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Advances in processing and post-harvest management of indigenous vegetables

Presently the value addition in vegetable sector is 2.2% and large quantities of vegetables (4.58-12.44%) amounting to ₹ 14,842 crore in 2014 (CIPHET Report, 2015) perish due to poor post harvest management and lack of suitable processing facilities. There is an urgent need of effective postharvest management practices and low cost processing technologies for handling large quantities of vegetables to produce cost effective value added processed products.

Challenges and prospects of Indigenous vegetable processing in India

Urban population in cities is demanding newer processed ready-to-eat and easy-to-cook form of vegetables due to rapid change in the eating habits of the urban population. There are 350 million strong urban middle class population which demand large quantities of processed vegetable products depending upon the taste. Ministry of Food Processing Industries, Govt. of India has introduced number of schemes for providing financial assistance for setting up modern vegetable processing units, building infrastructure, supporting R & D and skill development to encourage growth of vegetable processing sector. Our national policy also aims to increase the present level of processing from 2.2% to 25% by 2025. Vegetable processing level is alarmingly very low as compared to 35% level of processing in milk, 20% of buffalo meat, 26% of fish and 6% of poultry meat. There is an urgent need to address the problem related to low processing in vegetables as compared to large production and subsequently low return to producers due to low price of vegetables in peak production. Our infrastructural facilities in terms of post harvest management in vegetables are very poor which needs greater attention both from public and private sectors.

Vegetable processing challenges

- **Cold chain management:** Presently there are 7,645 cold storages in India with the capacity of 34.5 million tonnes against the required capacity of 61.13 million tonnes. Majority of cold storages are meant for storage of potato having optimum storage temperature of 2-4°C and 90-95% RH. Moreover, vegetable production is confined in villages and cold storages are constructed in cities. However, storage conditions would lead to chilling injuries in majority of vegetables during storage.
- **Lack of mechanized sorting/grading facility:** There have been no mechanized grading/sorting facilities for vegetables in many vegetable markets in India. Only handgrading/sorting facilities exist in vegetable markets which is cumbersome and time consuming. Furthermore, it is inefficient for the grading of large volumes of vegetables.
- **Non availability of varieties suitable for processing:** Vegetable breeding programme in public and private sector is confined mainly to develop varieties for higher yield. There is no serious thinking towards breeding programme for improvement in quality and more precisely for varieties suitable for processing. There have been no linkages among farmers, public institutions and processing industries. Many leading processing industries such as ITC, Heinz and Kisan are still importing tomato paste and tomato puree from China and European countries. Many public institutions can play big role in promoting their varieties suitable for processing.
- **Optimum harvesting stage of vegetables:** Vegetables attain maximum sensory perception during certain stage of their growth in terms of sensory qualities such as flavour, colour and appearance and overall acceptability. Harvesting of vegetables should be done at optimum maturity stage.
- **Complete value chain of vegetables:** There should be complete package of practices for product and by product utilization for sustainability as well as for better return to processing industries.

Post-harvest management practices of important indigenous vegetables in India

Pre-harvest practices also play an important role in the quality of harvested vegetables. The increased application of nitrogen fertilizer adversely affects the quality in terms of sensory perception as well as shelf life of vegetables. Apart from fertilizer, the quantity of irrigation as well as its duration also plays an important role in quality of vegetables. Harvesting time of vegetables is also very important. Vegetables should be normally harvested before maturity for obtaining the maximum sensory perception of the vegetables. It is also important that harvesting should be carried from the day of anthesis so that batch to batch quality variation gets be minimized. Some important post harvest management practices are as follows:

i) **Harvesting time:** The vegetables should preferably be harvested before sunrise or after sunset. Respiratory activity of vegetables is increased after harvest of vegetables. This leads to increase in temperature and adversely affects the quality of harvested vegetables. The harvesting time of few vegetables is documented with respect to attaining maximum quality. Eggplant is harvested 13-14 days after anthesis.

ii) **Sorting/grading:** The vegetables after harvest should be sorted/graded on the basis of size, shape and colour. The diseased vegetables should be discarded as it would spoil the whole lot of vegetables. Proper sorting and grading would fetch good return to producers.

iii) **Washing:** The vegetables should be washed thoroughly in potable water after harvest. This will reduce the temperature of the harvested vegetables as well as reduce the bacterial load of the vegetables as many vegetables are in direct contact of soil.

iv) **Maintenance of low temperature:** Vegetables after harvest should be maintained at desired low temperature to reduce the respiratory activity so that biochemical changes after harvest can be minimized. It is generally advisable that vegetables should be stored at a temperature above the chilling injury. All the vegetables have definite storage temperature at which there has been maintenance of maximum sensory perception as well as maximum shelf life. Many cucurbit vegetables such as sponge gourd, ridge gourd are preferably stored at 12-14°C to attain maximum shelf life and quality attributes.

v) **Edible coating:** Edible coating provides partial barrier to moisture and gas, especially carbon dioxide and oxygen exchange. Coating on the surface of vegetables improves mechanical handling properties, thus, retaining volatile flavour compounds and carrying food additives containing anti-microbial agents and anti-oxidants properties. The basic purpose of edible coatings for indigenous vegetables is enhancing the natural barrier properties or replacing with a new barrier in which handling and washing is partially removed or altered. Proteins, lipids and polysaccharides are commonly the main constituents of edible films and coatings. Among the commonly used protein-based edible coating, wheat gluten, corn zein, soy proteins, rice proteins, egg albumin and milk proteins are generally used as coating in vegetables. Polysaccharide-based edible coatings, such as alginate, pectin, cellulose and derivatives, starch and sucrose polyesters, have been used for extending the shelf life of indigenous vegetables. To extend the shelf life of perishables, lipids as well as resins are also used for extending the shelf life of harvested vegetables. Shellac resin, mostly produced in central India, is a secretion by the insect *Lacifer lacca*. This resin is composed of a complex mixture of aliphatic alicyclic hydroxy acid polymers, such as aleuritic and shelloic acids. This resin is soluble in alcohols and alkaline solutions. It is also compatible with most waxes, resulting in improved moisture barrier properties and increased gloss on the coated surface. It is permitted as an indirect food additive in food coatings and adhesives. The shellac coating emulsion is prepared by dissolving dewaxed and bleached shellac in alkaline aqueous medium with the addition of polyvinyl alcohol as binding and coating agent. Binder and defoaming agent is added to make stable emulsion after adding hot water, triethanol amine as surfactant and oleic acid as lubricant. Sodium alginate or carboxy methyl cellulose as thickener is added for effective and stable coating on the surface of fruits and vegetables.

Application

The shelf life of shellac coated pointed gourd is increased to 15 days at refrigerated storage as against 6–8 days of control pointed gourd during refrigerated storage. There has also been significant increase in shellac coated eggplant during ambient storage. As compared to 2–3 days of control eggplant during ambient storage, the shelf life of shellac-coated eggplant is increased to 7 days. There has been increase in physiological loss in weight from 6.0 to 25.7% and increase in total solids from 8.5 to 11.9% after 7 days of ambient storage. There had been 35–40% decrease in texture and 50–55% in antioxidant activity.

Potential vegetable processing technologies for commercial usage

The use of appropriate post-harvest technology reduces the post-harvest and storage losses, adds value to the product, generate employment in village and promote establishment of agro-industries in rural sector. Presently,

Shellac coated pointed gourd and brinjal

the farmers sell their products without processing. If they do primary processing and value addition in the villages, it will generate more income and employment in rural sector.

i) **Dehydration:** The drying operation in convection type of heating involves moisture transfer from wet material to heated air, which may be reflected as a transport of moisture from the material core to its surface, followed by evaporation from the surface of the material and dissipation of water vapour into the bulk of the drying air. Drying as such without suitable additive treatments causes irreversible structural damage to the cellular structure of vegetables. The damage to the cellular structure further prevents proper drying, and rehydration of dried products as well as quality of dried vegetables is adversely affected. The terms dried and dehydrated are used interchangeably, USDA lists dehydrated foods as those which contain no more than 2.5% water (dry basis), whereas dried foods apply to any food product with more than 2.5% water (dry basis). Vegetables and their products are dried to enhance the storage stability to minimize the packaging costs due to bulk reduction and to reduce the transportation cost. Nonetheless, in India, vegetables are dried on mechanized dryers at a very small scale. Still majority of drying is preferred as sun drying in rural areas of India. Drying process has not gained much popularity in India as consumers have biggest concern on the perception of nutritional and sensory qualities of dried vegetables and majority of Indian consumers are satisfied with homemade vegetable dishes. Furthermore, availability of many important vegetables throughout the year has also led to less demand of consumers for preferring dried vegetables. Drying processes can be channelized to improve the sensory perception of vegetables in terms of flavour, colour and body and texture of rehydrated vegetables along with handling of large quantities of vegetables during peak season of production. This would prevent the enormous post-harvest losses of perishable vegetables and would help in maintaining nutritional security as well as prevent the high prices of off season vegetables. Consumers today are highly pertinent to quality and safety of processed food products. Therefore, alternate technologies which offer convenience of traditional drying without compromising on quality are of much demand. The technologies include low-temperature drying, freeze drying and vacuum drying. The most applicable method of drying includes freeze, vacuum, osmotic, cabinet or tray, fluidized bed, spouted bed, microwave and combination thereof. These are the basic techniques to force water to vaporize, whereas forced air is applied to encourage the removal off the vapour. A large number of food and biomaterials are dehydrated in a variety of units with diverse processing conditions. The choice of drying method depends on various factors such as the type of product, availability of dryer, cost of dehydration and final quality of desiccated product. Energy consumption and quality of the dried produces are other critical areas in the selection of a drying process. To reduce the cost of fossil fuel, electrical energy is an alternate source of energy for drying applications, especially in which electricity is generated by a renewable energy source such as hydropower or wind power. 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 groups 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. Osmo-air drying of bitter gourd slices, cauliflower, carrot, okra, broccoli, cabbage, cow pea and ivy gourd slices during osmotic diffusion treatment in 5-10% salt solution at 40–60°C osmotic diffusion treatment for 2-3 hours followed by drying at 65-70° C for 6-8 hours. The effectiveness of drying technology requires the treatment of vegetables with permissible additives to ensure good rheological, sensory and rehydration properties.

ii) **Steeping preservation:** Vegetable production in India is seasonal and production of indigenous vegetables exceeds the demand during peak season of production, hence the producer is bound to dispose the perishable horticultural crops in no time of storage. Large quantities of vegetables during peak season of production can be preserved in steeping solution consisting of permissible chemical preservatives and other food additives which is non-thermal and alternate to processing technology with considerable scope for adoption at rural sector by women. Consumers are more conscious of health benefits and are demanding additive free processed food products. Food Safety Standards Authority of India (FSSAI) is regularly monitoring the level of the permitted food additives and some of the permitted additives are either deleted or the level is reduced depending upon nature of health hazards associated with additives. However, the steeping treatment involves the use of permitted additives at a low level of maximum permissible limit and at the same time it should not affect the sensory and nutritional properties of the product and should also be convenient and economical to use.

iii) **Ready-to-eat convenience vegetables:** Convenience foods refer to the category in which foods have undergone major processing by the manufacturers such that these type of products require no secondary processing and cooking before consumption. The choice of the day can be designed to suit all segments of population including armies, airways, railways and even patients with suitable supplement. The demand for convenience food is growing at a faster pace due to changes in social and economic patterns, as well as increase in urbanization, buying power and awareness about health foods, changes in meal pattern and existing food habit, desire to taste new products, etc. The consumer preference is focused towards convenient form of food products which are

Easy-to-cook spinach leaves

Easy-to-cook *Bassela* leaves

easy to procure and consume instantly. Hence, the vegetables can be suitably processed in ready-to-eat convenience form such as processing the vegetables for chips production.

iv) **Easy-to-cook leafy vegetables:** Large quantities of indigenous leafy vegetables spoil due to rapid loss of moisture. Leafy vegetables such as spinach and *Bassela* can be developed in the form of easy-cook-leafy vegetables. Leafy vegetables after sorting, cleaning and washing are blanched with permitted additives followed by osmotic diffusion treatment and subsequent drying at 50-55°C for 7-8 hours to reduce the final moisture to less than 1.0%. These dried leafy vegetables can be effectively preserved in polyethylene pouches for 6-8 months at ambient storage.

v) **Bio-preservation of vegetables:** The bio-preservation of vegetables in common salt or in vinegar is known as pickling. It is one of the most ancient method of preserving vegetables. Pickles are either manufactured at cottage or home scale as well as commercially manufactured and exported. Pickling is the result of fermentation by lactic acid bacteria which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acidic medium and in the presence of 8-10% salt solution, whereas the growth of majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30°C, so this temperature must be maintained as far as possible in the early stage of pickle manufacturing process. When vegetables are placed in brine, it penetrates into the tissues of vegetables and soluble material present in vegetable tissues diffuses into brine solution by osmosis. The soluble material basically includes fermentable sugars and minerals. The fermentable sugar is broken down by lactic acid bacteria which convert them into lactic and other acids. The acid brine, thus, formed acts upon vegetable tissues to produce characteristic taste and aroma of pickle.

Prospects of vegetable processing

India has strong supply base of indigenous vegetables. Considerable international demand of fresh and processed vegetables has placed big opportunities and challenges to the processors to produce nutraceuticals rich processed vegetables to consumers. The vegetable processing prospects can be focused due to following reasons:

- Fast growth in organized retail over the last two decades which acted as catalyst for increasing the growth similar to west.
- Consumer fast demanding trend convenience types of vegetables such as easy-to-cook and ready-to-eat vegetables.
- Global shift to outsourcing from India across products/ services to many countries in world.
- Deregulation and liberalization of the Indian economy helped to promote many new processed vegetable products in the market.

Projection of Indian Food Industry

The Indian food industry is projected to grow from US $100 billion to US $ 500 billion by the end of 2025. During this period, the share of processed food in terms of value is expected to increase from 43% to 50% of total food production. The food processing industry is of enormous significance for India's development as it has efficiently and effectively linked the nation's economy, industry and agriculture. The indigenous vegetable processing industry is highly decentralized and a large number of units are in cottage, household and small scale sectors, having small capacities of up to 250 tonnes per annum. In contrast to small scale processing, multinational companies are processing 30 tonnes per hour. Since 2000, the food processing industry has seen a large growth in ready-to-serve beverages, fruit juices and pulps, dehydrated and frozen fruits and vegetable products, pickles and ready mix vegetables.

Challenges and opportunities in indigenous vegetable sector

In view of huge post-harvest losses in indigenous vegetables and losses of valuable life protecting bioactive compounds, huge potential exists in safer environmental friendly post-harvest treatment in vegetables. Due to change in lifestyle and rapid growth in urban sector, the demand for processing in indigenous vegetable sector is increasing. Many low cost processing technologies have been focused to make the processed products affordable to a large section of population. In this regard, edible

coating in the form of carnauba wax and shellac based coating can make indigenous vegetables more attractive in the form of glossy appearance with much reduced respiration and transpiration thereby increasing the shelf life of vegetables to the greater extent. The demand of cut, core and sliced form of vegetables is quite high due the less time for processing and change in socio economic status of urban consumers. Minimal processing can be very effective for handling of vegetables with good safety measures for controlling of food borne diseases of Salmonella, Shigella, *Escherichia coli*, etc. Apart from traditional vegetable processing such as drying, canning, freezing, juice extraction and concentration etc., vegetable sector have huge potential to fuel the growth of food processing in India. Some potential future areas which require utmost importance are as follows:

- Nutraceuticals industry
- Ready-to-eat industry
- Cut fruit and vegetable industry
- Post harvest treatment in indigenous vegetables
- Development of low cost indigenous vegetable processing machines

Marketing problems and opportunities

A very large amount of indigenous vegetables get perished because of poor marketing infrastructure. The perishable nature of the produce and the careful handling needs are the major challenges to be attended with utmost care. Unlike milk, indigenous vegetables need a far different technological approach with regard to storage and marketing. There have been acute shortages of cold chain facility in rural and peri-urban areas where the availability of indigenous vegetables is surplus. Lack of preservation facilities leads farmers to sell their produce at unconsciously low prices during peak season. The States and Central Government should take concreted steps to resolve the situations of the farmers. The establishment of agro parks in many states has tried to solve the problem to a greater extent. However, these agro parks are used for other purposes because of the lack of enthusiasm from entrepreneurs. In recent years, the Ministry of Food Processing Industries is taking big strides to solve these ironical problems related to processing and marketing of perishable vegetables. In the west, the bulk of vegetables are processed and the scale of the processed food industry is so large that it can sell processed foods much cheaper than fresh vegetables. In the western markets the fresh vegetables are relatively expensive due to large demand and preference towards fresh vegetables. In dairy sector, farmers get 66% of the price which consumer pay for milk whereas in vegetable sector, farmers get less than 20% of what the consumers pay. This is quite clear that the price elasticity in dairy sector is more as compared to fruits and vegetable sector. Many big private players are joining regularly and posing challenges to public sector in dairy sector. However, the time has come for replicating the business of dairy sector into vegetable processing sector.

Major challenges for the processed vegetable industry

- Consumer education that processed vegetables can be more nutritious
- Low price-elasticity for processed vegetable products
- Need for distribution network and cold chain
- Backward-forward integration from farm to consumers
- Development of marketing channels of processed products
- Development of linkages between industry, government and institutions
- Streamlining of food laws

Innovative ideas in indigenous vegetable sector

- Focus on market build quality brands at low cost product development
- Focus on traditional food processing and technology such as low cost chapatti making technology, long shelf life idli/dosa batter, low cost large scale drying technology, efficient low cost cool chain management, focus on low cost food equipment design and R&D
- Focus on self-help group infrastructure development to meet the local demand
- Close association of food industries with public sector institution for solving the need based problem
- Focus on nutraceuticals industry to reduce the burden on healthcare industry
- Focus on refinement in zero energy cool chamber structure for long term usage
- Focus on concentrating Brand India concept to popularize the product.

SUMMARY

The processed indigenous vegetable industry has great potential to realize the agricultural resources. There has been a huge challenge to our industry to increase the processing of the perishables to provide sufficient growth to the global trade by adding increased value to the end products. The Ministry of Food Processing, Govt. of India, also intends to increase the processing of horticultural crops from 2% to 20%, value addition from 7% to 35% and share of global trade from 1% to 3%. Farmers particularly women in rural sector can play a crucial role to give a boost in the processing of perishable products at small sector. There is an urgent need to support farmer-managed rural production and marketing ventures in horticulture, and post-harvest processing and to provide technology training and input support to farmers to take advantage of emerging high-value agribusiness sector. Agro-processing particularly indigenous vegetable processing can generate employment for whole family of farmer so that farmer's income can be increased. Harvesting of indigenous vegetables at proper stage of maturity, storage under cold chain management and suitable processing with assured marketing of processed products can increase the income of the farmers and it would be a step towards fulfilling the mission of our Honourable Prime Minister by doubling the farmer's income by 2022.

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