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Application of Novel Technologies in Fruits and Vegetable Processing Industry

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Abstract

India is the second-largest producer of fruits and vegetables globally; its vast production base offers massive opportunities for exports. Postharvest handling practices like harvesting, pre-cooling, cleaning or disinfecting, sorting and grading, packaging, storage, and transporting plays an important role in maintaining quality and extending shelf life of the fruits and vegetables after harvest. Post harvest losses of fruits can be defined as a loss in quantity or quality or both that occurs after harvest and till the produce reaches to the consumers. There may be physical loss, physiological loss or biological losses. To reduce these kinds of losses different processing, packing and storing methods are discussed in this paper.

Introduction

India is known to be a fruit basket of the world. India being the second-largest producer of fruits and vegetables facilitates the fruit and vegetable processing industry in acquiring its primary resources. Canning, dehydration, pickling, provisional preservation, and bottling are some of the methods used in fruit and vegetable processing which help increase the shelf life of seasonal fruits and vegetables. The fruit and vegetable processing industry in India is likely to expand at a compound annual growth rate (CAGR) of ~7.62% between FY 2018 and FY 2023 to reach a value of INR 256.4 Bn in FY 2023 (Dublin, 2019). Currently, commercial processing of fruits and vegetables is extremely low in India, at around 2.2% of the total production as compared to countries like the Philippines at 78%, China at 23% and the United States (US) at 65%. The unorganized sector witnesses a stiff competition, owing to the presence of a large number of players competing for small shares in the overall market. Organized players compete with each other to maintain their market share and gain brand loyalty.

India also has a geographical advantage being close to the key export destinations such as Africa, the Middle East, Oceania and Southeast Asia. During FY 2018 India exported 3,91,283.8 metric tonnes (MT) of processed fruits and vegetables across the world, which was worth INR 34.04 Bn.

The fruit processing industry in Asian nations is decentralized. An oversized variety of units are within the cottage/ home scale and small-scale sector, having little capacities up to 250 tonnes per annum, huge Indian and multinational corporations have capacities within the variability of 30-50 tonnes per hour just about. The distinguished processed things are unit fruit pulp and juices, fruit based mostly ready-to-serve beverages, canned fruits and vegetables, jams, squashes, pickles, chutneys and dehydrated vegetables.

More recently, merchandise like frozen pulps and vegetables, frozen, dried fruits and vegetables, potable concentrates and vegetable curries in restorable pouches, canned mushroom and mushroom products are haunted for manufacture by the business. The process level in Asian nations is calculable to be around two. This suggests that there's a vast market nonetheless to be broached by the fruit process corporations within the country. India's major exports are a unit in fruit pulp, pickles, chutneys, canned fruits and vegetables, concentrated pulps and juices, dehydrated vegetables and frozen fruits and vegetables. This sector too has large potential.

Value Addition of Fruits and Vegetables

These days, a lot of attention is being given to the health and nutrition of individuals. Today, consumers demand food products, which are nutritious as well as convenient to use. Lot of focus has been given to the food products having some additional health benefits, rather than the conventional products. Food powders contain the natural flavor and health benefits, rather than artificial food flavoring substances and they can be used as natural food additives. The uses of food powders are unlimited, and they can be used to prepare processed products as well as for culinary purposes. The processing of the food in the forms which are preferred by the consumer, have long shelf life and involve low cost of production. Studies need to be carried out to optimize the processing and storage of the food products by preventing the heat and oxidative damage on the antioxidants. Hence, it is necessary both to minimize the safety and shelf life of the products and generate an easy technology, which can be used in our agro climatic and processing conditions. Thus, in the investigation, a systematic approach was followed to develop and standardize the process for the preparation of dehydrated carrot powder, tomato and ginger powder, fenugreek leaf powder, potato flour, potato grits, granules, sweet potato powder etc.

Novel Technologies in Processing of Fruits and Vegetables

Fruits and vegetables are valuable sources of nutritionally important compounds. The aim of novel technologies is to preserve the bioactive compounds with minimal impact on sensory quality and to improve quality control and safety along the food chain. Besides that, the production of shelf-stable semi-fresh products, the reduction of food losses through increased shelf life, the reduction of energy and water use, the generations of food ingredients from by-products are also very important objectives. To achieve the above-mentioned goals new technologies, like sensor technology, sustainable packaging, nonthermal pasteurization and sterilization, nano and microtechnology, the utilization of rest and by-products, the application of low energy and

low water technologies as well as better knowledge transfer should be applied. Recent sensor technologies that include uni-molecular sensors, bio arrays, solid state sensors, optical and spectrographic sensors, radio frequencies and sensor networks are widely tested with encouraging outcomes.

In this way the quality and safety can be controlled more precisely during the storage of a particular product. Combining sensor technologies and producing physiology (so called dynamic control system) offers more accurate storage conditions requirement (content of O_2 and CO_2) to better preserve quality, the content of bioactive compounds and thus inhibit some physiological disorders without usage of phytopharmaceuticals. Non-thermal technologies (pulsed electric field, cold plasma, high hydrostatic pressure) all enable inactivation of microorganisms and enzymes with minimal impact on sensory properties.

Processing of Fruits and Vegetables under Pulsed Electric Field

Pulsed electric field (PEF) is one of the most explored non-thermal technologies applied in food processing. The principle of PEF is based on its ability to electroporate microorganisms' cell walls which results in their inactivation. Beside inactivation of microorganisms, PEF is also applied to electroporate fruit tissue in order to increase juice yield or extraction of certain compounds, applied PEF at strength of 3 kV/cm and 10 kV/cm to increase juice yield of orange (25%), pomelo (37%) and lemon (59%) as compared to untreated control. More phenolic compounds were also found in juice produced by means of PEF. Bioavailability of bioactive compounds relates to their bio-accessibility that is the fraction released from the food matrix and later available for intestinal absorption. Although PEF disintegrates cell walls, it found no improved bio-accessibility for β -carotene and lycopene from tomatoes. Extractability of intracellular compounds can be enhanced due to PEF-treatment which provokes reversible pore formation. Immediately after the treatment, the juice yield increased with the increased strength of the electric field between 0.3 and 2.5 kV/cm. They also found an increase of soluble solids and titratable acidity. Among cyanidins an increase of cyanidin glucoside and cyanidin rutinoside increased with increasing PEF strength. When comparing PEF and thermal pasteurization (TP) of orange juice, I found better quality of PEF processed juice. Among individual parameters, PEF processed orange juice had higher content of ascorbic acid but only when processed at the electric field strength of 17 kV cm^{-1} . PEF processing resulted in no formation of methyl furfural during or after processing. In general, significant differences between PEF and TP processing were found in pH, titratable acidity, total dry matter, and browning index during storage period.

Cold Plasma Technique

Plasma is considered the fourth state of matter that recently attracted food scientists as a tool for decontamination. Cold plasma proved to be the efficient technique for inactivating microorganisms in juice processing. In their experiment, we were experimenting with N_2 plasma at flow rates of 10, 30 and 50 mL/min and treatment times of 5, 10 & 15 min. Plasma with lower flow N_2 rates and shorter duration promoted a slight increase of ascorbic acid total polyphenol content and the antioxidant activity, while overexposure provoked a decrease of ascorbic acid, experimented with cold plasma on anthocyanin stability in pomegranate juice. They found the greatest stability when employing moderate operating conditions, i.e. shorter treatment time (3 min), lower N_2 flow (3.5 L/min); comparing cold plasma pasteurization with TP of chokeberry juice, found significantly better stability of hydroxycinnamic acids but lower stability of anthocyanins in plasma treatment. In initial experiments cold plasma was effectively used to inactivate microorganisms on food surfaces, demonstrated that a direct contact between bacterial cells and plasma is not necessary to achieve adequate inactivation. They inactivate *Citrobacter freundii* in apple juice by about 5 log cycles, exposure time was 480 s using argon and 0.1% oxygen. In their study, it was shown that osmotic stress (NaCl) and suboptimal pH influence the efficacy of cold plasma to inactivate *Salmonella typhimurium* and *Listeria monocytogenes*. Namely, when *Salmonella typhimurium* and *Listeria monocytogenes* are grown under osmotic stress or suboptimal pH, both microorganisms becomes more resistant to plasma treatment.

Dynamic Atmosphere Method

To prolong storage life of fruit, storage conditions, that reduce fruit metabolism, should be applied. That includes low temperature (0 °C) and controlled atmosphere (reduced O_2 , elevated CO_2). At the beginning-controlled atmosphere consisted of around 3% of O_2 and 3% of CO_2 for most of climacteric fruit. With the progress of storage technology, O_2 and CO_2 concentration was lowered to 1% and was named ultra-low oxygen (ULO). Storage technology was developing further with O_2 amounting to 0.5%. That O_2 concentration may bring fruit to anaerobic metabolism, longer exposure of fruit to anaerobic metabolism may be detrimental to fruit quality. To prevent detrimental effects, a dynamic atmosphere was introduced where O_2 concentration is maintained at around 0.5% till anaerobic metabolism appears. Storing fruits in a dynamic atmosphere generally maintains fruit quality better than ULO. Quality parameters like firmness, titratable acidity and ground colour are better preserved under dynamic atmosphere. One important advantage is that dynamic atmosphere controls some physiological disorders like superficial scald. The mechanism to monitor the possible appearance of anaerobic metabolism

includes the method based on chlorophyll fluorescence. On the other hand, developed dynamic controlled atmosphere storage based on the respiratory quotient (RQ-DCA). The RQ-DC manages to control O_2 and CO_2 partial pressures in storage cells in an autonomous way.

Nanotechnology Applications

Nanotechnology is finding applications in the food sector as nanosensors, new packaging materials and encapsulated food components. This technology enables better solubility, improves bioavailability, controlled release and prevents bioactive compounds against deterioration. From a microbiological point of view, nanomaterials possess antimicrobial activity against bacteria. Nano sensors applied with polymers used to monitor pathogens and chemicals are of special interest. Sensors are able to detect toxins, microbiologically derived degradation products (H_2S) and thus track the product's history and expiration date.

Sustainable Packaging Methods

Packaging of fruit and vegetables is one of the important technological solutions for maintaining the quality, the content of biologically active substances and the safety along the food chain. Very important concept is so called "sustainable packaging", which anticipates the use of packaging to reduce food loss and maintain quality, the minimum packaging costs for optimum effects, and an increasingly important reduction of negative environmental effects and accumulation of waste materials. The uses of a modified atmosphere, which in fruits and vegetables has a very important effect on respiration intensity, maturation process and other physiological and microbiological activities, in combination with cooling has been for some time the most established technique to extend shelf-life. In the storage of large quantities of plant raw materials, various applications of the modified atmosphere and control methods are in use, as already mentioned in the text. Similar physiological effects can be achieved using modified atmosphere packaging (MAP) for fresh-cut fruits and vegetables. A suitable application of a modified atmosphere for various plant material types should take into account the ratio between the intensity of produce respiration and the permeability properties of the packaging films. Inappropriate permeability causes oxygen consumption and CO_2 accumulation leads to anaerobic conditions. Due to the damaged tissue in fresh-cut products, the intensity of respiration can be significantly increased. The formation of metabolites such as acetaldehyde and ethanol causes tissue decay and various off-flours.

Conclusion

Post-harvest study is the scientific knowledge of living plant tissues after picking. It has direct applications to postharvest handling in establishing the storage and

transport conditions that best prolong shelf life. Post-harvest handling is the ripening of fruit can be delayed, and thus their storage prolonged, by preventing fruit tissue respiration. Postharvest shelf life is typically determined by objective methods that determine the overall appearance, taste, flavor, and texture of the commodity. These methods usually include a combination of sensorial, biochemical, mechanical, and colorimetric measurements.

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