ^{O}C)

Flow diagram for preservation of onion paste

Usage: Onion paste is used for vegetable based curry preparation.

Quality attributes

- Significant reduction in microbial count (95-98%) of onion paste with increase in heat treatment at 100 ^{O}C for 3-5 min
- Maximum decrease (1.15 min – 0.69 min) in D value of onion paste with addition of 2% table salt, pH 2.75, 375 ppm of sulphur dioxide and heat treatment at 100 ^{O}C for 5 min
- Maximum overall acceptability score of 7.5 on 9 –point Hedonic scale after ambient storage for 60 days

Preservation of Onion paste with hurdle concept

Intermediate Moisture Leafy Vegetables

Green leafy vegetables are the storehouse of bioactive nutrients, which provide high amounts of micro-minerals and play vital roles in nutrient metabolism as well as retard degenerative diseases. The high dietary fibre in green leafy vegetables helps in regulating the digestive system aiding bowel health and weight management. Several studies have shown that high folate intake from green leafy vegetables may lower the risk of colon polyps by 30 to 40 percent compared to low intake of this vitamin suggesting that diets low in folate may increase the risk of colon cancer. Therefore, leafy vegetables are ideal for weight management as leafy vegetables are typically low in calories and are useful in reducing the risk of cancer and heart disease. Leafy vegetables are low in fat, high in dietary fibre and rich in folic acid, vitamin C, potassium and magnesium, as well as containing a host of phytochemicals, such as lutein, crypto-xanthin, zea-xanthin, and carotene which can also be converted into vitamin A and also improve immune function.

Many leafy vegetables are consumed without proper processing especially heat processing. Leafy vegetables are carrier of spoilage pathogenic organisms especially *E. coli, Salmonella* and *Shigella* and this can be of considerable public health concerns to the consumers. The consumers prefer many leafy vegetables especially coriander, radish and drumstick as such or with mild heat treatment for salads. Consumers are looking for fresh vegetables for salads in view of many benefits such as antioxidants, nutraceuticals, vitamins and minerals in diet. Various *Psychrotropic* bacteria such as Listeria mono-cytogenes and *Clostridium botulinum* are known to grow at low temperature.

Drying is one of the simplest technologies for reducing the post harvest losses in vegetables. But the quality is adversely affected in terms of sensory and rehydration quality in dried vegetables. The quality of dried vegetables is significantly improved with additive treatment during blanching treatment. However, rehydration of dried vegetables with moisture content less than 1-2% becomes difficult with reference to rheological and sensory qualities. In this regard, drying of vegetables under intermediate moisture range of 15-25% is better alternative for increasing the aesthetic qualities, shelf life and preserving the valuable nutrients for nutritional security.

Intermediate Moisture Amaranth (*Amaranthus caudatus*) leaves

Nutritional and health benefits of Amaranth leaves

- Good sources of vitamins such as vitamin A, vitamin C and folate and minerals such as calcium, iron, potassium, zinc, copper and manganese
- Rich source of □-carotene, lutein and zeaxanthin
- Helpful in reducing cholesterol level due to high dietary fibre content

Flow diagram for the manufacture of Intermediate moisture amaranth leaves

Amaranth leaves

⇓

Sorting, grading and cleaning

⇓

Washing in running water three times

⇓

Blanching with 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite at 50-55 ^{O}C for 2 min followed by dipping into chilled water for 5 min

⇓

Dipping into 500 ppm benzoic acid and 500 ppm sulphur dioxide for 10 min

⇓

Removal of amaranth leaves and dipping into 1% sodium alginate for 30 min

⇓

Dipping into 5% glycerol for 30 min

⇓

Drying at 50-55 ^{O}C for 3-4 hrs in the moisture range of 15-25%

⇓

Packaging in polypropylene pouches and storage at 10-15 ^{O}C for 3-4 months

Usage: Dried amaranth leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation

Quality attributes

- Good overall acceptability score of 8.0 on 9-point Hedonic scale after 50 days of storage at 10- 15 ^{O}C
- Decrease in ascorbic acid from 45.58 mg/100 g to 30.23 mg/100g after 50 days of storage
- Moisture content varied from 18.5- 15.75% during storage

Intermediate Moisture Amaranth (*Amaranthus caudatus*) leaves

Drying technology in Vegetables

Drying or dehydration is one of the most effective means to extend the shelf life of perishable fruits and vegetables. The main purpose of dehydration in preserving fruits and vegetables is to remove moisture so that water activity of the dehydrated products is low enough of aw less than 0.6 for preventing the spoilage and the growth of pathogenic microorganisms and subsequently to reduce the spoilage reactions. Dehydration is also used in combination with other preservative factors such as initial heating of vegetable in boiling water and salt solution to extend the shelf life of vegetables. Dehydration significantly reduces the cost of transportation

and storage due reduced weight and volume of dehydrated vegetables. Unlike fresh vegetables, dehydrated vegetables do not require refrigeration during storage. Sun drying has been used since ancient times to produce dehydrated vegetables. This method is expensive but the effectiveness of drying depends on bright sunshine and longer drying times. The dried vegetables with sun drying are not widely acceptable due to unhygienic quality. Another dehydration technique, viz., osmo-air drying is a simple process and has potential advantages for preservation of vegetables for longer duration. The inclusion of osmotic process in conventional dehydration has major objectives of quality improvement and energy savings. This process also resulted in quality improvement in terms of colour, flavour, texture, product stability, nutrient retention and prevention of microbial spoilage during storage. Different factors such as pretreatment, nature and concentration of osmotic solution, raw material characteristics, stage of maturity, size of slices, duration of osmosis, ratio of slice to brine concentration and agitation influence the quality of dried vegetables. Osmo air-drying has greater potential for drying of large quantities of vegetables with good sensory properties. This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help group in close association with NGOs. Small entrepreneurs can adopt this process on large scale. The principle involved during dehydration involves removal of moisture by application of heat under controlled conditions of temperature, humidity and air flow. In this process, single layer of sliced and shredded vegetables after blanching treatment is spread on trays in the dryer. The initial dryer temperature in cabinet or tray dryer is normally adjusted to 60-65 ^{O}C for 4-5 hrs and afterwards the dryer temperature is reduced to 50-55 ^{O}C for completion of drying with final moisture content to less than 2%. However, various factors such as composition of vegetables, size, shape and arrangements of vegetables in the tray, temperature and movement of hot air across the trays, heat transfer from vegetable surface such as conductive and convective rate of heat transfer. Newer innovative drying processes have significantly improved the sensory qualities and retention of nutrients in dried vegetables. The use of additives improves in retaining green colour, ascorbic acid and bioactive compounds in dried vegetables. Drying process also improves the rehydration quality and thus improves the aesthetic quality in dried vegetables. Vegetables during drying process behaves constant and falling drying rate of moisture removal from vegetables. Constant drying rate refers to removal of moisture in proportion to the application of heat. Higher heating temperature initially removes the moisture from faster rate during constant drying rate. However, during the course of drying, the moisture content is reduced to much lower level as a result moisture removal is not proportional to the application of heat to vegetable surface. The reduced level moisture removal refers to falling drying rate in vegetables.

This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help group in close association with NGOs. Small entrepreneurs can adopt this process on large scale. There is ample scope for cost reduction through the use of solar energy for brine concentration and dehydration process.

Drying of Okra (*Abelmoschus esculentus* L.)

Nutritional and Health benefits

- Effective prevention of colon cancer and skin dis-colouration due to presence of phytochemicals such as lutein, indoles, sulforaphane, carotenoids, iso-

flavones, etc.

- Higher presence of many nutrients including vitamins A, B6, C, iron, fibre, calcium and folic acid
- Stabilization of blood sugar through okra fibre from the intestinal tract
- Lubrication of large intestine due to its bulk laxative qualities of fibre
- Absorption of water and movement of stool in bulk
- Significant role in lowering serum cholesterol and reducing the risk of heart diseases
- Role in healing ulcers and to keep joints limber
- Help in neutralizing acids and temporary protective coating for the digestive tract
- Suitable treatment for lung inflammation, sore throat and irritable bowel syndrome
- Protection of cancer expansion of colorectal cancer and reducing the risk of cataracts
- Highly perishable crop having shelf life of 2-3 days at ambient storage temperature

Okra
⇓
Sorting, Grading and Washing
⇓
Blanching in boiling water containing 0.1% magnesium oxide for 1 min followed by dipping into 1% sodium sulphite solution for 10 min
⇓
Cutting into 0.25-0.3 cm slices
⇓
Drying in cabinet dryer at 55-60 ^{O}C for 6-8 hrs
⇓
Cooling at room temperature
⇓
Packaging in polypropylene pouches and storage at ambient temperature (20-25 ^{O}C) for 6-8 months

Flow diagram of drying of okra

Usage: Dried okra is fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

Quality attributes

- Retention of Vitamin C (6-8 mg/100g)
- Rehydration ratio (3-3.5) in boiling water for 4-5 min
- Recovery of dried okra slices (6.5-7.25%)

Drying of Okra

Osmo-air drying of Bitter gourd (*Momordica charantia* L.)

Nutritional and Health benefits

- Rich sources of vitamin A, B1, B2 and C and also presence of minerals such as calcium, phosphorus, copper and potassium.
- Potential health benefits such as antidotal, antilypolytic, lypogenic, antipyretic tonic, appetizing, stomachic, antibilious, purgative, antiinflammatory, antiflatulent and higher healing capacity.
- Typical bitter taste with many medicinal values

Bitter gourd

⇓

Washing and cutting into slices (0.25-0.3 cm)

⇓

Blanching of bitter gourd slices in boiling water containing 0.1% magnesium oxide for 1 min followed by dipping into 1% sodium sulphite solution for 10 min

⇓

Osmotic diffusion treatment in 4-5% sodium chloride solution at 50-60 ^{O}C for 60-90 min

⇓

Drying in cabinet dryer Ist stage of drying at 60 ^{O}C for 3-4 hrs

⇓

IInd stage of drying at 50-55 ^{O}C for 8-10 hrs

⇓

Cooling at room temperature

⇓

Packaging in polypropylene pouches and storage at room temperature at 20-25 ^{O}C for 6 months

Flow diagram of osmo-air drying of bitter gourd

Osmo-air drying of Bitter gourd

Usage: Dried bitter gourd slices are fried in refined oil along with spices followed by addition of water for rehydration.

Quality attributes

- Good overall acceptability sensory score of 7.5 on 9-point Hedonic scale of rehydrated bitter gourd slices during 6 months of storage.
- Vitamin C (20-27 mg/100g)
- Rehydration ratio (5.0-5.8)
- Recovery of dried bitter gourd slices (6.5-7.2%)

Osmo-air drying of Cauliflower (*Brassica oleracia* var botrytis)

Nutritional and Health benefits

- Rich sources of carbohydrates, proteins, dietary fibres, vitamins such as vitamin A (750 IU) and vitamin C (55-60 mg/100g) and rich sources of minerals such as sodium, potassium, magnesium, iron, calcium and phosphorus
- Presence of fairly good amounts of vitamin B complex and proteins in comparison to other leafy vegetables
- Major carotenoids such as lutein, neoxanthin, violaxanthin and □-carotene.
- Presence of good sources of tocopherols and other important bioactive compounds such as glucosinolate, ascorbic acid and phenolics including flavonoids
- Limited shelf life of 3-4 days at room temperature

Cauliflower florets (2.5-3.0 cm)

⇓

Washing

⇓

Blanching in boiling water for 30-45 sec followed by dipping into 0.2% potassium meta-bisulphite solution for 10 min

⇓

Osmotic diffusion treatment in 4-5% sodium chloride solution at 50-60 ^{O}C for 45-60 min

⇓

Drying in cabinet dryer Ist stage of drying at 60 ^{O}C for 3-4 hrs

⇓

IInd stage of drying at 50-55 ^{O}C for 8-10 hrs

⇓

Cooling at room temperature

⇓

Packaging in polypropylene pouches and storage at room temperature at 20-25 ^{O}C for 6-7 months

Flow diagram of osmo-air drying of cauliflower florets

Usage: Dried cauliflower pieces are fried in refined oil along with spices followed by addition of water for rehydration.

Quality attributes

- Final moisture content (1-2%)
- Retention of ascorbic acid (16-18 mg/100g) and total carotenoids (1.5-1.75 mg/100g)
- Sensory overall acceptability score of 8.0 on 9-point Hedonic scale
- Recovery of dried cauliflower (9.5-10.8%)

Osmo-air drying of Cauliflower

Osmo-air drying of Tomato (*Lycopersicon esculentum* L.) powder

Nutritional and health benefits

- Rich source of lycopene, an antioxidant with immunostimulatory properties
- Good source of ascorbic acid, □ carotene, phenolics such as ferulic, chlorogenic and caffeic acid and vitamin E
- Loss of lycopene during dehydration process
- Less losses of lycopene under osmotic diffusion due to fewer cis-isomers

Selection of fully red tomato

⇓

Washing in tap water

⇓

Blanching of tomatoes in muslin cloth in boiling water at 100 ^{O}C for 2 min

⇓

Immediate cooling in cold water (5-7 ^{O}C)

⇓

Osmotic diffusion treatment in 4-5% sodium chloride solution at 50-55 ^{O}C for 45-60 min

⇓

Cutting into thin slices of 0.25-0.3 cm

⇓

Dipping into 2% gelatinized starch solution for 10 min

⇓

Cabinet drying I stage (55 ^{O}C for 2-3 hrs)

⇓

II stage (45-50 ^{O}C for 8-10 hrs)

⇓

Cooling to room temperature

⇓

Grinding in grinder

⇓

Packaging in polypropylene pouches and storage at 15-20 ^{O}C for 4-5 months

Flow diagram for osmo-air drying of tomato powder

Usage: Tomato powder can be used in place of tomato in curry preparation.

Quality attributes

- Ascorbic acid (8-10 mg/100g)
- Lycopene (3-3.5 mg/100g)
- Rehydration ratio (1.5-2.0)
- Overall acceptability score of 7.5 on 9-point Hedonic scale
- Recovery of dried tomato powder (2.5-3.25%)

Osmo-air drying of tomato powder

Comparative Osmo-air and Osmo-freeze drying of Green pea (*Pisum sativum*)

Nutritional and Health benefits

- Most nutritious leguminous vegetable rich in health benefitting phytonutrients, minerals, vitamins and antioxidants
- Relatively low in calorie and free from cholesterol and adequate amounts of antioxidants such as carotene, lutein, zeaxanthin
- Good sources of proteins, vitamins, soluble and insoluble fibers
- Relatively higher amounts of ascorbic acid (40 mg/100g), and vitamin K (24.8 µg/100g)
- Rich sources of many vitamin B complex vitamins and minerals such as calcium, iron, copper, zinc and manganese

Green pea

⇓

Blanching in 20% sugar syrup at 100 ^{O}C for 2-3 min

⇓

Immediate cooling in chilled water for 20-30 min

⇓

Surface moisture drying at room temperature

⇓

Cabinet dryer at 50-55 ^{O}C for 6-8 hrs/Freeze drying at 0.042-0.062 mbar and -92 to -98 ^{O}C

⇓

Cooling and packaging in polypropylene pouches and storage at 20-25 ^{O}C for 6-8 months

Flow diagram for manufacture of osmo-air and osmo-freeze drying of green pea

Usage: Osmo-air and freeze dried pea after rehydration in boiling water for 7-8 min and 4-5 min, respectively can be used in curry or soup preparation.

Quality attributes

- Moisture content (1.0-1.5%)
- Decrease in total sugar content (18.55 – 19.34%)
- Decrease in green colour intensity in terms of a value from 11.74 - 12.5%

Osmo-air and Osmo-freeze drying of Green pea

Convenience Processed Vegetables

The demand of processed vegetables in India is increasing due to change in food habits and growing income of middle class families. There is a need to process the vegetables by applying low cost technologies as well as innovative processing technologies depending upon the market need so that nutritional security as well as food security could be managed. Large quantities of vegetables can be preserved by simple low cost steeping preservation with hurdle concept as well drying technologies with the concept of osmotic diffusion process followed by drying to improve the rehydration and sensory qualities of vegetables. Osmo-air drying is a simple process and has potential advantages for preservation of vegetables for longer duration. The inclusion of osmotic process in conventional dehydration has major objectives of quality improvement and energy savings. This process also results in quality improvement in terms of colour, flavour, texture, product stability, nutrient retention and prevention of microbial spoilage during storage. Different factors such as pre-treatment, nature and concentration of osmotic solution, raw material characteristics, stage of maturity, size of slices, duration of osmosis, ratio of slice to brine concentration and agitation influence the product quality. At the terminal stage, the drying can be achieved by using cabinet dryers or solar driers. Osmo air-drying has greater potential for drying of large quantities of vegetables with good sensory properties. This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help group in close association with NGOs. Small entrepreneurs can adopt this process on large scale. There is ample scope for cost reduction through the use of solar energy for brine concentration and dehydration process. The demand for convenience type of foods is increasing because of more convenience in terms of labour, time, energy and suitable for particular section of society. Convenience foods have attracted the working women to greater extent as there has been little time for working women to cook food with good taste and balanced nutrition. Different convenience types of foods have been developed to cater the needs of children, adult and aged population. Many snack foods have attracted the consumers due to crispness and good spicy taste. Very little vegetable based snack and convenience foods are available in the market. Potato chips as snack food are very popular among children and adults. But diabetic patients avoid relishing potato chips due to sugar content. In view of above facts there has been great scope to popularize the vegetable based products as convenience foods.

Bitter gourd chips (*Momordica charantia* L.)

Nutritional and Health benefits

- Rich sources of vitamin A, B1, B2 and C and also presence of minerals such as calcium, phosphorus, copper and potassium
- Potential health benefits such as antidotal, antilypolytic, lypogenic, antipyretic tonic, appetizing, stomachic, antibilious, purgative, antiinflammatory, antiflatulent and higher healing capacity
- Typical bitter taste with many medicinal values

Bitter gourd

⇓

Washing and cutting into slices (0.25-0.3 cm)

⇓

Blanching of bitter gourd slices in boiling water containing 0.1% magnesium oxide for 1 min followed by dipping into 1% sodium sulphite solution for 10 min

⇓

Osmotic diffusion treatment in 1-1.5% sodium chloride solution at 50-60 ^{O}C for 120 min

⇓

Drying in cabinet dryer Ist stage of drying at 60 ^{O}C for 3-4 hrs

⇓

II stage of drying at 50-55 ^{O}C for 8-10 hrs

⇓

Cooling at room temperature

⇓

Packaging in polypropylene pouches and storage at room temperature at 20-25 ^{O}C for 6 months

Flow diagram for manufacture of bitter gourd chips

Usage: Dried bitter gourd slices are fried in refined oil and are consumed as snack food.

Quality attributes

- Moisture (1.0%)
- Good overall acceptability sensory score of 8.0 on 9-point Hedonic scale during storage
- Vitamin C (20-22 mg/100g)
- Rehydration ratio (5.0-6.0)
- Dehydration ratio (5.8-6.0)
- Extent of browning (0.12-0.16)
- Recovery of dried bitter gourd slices (5.5-6.8%)

Bitter gourd chips

Easy-to-cook Bathua leaves (*Chenopodium album*)

Nutritional and Health benefits

- Store house of nutrients such as 0.8% fat, 4.3% protein, 2.1% dietary fibre and 90 mg/100 g vitamin C
- Good for functioning of liver, spleen and gall bladder
- Good appetizer and improvement in hemoglobin level

Bathua leaves

⇓

Sorting, grading, cleaning and washing in running water 3-4 times

⇓

Blanching in 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 80 ^{O}C for 30 sec

⇓

Osmotic diffusion treatment of 1% sodium chloride solution at 55-60 ^{O}C for 30-45 min

⇓

Drying in cabinet dryer at 55-60 ^{O}C for 4-5 hrs

⇓

Cooling and packaging in polypropylene pouches and storage for 6-7 months at 20-25 ^{O}C

Flow diagram of easy-to-cook bathua leaves

Usage: Dried bathua leaves are fried in refined oil alongwith spices followed by addition of water for rehydration during curry preparation.

Quality attributes

- Rehydration ratio (1.5-2.0)
- Vitamin C (20-25 mg/100g)
- Overall acceptability score of 8.0 on 9 –point Hedonic scale
- Recovery of dried bathua leaves (6.5-6.75%)

Easy-to-cook Bathua leaves

Instant Protein rich Vegetable Soup Mix

Nutritional and Health benefits

- Nourishing and appetizing qualities
- Comfort food being delicious and easy to made
- Good source of easily digestible nutrients such as protein, vitamins and minerals

Freeze dried of pea, carrot, cauliflower, onion and garlic pieces

⇓

Mixing of whey protein concentrate (260-270 g), corn flour (160-180 g), modified starch (180-190g), spices and condiments such as black pepper (8-10 g), cumin powder (5-8 g), onion (30-40 g), garlic (3-6 g), table salt (80-85g) and citric acid (3-5g)

⇓

Addition of freeze dried vegetables such as pea (60-65g), cauliflower (5-8 g), carrot (25-30g) and tomato powder (68-75 g)

⇓

Mixing of all the ingredients with sifting

⇓

Instant Protein rich Vegetable soup mix

Flow diagram of 1 kg instant protein rich vegetable soup mix

Usage: About 30 g instant protein rich vegetable soup mix is reconstituted in 500 ml water and is boiled for 4-5 min and soup is served in hot condition.

Quality attributes

- Moisture (4.3-5.5 %)
- Protein (20-23 %)
- Insolubility index (12.25 ml)
- Loose bulk density (0.39 g/cc) and Packed bulk density (0.51 g/cc)

Instant protein rich vegetable soup mix

Vegetable based sweets

Sweets are very popular in our Indian culture. Sweets are of great demand in every functions and festivals. It is liked by all sections of society such as children, adult and old people. It is a symbol to welcome guests by offering sweets in our culture. Various khoa, channa and cereal based sweets are commercially available in every sweetmeat shops. Many heart and diabetic patients often avoid consuming sweets from khoa and channa based sweets. The demand of vegetable based sweets is increasing because of many nutritional and functional attributes from vegetables in sweets. Among vegetable based sweets, petha is very popular dish of western parts of Uttar Pradesh such as Mathura, Agra and Kanpur. Many petha-based industries at small cottage scale as well as big established petha manufacturing industries are located to produce variety of sweets from ash gourd. The delicacy of sweet can be judged that it can be prepared and served in many forms depending upon the choice of

consumers. The variation in the variety of sweets from petha is reflected towards crystallized or glazed petha or dipping of cooked ash gourd in concentrated sugar syrup along with flavouring and colouring material for increasing the aesthetic quality. On composition basis, petha based sweets contain on an average 0.4% of fat, 65% of total carbohydrate, 3% of dietary fibre, 0.6% protein and 40% sugar content. Food Safety and Standards Act, 2006 limits the maximum permissible limit of 150 ppm of sulphur dioxide or 500 ppm sorbic acid in finished crystallized or glazed petha.

Nutritional and health benefits of Ash gourd (*Benincasa hispida* (Thunb. Cogn.)

- Rich sources of crude protein, crude fat, crude fibre, ash and low calorie carbohydrates
- Good sources of essential and nonessential amino acids such as arginine, histidine, lysine, tryptophan, phenylalanine, cysteine, methionine, tyrosine, threonine, leucine, aspartic acid, glutamic acid, proline , serine etc.
- Supply of fatty acids such as palmitic, stearic, arachidic, oleic, linoleic, linolenic etc.
- Medicinal properties such as styptic, laxative, diuretic, effective cure of internal hemorrhages and diseases of respiratory tract
- Popular antimercurial and antidote of alcoholic poisoning, cure of epilepsy, constipation, piles, dyspepsia, syphilis, diabetes etc.

Quality attributes

- Good overall sensory acceptability of 8.0 on 9-point Hedonic scale
- Maximum acceptability of crystalized petha with 7.5% lime concentration, 100 min lime water treatment and 70% sugar concentration
- Minimum overall acceptability score of 6.0 on 9-point
- Hedonic scale with 5% lime water concentration, 30 min of lime water treatment time and 50% sugar concentration

Crystallized petha

Soaking lime (1.0-1.2 kg) in 15-20 litre of water for 2-3 hr

⇓

Separation of lime water from stone

→

Lime water

⇓

Sugar syrup (7 kg sugar in 10 kg water)

⇓

Heating of sugar syrup (100 ^{O}C for 1 min)

↓

Ash gourd (20-25 kg)

⇓

Washing in tap water

⇓

Cutting horizontally with sharp stainless steel knife

⇓

Removal of peel

⇓

Immediate pricking with stainless fork

⇓

Dipping of ash gourd pieces in lime water with occasional stirring for 90-100 min

⇓

Washing with running water for 5-10 min

⇓

Dipping in chilled water (5-7 ^{O}C) for 1 hr

⇓

Cooking of ash gourd in boiling water (100 ^{O}C for 5 min)

⇓

Hot water (60-70 ^{O}C) dipping for 2 min for

removal of vegetable flavour

⇓

Filtration of sugar syrup with 2 folds muslin cloth → Cooking of ash gourd in sugar syrup and addition of 10-15 g sodium bi-sulphite after the concentration of 50 ^{O}Brix

⇓

Cooking of ash gourd in sugar syrup and 10-15 gm sodium bisulphite after the concentration of 68-70 ^{O}Brix

Removal of sugar coated ash gourd and dry in air overnight

Packaging of crystalized petha in polypropylene pouches

Storage at ambient temperature (15-20oC)

Flow diagram for manufacture of 10 kg crystallized petha

Manufacture of Pointed gourd (*Trichosanthes dioica*) sweet

Nutritional and Health benefits

- Presence of significant quantities of vitamins A, B and C, calcium, iron and protein
- Fairly high amounts of essential amino acid with the right balance, as well as high amounts of minerals and vitamins
- Control of hypertension in adults

Pointed gourd (12-15 kg)

⇓

Washing in running water

⇓

Peeling of pointed gourd

⇓

Sugar syrup (6-7 kg sugar in 10 litre Water)

⇓

Deep vertical cutting to remove seeds with sharp stainless steel knife

⇓

Boiling of sugar syrup (100 ^{O}C for 1 min) and addition of 15-20 gm citric acid

⇓

Cooking of pointed gourd in boiling water for 5 min

⇓

Filtration of sugar syrup in 2 folds muslin cloth → Cooking of pointed gourd in sugar syrup to the concentration of 60-65 ^{O}Brix

⇓

Filling of sweetened khoa with small quantity of almond pieces

⇓

Cooling to room temperature

⇓

Storage at 10-15 ^{O}C in paper board boxes

Flow diagram for manufacture of 10 kg pointed gourd sweet

Quality attributes

- Good consumer preference of overall acceptability score of 8.0 on 9-point Hedonic scale
- Shelf life of 15-20 days during storage at 10-15 ^{O}C

Pointed gourd (*Trichosanthes dioica*) sweet

(**Source:** Viswas et al., 2014)

Manufacture of Instant Bottle gourd kheer mix

Nutritional and Health benefits

- Excellent source of nutrition with minimum calories and fat
- Controlling urinary disorders with flushing excess water from body through urine
- Prevention of premature greying of hair and reduced ageing effect
- Helping in internal cleansing of skin and removing the problems of pimple
- Beneficial effect for early curing of jaundice and inflammation of kidneys

Freeze dried bottle gourd pieces (3-4%)

⇓

Addition of powdered sugar (5-5.5%)

⇓

Addition of whole milk powder (35-40%)

⇓

Reconstitution with 150-175 ml water

⇓

Mixing and boiling reconstituted bottle gourd kheer for 2-3 min

⇓

Bottle gourd kheer

Flow diagram for manufacture of instant bottle gourd kheer mix

Quality attributes

- Good overall acceptability score of 8.5 on 9 point Hedonic scale
- Protein content of instant bottle gourd kheer mix (22.0-22.5%)
- Loose bilk density (20.0-20.2 g/cc)
- Insolubility index (22.0-22.5 ml)

Instant Bottle gourd kheer mix

References

Kore, V. T., Tawade, S. S. and Kabir, J. (2017). Application of edible coating of fruits and vegetables. *Imperial Journal of Interdisciplinary Research*. **3**(1): 591-603.

Singh, S. and Singh, B. (2015). Value addition of vegetable crops. IIVR Technical Bulletin No. **65**, pp 1-76.

Singh, S., Singh, A., Singh, V., Khemariya, P., Rai, A. and Pandey, A. K. (2015). Steeping preservation of cauliflower with hurdle concept. *Journal of Food Science and Technology*. **55**(3): 1350-1360.

Viswas, N. R., Pandey, R. K., Singh, V. P., Dubey, M. and Choubey, A. K. (2014). Technology of Stuffed Parwal Sweet Production. *International Journal of Research Studies in Biosciences*. **2**(8): 1-5.

Chapter – 5

Avenues in Value Addition and Processing of Flowers

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Floriculture has emerged as a major diversification option in the agri-business in recent years. It is presently considered as one of the most lucrative horti-enterprise to make profit in the global market. Indian Floriculture Industry which has been growing at a decent growth rate over the past decade comprises the florist trade, nursery plants, potted plants, bulbs and seeds, micro propagated plants and essential oils from flowers. In recent days, there is a growing demand not only for fresh flowers but also for value added floriculture products, coupled with the associated need for flavouring compounds from natural sources, have provided a major boost to the essential oils and oleoresins market. There is a need for value addition in floricultural products through processing, packaging, and supply chain management so that farm incomes expand and employment is generated. Value-added products are products that are obtained from main and by-products after some sort of processing and subsequently marketed for higher profit. A higher price is achieved by means of enhancing the quality (through processing, packing or other such methods) for the same volume of primary product. Value-addition ensures high premium to the grower, while providing more acceptable quality products for the domestic and export market, and it provides the most important aspects of marketing and give the customers a reason to buy such products. The value-addition for marketing flowers includes adoption of post-harvest technology and improved logistics. The value-added products from non- conventional floricultural crops like essential oil of rose, tuberose, jasmine, marigold etc. and plants extracts used in medicines and pharmaceutical industry are unique and have the potential for export and other import substitution.

Hence, value addition has become very popular towards the expansion of floricultural trade by the art of preservation of ornamental plants and the creation of novel products that appeal to the tastes and preferences of the customers. The procreative skills such as dry flowers, flower arrangements, artificial colouring of flowers, aqua packing for better presentation, three dimensional windows packing of flowers, garlands, *venis*, bouquets, greeting cards using petal-embedded craft papers, potpourris, etc. are some of the value-added products that have acquired a successive position in the global market. Other value added products obtained from flower crops are essential oils, flavours, fragrance, pharmaceutical and nutraceutical compounds, insecticidal and nematicidal compounds, pigments and natural dye, gulkand, rose water, vanilla products etc. (Table 1).

The basic objectives of value addition & processing in flowers have been:

- To reduce post harvest loss (45% of the flowers of the floral industry die before they are even sold)
- Use of unsold flowers/Re-use of waste flowers
- To overcome glut & market instability of raw flowers

- To provide eco-friendly and bio-degradable novel products
- Round the year availability
- To generate employment

Table 1. Value added commercial products from some flowers

Crops	**Value Added Products**
Rose	Rose water, rose oil, Gulkand, Rose tea
Chrysanthemum	Garlands, Dry flowers & Potpourri , Edible chrysanthemums, insecticide (pyrethrin), Cosmetics
Carnation	Concrete and absolutes, Dry flowers, Edible carnations
Crops	Value Added Products
Gladiolus	Bouquets, Flower arrangement, Scented gladiolus
Tuberose	Floral ornaments, Essential oils, Medicines, Edible tuberose
Jasmine	Essential oils, medicines, Jasmine tea, Jasmine syrup
Marigold	Phytochemicals, Natural dyes, essential oils, edible product like salad from *Tagetes lucida*

(Mebakerlin and Chakravorty, 2015)

Value addition in Flowers

With immense possibilities and prospects of value addition and processing in flowers, some of the prominent avenues are discussed as under:

Dried flowers and plant parts

Dried flowers are long lasting, can be used several times and also meet the decorative demand throughout the year (Susan, 1990). India, with its vast resources, varied products and experience in the field of dried flowers and plant parts enjoy a distinct advantage in the world export market. The country also has the benefit of cheap labour and favourable climate as against other countries. Dehydration is an important post harvest technology for enhancing the ornamental quality of flowers. Dried or dehydrated flowers or plant parts (dried shoots, seeds, barks etc.) are used for ornamental purposes. Dry flowers are long lasting and retain their aesthetic value irrespective of the season. The beauty and value of the dried flowers are that they can be kept and cherished for years, which survive the cold of winter and heat of summer. With growing eco-consciousness, the use of more and more nature-friendly things like these come as a natural choice for decoration. The life of dried flowers varies according to the species, texture of their petals and total consistency of flowers. The processing of dried flowers involves drying, bleaching and colouring after their collection. Drying of flowers and foliage is done by methods like air drying, sun drying, press drying, oven and microwave oven drying, freeze drying, embedded drying and glycerin (foliage). The most effective method of flower preservation is freeze drying. Dried flowers can be effectively used for making decorative floral craft items for interior decoration and commercial exploitation (Ranjan and Misra, 2002). They are widely used to make handmade paper, greeting cards, candle holders, photo

frames, boxes, wall quilts, lampshades, gifts, pot pourri etc. The commonly used flowers in dry flower technology are Helichrysum, Helipterum, Limonium, Nigella, Gypsophila, Delphinium, Amaranthus, Papaver, Carthamus, Rosa, Bael, Bamboo, Cassia fistula, Dioscorea, Mallotus, Pine Cones, *Abrus precatorius*, gomphrena, golden rod,Grasses and sedges, ferns, barks of trees etc. Almost all plant parts can be dried from flowers, foliage and branches to grains, cones, nuts, berries and other fruits for utilizing in dry flower products. Their original shape, colour and size are not affected by dehydration thereby making them highly suitable raw materials for interior decoration for several years. Lately, new species have been identified and used as dry flower & foliage, some of which are in the following table (Sharma, 2020):

S.N.	Common Name
1	**Flowers:** Rose, daisy, helichrysum, cosmos, dahlia, euphorbia, calendula, chrysanthemum, antirrhinum, candytuft, marigold, zinnia, hollyhock, orn poppy, annual sunflower, larkspur, cornflower, gladiolus, gaillardia gerbera, heliconia, lilium
2	**Palms:** Datepalm, cycus, fishtail palm, areca palm
3.	**Common weeds:** • *Leucas aspera* • *Celosia argentia var spicata* • *Xanthium strumarium* • *Malva pusilla* • *Chloris barbata* • Parthenium
4.	**Vegetables:** Bottleguard, onion and leafy vegetables
5.	**Trees:** Ficus species, semal, cassia, gulmohar, neem
6.	**Cereals/Pulses & oilseed crops:** Maize, wheat, rice, til, safflower

Out of total floriculture exports from India, nearly 60% comprise of dry flowers (2018-19). India is the 5th largest exporter of dried flowers, and second largest exporter of dried foliage in the world. The demand for the dry flowers is increasing at an impressive rate of 8-10% (Connect2India, 2021). The top trading partners of India are USA, United Arab Emirates, Singapore, Malaysia, and Germany. Spain has shown significant growth in their Dried Flowers import from India (86.67%), followed by Egypt which is up by 63.64%. In 2018, India exported 3476469 million metric tons of Dried Flowers. The major dried ornamentals being exported from India are lotus pods, Camellia, Dahlia, Bell cups, Marigold, Jute flowers, Wood rose, Wild lilies, Paper flower etc. The major exporting ports of dried flowers and plant parts are located in Tuticorin and Kolkata. In this industry, cut flowers, foliage and ferns; grasses and sedges; seed pods and flower skeletons; nuts, fruits and cones; barks, branches, lichens and fungus are utilized. In the earlier days, most of the material was marketed raw, but in recent times more attention is being paid by exporters on value added products. Being of low cost and having high demand, the small scale drying industry can be started at various parts of the country.

Natural pigments and dyes

Flowers are used for extracting and preparing natural dyes. From flowers, pigments is extracted which is used as natural colouring agent like from chrysanthemum flower, yellow coloured dye is extracted for use in food products and cosmetics. Orange red dye is extracted from the arils of *Bixa orellana*, which is used

in cosmetics and medicine. Golden rod flowers also yield yellow coloured dye and find use in cosmetics. Like this, there are many flowers from which dye can be extracted which may find extensive use in the food, cosmetic, medicine and textile industries. Colourful dye can be extracted from flowers. As synthetic dyes are proving to be carcinogenic in nature, there has been an increase in demand of natural colours/dyes. The floral dyes are soft natural colorants which are eco-friendly and have no allergic action on skin like the synthetic dye. At present herbal dyes market is growing tremendously @ of 12% per annum. India exported natural dyes worth 47.68 Million USD (2016), mainly to UAE, Nepal, Japan. Per capita consumption of dyes is 400g to 5 kg in for their utility in paints, inks, textiles, polymers etc. (Gokhale *et al.*, 2015). The use of non-allergic, non-toxic and eco-friendly natural dyes on textiles have become a matter of significant importance due to the increased environmental awareness in order to avoid some hazardous synthetic dyes (Agarwal, 2017). Moreover, the procedure for making them is very cost-effective and depending on it, small scale Industry as well as Large scale Industry can be set up. Some of the flowers used commercially for their pigments as dye are as below (Table 2 and 3):

Table 2. Some common flowers used for colouring pigments

Common name (Indian name)	**Botanical name**	**Family**	**Colouring pigment**
China rose (Gurhal)	*Hibiscus rosa-sinensis*	Malvaceae	Anthocyanin
French Marigold (Genda)	*Tagetus petula*	Asteraceae	Rubixanthin, Violaxanthin
Flame of the forest (Palas, Tesu)	*Butea monosperma*	Fabaceae	Butrin, butein
Yellow Bells (Piliya)	*Tecoma stans*	Bignoniaceae	Flavanoid, Zeaxanthin

(Agarwal, 2017)

Table 3. List of some dye yielding plants in India

Botanical name & Family	**Parts used**	**Colouring components**	**Uses and colour with mordant**
Althaea rosea Cav. (Malvaceae)	Flowers	Anthocyanin, Altheanin	Indicator in Acidic and Alkalimetry (Red dye)
Bixa orellana Linn. (Bixaceae)	Pulp (aril) surrounding the seeds	Bixin, Orellin, Methyl Bixin, Beta-carotene, Cryptoxanthine	Colouring silk and cotton (Orange yellow)
Bougainvillea glabra Choisy (Nyctaginaceae)	Flower with ivory white bracts	Quercetin-xyloside, Isorhamnetin	(Yellow) Tin, (Brown) Ferrous sulphate + Acid/Neutral (Green) Alum + Base & Ferrous sulphate + Acid (Orange) Stannous chloride +Acid, Alum + Base
Butea monosperma	Dried	Butin, Butein,	Colouring sarees (Brilliant

(Lam.) Kuntze (Fabaceae)	flowers	Butrin, Isobutrin, Palasitrin, Coreopsin	yellow dye)
Carthamus tinctorius Linn. (Asteraceae)	Flowers	Carthamin (Scarlet red), Carthamon	Dyeing wool, silk and food (Red & Yellow)
Impatiens balsamina Linn.	Flower	Monoglycosidic	(Brown) Alum, (Orange)Tin
Nyctanthes arbor-tristis Linn. (Oleaceae)	Flower glycoside	Nyctanthin, Iridoid	Chrome (Yellow)
Nymphaea alba Linn. (Nymphaceae)	Rhizome	Tannins and Myricetrin	Blue
Tagetes erecta Linn. and *T. patula* Linn. (Asteraceae)	Flower	Petulitrin (flavonoid glycoside) Xanthophyll Cyanidine	(Yellow) Chrome (Brown) Chrome
Woodfordia fruticosa Kurz (Lythraceae)	Leaves and Flower	Lawsone (2-hydroxy naphthoquinone)	Dyeing (Pink or Red)

(Adapted from Gokhale *et al.*, 2015)

Similarly, in India, demand for natural gulal is very high and it is being prepared from plant parts for use in festivals like Holi and various other functions. Some of the flowers/plant part used for preparing various coloured gulal commercially is as follows:

Colour	**Flowers of Plants used**
Red	Butea monosperma, Hibiscus
Yellow	Marigold, Chrysanthemum, Amaltas (Cassia fistula)
Green	Henna (Mehandi), Gulmohar leaves
Blue	Jacaranda, Blue Hibiscus

Perfumes, essential oils and concrete

Demand for floral extracts like perfumes from flowers is increasing day by day. The flowers like jasmine, rose, tuberose, marigold, plumeria, champaka, magnolia, millingtonia etc are used for extraction of essential oils which is base for preparation of perfumes, scents or attar. Floral essential oils are basically produced or extracted from the flowering part of the plant. Most flowers possess naturally sweet and floral scent that is responsible for the same type of aroma produced from its natural essential oil. Hence, they are most famous for use in perfumes and other type of fragrances. Essential oils are concentrated volatile aromatic compounds produced

by plants. They are made up of different chemical compounds like alcohols, hydrocarbons, phenols, aldehydes, esters and ketones. It is generally extracted by distillation, though other methods like expression and solvent extraction are also used. Technically speaking, oils obtained through the process of solvent extraction are known by different names like oleoresins, concretes and absolutes, depending on the solvent used for extraction and the plants from which these are obtained. Factors such as types of plants, chemical make-up of oil and the plant part influence the extraction of oils from plants. India is the largest exporter of jasmine oil in the world accounting for over 40% of total world exports in jasmine oil. Jasmine and tuberose concentrate from South India have created a marks in world market. Growth in perfumery is higher in India (15%) compared to 7% in America and 5% in Europe. Bulgaria, Turkey, Morocco, France are leaders in essential oil production.

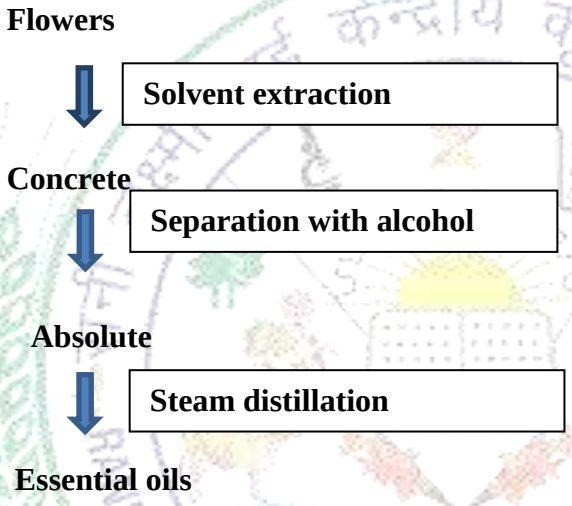

Fig 1. Extraction process of essential oils from flowers

The natural concretes of rose, jasmine and tuberose are highly priced and are very popular. From 30 tonnes of tuberose flowers, 27.5 Kg concrete from which 5.50 Kg absolute is obtained. Among roses, *Rosa damascene, Rosa bourboniana and Rosa centifolia* are commonly used species for essential oils. In India, Damask rose is widely cultivated in Azmir, Udaipur, Palampur and Kullu, Aligarh, Kannauj and Lucknow. In case of jasmine and tuberose, major flower species for Essential Oil are (Table 4):

Table 4. Major flower species for Essential Oil with world leaders

Crop	**Species**	**Leaders**
Jasmine	*Jasminum grandiflorum* *Jasminum auriculatum* *Jasminum officinale*	China, India, Egypt, Morocco
Jasminum auriculatum (Juhi) has highest oil recovery (0.29%) and *Jasminum grandiflorum (*Chameli) has best quality oil		
Tuberose	*Polianthes tuberosa*	India, Egypt, France
Concrete content is 0.08 to 0.11 per cent in single type		
Tagetes Oil	*Tagetes minuta*	Zimbabwe, South Africa,

	T. tenuifolia *Tagetes erecta* *T. patula*	India

The above mentioned species are used in high-grade perfumery products. Other plant species producing fragrant flowers viz., *Anthocephalus cadamba, Canangium odoratum, Cestrum nocturnum, Crocus sativus, Gardenia florida and other species, Hedychium flavum, Lawsonia inermis, Lippia citriodora, Magnolia grandiflora, Mimusops elengi, Murraya exotica, Murraya paniculata, Michelia champaca, Narcissus poeticus, Narcissus tazetta, Nyctanthes arbor-tristis, Plumeria species, Pendanus odoratissium, Reseda odorata, Tagetes lucidia, Tagetes petula, Viola odorata,* are also used in this industry . These are also used for providing essence in *agarbattis* and *dhoopbattis*.

Pharmaceutical & nutraceuticals

Apart from its significance in commercial floriculture, flowers have been valued for multipurpose use including industrial use for pharmaceuticals, neutraceuticals and food industry. For example, marigold flowers are one of the richest sources of natural carotenoids and its carotenoid pigment namely xanthophyll (Naik *et al.*, 2005) which is in great demand. Carotenoids are responsible for the yellow, orange and red pigments in the plant. Industrial use of carotenoids extracted from flowers like marigold is being used commercially in pharmaceuticals, food supplements, animal feed additives and as food colourant. It has been reported to be beneficial in several aspects of human health such as supporting eyes and skin, and reducing the failure of the eyesight due to age-related macular degeneration (AMD). Of late, many multinational companies are being involved for extraction of carotenoid pigments from the flower petals. There are large areas under contract farming of marigold in Karnataka, Andhra Pradesh and Maharashtra and to a limited extent in Tamil Nadu, but most of the extraction units are located in Kerala and Andhra Pradesh (Manik and Sharma, 2016). Industrial use of carotenoids extracted from flowers is being used commercially in:

- *Pharmaceuticals:* Lutein (carotenoid) esters have been reported to be beneficial in reducing the failure of the eyesight due to age-related macular degeneration (AMD), coronary heart disease and cancer.
- *Nutraceuticals:* Lutein is used as a natural food colorant and a nutrient/food supplement in nutraceutical industries.
- *Animal feed additives (Poultry feed):* There is demand of lutein in poultry industries as dried petals are added to the poultry feed after grinding in order to intensify the yellow colour of egg yolks and broiler skin

Vermicomposting

One of the main causes of environmental pollution is mismanagement of organic waste including temple waste. Flowers or floral parts come as waste from hotels, wedding gardens, worship places and a spread of civilizing and sacred ceremonies, which make them a usual source of floral waste. Every day these flowers offered by the devotees in temples are left unused and therefore become waste. These flower wastes gets accumulated at religious sites and do not have a suitable means of disposal and are disposed randomly at several public places and particularly in rivers. Degradation of floral waste is an extremely slow process as compared to degradation

of kitchen waste. Hence proper and eco-friendly process for floral waste treatment is required. These wasted flowers can be used in various ways of which converting into vermicompost is a feasible option. It can be successfully applied in places nearby the religious places as the farmers can get the flower waste for converting into vermicompost *ex situ* or *in situ*. Vermicomposting technology for bioconversion of flowers into value-added compost will help reduce volume of temple waste and also generate additional revenue for the temples as well as the farmers. The main advantage of vermicomposting is that it is one of the eco-friendly technologies since it overcomes the problem of organic waste disposal.

Fresh flower arrangement

Flower arrangement is the art of organizing flowers, foliage and receptacles into compositions having harmony of form, texture and colour. Its purpose is to add cheer, life and beauty to surroundings. there have been two different approaches to floral designs: **western styles,** employing a 'mass' concept of arranging flowers in an even symmetry, and **the eastern or Japanese or Ikebana styles,** which are based on specific rules and angles, using less material. Western style flower arrangements are associated with 'mass' or a number of flowers and foliage arranged together in a graceful manner. In England and Europe, this style was first used to decorate palaces, mansions and churches. Traditionally, triangular, round or oval shapes were created, but after the Second World War, more designs like the L-Shape, Crescent and S-Shape were introduced. These are said to be more American in their influence. he structure of a Japanese flower arrangement is based on a scalene triangle delineated by three main points, usually twigs, considered in some schools to symbolize heaven, earth, and man and in others sun, moon, love and earth. The container is also a key element of the composition, and various styles of pottery may be used in their construction. Another aspect present in ikebana is its employment of minimalism. That is, an arrangement may consist of only a minimal number of blooms interspersed among stalks and leaves. The opportunity for making money by creating and selling flower arrangements are endless--everything from creating small bouquets to large centrepieces to establishing joint ventures with interior decorators and event planners. Interestingly, India's export for flower bouquet amounted to 7.95 Million USD (2019-20). USA is the largest importer of Flower Bouquet from India (27.67%) of India's exports for this commodity. More innovations are coming up in these type of works (Connect2India, 2020).

Like Aqua-Box concept which is the merging of a bouquet, gift wrap and greeting card all in one, while keeping each bouquet in water for fresh and long lasting flowers.

Flower ornaments

Various flower ornaments have been used by the people from time immemorial. The commonly used floral ornaments are garland, *veni/gajra*, wreath etc. Garlands are being used in every type of functions. It is so common that it has become a part of our lifestyle right from birth to death. Today, the craze for bridal and groom floral ornaments is also on rise. In fact, the profit earned by farmers from these has been more than that of loose flowers.

Flower tinting

Tinting is an important value addition technique in flowers where colour pigments are either absent or light in colour. It is done on natural flowers by adding food colouring

agents. It enhances the aesthetic beauty of fresh flowers. The Coloured inflorescences of the cut flowers with edible dyes enhance the appearance and appeal the arrangement to be more attractive. It can also provide a great variety of colours for aesthetic beautification (Sowmeya, et al., 2017). Tinting is being successfully carried out in various flowers viz., tuberose, gladiolus, carnation, candytuft, Lady's lace through synthetic food colouring dyes. During tinting, flowers should be placed at room temperature and optimum relative humidity should be maintained as these factors influence the intensity of colour induction in the flower. For better postharvest quality, tinting can be combined with pulsing treatment. Thus, tinting of flowers is an easy method to have brilliantly and uniquely coloured flowers at our disposal, anytime for any occasion.

Cosmetics from flowers

A cosmetic formulation, including active principles of strictly natural origin, is designed to protect the skin against exogenous or endogenous harmful agents, as well as to balance again the dermal homeostasis lipids altered by dermatosis and ageing. The use of plant extracts in cosmetic formulation is increasing, mostly because of the poor image that animal-derived extracts have acquired during the past few years (Aburjai and Natsheh, 2003). Generally, botanical products from flowers and other plants are a rich source of vitamins, antioxidants, essential oils and oils, hydrocolloids, proteins, terpenoids and other bioactive compounds (Dubey et al., 2004). Flower plant extracts from plants or wastes from plants processed industrially can be used for cosmetics such as:

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Flowers	**Cosmetics**
Rose	Soaps and body creams
Calendula	Moisturizer
Verbena	Acne creams, but also make deodorants and hand wipes
Pansy	Face washes, cleansers, and face mists
Hibiscus	Face cream/wash

There are also some popular brands of natural cosmetics which have a large number of cosmetics based on flowers, with products such as balms to melt makeup instantly. They use and grow their own flowers carefully to obtain the best benefits. They market cosmetics such as moisturizers, fragrances, acne creams and much more.

Processed flower Products

The demand for processed flower products is increasing day by day. Various beverages and eatable products are prepared from flowers which are nutritious and healthy. Some of the processed flower products are:

Rose water

Rose water or *gulab-jal* has a very distinctive flavour and is much used in

India. It is a by-product which is derived during the process of distillation of rose petals and water for the production of rose oil. Thus, it is basically obtained as a leftover liquid. Traditionally, damask roses are used for the production of rose water. This special kind of rose has a large number of petals. Rose water worth of 1.33 million USD (2019-20) is exported to over 110 countries (Connect2India, 2020).

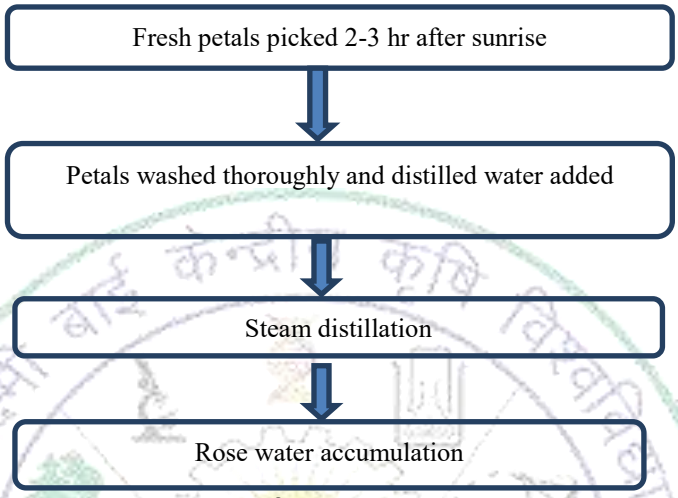

Fig. Preparation of rose water (*gulab jal*)

Food and beverages:

There is a vast range of Food/beverage Product from flowers viz., Jam, jelly, marmalade and soup, Floral Teas, Syrup, Wine, Gulkand, Edible flowers etc.

Gulkand

Gulkand is a sweet preserve of rose petals. *Gul* means the flower and *qand* means sweet, so literally it is a 'sweet made from flowers'. *Gulkand* is a very popular rose petal spread from India. It is known for its innumerable medicinal and ayurvedic properties. It is best known for its cooling properties especially in the hot and humid summer days. It is also used as a mouth freshener wrapped in *Paan* leaf.

Fig. Preparation of *gulkand*

Floral teas

Rich in antioxidants, floral teas are also almost zero-calorie drinks. Floral Teas is a collection of sensory teas blended with exotic and therapeutic flowers like rose, jasmine, lilies, sunflowers, chamomile, etc to create tea blends that are far superior in

flavour and aroma. Some of the commonly used flower teas with their advantages are as follows:

Flower's tea	Advantages
Hibiscus tea	helps in lowering blood pressure, support healthy cholesterol and triglycerides, prevent oxidative stress, reduce the risk of obesity, act as anti-depressants
Rose tea	has anti-oxidative, anti-allergen, and anti-inflammatory properties. It helps in strengthening the immune system, improve digestive system and cure constipation.
Jasmine tea	offers numerous health benefits such as relieving stress, control of diabetes, and boosting immunity system

Edible flowers

Though edible flowers are not commonly used in our daily household cooking, some flowers which are marked safe to eat are used in many different styles of cuisines all over the world. These flowers offer unique flavour and tint to many dishes and beverages. Some of them rich in antioxidants, vitamins, and bioactive components provide health benefits when used as tea, in jam, or just sprinkled over salads or juices. Some of the most common edible flowers are nasturtium, lavender, pansy, marigold, rose, carnation, peonies, hibiscus, snapdragon etc.

Conclusion

There is vast opportunity in value added floriculture trade. The consumption pattern is diversifying towards value added products such as dry flowers, essences, perfumes, beverages and other by-products from flowers for more profit. Moreover, due to Covid-19 pandemic, floriculture sector is facing hardship and trading of fresh flowers has become a big challenge. Under these circumstances it is important to diversify in to value addition where ever possible for alternative income through various feasible products like gulal, agarbattis/dhoopbattis making, Poultry feed, gulkand and rose water, pigment and dyes extraction, essential oil extraction, dry flower for those flowers which are eligible for such conversion and also Vermicompost for recycling the spoiled flowers.

References

Aburjai, T. and Natsheh, F. 2003. Plants Used in Cosmetics. Phytotherapy research : PTR, 17: 987-1000

Adhikary, K. 2020. Management of Temple Floral Waste and Utilization of Value Added Floral Waste Product: A Review, International Journal for Environmental Rehabilitation and Conservation. 11 (SP2): 120-128

Agrawal, B.J. 2017. Influence of mordant application on the dyeing of nylon substrate with natural dyes extracted from flowers. International Research Journal of Chemistry and Chemical Sciences, 4(1): 67-74.

Agarwal, K. 2009. Application of natural dyes on textiles, Indian Journal of Fibre & Textile Research, 34:384-399

Bhattacharjee, S.K. and De, L.C. 2003. Dried flowers and plant parts. Advanced Commercial Floriculture, pp.162-173.

Bhutani, J.C. 1990. Capturing nature, a way with flower “everlastings”. Indian Horticulture, 34(3): 15-18.

Dubey, N.K., Kumar, R. and Tripathi, P. 2004. Global promotion of herbal medicine: India’s opportunity. Current Science, 86, 37–41

Gokhale, S. B. , Tatiya, A. U., Bakliwal, S. R. and Fursule, R. A. 2004. Natural dye yielding plants in India. Natural Product Radiance, 3(4)

https://connect2india.com/global/

Manik, H. and Sharma, G.2016.Promising Marigold Genotypes for Flower and Xanthophyll Yield Under Chhattisgarh Plains Condition. Advances in Life Sciences, 5(7): 2659-2662

Mebakerlin, M. S. and Chakravorty, S. 2015. Value Addition in Flowers, In: Sharangi A B and Datta S (Eds.), ibid, 83-99

Naik, B.H., Patil, A.A. and Basavaraj, N. 2005. Stability analysis in African marigold (*Tagetes erecta* L.) genotypes for growth and flower yield. Karnataka Journal of Agricultural Science,18(3): 758-763.

Prajapati, P. , Singh, A. and Jadhav, P. B. 2016. Value addition in floriculture through essential oils. International Journal of Information Research and Review, 3(9): 2795-2799

Puri, A. 1995. Economic potential of dried flowers. Agricultural Marketing, 36(1): 43-46

Raghupathy, R., Amuthan, G. and Kailappan, R. 2000. Dried flowers: Significance. Kisan World, 27: 39.

Ranjan, J.K. and Misra, S. 2002. Dried flowers: a way to enjoy their beauty for a long period. Indian Horticulture, 46: 32-33.

Sharma, G. 2020. Value addition in flowers. National Webinar on Advances in Floriculture, UHS, Bagalkot and SAAHAS, September, 27

Singh, D.B. 2003. Exploring export potential of dried wild flowers and their value-added products. Indian Horticulture, 48: 38-40.

Sowmeya, S., Kumaresan, S. and Sanmuga priya, L.. 2017. Effect of Multi Colours in Tinting Techniques in Cut Flowers (Rose and Carnation). Chem Sci Rev Lett 2017, 6(24), 2250-2253

Susan. 1990. Dried Flowers. Merchants Ltd. Ferry House, London, p.144.

Chapter – 6

Recent Innovation in Food Packaging Technology

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Introduction

India is Agriculture based country having the population of 130 Crores which has a very big role worldwide to contribute the production of fruits and vegetables and processed foods for the survival of mankind. It has been observed that consumption pattern of food is being increased many fold for last ten years. At the same time, the population of the country has also been increased very much. It was important to have technological development of production of food for the people along with innovative packaging system to keep the food available in fresh condition for the consumption at the right time in a right quantity and in a right quality. Innovative packaging for food products has made it possible to serve the customer in that fashion. It has also been observed that huge quantity of fresh food and vegetables produced in our country are transported to villages to urban market for selling purpose every day. The proper packaging, transportation, handling and storage are very much essential to save those fresh agricultural produces from the spoilage while reaching to the market. It has been noted that around 25-30% of loss of agriculture produces every year due to improper packaging and storage and handling mistakes. There is a huge scope of packaging innovation to be used for food products packaging to save our products from losses and could be utilized those food for serving better to the needs to increase the GDP of our country. The different types of innovative packaging system has been listed below and explained topic wise.

Food Packaging is a combination of science, art and technology, which provides physical, chemical, microbial and environmental protection to product. It provides convenience and product information to the consumers. Packaging is the integral part of the production and physical distribution. Packaging protects what it sells and packaging sells what it protects. Packaging delivers the food products in the factory fresh condition at a minimum overall cost. The role of food packaging is very much important to serve the food to the customer in fresh condition within stipulated date and time printed on the packages. The role of Government of India by guiding the regulations of FSSAI is very much useful in the packaging of food products. Packaging is a necessity for maintaining the quality, safety, and integrity of produce as well as processed products from the farm or plant to the end use.

Need of Innovations in Food Packaging: It has been observed that the lifestyle of people has been changed drastically within last ten years. Innovation for retail packs

and with lot of latest features is demanded through market research and customer delightness in the domestic market as well as international market. It has also been observed that packaging requirement for the customer is also different and is depending on the living standards of the customer. New generation are demanding with lot of features like easy to open, easy to close, east to store, easy to stack, easy to recycle, easy for production, attractive, aesthetic, pilfer proof and convenient for consumption of the food at any point of time. All the innovations in the food packaging have come up with the demand of above attributes mentioned.

There are some major reasons given below for which the food packaging sector is growing drastically:

i. More women in workforce
ii. More nuclear families
iii. More urbanization
iv. Single person household
v. Increasing income per capita
vi. E-commerce in packaging
vii. Evaluation of shopping mall and departmental stores
viii. Circular Economy globally

There are various types of food packaging methods are available. The packaging can be categorized broadly in three type i.e. primary, secondary and tertiary packaging. Primary packaging envelops the product and remains in touch with content of products. Secondary packaging packs the primary packages while tertiary packaging holds secondary packaging. It is also called as bulk packaging and transit packaging because tertiary packaging is done for shipping or transportation of products. The objective of all the different types of packaging is different. Hence, requirements of innovation are also different.

Packaging of foods require various packaging materials which should have some definite characteristics such as it should be nontoxic, must not react with products, must not give odor or taste to product, should be FDA approved, must protect products from outer environment. The packaging materials are divided under rigid packaging, flexible packaging and ancillary packaging. Glass, metal, paper and paperboard, plastic, film, laminates, foil, composite, wooden container, collapsible tubes, corrugated fiber board box, duplex board carton, lined carton, tetra pack, vacuum pack, aerosol container, cups tubes, blister pack, skin pack, retort pack etc. are the example of latest packaging materials used for food packaging.

Glass is composed of SiO_2, Na_2O, CaO, MgO and Al_2O_3. It is transparent, easy to label and can be sterilized as well. But at the same time, it possesses some disadvantage such as it is fragile, heavy and releases alkali in aqueous medium. Metal is an impermeable to light, gases, moisture, bacteria and odor. It is high or low temperature resistant. Rubber is called elastomer meaning it can be stretched out when pulls and comes back in original shape when let go. Rubber is used in making seal or closures of the packages. There are two types of rubber. First is natural rubber,

which contains additives. It is used to make closures, which can be used multiple times. Second is synthetic rubber, which contains fewer additives and can't be used for multiple times like silicone. Plastic is non-breakable flexible and lightweight packaging material, which is easy in transportation. It has some disadvantages such as it is reactive and permeable to gas and vapour. Based on its behaviour with heating, it can be categorized as thermoplastic and thermoset. Thermoplastic (example polystyrene, polyethylene, polyvinyl chloride) can take shape after initial heating and solidifying by cooling. It is not rigid, non-breakable and cheap to produce. From this, attractive containers can be made for product storage. Thermosets (examples polyurethane, polyester) is rigid packaging material, which is produced by heating of plastic to make permanent shape of plastic. The fibrous materials include paper and paper board. These packaging materials provide increased display area, physical protection and convenient shipping. Paper (example kraft paper, sulfite paper) and paper board is made up of cellulose fiber of wood by using sulfate and sulfite. These fibers are pulped, bleached, strengthening by chemicals to produce paper. Greaseproof paper is produced by process of beating in which cellulose fiber is kept hydrated for long period of time so that fiber gets gelatinous. This paper is smooth and glossy which is used in wrapping biscuits, bakery etc. Parchment paper is formed by reaction between cellulose and sulphuric acid to make smooth modification in cellulose fiber. Paperboard is thick heavy than paper. It has multiple layers and used to make cartons for shipping purposes. Foil is aluminum-packaging material. Film is cellophane packaging material while laminates is a combination of foil and films. Adhesive is used to join foil and film.

Recent innovations in Food Packaging

Food innovation is the process of translating ideas or the development and commoditization of new food products, processes, and services. Today's consumer demands and expectations are constantly changing with time. Innovation makes a significant difference to a food business. This change leads to a continuous meeting of consumer needs and therefore growth. Innovation offers huge challenges and opportunities. Most food businesses fail because they don't recognize the need for change. Innovation is a strategic resource. It can be a complex process that carries significant risk and requires robust and systematic management. Innovative and safe packaging is the need of time due to the rapid rising consumers' demands towards the fresher, safer, less processed, highly convenient and prolonged shelf life foods. To fulfill the consumers' expectation, various innovations have been carried out in food and beverages industry. Some major innovations done in food packaging have been described as below:

1. Active Packaging

This packaging includes addition of definite compounds to the package entity which absorb or release the substances from or into the packaged products or the environment to maintain the nutritional as well as sensory quality while increasing the shelf life and securing the microbial safety of products. This packaging utilizes

scavengers (absorber), emitters (releaser), and regulators to observe the changes in product inside packaging material. These react with change in oxygen, CO_2 and ethylene composition of product with time. Active packaging is named so because package remains active to interact with the food, package, and headspace of the package to maintain the food quality to optimum.

The most important active packaging system is described below:

a. Oxygen Scavengers/Absorbers

Oxygen scavengers absorb oxygen inside packaging material and thus reduce food metabolism, aerobic microbial growth, oxidative rancidity, pigment and vitamin oxidation, enzyme discoloration. There are two types of oxygen scavengers first is metallic scavenger- example is iron based powder packed in small sachet which is kept with food that reacts with water of food and get converted into reducing agent which absorbs oxygen and second is non-metallic scavengers. These are organic compound based scavengers example ascorbic acid and catechol.

b. CO_2 scavengers

It is used for freshly roasted coffee and coffee powder. When freshly roasted coffee is packed it produces CO_2, which can burst the pack. There are two methods used- first is use of one way valve to release CO_2 from pack and second way is to use of CO_2 scavenger sachet containing calcium hydroxide or dual action sachet contains oxygen scavenger plus CO_2 scavenger.

c. Ethylene absorber

It is used to reduce respiration and senescence caused by ethylene. This scavenger is consisted of sachet containing $KMNO_4$immobilized on inert substrate alumina or silica gel. $KMNO_4$ oxidizes ethylene to form acetic acid and ethanol and so colour change occurs from purple to brown.

d. Moisture absorbers

Moisture scavengers are necessary for controlling the moisture formation from high water activity foods to prevent microorganism growth and improve the product appearance. Moisture Scavengers/Absorbers are used as pads, sachets, sheets, or blankets. Desiccants like activated clays, silica gel, calcium oxide (CaO), and other minerals are generally used to control moisture and humidity in case of dried food packaging. The best-known moisture scavengers are conventional silica gels.

e. Antimicrobial Packaging

The packaging which possesses the self-sterilizing capability and which increases the shelf life of perishables such as meat, fish, poultry and horticultural produce by inhibiting microbial growth is antimicrobial packaging. It lengthens the lag phase and minimizes the log phase of the growth cycle of microorganisms and thus reduces their multiplication in food. Carbon dioxide, ethanol, chlorine dioxide, silver ions,

bacteriocins (niasin), antibiotics, organic acids, peptides, spices, essential oils etc. are some examples of antimicrobials, which can be used in following ways:

1. Direct introduction into polymer film
2. Addition in the form of pad/sachet and kept inside the package
3. Use of antimicrobial polymer
4. Coating the packaging film with antimicrobials

f. Antioxidant packaging

This packaging system uses the antioxidant agents in the package to remove the oxygen, which is produced due to oxidative reactions like fat oxidation of product for increasing the shelf life of the product. The oxidation of lipids leads to the rancidity development and forms the poisonous aldehyde compounds thus deteriorating the nutritional quality due to the degradation of polyunsaturated fatty acid (PUFA). Various synthetic and natural antioxidant compounds are available. But in recent time, natural antioxidant compounds like tocopherol, ascorbic acid,, and essential oils are widely used

2. Intelligent Packaging

The packaging system which performs intelligent tasks such as identifying, tracing, sensing, recording and communicating the information/possible problems in food packages to increase the safety, quality and shelf life of food package is termed as Intelligent Packaging. This packaging system uses inexpensive smart devices either tags, sensors, or labels in food packages in order to perform its activity.

a. Barcode

It is 12 numerals of data represented by parallel lines. It has dark lines with white space. First five numbers shows manufacturers ID, next five number shows product item number and there is last number is for check digit. All these printed barcode is read by scanner, which converts barcode into electrical signal. Information about lot/batch number, packing date, package weight, nutritional information, how to use, and website address of manufacturers can be encoded in barcodes. This information is even readable by the smart phones thus offering great convenience for retailers and consumers.

b. Radio-Frequency Identification Device (RFID)

RFID carries the electronic information. It is a technology in which RFID tag or smart label is attached with any object. It is read by radio waves releasing from RFID reader. This reader converts the digital information of radio waves in usable data. It has huge data storage capacity. RFID tag contains integrated circuit. The RFID tag consists of a very small transponder and antenna with distinctive alphanumerical or number sequence. A reader releases the radio wave to record the data from the RFID tag, which is then transferred to the host computer using real-time database server for decision-making and analysis. There are two types of tag- Passive RFID tag and active RFID tag. Passive tag gets power from RFID reader to be functional while

active RFID tag has its own power supply by battery. In mall or mega stores the prices of products are calculated by this system. It is applied in personal tracking, in tracking restricted area.

c. Time-Temperature Indicators (TTI)

TTI is easy to use device affixed self-adhesive label, which monitors, records, and displays the quantifiable time-temperature-based changes occurring in food package due to chemical, electrochemical, mechanical, microbiological, or enzymatic changes.

d. Gas Indicators

Gas indicators are the devices which sense any alternation in the make-up of gas mixture due to package nature and activity of the food like respiration and gas production by growth of microorganisms thus monitoring the food quality, safety, and integrity. A commonly used gas indicator is oxygen indicator due to its side effects on quality of food through oxidative rancidity, microbial spoilage, and colour change.

e. Pathogen Indicators/Biosensors

Pathogen indicators or biosensors detect and record the biochemical reactions or simply contamination by the pathogenic microorganisms. These are composed of biological compounds like antigen, microbe, enzyme, hormone, or nucleic acid that identifies the target analyte and a transducer (electrochemical, optical, or calorimetric), which produces measurable electrical response from the conversion of biochemical signals and changes the colour to warn the consumers.

3. Bioactive Packaging

This packaging technique utilizes bioactive compounds which are emitted within the package throughout the storage or before consumption to improve the consumer's health".

4. Biodegradable Packaging or Green Packing Material

Biodegradable packaging material is degraded by naturally occurring microbes. This packaging material is made up of bio-based polymer. Example is protein such as whey protein, fat and polysaccharide like starch cellulose. Example of biodegradable packaging is PLA (poly lactic acid).

5. Edible Packaging

In this packaging system, a thin layer of edible material is coated over product. The edible film is produced by edible compounds such as polysaccharide (starch) protein (whey protein, soy protein) and lipids. This packaging is non toxic, non polluting, low cost, antimicrobial, antioxidant rich.

6. Vacuum Packaging

In this packaging system, gas is removed from packaging materials contains food and vacuum is created inside but no other gases are filled. Examples cheese, meat, dates.

7. Modified Atmosphere Packaging

In this packaging system, gases are removed from food packaging materials and pre-determined gaseous mixture of nitrogen, oxygen and CO_2 is added. CO_2 reacts with water to form acidic carbonic acid which prevents microbial growth and nitrogen inhibits oxidation of fat.

8. Controlled Atmosphere Packaging

In this packaging system, pre-determined gas ratios are flushed and are controlled throughout the time of storage before use by the customer. The control is being done through computerized dosage system to inject the gases as and when it is required to maintain the gas ratios to keep the product fresh.

- Mixture of Gases (Carbon Di Oxide, Nitrogen and Oxygen)
- Carbon Di Oxide Used to Retard the Growth of Micro Organism
- Nitrogen Used to Displace Oxygen
- Very Low Content Oxygen Used to Retain the Colour of Meat etc.
- Ratios maintained throughout for Cap System

9. Nano-packaging Material

In this packaging system, nano-scale (1 to 100 nm) innovations are done with packaging material to increase shelf life and quality of food. Example- nanoparticles are embedded in the polymeric film while processing to get the targeted properties from the packaging material for light, fire, mechanical, thermal property and less gas absorption for better shelf life. Similarly nano-sensors are used to detect chemical, physical and microbial activity of product.

10. Aseptic Packaging System

Various aseptic packaging systems are adopted to make food packaging fresh with higher shelf life. The list of such system is given as follows:

- Heating through heat exchanger
- (UHT, Induction heating HTST) - milk
- Heating by steam
- Hydrogen per oxide - tetra brick pack fruit juice
- Gama radiation –meat, poultry, seafood, vegetable, spice, grains.

11. Retort Packaging

Retort is a kind of sterilization system to kill the microorganism for long term food preservation by using retort chamber with the temperature from 120 – 135^{O}C.

- Retort Sterilization
- Hygrothermal Sterilization at temperature higher than 100^{O}Cby pressurizing.
    - There exists steam type and hot water type

There are two types of condition:

- General Retort＝120^{O}C ×30 Min.

- High Retort＝135 ^{O}C×10 Min.

Types of Retort Lamination and the structures:

Aluminium foil based report:

- PET/AL/CPP 9-25 PET, 9-25 AL, 50-85 CPP
- PET/AL/NY/CPP
- PET/NY/AL/CPP

Transparent Retort:

- NY/CPP
- PET/NY/CPP
- 12PET/EVOH OR PVDC/CPP

The list of processed food products is available in the market in retort packaging:

Alloo Matar, Chicken Curry, Palak paneer, Butter Chicken, Sarso Ka Saag, Karahi Chicken, Chana Masala, Mughalai Chicken, KadiPakora, Mutton Masala, Cheese Tomato, Mutton Korma, Dal Makhani, Karahi Mutton, Rajma Masala, Mutton Biryani, Gajar Ka Halwa, Suji Ka Halwa, Milk Kheer etc.

Conclusion

The consumers' demand for safe products has forced the food packaging industry towards innovative packaging systems to improve the safety, organoleptic and nutritional qualities of food. In order to fulfill the same various efforts have been carried out towards innovative approaches of packaging materials for food items. However, several safety issues such as degradation of the product quality and negative effects on human health must be resolved before their use. Therefore, there must be complete understanding of working principles, mechanisms and their optimal use to synthesize the packaging systems, which would be efficient to maintain the food quality and safety. It is also necessary to fulfill the latest marketing needs to serve the food packages to the customer in a convenient, aesthetic and eye-appealing manner.

Chapter – 7

Recent Advances in Processing and Value Addition of Jackfruit

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Jackfruit *(Artocarpus heterophyllus)*, belonging to the family Moraceae, is one of the most remunerative and important underutilized native fruits of India. It is widely cultivated in tropical regions of India, Bangladesh, Nepal, Sri Lanka, Vietnam, Thailand, Malaysia, Indonesia and the Philippines. Jackfruit is also found across Africa *e.g.*, in Cameroon, Uganda, Tanzania, and Mauritius, as well as throughout Brazil and Caribbean nations such as Jamaica. However, India is considered to be the native of jackfruit being grown all over the country upto the elevation of 1500m above msl. The major areas of cultivation in India are the eastern and southern parts of the country, which include the states of Jharkhand, Bihar, West Bengal, Uttar Pradesh, Orissa, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Assam and foothills of Himalayas.

The name originated from its Malayalam name *Chakka*. It is also called *kathhal* (hindi and urdu), *pala* (tamil), *halasina hannu* (kannada), *panasa pandu* (telugu), *phanos* (marathi and Konkani), *theibong* (Manipuri), *kothal* (Assamese), *lamkhuang* (Mizo) and *thatchu* (Angami). The fleshy carpel, which is botanically the perianth, is the edible portion. Among the tropical fruits, jackfruit is often called the poor man's fruit because of its availability in large quantities during the peak season and its affordability.

Jackfruit trees are highly productive and bear regularly with a production of approximately 300-500 kg fruits per tree with each individual fruit weighing 0.90-58.0 kg depending on the age of the tree and conditions under which it is grown. The fruit contributes to the livelihoods of the poor people as the fruits can be harvested from wild or locally available trees.

Table 1. Nutritive value of jackfruit (per 100g of edible portion)

Sl. No.	Constituent	Average value	Sl. No.	Constituent	Average value
1	Moisture (%)	76.20	9	Phosphorus (mg)	41.00
2	Energy (K cal)	88.00	10	Iron (mg)	0.56
3	Protein (g)	1.90	11	β-carotene (mg)	175.00
4	Fat (g)	0.10	12	Thiamine (mg)	0.03
5	Fiber (g)	1.10	13	Riboflavin (mg)	0.13
6	Carbohydrates (g)	19.80	14	Niacin (mg)	0.40
7	Potassium (mg)	107.00	15	Vitamin C (mg)	7.00
8	Calcium (mg)	20.00			

The compound fruit of jackfruit is made of three parts *viz.*, bulb (30-32%), seeds (18%) and the rind (5-55%). The primary economic product of jackfruit is the fruit, used both when immature and when mature. The main use of jackfruit is as

vegetables when still unripe; however, ripened fruits (arils) are also eaten when ripe as a dessert. The jackfruit is nutritionally very rich and contains high amount of vitamins like thiamine, riboflavin, and niacin and minerals like calcium and potassium.

The seeds are reported to be more nutritious than the bulb, being richer in protein, fat, potassium and carbohydrate with considerable amount of phosphorus and calcium. Moreover, the timber of the tree is highly valued for its strength and sought for construction and furniture. The dried leaves are stitched to make disposable plates. Thus, jackfruit provides huge opportunity for livelihood as well as nutritional and food security of the rural communities of India.

The total jackfruit production in India has been recorded around 1.82 million tones (NHB, 2019). However, during the peak season, the post harvest losses in jackfruit are around 30-35 per cent because of its highly perishable nature and seasonal glut. Therefore, jackfruit has great potential for value addition for minimizing post-harvest loses and increasing availability during off-season. The growers and consumers know the importance of the fruit, seed and rind very little. Absence of organized marketing strategies among the grower's results in wastage of major quantity of the jackfruit produced. Hence, value addition is important to utilize the surplus fruits available during the season as well to improve the livelihood of the farmers by producing value added products.

Value addition is the process of changing or transforming a product from its original state to a more valuable state. Value addition to agricultural products is the process of increasing the economic value and consumer appeal of an agricultural commodity. Various processing and preservation techniques can be applied to jackfruit to increase its value. The value added products from unripe, half ripe and ripe jackfruit and seed are discussed here as follows:

Value added products from unripe jackfruit:

***Chips*:**

Raw or unripe jackfruits are used for preparing chips. Slices of suitable sizes are cut and blanched into hot water at 95 ^{O}C for 5 minutes. Then the slices are dried at 60 ^{O}C for 1 hour and 70 ^{O}C for next 6 hours. Finally the slices are fried at 160° C in edible oil. The slices are removed from the pan when they turn light yellow in colour and mixed with salt and packed.

***Pickle*:**

Unripe jackfruits are used for preparing pickle. Small pieces are made from bulbs and seeds and they are mixed with oil, salt and spices before packing.

***Brined product*:**

Mature green jackfruits are washed with clean water, peeled and cut into small pieces. Then they are kept in 8 per cent salt, 1.25 per cent acetic acid, 0.1 per cent KMS and 91.65 per cent water solution. Then the materials is poured into airtight plastic container and stored in cool and dry place.

***Ready to cook (RTC) jackfruit*:**

The jackfruit is washed, peeled and cut into suitable sized pieces. These pieces can be preserved and packaged with minimal processing to prepare ready to cook jackfruit products.

***Dehydrated jackfruit*:**

The unripe mature bulbs can be blanched and dehydrated for further use throughout the year. Dried jackfruit is produced by first soaking the jackfruit flesh in 2% salt solution containing 0.4% citric acid, followed by blanching in boiling water. The flesh is then cooled and further soaked in water containing sulphur dioxide at a level of 0.2% for 15 min. After draining, the flesh is dried in a drying cabinet at a temperature of 60-65°C until the moisture content has decreased to 5%. The dried product is usually packed and kept at ambient temperature. Rehydration of dried jackfruit is done by soaking the dried fruit in water containing 1% salt at 65 ^{O}C for 30 min. This will result in jackfruit with the texture of fresh fruit.

Value added product from half-ripe jackfruit:

***Jackfruit candy*:**

For candy preparation half-ripe jackfruit (medium hard flesh) is selected and washed. Then it is cut into 1x 0.5x 0.5 cm pieces and blanched in hot water at 95 ^{O}C for 4 minutes. After that the pieces are immersed in 2 per cent calcium lactate and 0.1 per cent KMS for 2 hours and drained. The pieces are then dipped into sugar solution of 25, 35, 45, 50, 60 and 70 ^{O}Brix at 12 hours interval. The slices are drained and washed with clean water to remove adhering syrup followed by drying at 70 ^{O}C in a cabinet dryer until the moisture content reaches to 10 per cent. The product is packed in polypropylene pouch and stored at room temperature (28-32 ^{O}C).

Value added products from ripe jackfruit:

The recovery of bulbs or edible portion (pulp) from jackfruit varies from 20 per cent to 25 per cent. The bulbs from the fruits are removed manually after cutting the fruit in several pieces. As the fruit contains sticky latex, small quantity of vegetable oil is applied on hands and then seeds are removed from bulbs.

***Jam*:**

Jam is prepared from the pulp of ripe fruits with additives. Bulbs from a fully ripe jackfruit are blended and boiled for 5-7 minutes to extract juice. Then 700g sugar and 10g pectin is added to 1kg jackfruit pulp and cooked until the TSS reaches to 64 ^{O}Brix, then citric acid (0.25%) is added. End point is determined through flake test and the jam is poured while hot in sterilized bottle and stored at room temperature.

***Jackfruit leathers*:**

Fully ripe jackfruit is washed and bulbs are taken after removing the seeds. These bulbs are blended with 10-15 per cent sugar and boiled for 5-7 minutes for extracting juice. After this KMS @ 0.1g/kg is added and then further boiled for 3-5 minutes. The mixture is concentrated with steam-jacketed pan and spread in a stainless steel tray. The tray is put in a cabinet dryer and dried for 20 hours at 60 ^{O}C until the moisture content reaches to 20 per cent. After cooling it is cut into pieces of desirable sizes and stored after packaging.

Jackfruit jelly:

Fully matured ripe jackfruit are harvested and washed with clean water. Rind is separated and cut into small pieces. Then, 1.5 lit water and 2g citric acid is added for each kg rind and the contents are boiled for 35 minutes. The juice is extracted

from the rind. To this juice, 700g sugar and 200 mg citric acid is added and the juice is then cooked until the TSS reach to 65 ^{O}Brix followed by addition of citric acid. The jelly is then poured into sterilized bottle and stored at room temperature.

***Nectar*:**

The bulbs are passed through pulping machine and mixing around 10 per cent hot water makes pulp. Nectar is prepared from this pulp.

***Ready to eat (RTE) products*:**

Ripe jackfruit bulbs can also be preserved with minimal processing into ready to eat convenience food product. But this product has a limited shelf-life and has to be stored and transported under refrigerated conditions.

Jackfruit cordial:

Fruit cordial is a soft drink composed of syrup and juice, with or without other edible portions, of one or more types of fruit. A cordial should contain not less than 25% w/v of the juice and other portions of one or more types of fruit. Jackfruit cordial is usually processed using fruit puree that is mixed with water, sugar and citric acid. This mixture is heated up to 95°C in order to pasteurize it until it reaches 48-55° Brix. The product is golden yellow. Fruit cordials are allowed to contain permitted preservatives, permitted coloring substances, permitted flavoring substances and permitted food conditioners.

***Canning*:**

The unripe bulbs are canned with a small quantity of citric acid while the ripe bulbs can be preserved in sugar syrup or in the form of sweetened pulp for upto one year. This pulp can be used for preparing other value added products like squash, ready to serve (RTS) drink, chutney, toffee etc. and for flavoring ice-creams, custard, beverages and bakery products. Other than canning, advances in processing technologies too, have pushed toward more new products. Freeze dried, vacuum-fried and cryogenic processing are some modern preservation technologies for jackfruit-based value added products.

Freeze dried jackfruit:

Freeze-dried jackfruit is commercially produced and sold as a snack. To process it, the fruit flesh in strips is frozen in freezing equipment before it is dried in a freeze dryer under vacuum. In this machine, ice is converted into vapour without turning into liquid first. This process produces products that are dry, crispy and ready to be eaten.

Vacuum-fried jackfruit:

Vacuum-fried jackfruit is a commercially produced non-oily snack. It is popular in Japan, Taiwan, Malaysia and Vietnam due to its strong unique flavor and crispness. The product is prepared by first freezing the jackfruit strips before frying it in a vacuum fryer until crisp. The vacuum fryer is able to remove the water from the jackfruit under vacuum, at temperatures lower than 100 ^{O}C, as compared to normal frying which usually takes place at 120-270 ^{O}C. The product is then removed from the vacuum fryer, allowed to cool and then centrifuged using a centrifugal basket for 5-10 min to remove excess oil before packing in suitable packaging material.

Osmo-dehydrated ripe jackfruit:

Jackfruit bulbs added to the sugar solution and the mixture is kept for 3 hours for osmosis. Drying in tray dryer at 60 ^{O}C and packaging follows this.

Cryogenic frozen jackfruit:

Cryogenic freezing is a method that has the potential to extend the shelf life of jackfruit. Whole jackfruit bulbs that have been soaked in a mixture of 0.15% ascorbic acid and 0.2% calcium chloride in a 22 ^{O}Brix are frozen cryogenically at –80 ^{O}C using liquid nitrogen as the freezing agent. In cryogenic freezing, food products that have been thinly wrapped or food products that have not been wrapped are exposed to the freezing agent that is extremely cold *e.g.* liquid nitrogen or carbon dioxide. Cryogenic freezing helps to maintain the original taste and colour of the fruit while minimizing the loss in quality and texture. Jackfruit that is frozen at –80 ^{O}C can be kept at -20 ^{O}C for at least a year. When defrosted with a microwave, the jackfruit will retain good texture and colour.

Jackfruit seed:

Jackfruit seed is used for culinary preparation as vegetables and can be processed into seed powder or Jackfruit seed flour. Flour can be produced from the fresh seed of the jackfruit by using a dryer to dry the seed until the moisture content is less that 5%. The dried seeds are then converted into powder by using a machine called a “hammer mill”. We can also boil the seeds for 10 min in an open kettle after which the membranes are peeled off. The seeds are cut into small pieces and dried at 65 ^{O}C to moisture content of 3%. The dried pieces are milled into flour using a hammer mill. This flour can be used to prepare crisps. Moreover, the seeds are also roasted and eaten like nuts. Jackfruit, being rich in nutritional, medicinal and processing qualities can play a very significant role in the livelihood security of the rural communities through enhanced household income and employment generation. Jackfruit also has a great potential for commercial cultivation for fruit as well as timber and fodder. The native communities are slowly becoming aware about the potential importance of jackfruit and its value addition in their food and livelihood security. Some small-scale industries have also started the process of value addition of jackfruit. However, there is a great scope of establishing large-scale jackfruit processing industries in the country because of significant production of this fruit. Technologies for processing and value addition of jackfruit need to be promoted and commercialized for ensuring availability of the fruit throughout the year and for avoiding the wastage of this fruit as well as for providing nutrition and income generation to the growers. Emphasis should be given on imparting trainings to more and more farmers on value addition in jackfruit. At the same time, capacity building of marginal farmers in processing jackfruits should also be focused upon.

Chapter – 8

Postharvest Management practices to Minimise Losses of Mushroom

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Mushrooms are the fruiting bodies of a fungus that usually look like tiny umbrellas. They are placed in a separate kingdom "the kingdom fungi". Mushroom is an exotic and nutritious source of vegetarian food. It is considered as a suitable substitute for meat and eggs and easily digestible. Market for mushroom is growing rapidly because of its rich nutritional value and special taste aroma, flavour etc. Mushrooms contain no chlorophyll and most are usually saprophytes. Mushrooms have been consumed since earliest history. Nowadays, they are more admired because of its high nutritional value. They promote health and are used in the treatment of many diseases like Parkinson, Alzheimer, high blood pressure, cancer. Mushrooms are antibacterial, antiviral, antidiabetic, antiallergic, cardiovascular protector. They are rich in B vitamins such as B-2 (riboflavin), B-9 (folate), B-1 (thiamine), and B-3 (niacin). Other minerals such as selenium, potassium, iron, copper, phosphorus are available in mushrooms. Mushrooms are the only natural vitamin D ingredient for vegetarians. When Protein content was compared on dry weight basis it was fund that the protein % in mushroom is 19.36%, as compared with soybean i.e. 19.7%. Since soya protein is not easily digestible hence soya protein can be replaced with mushroom protein, which is easily digestible.

Mushrooms are categorized as edible and non-edible. There are about 2,000 species of mushroom that exists in nature but 20 are accepted as food. The most common edible mushrooms are Agaricus bisporus, Pleurotus spp, Lentinus edodes, Auricularia polytricha etc. India produces about 85% button mushrooms of total mushroom production. Besides the button mushroom, oyster mushroom and paddy straw mushroom are cultivated in limited quantities mostly in tropical cluster of the country. Mushrooms are consumed by mankind in enormous rate because of its

multiple functional characteristic and manageable cultivate conditions.

But as mushrooms are delicate in nature and has less shelf life it is utmost important to take care of them. Increased productivity demands proper post harvest management to increase their shelf life as they cannot be kept fresh for more than 24 hours. They become brown after some time which results in the quality deterioration and loss in marketability. Moreover, microbial spoilage, veil opening, weight loss are also some of the serious problems in button mushrooms. The post harvest physiological and chemical changes that are usually observed are change in color, odour, metabolism etc. To overcome such problems proper post harvest practices are to be followed for better marketing. Practices such as proper harvesting time, grading, cooling, packaging and storage should be done with extreme care. Harvesting should be done at proper time. Grading is important for marketing of mushrooms. Grading is segregation of mushrooms according to various grade standards as per market demand. Button mushroom are graded as A, B and C. Pre-cooling is the another step where the produce is kept in a plastic bag and stored in cooling unit. There are different types of cooling system depending upon the quantity to be handled. Refrigeration, freezing, forced chilled air, ice bank and vacuum cooling system are some of the cooling systems. To ensure high quality of mushrooms in the market with better shelf life these must be cooled as quickly as possible and should keep cold throughout. Packaging is another crucial aspect of post harvest and plays an important role in handling, transportation and marketing of the produce. If the packaging is not done properly, mushrooms not only results in quality deterioration but also their nutritional property is lost due to enzymatic reactions.

The mushrooms are generally tray packed wrapped with PVC film. They are also put in small packets of polypropylene or polyethylene sheets. For transportation these small packets are stacked into large containers. After packaging the mushrooms are to be stored for short term as well as for long term use. Storage of fresh mushrooms should receive the attention of the players in this field. The researchers should focus more on value added mushroom products such as pickle, soup, powder, papad, masala, biscuits for long term storage. Special emphasis should be made on button mushroom keeping in view its present production and consumption in the country. Cold storage and refrigeration are the two main attributes of post harvest care of mushrooms. Button mushroom temperature rises steadily after storage due to respiration and atmospheric temperature which causes heat which results in the quality deterioration. Hence, the heat should be removed completely after the harvest and the temperature should brought down to 4-7˚C. Low temperature retards the growth, minimizes moisture and reduces the rate of metabolic activities. Short term storage does not require much handling and care but to fulfill the demand during off season and to gain high profits long term storage is necessary. Long-term storage method includes canning, drying, steeping and pickling. These methods can extend the shelf life and can also make mushrooms available during off season.

During off season mushrooms can be made available to consumers through the value added products which are liked by many. Value can be added to the products from various extents at various levels right from the snacks to the main course. Ready to make mushroom soup powder, mushroom biscuits, mushroom candy, mushroom murabba, mushroom ketchup, mushroom chips, mushroom nuggets are not only liked by children but they have become adult favorites too. These products can be easily packed in polythene, polypropylene bags, tin cans, lug bottles, butter paper, laminated pouches etc and has storage period from 2-6 months

depending upon the packaging material.

The wheels of this industry will attain speed with the adoption of the proper storage, packaging and processing technology. The production and consumption of mushrooms is growing enormously due to greater awareness of its nutritional and medicinal properties. It has also been included in mid day meal and acts as immunity booster in this corona era. Therefore, in order to fulfill the increasing demand utmost post harvest care should be taken.

Chapter – 9

Transforming Indian Agriculture to Transform India- Role of Food Processing

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Introduction

Indian horticulture sector has been growing at phenomenal pace, surpassing crop sector and presently its production is around 307 million tonnes, consisting of fruits (about 100 million tonnes) and vegetables (about 207 million tonnes) and is 2nd largest producer in the world. While the production side looks bright, it cannot be said about its harvest, handling, transport, storage and processing. Huge losses (more than 15 %) in fruits and vegetables have been reported due to inadequate technology application and inadequate infrastructure support *viz*. packaging houses, cool/cold chain and cold storages. The scenario on processing and value addition is quite distressing. This not only causes loss of income to producers, traders and consumers but to also exchequer. It is a result of lack of knowledge, planning and infrastructure, claims to the contrary not with standing.

Indian culture is visible in its agriculture where horticulture brings a unique, multi colored aromatic culture. With each passing day, value of horticulture is increasing by enhancing productivity, profitability, sustainability, nutritional, equity and balance agriculture growth.

What Hits Indian Farmers?

Indian farmers remain supplier of raw materials, which in economic sense is the lowest economic activity. While farmers struggle to survive, other players in post-production sector like handlers and transporters, storage people, processors and retailers. No wonder, while poor investment in production sectors, big corporate have plunged into retail. Retail of food products is a multi-billion business. Farmers have suffered because:

- They are resource less
- Unable to invest in quality inputs including seeds and planting material, fertilizers, chemicals, water etc. timely without which input sensitive varieties don't respond
- Unable to invest in energy and technology
- Farm labour is not available when needed or the wages have gone up tremendously which he can't afford
- Need money immediately after harvest to pay back loans to banks and moneylenders and meet family needs
- No capacity to store their produce, especially perishables/semi-perishables

- No control over price of inputs for which they pay at market rate while they are in position to bargain the sale price of inputs, resulting in gluts, especially for perishables and is exploited by unscrupulous dealers and agents.

Indian Agriculture's Vicious Circle:

- It contributes < 13 % to National GDP, which is declining
- Lowland holdings (>70 % small and marginal farmers)
- Low input (due to inability to invest)
- Low technology (lack of awareness and no resources to acquire)
- Low productivity (low input intake)
- Low quality (lack of awareness, no incentive for higher quality)
- Huge post –harvest losses (Rs.55, 000 crores annually)
- Less competitive, thus less remunerative,
- Low profitability, hence no surplus to invest back
- Low processing levels through organized sector

Source: Dr. S. M. Ilyas, Farmer V.C., NDAUT, Faizabad, In Knowledge Series organized by IES University, Bhopal in August, 2020

Need for converting vicious circle into virtuous circle is quite obvious and this offers the Challenge of transforming Indian agriculture. The question is how?

Comparative State of Value Addition

India: <10%, Malaysia: 78%, Philippines: 45%, Thailand: 30%, China: 27%

So we have to enhance the level of value addition. Is it not so? Again the question is How?

Too many middlemen (between producer and consumer):

India: 5-7 & USA: 2-3

Indian producer gets: 25- 40 % of retail price Producers in US, UK, Europe: 60-70% share of raw material in branded processed food price is barely 2 per cent

Status of Food Processing in India

India is the world's second largest producer of fruits & vegetables after China but hardly 2% of the produce is processed. In spite of a large production base, the level of processing is low (less than 10%). Approximately 2% of fruits and vegetables, 8% marine, 35% milk, 6% poultry are processed. According to Annual Survey of Industries, Indian food processing sector accounts for 32% of country's total food market and one of the largest industries in India. It's rank fifth in terms of production, consumption, export and expected growth and it contributes around 14% of the manufacturing gross domestic product (GDP), 13% of the country's exports and 6% of the total investments. The world ranking in production of variety of food products and diversified agro/climatic conditions through strategic geographical location with vast natural resources. The major countries importing process food products from India are Australia, Bahrain, Canada, Kenya, Maldives, Malaysia, Nepal, Oman, Qatar, Russia, Saudi Arabia, Sri Lanka, UAE, UK, USA, Vietnam etc.

Technological Innovations

- Process Protocols
- Products

- Equipment and Machineries/Pilot plants

Conclusion

To minimize the losses or wastes basically in low-income countries are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems. The food supply chains in developing countries need to be strengthened by, inter alia, encouraging small farmers to organize and to diversify and upscale their production and marketing. Investments in infrastructure, transportation, food industries and packaging industries are also required. Both the public and private sectors have a role to play in achieving this.

Chapter – 10

Promoting the Growth of Fruits and Vegetables Processing Industry through Contract Farming

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Contract farming can be defined as an agreement between a farmer and processing and/or marketing firm for the production and supply of agricultural products under forward agreements, frequently at predetermined prices (Charles and Shepherd, 2001). Contract Farming has been promoted in the recent three decades as an institutional innovation to improve agricultural performance in less developed countries. This system was accepted and used as one of the promising institutional frameworks for the delivery of price incentives, technology and other agricultural inputs. Local Governments, private local firms, Multinational companies, some international aid and lending agencies etc have been involved in these contract farming schemes (Glover, 1984). In processing sectors, contract farming is an agreement between the farmers and the food processing companies. The agreement can be formal, semi-formal or even verbal. The farmer promises to provide a certain quantity of crops in a stipulated time frame. In return, the buyer assures the farmer a pre-determined price for the produce. The contract may include loose buying arrangements, simple purchase agreements and supervised production with input provision, or tied loans and risk coverage. In supervised production, the processing company trains the farmer in the latest farming methods. It gives farmers access to the most advanced technology and equipment. This results in increased productivity and higher quality crop, which helps both the farmer and the company. Therefore, this model benefits both the farmers and the food processing companies.

Contract Farming a Viable Solution of Fragmented Holdings in India

The average size of the operational marginal holdings was only 0.35 hectares and those of the small holdings 1.41 hectares in 1992 compared with 2.69 and 5.79 hectares respectively of the semi- medium and medium category holdings and 15.41 hectares in the case of large category holdings. The ownership holding averages for these categories were even smaller with the exception only of large category holdings which was slightly larger (Singh, 2005). In fact, it has been argued that the small and marginal farms even in states like Punjab are not viable for sustaining a family and need larger holdings (Johl, 1995). Land transactions have led to further fragmentation making them non-viable in terms of resource use as well as family sustenance. The costs of fragmentation included increased travel time between farms and hence lower labour productivity, higher transportation costs of inputs and outputs, negative externalities for land quality improvement like irrigation, loss of land on boundaries and greater potential for disputes (Mani and Pandey, 1995). A study of a Tamil Nadu village found that, of the small farmers (60% of all) who owned less than three hectares of land each, 35% had 3-5 plots and 25% had 5-10 plots and the remaining less than three plots. On the other hand, of all the farmers in the village, only 20% farmers had more than five plots each, another 40% had 3-5 plots each and remaining

less than three plots each. Thus, small farms were somewhat more fragmented. Further, the study showed that fragmentation had adverse impact on the technical efficiency and the production of most of the crops, and consolidation led to large gains in technical efficiency. But, still markets have not even led farmers to consolidate their operational holding, if not owned holdings (Parikh and Nagarajan, 2004).

Opting Contract Farming towards Technology led Agriculture

Contract farming is expected to increase the productivity and efficiency of a farm (Bauman, 2000; Eaton and Shepred, 2001; Ramswami *et al.*, 2005). The argument is that for growing crop contract, contractor facilitates the production so it reduces risks like credit, input, technology and also the price. The technical assistant of contract firm visits the grower, to manage the production strategy – advice grower to apply seeds, pesticide, and fertilizer at the right time and in correct proportions. Contracting could therefore, serve to relieve farmer from credit constraint and market constraint, and thus enabling them to apply inputs at an optimum level. On the other hand, farmer has to incur entire cost of production for growing non-contract crop, and farmers may not apply inputs at optimal level because the market imperfections.

Food Processing Industries of India

In India, the food sector has emerged as a high-growth and high-profit sector due to its immense potential for value addition, particularly within the food processing industry. The Indian food processing industry accounts for 32 per cent 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. It contributes around 8.80 and 8.39 per cent of Gross Value Added (GVA) in Manufacturing and Agriculture respectively, 13 per cent of India's exports and six per cent of total industrial investment. The Indian gourmet food market is currently valued at US$ 1.3 billion and is growing at a Compound Annual Growth Rate (CAGR) of 20 per cent. Further, India's organic food market is expected to increase by three times by 2020. In our country, the online food ordering business is in its nascent stage, but witnessing exponential growth. With online food delivery players like FoodPanda, Zomato, TinyOwl and Swiggy building scale through partnerships. The organised food business has a huge potential and a promising future. The online food delivery industry grew at 150 per cent year-on-year with an estimated Gross Merchandise Value (GMV) of US$ 300 million in 2016. The food processing sector in India has received around US$ 7.54 billion worth of Foreign Direct Investment (FDI) during the period April 2000-March 2017(Department of Industrial Policies and Promotion (DIPP). The Confederation of Indian Industry (CII) estimates that the food processing sectors have the potential to attract as much as US$ 33 billion of investment over the next 10 years and also to generate employment of nine million person-days.

Government initiatives to improve food processing sectors in India

- The Government of India aims to boost growth in the food processing sector by leveraging reforms such as 100 per cent foreign direct investment (FDI) in marketing of food products and various incentives at central and state government level along with a strong focus on supply chain infrastructure.
- In Union Budget 2017-18, the Government of India has set up a dairy processing infra fund worth Rs 8,000 crore (US$ 1.2 billion).

- The Government of India has relaxed foreign direct investment (FDI) norms for the sector, allowing up to 100 per cent FDI in food product e-commerce through automatic route.
- The Food Safety and Standards Authority of India (FSSAI) plans to invest around Rs 482 crore (US$ 72.3 million) to strengthen the food testing infrastructure in India, by upgrading 59 existing food testing laboratories and setting up 62 new mobile testing labs across the country.
- The Indian Council for Fertilizer and Nutrient Research (ICFNR) will adopt international best practices for research in fertiliser sector, which will enable farmers to get good quality fertilisers at affordable rates and thereby achieve food security for the common man.
- The Ministry of Food Processing Industries announced a scheme for Human Resource Development (HRD) in the food processing sector. The HRD scheme is being implemented through State Governments under the National Mission on Food Processing. The scheme has the following four components:

1. Creation of infrastructure facilities for degree/diploma courses in food processing sector
2. Entrepreneurship Development Programme (EDP)
3. Food Processing Training Centres (FPTC)
4. Training at recognised institutions at State/National level

Processing of Fruits and Vegetables in India

Horticultural production is estimated around a record 314.7 million tonnes (mt) in 2018-19 as per third advance estimates over 311.71 mt in the previous year production. Vegetable production was expected to have crawled up higher at 185.88 million tonnes (mt) in the year on productivity gains, even after a slight decline in onion and tomato production. Potato production was, however, estimated to be higher by 3.4 per cent at 53.03 mt. India is the second largest producer of fruits and its production is estimated to be around 98.57 mt in 2018-19, compared with (97.36 mt) what was achieved in 2017-18.

Table 1. Three Year Export Statement of Processed Fruits and Vegetables (Qty in MT, Value in Rs. Lacs)

	2017-18		2018-19		2019-20	
PRODUCT	**Qty**	**Rs. Lacs**	**Qty**	**Rs. Lacs**	**Qty**	**Rs. Lacs**
PROCESSED FRUITS AND VEGETABLES						
Cucumber & Gherkins (Prepd. & Presvd.)	220939	128522	212820	143713	189343	124121
Proc. Vegetables	226484	221159	248122	247400	253277	276053
Mango Pulp	110924	67392.1	105873	65767	85725.6	58432
Proc. Fruits, Juices & Nuts	317353	264784	339607	280497	360488	308644
Total	**875700**	**681857.4**	**906422**	**737376.9**	**888833.6**	**767249.3**

Source : APEDA, 2019-20

India has the potential to grow all types of temperate, subtropical and tropical fruits and vegetables because of varied agro-climatic diversity. The losses are estimated to the extent of 20 -30 per cent due to lack of proper facilities of mechanized harvesting, processing, value addition and integrated storage. The various popular products from fruits and vegetables are beverages, intermediate moisture food, preserves, canned and dehydrated fruits and vegetables, pickles, soup mixes, sauces and ketchup etc. India is a significantly exporting the various processed and value added products. During 2019-20, the country exported 253276.97 mt proceeded vegetables worth of Rs. 2760.53 crores. During the same period export of mango pulp was 85725.57 mt with the export of value of Rs. 584.31 crores. Export of other fresh and processed horticultural products is given in table (1.1)

National Institute of Food Technology Entrepreneurship and Management (NIFTEM):

NIFTEM was established by the Ministry of Food Processing Industries, Government of India and also declared as Deemed to be University under *De Novo* category by the Ministry of Human Resource Development, Department of Higher Education. The main mandate of NIFTEM is to offer high quality education, research and management programme specific to the food industry; disseminate knowledge to the food sector and provide referral advice on food standards and provide business incubation facilities. The All India Council for Technical Education (AICTE) in April, 2013, approved the undergraduate & postgraduate courses to be offered by NIFTEM. The Union Cabinet approved the National Institutes of Food Technology, Entrepreneurship and Management (NIFTEM) Bill, 2019 under which the two existing institutes under administrative control of Ministry of Food Processing Industries (MoFPI), namely National Institute of Food Technology Entrepreneurship and Management (NIFTEM) at Kundli, Haryana and Indian Institute of Food Processing Technology (IIFPT) at Thanjavur, Tamil Nadu, would be declared as Institutions of National Importance (INI).

Success Story of Contract Farming

Contract farming has been found very successful for assured supply of raw materials to the processing industries and it has given tremendous success in export of pickling cucumber (gherkin) from India. Salient success of contract farming has been briefly described as under:

Contract Farming of tomato in Punjab by Pepsi Foods Ltd.

Launching its agro-business in India with special focus on exports of value-added processed foods, Pepsi Foods Ltd. ('PepsiCo' hereafter) entered India in 1989 by installing a Rs 22 crore state of- the-art tomato processing plant at Zahura in Hoshiarpur district of Punjab. The company intended to produce aseptically packed pastes and purees for the international market. However, before long, the company recognized that investment in agro-processing plants would not be viable unless the yields and quality of agricultural produce to be processed were up to international standards. At that point of time, tomato had never been cultivated in Punjab for its solid content, with a focus on high yields and other desirable processing characteristics such as colour, viscosity and water binding properties. Furthermore, little effort had been made to create a database on the performance of various varieties and hybrids, or to introduce modern farming practices. There were no logistically efficient procurement models for fruits and vegetables that could be built on by the

company. These apart, there were simply not enough quantities of tomato available even if the grown varieties/hybrids were procured from the open market. The total Punjab tomato crop was 28000 tons, available over a 25-28 day period, while PepsiCo required at least 40000 tons of tomato to operate its factory, which had a gigantic capacity of 39 tons fresh fruit per hour. The company required this intake over a minimum 55-day time frame, and in 1989, the season in Punjab did not last beyond 28 days. Sceptics had expressed doubts over the feasibility of the Zahura tomato processing plant, and had said that it would remain a museum piece! There were formidable challenges before the company and nothing short of a horticultural revolution was required to solve the problem. There was no choice but to alter the tomato production and logistics situation in Punjab. This led to the birth of PepsiCo's backward linkage with farmers of Punjab. PepsiCo follows the contract farming method described earlier, where the grower plants the company's crops on his land, and the company provides selected inputs like seeds/saplings, agricultural practices, and regular inspection of the crop and advisory services on crop management. The PepsiCo model of contract farming, measured in terms of new options for farmers, productivity increases, and the introduction of modern technology, has been an unparalleled success. The company focused on developing region- and desired produce-specific research, and extensive extension services. It was thus successful in bringing about a drastic change in the Punjab farmers' production system towards its objective of ensuring supply of right produce at the right time in required quantities to its processing plant. Another important factor in PepsiCo's success is the strategic partnership of the company with local bodies like the Punjab Agricultural University (PAU) and Punjab Agro Industries Corporation Ltd. (PAIC). Right from the beginning, PepsiCo knew that changing the mindset and winning the confidence of farmers would not be an easy task for outsiders. The company's unique partnership with PAU and PAIC fuelled its growth in Punjab. Apart from getting enormous success in tomato following contract mode of farming, company achieved tremendous success in production of Basmati rice for export purpose.

Contract Farming of Gherkin in Karnataka

Gherkin belongs to the family Cucurbitaceae and its cultivation in India is driven through contract farming, where company/firm provides all inputs and buys back the produce at a pre-agreed price. Karnataka is a major producer of gherkin, which constitutes 90% of the total gherkin exports from India. More than 25 private companies are engaged in commercial cultivation of the crop. During year 2019-20 the country exported around 1,10,030.83 MT of gherkin worth Rs 709.66 crores. Detail export of gherkin for lat 03 years have been given in table (1.2)

Table 2. Three Years India's Export Statement of Gherkin

Country	2017-18		2018-19		2019-20	
	Qty in MT	**Rs. Lacs**	**Qty in MT**	**Rs. Lacs**	**Qty in MT**	**Rs. Lacs**
S A	40,409.57	24,354.00	37,577.16	27,466.44	45,760.43	31,178.07
France	17,591.64	11,685.85	21,421.21	15,630.42	14,020.84	10,734.36
Russia	25,168.32	11,630.47	25,597.19	13,168.69	20,330.60	10,681.04
Spain	20,643.62	12,771.67	15,509.64	9,227.51	17,000.61	9,533.96
Germany	20,906.96	10,895.67	10,941.88	8,256.83	12,918.35	8,838.63
Total	1,24,720.11	71,337.66	1,11,047.08	73,749.89	1,10,030.83	70,966.06

Source : APEDA, 2019-20

A study was conducted to study the terms and conditions of gherkin contracting firms in Tumkur district of Karnataka state. The results revealed that the Global Green Company (GGC) contracted with minimum one year duration of agreement, whereas Reitzil Company restricted the duration of agreement to only one cropping season. Decision making power of farmer was weak in GGC contract, whereas farmer has a freedom of decision making in Reitzil Company.

Contract farming for boosting the seed production by Industries

Public seed companies (NSC, SFCI) had large captive farms on which they could multiply seed, but private seed companies could not own land to multiply their own seed. Their search for a suitable solution led to contract farming in select parts of the country. This solution was adopted by both Indian and multinational companies. The first large-scale activity started under the aegis of Mahyco in the early 1970s, mainly in the Marathwada region of Maharashtra. It spread to neighboring areas of Andhra Pradesh, Vidarbha and Karnataka. These states/areas dominate the seed business even today, save for the hybrids of cold-weather crops. The original selection may have been based on the promoters' familiarity, but it has been proven sound by the agro-climatic factors and relative isolation which make controlling conditions easier, as well as hardworking and loyal peasantry. The original contracts were mostly with individuals. At present, almost all companies follow a group approach. The main features of the contract system are:

- On-farm multiplication of seeds requires observance of both a specified package of practices and adequate isolation and other quarantine procedures to maintain the genetic identity of planting material. Hence, multiplication is taken up on contiguous blocks which could be effectively isolated from the remainder of agricultural activity in the vicinity;
- Seed producers find it useful to contract all farmers of the area that they want to operate in;
- Companies have identified their respective zones of operation and groups of farmers for reproduction;
- Companies specify areas, supply parent seeds, provide advance at times, supervise production, and estimate likely crop size;
- Company staff ensures that standard contracted practices are followed on farm through well-scheduled supervision visits and test

Contract Farming for boosting the export of mango

The study reveals that the contract farming will enhance export potential and the likelihood of improving the social and economic condition of the mango farmers particularly the small mango cultivators. It was seen that the market for the Indian mangos that to 1.19% of exports in the world which is said to be low and most of the exports are by the large formers but according to the pilot study there are more number of small farmers who are lack of proper post harvest facilities, lack of bargaining power, lack of motivation and unable to market their produce for fair cost. The strategy to help the small farmers to go for commercialization of the mango cultivation through contract farming this will help in enhancing the living condition of the farmers and a better bargaining capacity. Moreover the contract farming will improve the good link for small and marginal farmers with private sector and exploit the potential of agro-processing sector by supply the raw commodities to agro

processing industries (Satish, 2020)

Problems related with Contract farming in India:

- Problems of Contract Farming In the first place there is no credible enforcement mechanism for contract farming in India (Ramsundar and Shubhabrata, 2014).
- In our country size of the holdings is small; the company will have to enter into contract with a large number of farmers. This increases costs of the company.
- There is a lack of comprehensive crop insurance scheme in India.
- The medium size farmer may not be literate enough to understand the nitty gritty of the contract and all the clauses, and if the produce does not meet the standards of the company, he may face mass rejection.
- The farmer may be forced to produce only tomatoes or onions year after year which will lead to monoculture and he will have no options left to produce whatever mix of crops which he may think is good for his farm.
- Predetermined prices do not take care of food inflation and in case there is a price rise of the product, the farmer cannot take advantage and make a windfall profit because he is under contract to sell at the price agreed upon beforehand.
- The average farmer being poor and semi-literate has little bargaining power vis-à-vis big corporations and hence there is little chance of his getting a fair price for his produce.
- The corporate sector takes over our agricultural operations. It may affect the food security of the country.
- Contract farming is best suited to special types of crops and not all farming activities. In China, only specific agricultural produce is under contract farming.
- The Niti Ayog thinks a model law is needed to streamline the contract farming system and make it more uniform across the States.
- Presently, contract farming has been co-opted by 22 States but there is no uniformity or homogeneity regarding the kinds of produce that can come under it and the conditions under which contract farming should be allowed.

Way forward for contract farming in India:

- To make contract farming inclusive, farming groups like cooperatives should be encouraged.
- Food processing industries may also consider small farmers because there is benefit of low cost of production as these farmers have access to cheaper family labour who work more conscientiously than hired labour.
- The best practices from the most successful cases of contract farming should be taken into account when drafting the model law.
- There should be provisions for quick and just dispute settlement between the big corporations and small and medium farmers.
- Companies and States should promote group contracts with the intermediation of local NGOs and other organisations and institutions so that contractual relationships are more durable and fair.

- Insurance component is a must to protect contract famers' interests. There is thus the need for collective action through cooperative process to be able to buy and sell at better prices.
- There has to be a system which monitors contracts to facilitate its smooth functioning in the context of small farmers.
- According to Niti Ayog, "The law that shall be formulated will be a general one for all commodities and will aim at laying down a uniform set of terms and conditions that will significantly reduce conflicts. It is quite clear that such a law will be positive and a good move."
- The idea of a model Act is to vertically integrate farmers producing fruits and vegetables with agro processing units for better price realization and post-harvest losses.

References:

1. Boumann, P.(2000). Equity and efficiency in contract farming schemes, the experience of agricultural tree crops. Development Institute Working Paper-139.
2. Charles, E. and Shepherd, A. (2001). Contract Farming- Partnership for growth. FAO, Agricultural Services Bulletin.145. Food and Agriculture Organization of the United Nations. 2001.
3. Eaton, C. and Shepherd, A. (2001) Contract Farming: Partnerships for Growth. Food and Agriculture Organization of the United Nations, Rome.
4. Glover, D. (1984). Contract Farming and Smaller holder Out grower Schemes in the Less Developed Countries, World Development, Pp. 1143-1157. 66
5. Johl, S.S. (1995). Agricultural Sector and New Economic Policy. Indian Journal of Agricultural Economics, 50(3): 473-487.
6. Mani, G. and Pandey, V. K. (1995). Agrarian Structure under the New Economic Policy. Indian Journal of Agricultural Economics, 50(3): 524-530.
7. Parikh, K. and Nagarajan, H. K. (2004): How Important is Land Consolidation? Land Fragmentation and Implications for Productivity: Case Study of Village Nelpathur in Tamil Nadu, National Bank for Agricultural and Rural Development (NABARD) Occasional Paper No. 31, NABARD, Mumbai.
8. Ramsundar, B. and Shubhabrata, S. (2014). Problems and prospects of contract farming in India. Global Journals of Commerce and Management Perspectives, 3(6):12-17.
9. Ramswami, B., Birthal, P. S. and Joshi, P. K. (2005). Efficiency and distribution in contract farming: Case of Indian poultry grower, Discussion Paper, Indian Statistical Institute, New Delhi. 107p
10. Satish, S.B. (2020). Contract Farming – A way to Sustainable Agriculture: A Case of Mango Contract Farming in Karnataka. DOI:10.18311/sdmimd/2020/26237. pp9-20.
11. Singh, J. P. (2005). Changing Agrarian Relations in Rural India, a Keynote Paper presented at the 65th Annual Conference of the ISAE held at PAU, Ludhiana, November 24-26.

Chapter – 11

Application of Nanotechnology in Food Processing and Packaging

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The Nanotechnology presently we are talking about which have touched almost all area of life due to its unique characteristic features. It is not a new as it was known dates back to the 9th century in Mesopotamia when artisans used silver and copper nanoparticles, to generate a glittering effect on the surface of pots. However the modern concept of nanotechnology was given by Richard Feynman who is also called the founding father of nanotechnology. However the term of nanotechnology was coined by Norio Tanguchi and according to him Nanotechnology is ability to engineer materials precisely at the scale of nanometre.Michael Faraday provided the first description, in scientific terms, of the optical properties of nanometre-scale metals in his 1857 paper and in 1980 K. Eric Drexler established the department of molecular nano technology . The term nanotechnology it may be define as the design, production, characterizations, and application of *structures, and devices by controlled manipulation at the* nanoscale dimensions to produce desired product for human welfare is called nanotechnology. For examples carbon nanotube, titanium nano flower and silver nano tube aerosol, fogs, virus and DNA diameter etc all are comes in range of nano scale as some are depicted in figure 1. Nanomaterials can exist in single, fused, aggregated or agglomerated forms with spherical, tubular, and irregular shapes. Common types of nanomaterials include nanotubes, dendrimers, and quantum dots and fullerenes. Nanomaterials can be classified primarily into two types: Natural ones and artificially fabricated ones.

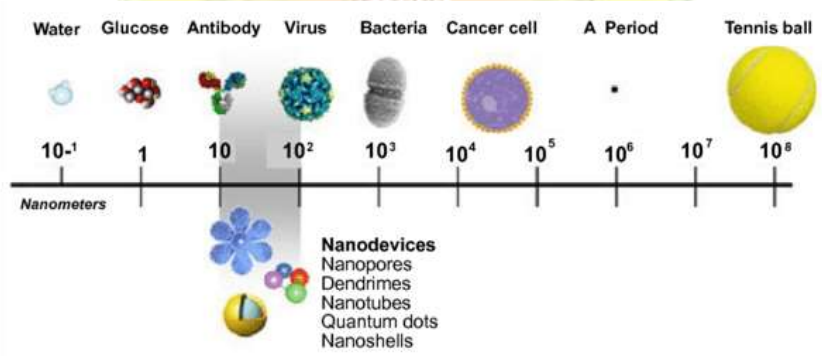

Figure.1: Different size of nanoparticles

Source:
https://www.researchgate.net/publication/316700708_Development_of_DNA_Nanotechnology_and_Uses_in_Molecular_Medicine_and_Biology/figures?lo=1

Preparation of nanoparticles

There are two main approaches for the synthesis of nanoparticles the first one is called top-down approach (emulsification method and homogenization etc.) and another is bottom-up approach (nanoprecipitation and coacervation etc.) as depicted in figure.2.

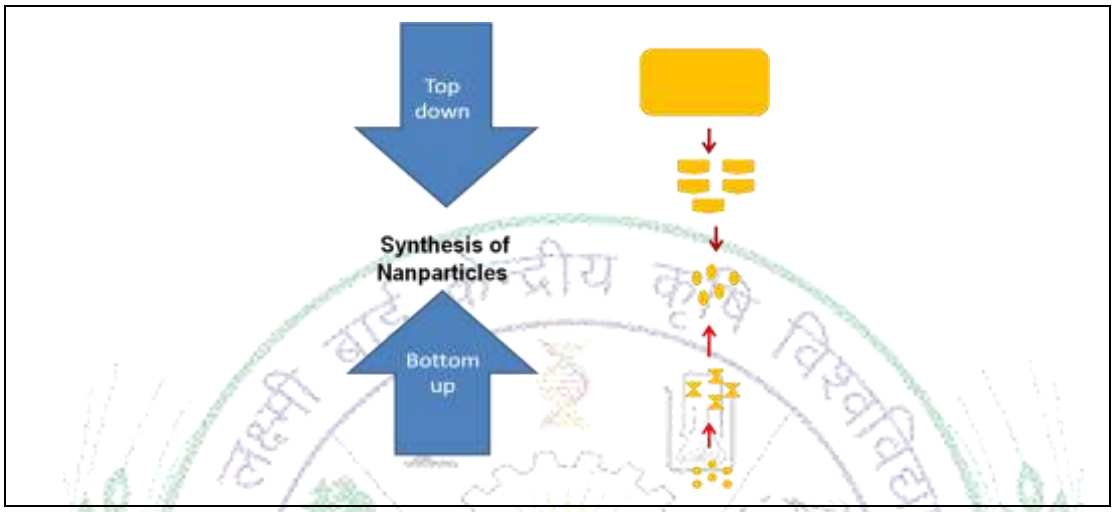

Figure 2. Synthesis methods of nanoparticles

Characterization of nanoparticles

The detection and characterization of nanoparticles is challenges job being smaller in size and they are observable under optical microscopes only. Therefore specialized techniques are required to visualize the formulated nanoparticles such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM). These techniques can image the nanoparticles and directly measure the sizes, with proper information about the shape, however they are limited to studying only a few particles at a time. In general, these techniques can be quite effective for obtaining basic information about nanoparticles.

Unique properties of nanoparticles

It is an emerging area and engages almost every technical discipline from basic sciences to applied science. Nanomaterils and its devices have tremendous application in different fields since two decades because of some important properties of the nanoparticles. Nanoparticles have a relatively larger surface area when compared to the same mass of material produced in a larger form (Figure 3) and this make materials are more chemically reactive. It has high surface energy, spatial confinement, and reduced imperfections. It exhibits quantum effects such as the optical, electrical and magnetic behaviour of materials (Figure 3). Materials can be produced that are nanoscale in one dimension (for example, nanowires, nanorods and nanotubes), in two dimensions (plate-like shapes like nanocoatings, nanolayers, and graphene) or in all three dimensions which are also showing high range of free movability.

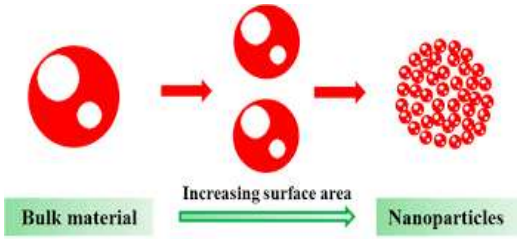

Figure.3: Nanoparticles have more surface area

Source:https://www.google.com/search?q=nano+particless+have+a+relatively+larger+surface+area&tbm=isch&ved=2ah.

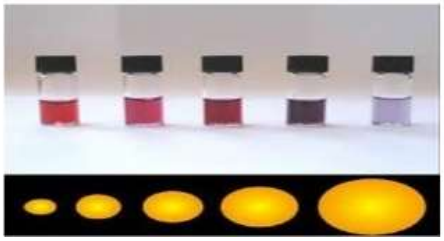

Figure.4: Nanoparticles exhibits quantum effect

Source:https://www.google.com/search?q=nanoparticles+exhibits+quantum+effects.

Applications of nanoparticles for food processing and packing

The food processing and packaging is toady very promising area since it make user-friendly to the consumer apart from increasing the marketable value and well conversion of raw ingredient into useful form. Moreover it also increases the durability of the food products because of the incorporation of specific nanomaterial's during the processing and packaging. Presently the use of nanomaterial's touched the different area of the food industry such as the improvement of food quality modification of food structures and textures, apart from the detection and neutralization of biochemical, microbiological gents (Figure 5).

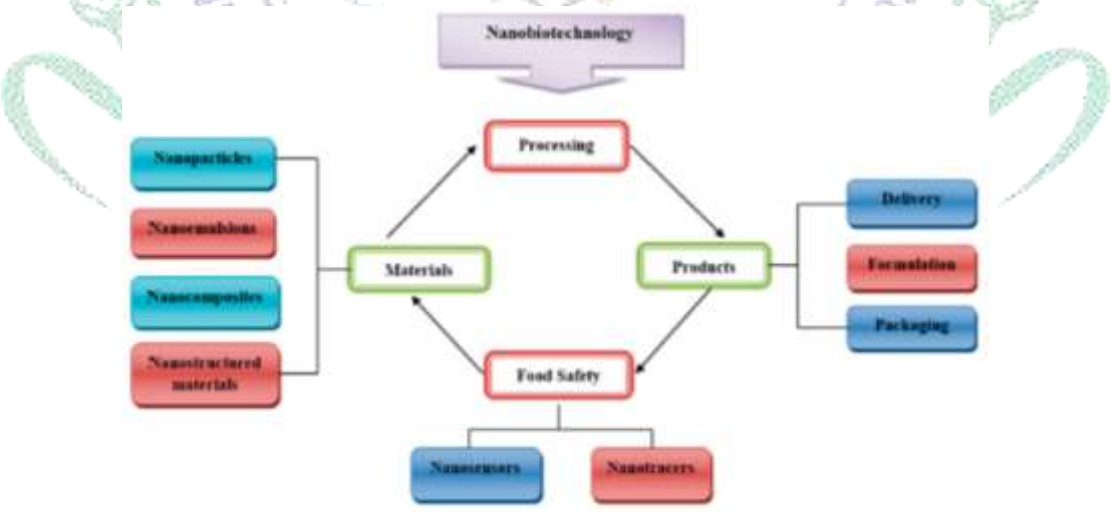

Figure.5: The potential role of nanotechnology in food industry

Source: https://www.mdpi.com/2304-8158/9/2/148/htm.

Even biomolecule like protein used as protein Nano particles for the manufacture of food products since more solubilize nature of protein. Different types of nanoparticles have been used in food industry besides the use of solid core mesoporous nanoparticles, branched gold nanoparticles, carbon nanotubes etc. The wide range applications of nanotechnology in food science are rapidly demanding. Presently

many more some nanoparticles have been used in food industry some are mentions below in table 1.

Table 1. Various applications of nano materials in the food industry.

Nano materials	Type of Nano materials	Applications in Food Industry	References
Nanoparticles	Ag, ZnO, Mg, SiO2	Food packaging, oxidation of Contaminant, anti-bacterial	Shi *et al*., 2014, Chernousova, *et al*., 2013 and Hoseinnejad, *et al*., 2018.
Nano sieves	Specific nanoparticles	Removal of pathogens or contaminants	Maguire-Boyle *et al*., 2012, Smith et al., 2015.
Nano capsules	Bioactive compounds	Increased ecacy and water solubility, local and controlled release	Cosco *et al*., 2015 and Yun, *et al*., 2014.
Nano-emulsions	Tweens or spans; gum arabica or modified starch, soy, caseinate	Food encapsulation, food processing, antimicrobial and storage, stability, colorant	Silva *et al*., 2012, Sugumar, *et al*., 2013 and. Gupta *et al*., 2016.
Nano spheres	Starch nano sphere	Food encapsulation, synthetic adhesives	Liang *et al*., 2017, Mozafari, *et al*., 2008 and López, *et al*., 2015.
Nano sensors	Apta sensors	Detection of micro-organisms, food deterioration control	Sutarlie *et al*., 2017, Fuertes *et al*., 2016 and Majdinasab, *et al* ., 2018.
Nano cochleates	Coiled Nanoparticles	Enhanced nutritional value of food, antioxidant, food protection and stability	Luykx *et al*., 2008, Singh, *et al*., 2018 and Kaya-Celiker *et al*., 2012.
Nano composite	Fe-Cr/Al2O3 Ni/Al2O3.	Enhanced shelf life of food, food protection and food packaging.	Llorens *et al*., 2012, de Azeredo *et al*., Rai *et al* 2019.
Nano micelles	novasol Liquid	Carrier, enhanced solubility	Dasgupta, *et al*., 2018, Yang,*et al*, 2016, Dickinson *et al* ., 2015.

Food processing

Food processing is the conversion of raw ingredients into food and its other forms by making it marketable and with long shelf life. Processing includes toxin removal, prevention from pathogens, preservation, improving the consistency of foods for

better marketing and distribution. Processed foods are usually less susceptible to early spoilage than fresh foods and are better suited for long distance transportation from the source to the consumer. All these are made more effective by the incorporation of the nanotechnology nowadays. Nan capsules delivery systems, plays an important role in processing sector and the functional property are maintained by encapsulating simple solutions, colloids, emulsions, biopolymers and others into foods. The application of nanoparticles improved the freshness of vegetables by the minimal processing methodology. It have been reported by the many researches as the different types of nanoparticles such as silver, copper, chitosan, and metal oxide based nanoparticles like titanium oxide or zinc oxide played pivotal role in food industry as a antibacterial property, improved the nutritional value, food texture and physical performance.

Presently the German industry magazine “Fleischwirtschaft" claims that Nova Sol offers considerable advantages of faster meat processing, cheaper ingredients, higher color stability (Figure 6) and ready to use liquid form. Nanotechnology product vegetable cleanse as a Nano cleaning suspension comprising clay mineral nanoparticles complemented by two liquid ingredients, for eliminating unwanted pesticides and bacteria (Figure 7). Nanotechnology advances have been applied to innumerable industries ranging from electronics and batteries to medicine and food products. In the food industry, nanotechnology has been utilized in order to enhance the delivery of food ingredients to target sites, which increase the flavor, inhibit bacterial growth, extend product shelf life and improve food safety. This new, rapidly developing technology impacts every aspect of the food system from cultivation to food production to processing, packaging, transportation, shelf life and bioavailability by using different nanoparticles such as TiO2 and SiO2 and amorphous silica etc. TiO2 is used as a coloring in the powdered sugar coating on doughnuts. It has been also intensively used in the food processing industry, which provides many benefits such as improved mechanical quality apart from the texture and flavors (Figure 8).

	
Figure.6: Nanotechnology used in meat processing Source:https://www.researchgate.net/publication/47904547_Use_of_nanotechnology_in_food_processing_packaging_and_safety_review.	Figure.7: Nano cleaning suspension for eliminating pesticides and bacteria Source:https://www.taylorfrancis.com/books/e/9781351046312/chapters/10.1201/9781351046312-16.

Figure.8: Nanotechnology in the food processing industry

Source: https://www.docsity.com/en/food-industry-nanotechnology-lecture-slides/394409/.

Figure.9: Nanotechnology used in the manufacture of RFID tags

Source: https://www.azonano.com/article.aspx?ArticleID=3035.

Beside the above mention application of nanoparticles it has been also reported in various others use such as in protection of sugar beet vegetables as a anti-microbial activities. A University of Toronto graduate school project is now extending the life of widely used crop protection products. Nanoparticles extended the shelf-life of vegetables by injecting with Syringe. Nanotechnology used in the manufacture of RFID (Radio Frequency Identification) tags, which will provide the data about the temperature and shelf life etc. (Figure 9).

Food Packaging

Food packaging for food requires protection, tampering resistance, and special physical, chemical, or biological needs. It also shows the product that is labelled to show any nutrition information on the food being consumed. The packing has a great significance in preserving the food to make it marketable. Innovations in packaging have lead to quality packing and consumer friendly approach in determining the shelf life, biodegradable packing and many more. The smart packaging (Figure 10) of food constitutes active and intelligent packaging. Active packaging generally enhances the shelf life, and maintains and improves the packaged food. Bioactive packaging provides a positive impact for the health of consumers with the production of packaged foods which are good for health.

Materials of nano scale dimensions, including polymers, biopolymers and other nano composites, can be incorporated into food packaging to increase the strength, durability, gas barrier, humidity resistance and biodegradability of the packaging. Nanoparticles have been also used in increasing the food safety by using nano-based solutions in the food packaging industry. Many sunscreens now incorporate nanoparticles of titanium dioxide, which is very effective in food packaging apart from blocking the ultraviolet rays that lead to sunburn and cause the skin cancer.

Figure.10: Different type of smart nanopackaging

Source: https://www.mdpi.com/2304-8158/9/2/148/htm.

Nanotechnology being used in plastic for food packing, which makes it's stronger, lighter and performs better after food packaging. The international standard also addresses the impermeability characteristics of nano composite polymer films, which are useful to improve food packaging. Nanotechnology for smart packaging which increases the reliability of the products, non-toxic and compatible with legislation. Active food packaging technologies offer several benefits, including increased food safety, extended shelf-life, improved freshness, reduced food waste, and more. It has been reported that the Nano Pack based food-packaging technologies got the landmark among the consumers and retailers. Nanotechnology used in food nanotechnology packing, which enhances the food durability apart from the flavor, stability and safety issue of the food (Figure 11).

In addition to lowering the risk of microbial contamination in foods, nanotechnology in packaging offers the promise of extending food shelf life and reducing waste, by bioprocessing engineering and nanotechnology at the U.S. Department of Agriculture (Figure 12). Additionally, recent studies have gone a long way toward easing safety concerns about the technology. Self-healing polymers have been under investigation by researchers for quite some years now, and some examples have appeared on the market. Use of these materials as an outer layer in food packaging could allow small punctures and tears in the wrapping, reducing wastage due to damaged packaging the applications of nano cellulose in fruits packaging (Figure 30).

	
Figure.11: Nanotechnology helping in food packaging Source: https://www.nuffoodsspectrum.in/news/30/4455/consumers-willing-to-adopt-nanotechnology-for-food-packaging.html.	Figure.12: Nanotechnology in food packaging Source:https://www.foodbusinessnews.net/articles/9543-food-packaging-as-a-key-for-enhancing-food-safety.

Nanotechnology and food safety

Presently, the applications of nanoparticles touched almost all field of our life. Therefore it must be utilized properly after understanding the well known relationship between nanoparticles and the environment since it has high mobility apart from high absorb capacity. Thus, in addition to the potential use of nanoparticles to remove chemical contaminants from the environment, Nanoparticles also can have benifical impacts on the environment and appear to contribute to natural processes. Therefore it is advisable here even before pose the new health risk by nanomaterils used for food processing and packaging apart from nanofood additives must be quantify the nonmaterial throughout the food life cycle is critical for manufacturing consistency before reaching to the door of consumers since public acceptance of food and food-related products containing nanomaterials will depend on their safety.

Conclusion and future prospective

As we could understand the vast applicability of nanotechnology not only in the area of food processing and packaging but also in preparation of Nano foods. Moreover its merits are documented. For prolonged storage duration namely, food processing, food additive delivery systems, fruit and vegetable packaging besides discussing their antimicrobial barrier and coating properties etc. However the existing process of mass production of Nano-packaging materials for food processing and food packaging is not very simple. Therefore, it is need for improvement of the existing processing technology apart from the requirement of the user-friendly tools and techniques with the understanding of the safety issue of the Nanometrials.

References

1.https://www.google.com/search?q=nonmaterial+have+a+relatively+larger+surface+are.

2.https://www.google.com/search?q=nanoparticles+exhibits+quantum+effects.

3.https://www.slideshare.net/preetibirwal007/preeti-birwal.

4.https://www.whatech.com/market-research/food-beverage/641017-new-study-explores-excellent-growth-of-food-nanotechnology-market-2020-with-new-business-opportunities-and-key-players.

5.https://www.intechopen.com/books/functional-food-improve-health-through-adequate-food/the-role-of-legumes-in-human-nutrition.

6.https://www.thebetterindia.com/223668/bengaluru-startup-log9-coronaoven-covid19-innovation-disinfection-chamber-india-nor41/.

7.https://pl.pinterest.com/gcelichowski/nano/.

8.https://nano-magazine.com/news/2019/2/20/study-says-consumers-prefer-nanotechnology-in-active-food-packaging.

9.http://gonano-project.eu/nanotech-developments-in-the-food-sector/.

10.https://www.researchgate.net/publication/331944127_Nanotechnology__A_shelf_life_extension_strategy_for_fruits_and_vegetables.

11.https://www.researchgate.net/publication/327333235_Application_of_edible_coatings_on_fresh_and_minimally_processed_vegetables_a_review.

12.https://www.magzter.com/article/Technology/Food-Marketing-Technology-India/Nanotechnology-Redefining-Beverage-Packaging-Industry.

13.https://www.taylorfrancis.com/books/e/9781351046312/chapters/10.1201/9781351046312-16.

14.https://www.omanobserver.om/oman-researchers-tech-gives-veggies-long-shelf-life/.

15.https://katanaproject.eu/future-trends/nanotechnology/.

16.https://en.wikipedia.org.

17.https://www.packaging-gateway.com/news/oman-researchers-create-nanotechnology-based-packaging-okra/.

18.https://katanaproject.eu/future-trends/nanotechnology/.

19.https://www.intechopen.com/books/functional-food-improve-health-through-adequate-food/the-role-of-legumes-in-human-nutrition.

20.http://downloads.hindawi.com/journals/bmri/2015/365672.pdf.

21. https://www.hindawi.com/journals/bmri/2015/365672/.

22. https://www.ijcmas.com/vol-4-5/Mahmoud%20M.%20Berekaa.pdf

23.https://www.slideshare.net/teixeiravasco/opportunities-and-challenges-in-nanotechnologybased-food-packaging-industry.

24.https://www.slideshare.net/apexflora/nanotechnology-in-food-industry.

25.https://www.frontiersin.org/research-topics/5194/application-of-nanotechnology-in-food-science-and-food-microbiology.

26.https://www.elsevier.com/books/nanotechnology-applications-in-food/grumezescu/978-0-12-811942-6.

27. https://www.azonano.com/article.aspx?ArticleID=4069.

28.https://www.docsity.com/en/food-industry-nanotechnology-lecture-slides/394409/.

29.https://www.google.com/search?q=nano+particless+have+a+relatively+larger+surface+area&tbm=isch&ved=2ah.

30.https://nanohub.org/resources/20987/download/e304_1_bigpicture.pdf.

31.https://www.foodsafetymagazine.com/magazinearchive1/februarymarch2017/nanotechnology-in-the-food-industry-a-short-review.

32.https://www.sciencedirect.com/science/article/pii/B9780128114414000042.

33.https://www.mdpi.com/2304-8158/9/2/148/htm.

34.https://www.foodbusinessnews.net/articles/9543-food-packaging-as-a-key-for-enhancing-food-safety.

35.https://www.supermarketnews.com/technology/small-change-nanotechnology-food-packaging.

36.https://nano-magazine.com/news/2019/4/20/how-nanotechnology-could-change-food-packaging.

37.https://www.nuffoodsspectrum.in/news/30/4455/consumers-willing-to-adopt-nanotechnology-for-food-packaging.html.

38. http://en.isti.ir/News%E2%80%93Archive/Health-Ecosystem%3B-The-Seventh-International-Standard-in-the-Nanotechnology-Field-Is-Allocated-to-Iran-/68411.

39.https://www.docsity.com/en/food-industry-nanotechnology-lecture-slides/394409/.

40. Abbas KA, Saleh, A.M, Mohamed, A, MohdAzhan N.(2009).The recent advances in the nanotechnology and its applications in foodprocessing: A review-*Journal of Food, Agriculture & Environment,*; 7 , 1 4 - 1 7.

41.Abo-Elseoud, W.S.; Hassan, M.L.; Sabaa, M.W.; Basha, M.; Hassan, E.A.; Fadel, S.M. (2018).Chitosan nanoparticles/cellulose nanocrystals nanocomposites as a carrier system for the controlled release of repaglinide. *Int. J. Biol. Macromol.*, 111, 604–613.

42. Bradley, E. L., Castle, L., and Chaudhry, Q. (2011). Applications of nanomaterials in food packaging with a consideration of opportunities for developing countries.*Trends Food Sci. Technol*. 22, 603–610.

43. Chernousova, S.; Epple, M. (2013).Silver as antibacterial agent: Ion, nanoparticle, and metal. Angew. *Chem. Int. Ed*., 52, 1636–1653.

44.Cosco, D.; Paolino, D.; De Angelis, F.; Cilurzo, F.; Celia, C.; Di Marzio, L.; Russo, D.; Tsapis, N.; Fattal, E.; Fresta, M. (2015).Aqueous-Core PEG-coated PLA nanocapsules for an e_cient entrapment of water soluble anticancer drugs and a smart therapeutic response. *Eur. J. Pharm. Biopharm*., 89, 30–39.

45. Dasgupta, N.; Ranjan, S. (2018). Nanotechnology in food sector. In An Introduction to Food Grade Nanoemulsions; *Springer book* 1–18.

46.de Azeredo, H.M.C.; Mattoso, L.H.C.; McHugh, T.H. (2011).Nanocomposites in food packaging–A review.In Advances in Diverse Industrial Applications of Nanocomposites; *IntechOpen: London, UK*. 57–78.

47. Dickinson, E. (2015). Microgels -An alternative colloidal ingredient for stabilization of food emulsions. *Trends Food Sci. Technol*., 43, 178–188.

48. Fuertes, G.; Soto, I.; Carrasco, R.; Vargas, M.; Sabattin, J.; Lagos, C. (2016).Intelligent packaging systems: Sensors and nanosensors to monitor food quality and safety. J. Sens. 1-8, http://dx.doi.org/10.1155/2016/4046061.

49.Gerloff, K et al. (2009). "Cytotoxicity and Oxidative DNA Damage by Nanoparticles in Human Intestinal Caco-2 Cells." *Nanotoxicol* 3(4):355–364.

50. Gupta, A.; Eral, H.B.; Hatton, T.A.; Doyle, P.S. (2016).Nanoemulsions: Formation, properties and applications. Soft Matter 12, 2826–2841.

51.Hoseinnejad, M.; Jafari, S.M.; Katouzian, I. (2018).Inorganic and metal nanoparticles and their antimicrobial activity in food packaging applications. Crit. Rev. Microbiol., 44, 161–181.

52.Ilaria S., Antonietta L. and Alfredo A .(2019). Nanotechnology in Plant Sciences: To make long Story Short. Mini review article. Frontiers in Bioengineering and Biotechnology.

53.Jim Dingman. (2008). Nanotechnology: Its impact on food safety. Journal of Environmental Health,. 70, 47-50.

54. Kaya-Celiker, H.(2012).Mallikarjunan, K. Better nutrients and therapeutics delivery in food through nanotechnology.Food Eng. Rev., 4, 114–123.

55.Kessler, R. (2011). "Engineered Nanoparticles in Consumer Products: Understanding a New Ingredient." *Environ Health Perspect* 119(3):A120–A125.

56.Liang, J.; Yan, H.; Wang, X.; Zhou, Y.; Gao, X.; Puligundla, P.; Wan, X. (2017).Encapsulation of epigallocatechin gallate in zein/chitosan nanoparticles for controlled applications in food systems. *Food Chem*., 231, 19–24.

57.Llorens, A.; Lloret, E.; Picouet, P.A.; Trbojevich, R.; Fernandez, A. (2012).Metallic-Based micro and nanocomposites in food contact materials and active food packaging. *Trends Food Sci. Technol*., 24, 19–29.

58.López, O.V.; Castillo, L.A.; Garcia, M.A.; Villar, M.A.; Barbosa, S.E. (2015) Food packaging bags based on thermoplastic corn starch reinforced with talc nanoparticles. *Food Hydrocoll*., 43, 18–24.

59.Luykx, D.M.; Peters, R.J.; van Ruth, S.M.; Bouwmeester, H. (2008).A review of analytical methods for the identification and characterization of nano delivery systems in food. *J. Agric. Food Chem*. 56, 8231–8247.

60.Maguire-Boyle, S.J.; Liga, M.V.; Li, Q.; Barron, A.R. (2012).Alumoxane/Ferroxane nanoparticles for the removal of viral pathogens: The importance of surface functionality to nanoparticle activity. *Nanoscale.*, 4, 5627–5632.

61.Majdinasab, M.; Hayat, A.; Marty, J.L. (2018).Aptamer-Based assays and aptasensors for detection of pathogenic bacteria in food samples. *TrAC Trends Anal.* Chem., 107, 60–77.

62.Morris, VJ et al. (2011). "Atomic Force Microscopy as a Nanoscience Tool in Rational Food Design." *J Sci Food Agric* 91:2117–2125.

63.Mozafari, M.R.; Johnson, C.; Hatziantoniou, S.; Demetzos, C. (2008) Nanoliposomes and their applications in food nanotechnology. *J. Liposome Res*. 18, 309–327.

64.Oberdorster, G et al. (2005). "Nanotoxicology; an Emerging Discipline Evolving from Studies of Ultrafine Particles." *Environ Health Perspect* 113:823–839.

65. Rai, M.; Ingle, A.P.; Gupta, I.; Pandit, R.; Paralikar, P.; Gade, A.; Chaud, M.V.; dos Santos, C.A. (2019).Smart nanopackaging for the enhancement of food shelf life. Environ. Chem. Lett., 17, 277–290.

66.Robert Mikkelsen (2018), Nanofertilizer and Nanotechnology: A quick look, Better Crops 102 – 3. DOI:10.24047/BC102318.

67.Silva, H.D.; Cerqueira, M.Â.; Vicente, A.A. (2012).Nanoemulsions for food applications: Development and characterization. *Food Bioprocess Technol*., 5, 854–867.

68. Singh, P. (2018).Nanotechnology in food preservation. *Food Sci*., 9, 435–441.

69. Smith, S.C.; Rodrigues, D.F. (2015).Carbon-Based nanomaterials for removal of chemical and biological contaminants from water: A review of mechanisms and applications. *Carbon*, 91, 122–143.

70.Sugumar, S.; Nirmala, J.; Ghosh, V.; Anjali, H.; Mukherjee, A.; Chandrasekaran, N. (2013).Bio-Based nanoemulsion formulation, characterization and antibacterial activity against food-borne pathogens. *J. Basic Microbiol*., 53, 677–685.

71. Sutarlie, L.; Ow, S.Y.; Su, X. (2017).Nanomaterials-Based biosensors for detection of microorganisms and microbialtoxins. *Biotechnol. J.* 12.

72. Tan, H., Ma, R., Lin, C., Liu, Z., and Tang, T. (2013). Quaternized chitosan as an

antimicrobial agent: antimicrobial activity, mechanism of action and biomedical applications in orthopedics. *Int. J. Mol. Sci.* 14, 1854–1869.doi: 10.3390/ijms14011854.

73. Uboldi, C et al. (2012). "Amorphous Silica Nanoparticles Do Not Induce Cytotoxicity, Cell Transformation or Genotoxicity in Balb/3T3 Mouse Fibroblasts." *Mutat Res* 745(1-2):11–20.

74. Wang et al (2016), potential entry points of nanoparticles in to plants.

56. Yang, Y.; Guo, Y.; Sun, R.; Wang, X. (2016).Self-Assembly and carotene loading capacity of hydroxyethyl cellulose-graft-linoleic acid nanomicelles. Carbohydr. *Polym.*, 145, 56–63.

76. Yun, G.; Hassan, Z.; Lee, J.; Kim, J.; Lee, N.S.; Kim, N.H.; Baek, K.; Hwang, I.; Park, C.G.; Kim, K.(2014). Highly stable, water-dispersible metal-nanoparticle-decorated polymer nanocapsules and their catalytic applications. *Angew. Chem. Int. Ed.* 53, 6414–6418.

Chapter – 12

Nutraceutical Properties of Blood fruit (*Haematocarpus validus* Bakh. f. ex Forman)

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Blood fruit (*Haematocarpus validus* Bakh. f. ex Forman) belongs to family Menispermacea is one among the lesser known and underutilized plant which has a rich source of antioxidant and are famous for their traditional medicinal usages Fruits are slightly acidic sweet in taste and ripe fruits are available from the month of April to June. It is found growing in wild in the forest of West Garo Hill, Meghalaya. The average fruit weight was around 21.34 g, 3.87 cm long and 2.9 cm in diameter. The fruits are single seeded and each seed weight about 5g with 2.59 cm long and 1.70 cm in diameter. The fruit were analyzed and the amount of TSS, Total sugar, reducing sugar, titrable acidity, ascorbic acid, protein, beta carotene content of the fruits were14.5° brix, 7.14 %, 4.54 %, 0.26%, 5.33%, 7.60 %, 138.42 IU respectively. The fruit had one of the rich sources of carbohydrates and anthocyanin's content about 8.68 % carbohydrate and 195.93mg/ 100g pulp of total monomeric anthocyanin's respectively. The fruit also content trace amount of starch 0.23 g/100 g. The high nutritional value of blood fruit indicates good potential for exploration and value added products like wine, juice and chutney can be processed for consumption during off season.

Keywords: Blood fruit, nutraceutical properties

Introduction

Blood fruit (*Haematocarpus validus* Bakh. f. ex Forman) is one of the rather extinct and underutilized fruits belonging to family Menispermacea that is known to contain plants rich in different alkaloids and are famous for their traditional medicinal usages. Etymologically, the word *Haematocarpus* is derived from two-word haemato meaning blood red and carpus meaning fruit. As the species yield fruits of blood red colour, hence the name.

Till date no specific origin of blood fruit is found, but it is believed to be originated from South East Asia. Blood fruit was recoup after a period of 100 years in India, adding new location to Indo-Myanmar biodiversity hotspot province (Singh and Bedi, 2016). In India, natural populations of the species have been reported from the Andaman and Nicobar Islands, Tripura, Meghalaya, Assam and West Bengal. Apart from India, the species is also distributed in Chittagong hills of Bangladesh, Indonesia, Singapore and Pakistan. They are known by different name as Blood fruit (English), Khoonphal (Hindi), Roktogula/Lalgula (Bengali), Rosco (Chakma), Thoyphal (Tripura), Tepattang (Garo), Theichhung-sen (Mizo), Ranguichi (Marma) Raktaphal (Tamil/Telugu/Malayalam), Sohsnam (Khasi&Pnar) (Momin *et al* ., 2018). Many bioactive compounds are present in this fruit which neutralize free radical

species generated as a part of biochemical reactions in our body system . Alkaloid compounds including Sinomenine, (S)-Reticuline, Ambelline, Metanephrine, Ecgonine and Choline were detected from the fruit and leaves of blood fruit. This alkaloids show biological significance in terms of hepatoprotective, anti-inflammatory, anti-rheumatic, cardiovascular, antimicrobial, anticancer and antioxidant properties (Blessymole *et al*., 2017).

Blood fruit is an evergreen perennial creeping woody climber capable of growing under extreme conditions, from very dry environments to highly acidic soils. It grows up to 1000 m and more in height (Rahim *et al*., 2015) with dark green glabrous profusely branched stems. The flowering time varies depending on the place. Under Andaman conditions, the species has been observed to flower more than once in a year. Peak season of harvesting is from April to August (Bohra *et al*., 2016). In Bangladesh, the vines of the tree produce flower in mid November-January and the fruiting season is May to August (Khatun *et al*., 2014). Under Garo hills condition of Meghalaya, the vine comes into flowering from October to December and fruits are available in the local markets from last week of March till June (Momin *et al*., 2016). The vines of the tree produce flower in middle of November-January.

Table 1. Morphological characteristics of Blood fruit collected from Garo Hills, Meghalaya

Characters	Value	Characters	Value
Leaf length	9.34-13.00 cm	Seed weight	1.47 -6.41 g
Leaf width	3.89-5.78 cm	Seed length	3.20-5.20 cm
Fruit weight	12.85-30.85 g	Seed girth	14.0-19.69 mm
Fruit girth	25.34-35.93 mm	Pulp weight	3.21-8.79 g
Rind weight	6.21-16.34 g	Pulp peel ratio	0.32-0.95%
Rind thickness	3.98-5.31 mm	Pulp seed weight	4.96-15.08 g

(Source: Momin *et al*., 2018)

Table 2. The nutritional composition of fruits of blood fruit

Item	Amount (Per 100 g)	Item	Amount (Per 100 g)
Moisture (g)	90.12	Iron (g)	0.57
Protein (g)	0.6	Copper (µg)	129.57
Carbohydrate (g)	6.99	Zinc (µg)	0.14
Fat (g)	1.44	Manganese (µg)	152.04
Crude fibre (g)	1.22	Calcium (g)	9.16
Ash (g)	1.23	Magnesium (g)	6.86
Vitamin C (g)	13.15	Potassium (g)	255.70
Total carotenoids (µg)	1170	Phosphorus (g)	39.50
β- carotene (µg)	9.0	Potassium (g)	255.70

(Source: Rahim *et al*., 2015)

The fruit content about 1.44% fat and 1.23% ash respectively. Blood fruit can be recommended to individuals suffering from overweight or obesity due to generally low level of fat in the fruits (Rahim *et al*., 2015) . Fruits of *Haematocarpus validus* are found to be rich in iron (0.57 mg/100 g) and seeds contain 0.11 mg/100g, which is comparatively higher than the commercial fruit crops such as mango (0.2 mg/100g), apple (0.1 mg/100g), guava and cherries (0.3 mg/100g) (Singh *et al*., 2013). Vitamin

C content (13.15 mg) is also higher than the commercially available fruits, viz., jackfruit (11.08 mg), litchi (7 mg), papaya (7.48 mg) and mango (10.88 mg) (Islam et al., 2012). Besides fruits are also a rich source of micronutrients like Ca, Mg, K and P and natural antioxidants.

Table 3. Anti-Nutritional factors (mg/100g) in *Haematocarpus validus*

Fruit Fraction	Anti-Nutritional Factors (mg/100g)			
	Nitrate	Phytate	Oxalate	Saponin
Pulp	16.25	422.68	34.95	85.56
Pericarp	25.00	506.83	39.82	85.28
Seed	19.58	415.83	33.82	100.06

Source: Singh *et al*., 2014

The Blood fruit was also found to contain anti-nutritional compounds like nitrate, phytate, oxalate and saponin hindering the utilization of the fruits. Singh *et al*., 2014 reported that the pulp which is edible potion had low nitrate and oxalate content. However, their quantities are in safe health limit for consumption. The seeds were comparatively had high amount of saponin which indicates its potential in industrial purpose.

Uses of blood fruit

Blood fruit is one of the promising and potential sources as fruit, medicine, nutrition and natural colorants among the underutilized plant. The importance and ethno-medicinal values of this fruit is well recognized and are utilized by few old members of the village people. Blood fruit are eaten as raw. The Ethnic community of CHT (Chittagong Hill Tracts in Bangladesh) uses the fruit extract as natural and organic source of food colour for coloring soft drinks and desserts Leaves are also used as organic matter reducing health risk associated with artificial coloring. The Chakma and Marma tribes of Chittagong in Bangladesh use the tender shoots extract as curative measure for jaundice. Fruits and seeds are also used as curative measure for anemia and root extract is used to get relief from itching (Rahim et al., 2015). Blood fruit are highly valued by valued by the Garo tribe in Meghalaya because of rich iron content of the fruits. The fruits are used to treat anemic or blood related disorders. Ripe fruits are sliced and soaked in a glass of water overnight and taken as medicine the next morning (Momin *et al*., 2018). They also use this fruit for preparing wines. In Tripura, the fruits are being used as a dye in coloring the handicrafts and also in preparation of squash. Processed products like pickles and chutneys are also prepared from green fruits. In spite of their potential, this underutilized plants that have still not been properly addressed for their nutritional issues and are still greatly neglected in daily diets (Momin *et al*., 2018).

Why processing of blood fruit is a must

Blood fruit consist of very low pulp content. The pulp of the fruit along with peel contribute to about 58.72 % of the fruit weight, single seed constituted to 41.28 % indicating its potential in processing industry (Sangma, 2017). This fruit is highly perishable and has short shelf life i.e., 4-5 days at room temperature. It spoils rapidly during harvesting, storage and transportation due to surface bruising, senescence and surface microbial decay (Sasikumar *et al*., 2017). As the fruit cannot be stored for a longer period of time one of the best option to overcome these problem are by

processing them into products like wine. Considering the important of this fruits seasonal products should be processed for consumption during off-season.

Materials and Methods

The experiment was conducted in the Department of Horticulture laboratory, North Eastern Hill University, Tura, Meghalaya in year of 2017-2019 with a view to analyze the physico-chemical characteristics of blood fruit. The freshly ripened blood fruits were collected from Chitoktak area, Tura, West Garo Hills, Meghalaya. The good quality fruits were selected for the experiment. Fruits were washed under running water to remove the adhering dust and other impurities from the surface. Blood fruit are also processed into wine after the analysis of physical and chemical properties of the fruit. They are then fermented using bamboo container.

Results and Discussion

Physical properties of blood fruit

Various physical properties of blood fruit were determined and results are presented as under:

Sl. No.	Physical parameter	Content	Sl. No.	Physical parameter	Content
1	Fruit weight (g)	21.34	7	Shape of fruit	Round/ ovoid
2	Fruit length (cm)	3.87	8	Colour of pericarp	Red
3	Fruit width (cm)	2.90	9	Colour of Mesocarp	Blood red
4	Seed weight (g)	5.00	10	No. of fruits per bunch	50-80
5	Seed length (cm)	2.59	11	Juice (%)	19.41
6	Seed width (cm)	1.70			

The study on the morphological characteristics of this plant was conducted and studies revealed that the plants have a climbing growth habit, tall and fruit are drupe and shapes were recorded to be round to ovoid with very thick skin and are borne in grapelike, pendent clusters. The average weight of the fruit is around 21.34 g, 3.87 cm long and 2.9 cm width. The fruits seed weight around 5g, seed length of 2.59 cm and breadth of 1.70 cm. The colour of blood fruit changes from light green to dark red colour when ripe. Colour of pericarp and mesocarp were observed as red/pink and dark red or blood red. Number of fruit per bunch ranges from 50-80 fruit per bunch and colour of pericarp and mesocarp were observed as red/pink and dark red or blood red. The results are more or less similar with results given by Momin *et al.,* 2018, Rahim *et al.,* 2015 and Sangma, 2017.

Chemical composition of blood fruit

The data containing various chemical and nutritional compositions of the fruit are illustrated as under:

Sl. No.	Parameter	Content	Sl. No.	Parameter	Content
1	TSS (ºBrix)	14.5	7	β-carotene (IU)	138.42
2	Total sugars (%)	7.14	8	Anthocyanin (mg/100g)	195.93
3	Reducing sugar (%)	4.54	9	Total soluble protein (%)	7.60
4	Non-reducing sugar (%)	2.47	10	Total carbohydrates (%)	8.68
5	Acidity (%)	0.26	11	Starch (g/100g)	0.23

6	Ascorbic acid (mg/100g)	5.33			

The amount of TSS, Total sugar, reducing sugar and non reducing sugar content of this fruit are 14.5 ^{O}Brix, 7.14 %, 4.54 % and 2.47 % respectively. The amount of sugar content increases as the fruit ripe Fresh fruit content sugar in the range of 2- 30 % (Norman 1976). The fruit is acidic in taste when unripe but as the fruit ripe it is sub acidic and gives a pleasant flavor. In the present study, it was found that the fruit has about 0.26 % titrable acidity in term of citric acid, 5.33 mg/100 g pulp ascorbic acid which was similar with the work done by Sangma, 2017. Roktogota fruit content about 7.60 % protein in dry weight basis. This finding is similar with the findings of Sangma, 2017. Blood fruit also content trace amount of starch (0.23 g per 100 g of fresh weight). Blood fruit is also a good source of β-carotene. The fruit content about138.42 IU β-carotene. In the about 8.68 % in dry weight basis. Similar findings were reported by Rahim *et al*., 2015, Francis *et al*., 2017, Khatun *et al*., 2014 by Momin *et al.,* 2018, Rahim *et al.,* 2015 and Sangma, 2017. In the present study carbohydrates concentration of the fruit ranges about 8.68 % in Dry weight basis. The results were comparable with data reported by Rahim *et al*., 2015, Francis *et al*., 2017, Khatun *et al*., 2014. This fruit showed the high amount of energy 50 kcal/100g due to its high carbohydrate content. The fruits have high anthocyanin content which gives true blood red colour, which can be used as a natural coloring agent and natural additive dye for food products reducing health risk associated with artificial coloring (Singh *et al.,* 2014). Anthocyanin's are water-soluble natural phenolic and possess coloring and therapeutic properties. In present study, the total concentration of anthocyanin in the investigated fruits was found to be about 195.93 mg/100 g. The findings were similar to the observation made by Singh *et al.,* 2014. Bohra *et al*., 2020 reported that in blood fruit the dominant anthocyanin was Pelargonidin followed by Cyanidin, Peonidin and Petunidin.

Conclusion

Biochemical analysis of ripe fruits revealed that the fruit contain good amount of iron, ascorbic acid, β-carotene and anthocyanin's Consumption of blood fruit can help in overcoming iron deficiency problems and also anemia related disorders. As the edible portion *i.e.* the pulp content lower amount of nitrate and oxalate as compared to the seeds and in a safe health limit for consumption indicates its potential for use in processing industries. Processing is one of the important aspects as it helps to reduce post harvest losses and can be store to be used during off-season

References

Blessymole, K. A., Koshy, E. P. and Thomas, G. (2017). Alkaloids of the Ethnic Fruit Crop Khoonphal [*Haematocarpus validus* (Miers.) Bakh. f. ex Forman] from Andaman and Nicobar Islands. *Int.J.Curr.Microbiol. App.Sci*, **6**(12): 2797-2802.

Bohra, P., Waman, A. A. and Roy, S. D. (2016). Khoon phal (*Haematocarpus validus* (Miers.) Bakh. Ex F. Forman) CRPAB/Underutilized Species/T.B.-01, ICAR-CIARI, Port Blair, 1-8.

Bohra, P., Waman, A. A., Roy, S. D. and Shivashankara, K. S. (2020). Blood fruit (*Haematocarpus validus* (Miers.) Bakh. f. ex Forman). A novel source of natural food colourant. *Journal of Food Science and Technology*, **57** (1): 381-389.

Momin, K. C., Suresh, C. P., Momin, B. C., Singh, Y. S. and Singh, S. K. (2016). An ethno-botanical study of wild plants in Garo Hills region of Meghalaya and their usage. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, **2**(1): 47-53.

Rahim, M.A., Khatun, M. J. M., Rahman, M. M., Anwar, M. M and Mirdah, M. H. (2015). Study on the morphology and nutritional status of Roktogota (*Haematocarpus validus*)-an important medicinal fruit plant of hilly areas of Bangladesh. *International Journal of Minor Fruits, Medicinal and Aromatic Plants***, 1**(1): 11-19.

Sangma, F. A. (2017). Standardisation of fermented beverage from beet root and blood fruit. M.Sc. Thesis submitted to North Eastern Hill University, Tura Campus. Meghalaya.

Sasikumar, R., Vivek, K., Chakaravarthy, S. and Deka, S. C. (2017). Effect of Post-harvest Quality Parameters on Ultra-Sonication Treatment of Khoonphal (Haematocarpus validus) of Meghalaya, North-East India. *J Food Process Technol.*, **8**: 668.

Singh, B. and Bedi, Y. S. (2016). Rediscovery, taxonomic history and extended enumeration of *Haematocarpus validus* Bakh. f. ex Forman (Menispermaceae) to Indo-Myanmar biodiversity hot-spot. *National Academic Science Letter*, **39**(5): 383-387.

Singh, D. R., Singh, S., Salim, K. M. and Srivastava, R. C. (2012). Estimation of phytochemicals and antioxidant activity of underutilized fruits of Andaman Islands (India). *Int J Food Sci Nutri*. **63**: 446-452.

Singh, D. R., Singh, S. and Shajeeda, B. V. (2014). Estimation of phytochemicals and determination of beta carotene in Haematocarpusvalidus, an underutilized fruit of Andaman and Nicobar Islands. *European Journal of Environmental Ecology*, **1**(1): 12-15.

Chapter – 13

Hidden Hunger and Fortification

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The world today faces the 'triple burden' of malnutrition viz. under nutrition, over nutrition and micronutrient deficiency. Although micronutrient deficiencies are twice as common as under nutrition, its symptoms are generally seen only when it becomes severe and as such the deficiencies remain 'hidden' although they continue to hamper the growth and development of a person. Due to this phenomenon, micronutrient deficiency is also referred to as 'hidden hunger'. The common causes of rampant prevalence of micronutrient deficiencies are commonly considered to be due to unavailability of food, poor diet *i.e.* diet which are deficient in certain nutrients, disease conditions interfering with the absorption and metabolism of micro nutrients, increased needs which are not met during certain physiological conditions such as pregnancy and lactation. The lack of micronutrients leads conditions such as anemia in iron deficiency, blindness in Vitamin A deficiency, poor growth and stunting in children in zinc deficiency, goitre, mental retardation, cretinism, abortion, still birth in iodine deficiency, rickets and osteomalacia in vitamin D deficiency etc. In the world today, there are 2 billion people who are suffering from micronutrient deficiency i.e. 1 in every 4 individual. In India, 58.4% of children in the age group of 6 to 59 months, and 53.1% of pregnant women are anemic.

To address the problems of hidden hunger, various options such as dietary diversification, giving food supplements and food fortifications are explored. Dietary diversification is the method of ensuring a healthy diet that contains a balanced and adequate combination of macronutrients, essential micronutrient and other food-based substances such as dietary fiber. It is one of the most effective and sustainable method of preventing hunger, but the disadvantage remains in the fact that it requires a long period of time to implement as it involves the change in people's food habit and preferences. Consumption of food supplements such as micronutrient rich capsules remains an option but the low purchasing power of the poor hampers its success. Food product fortification is the process of addition of vitamins and minerals such as iron, iodine, zinc, vitamins A and D to staple food such as rice, wheat, oil salt etc to improve the nutrient content.

These nutrients may or may not have been originally present in the food before processing or may have been lost during processing and It does not alter the characteristics of the food like the taste, aroma or the texture of the food. Some of fortified food available in India are such as fortified salt (iron and iodine), fortified wheat (iron, vitamin A, folic Acid), fortified rice (iron, folic acid, vitamin B 12), fortified milk (vitamins A and D) and fortified oil (vitamins A and D). Constraints such as lack of better infrastructure, efficient technology, and a reliable distribution system has made it an unattainable option at a large scale. A new method of fortification called bio-fortification has been introduced to overcome the aforementioned hurdles. Bio-fortification is the process by which the nutritional quality (increase in nutrient level) of food crops is improved through, agronomic

practices, conventional plant breeding or modern biotechnology and the breeding methods used is selective breeding, seed priming and genetic modification. The benefits seen with bio-fortified foods are –

1. Increased micronutrient levels in staple crops, which can then help prevent and reduce the micronutrient deficiencies in the poor. *e.g.* In a trial in Mozambique, eating sweet potatoes bio-fortified with beta-carotene reduced the incidence of vitamin A deficiency in children by 24%.
2. Ability to reach the country's most vulnerable people living in remote rural areas with no access or money for commercially marketed fortified foods.
3. It is cost effective.
4. Bio-fortification is sustainable as it produces higher yields in an environmentally friendly way.

India under its the nutrition security has bio-fortified cereals (rice-protein and zinc rich varieties, wheat-zinc, protein and iron rich varieties, maize-pro-vitamin-A, lysine and tryptophan rich varieties, millet-iron and zinc rich varieties), pulses (lentil-iron rich variety), fruits (pomegranate- iron, zinc and vitamin-C rich variety) and vegetables (mustard-low erucic acid and low glucosinolate varieties, cauliflower-β-carotene rich variety) are available.

References

Yadava, D. K., Hossain, F., and Mohapatra, M. (2018). Nutritional security through crop bio-fortification in India: Status & future prospects. *Indian Journal of Medical Research*. **148**: 621-631.

The Hindu (2020). Bio-fortification. Retrieved from https://www.manifestias.com/2020/05/15/biofortification/

Kumar, N. and Kumar, A. (2020). The Bio-fortification: A plausible antidote to hidden hunger. Retrieved from https://www.financialexpress.com/opinion/biofortification-a-plausible-antidote-to-hidden-hunger/1800317/

Singh, A. K. (2017). Nutritional security through crop bio-fortification. ICAR-Indian Agricultural Research Institute, New Delhi.

Programme

S. No.	Topic	Speaker	Address	Timing
	Inaugural Session			
1.	Welcome address and about the webinar	Dr. A. K. Pandey	Dean CoH&F, RLBCAU, Jhansi	10:30-10:35 am
2.	Address	Dr. Madhab Chakraborty	Joint Director , Indian Institute of Packaging, New Delhi	10:35-10:55 am
3.	Keynote address	Dr. Anil Kothari	Hon'ble DG, MP Council of Science and Technology, Bhopal	11:00-11:20 am
4.	Presidential address	Dr. Arvind Kumar	Hon'ble VC, RLBCAU, Jhansi	11:25-11:45 am
5.	Vote of Thanks	Dr. Gaurav Sharma		11.45-11.50AM
	Technical Session			
6.	Transforming Indian Agriculture to transform India: role of food processing	Dr. P.K. Srivastava	IES, Univ., Bhopal	11:50 am-12:10 pm
7.	Promising PHT in processing for value addition in fruits and vegetables	Dr. R. A. Singh	IARI, New Delhi	12:15-12:35 pm
8.	Advances in value addition of vegetable crops	Dr. Sudheer Singh	IIVR, Varanasi	12:40 - 1:00 pm
9.	Contract farming for un-interrupted supply of fruits and vegetables to processing industry	Dr A. K. Pandey	RLBCAU, Jhansi	1:05-1:25 pm
10.	Packaging Techeology	Dr. Madhab Chakraborty	IIP, New Delhi	1:30-1:50 pm
11.	Mushroom Cultivation, processing and Entrepreneurship Development	Dr. Anita Tiwari	MPCST, Bhopal	1:55-2:15pm
12.	Nutraceutical Properties of Blood Fruit	Dr. A. K. Chaurasiya	NEHU, Meghalaya	2:20 -2:40 pm
13.	Recent advances in Processing and value addition of Jackfruit	Dr. Piloo Ngangbam	CAU, Imphal	2:45-3:05 pm
14.	Food Fortification and Hidden Hunger	Dr. Theloni Vida	CAU, Imphal	3:10 -3:30 pm
15.	Recent advances in processing and value addition in flowers	Dr. Gaurav Sharma	RLBCAU, Jhansi	3:35-3:55 pm
16.	Boosting immunity through processed enriched products	Dr. Amit Kumar Singh	RLBCAU, Jhansi	4:00-4:20 pm
17.	Innovation in Post harvest technology for Maintaining Quality of Fruits and Vegetables	Dr. Ghan Shyam Abrol	RLBCAU, Jhansi	4:20-4:40 pm
18.	Application of Nano-technology in food processing and packaging	Dr Abhishek Kumar	RLBCAU, Jhansi	4:45-5:05 pm
	Discussion			
19.	**Vote of Thanks**	Dr. Gaurav Sharma	RLBCAU, Jhansi	5:05-5:10 pm