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Osmo Dehydration of Pineapple Fruits: An Overall Review

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Abstract

Application of osmotic dehydration for different fruits has been increased significantly in recent years. Among different fruits, pineapple have characteristic pleasant flavour, distinct aroma and exquisite taste and ranks 6th position in world fruit production and is one of the most suitable fruit used for osmotic dehydration. Osmo dehydration is one of the relatively simple preservation techniques for processing of fruits which does not require any sophisticated equipments. So, the pineapple growers can use such type of technique and can convert pineapples into dehydrated form during the excess production during glut season and to reduce huge post harvest losses. In the osmotic dehydration process, partial dehydration of the fruit pieces is accomplished by dipping in concentrated sugar syrup solution followed by hot air dehydration. It is a useful technique for producing safe, stable, nutritious, tasty, economical and concentrated fruit products. The products prepared from pineapple by osmo-dehydration process remain good up to six months of storage at room temperature. COEX nitrogen package followed by storage at low temperature (7°C ± 1°C) and aluminum pouches maintain the quality of the product for long period.

Keywords: Pineapple; Osmo-dehydration; Quality; Packaging; Storage

Introduction

Fruits and vegetables play an important role in human nutrition. Besides supplying complex carbohydrates and proteins, the fruits are vital sources of essential minerals, vitamins and dietary fiber [1]. Pineapple (*Ananas comosus* (L.) *Merr.*) is one of the commercially important fruit crops of tropical world. The origin of the pineapple is the American continent, probably Brazil and Paraguay. It has spread throughout tropical and subtropical regions as a commercial fruit crop. Pineapple ranks 6th position in world fruit production. The main producer countries reported are Brazil (2.21 million tons), Philippines (2.17 million tons), Costa Rica (1.98 million tons), Thailand (1.92 million tons) and China with 1.52 million tons [2]. The important pineapple growing countries of the world are the Hawaiian Islands, Philippines, Malaysia, Thailand, Brazil, Ghana, Kenya, Mexico, Taiwan, South Africa, Australia, Puerto Rico and India. Currently, India produces 1.57 million tonnes of pineapple with productivity of 14.93 t/ha. In India, pineapple shares 1.9% of total fruit production of fruits [3]. Pineapple is a fruit appreciated by consumers around the world, mainly due to its sensory characteristics and characteristic pleasant flavour, distinct aroma, exquisite taste and absence of seeds. It is a good source of carotene and ascorbic acid, and is fairly rich in vitamin B and B_2 [4-7]. It also contains phosphorus and minerals like calcium, magnesium, potassium and iron [8-11]. Furthermore, this fruit contains a proteolytic enzyme called bromelin, which aids in reducing inflammations and also contributes to good digestion [12,13]. It is used as a constituent of several home remedies and folk medicines. India produces more than 8% of total world production of pineapple. The major pineapple producing states in India are West Bengal, Assam, Karnataka, Tripura, Bihar, Manipur, Meghalaya, Nagaland, Kerala, Arunachal Pradesh, Andaman and Nikobar Islands, Goa, Jharkhand, Madhya Pradesh, Mizoram, Odisha, Sikkim, Tamil Nadu and Uttarakhand [14,15]. The year wise production status, area and productivity of pineapple in India are presented in Table 1 [16-18]. Value addition has become the watch-word as it involves processing and preservation of the commodities which otherwise get disposed at cheaper price or lost without intellectual and technical inputs. In order to prevent losses, avoid gluts in the season and to ensure optimum utilization, it is required to subject these perishables for processing into more stable value-added products.

Year	Area (000 HA)	Production (000 MT)	Productivity (T/HA)
2006-2007	86	1362	15.8
2007-2008	80	1216	15.1
2008-2009	84	1341	16.0
2009-2010	92	1387	15.1
2010-2011	89	1415	15.9
2011-2012	102	1500	14.7
2012-2013	105	1571	14.9
HA: Hectare; MT: Metric tonne; T/HA: Tonne/Hectare			

Table 1: Year wise production status, area and productivity of pineapple in India.

The nutritional composition of pineapple fruit (per 100 g pulp) is illustrated in Table 2 [18].

Literature Review

Osmotic dehydration

It is a process that entails the partial removal of water from fruits which is based on a tendency to reach equilibrium between osmotic pressure inside the biological cells (fruit) and the surrounding osmotic solution, which has an increased osmotic pressure caused by high concentration of soluble osmotic agent. The mechanism behinds that molecular diffusion of water through semi-permeable membranes takes place and fruit loses its water. Some soluble solids present in the solution may be taken up by the material and part of the soluble solids present in the original material may leach in the solution [19-23]. The osmotic dehydration process is stopped when the osmotic pressure inside the tissue reaches the osmotic pressure of the surrounding syrup

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Composition	Level
Water (g)	87.00
Protein (g)	0.60
Fat (g)	0.10
Carbohydrate (g)	12.30
Calcium (mg)	12.00
Phosphorus (mg)	10.00
Iron (mg)	0.40
Potassium (mg)	250.00
Sodium (mg)	1.50
Copper (mg)	0.08
Magnesium (mg)	17.00
Carotene (Iu)	50.00
Vitamin B_1 (mg)	0.02
Vitamin B_2 (mg)	0.12
Folic acid (mg)	4.00
Ascorbic acid (mg)	50.00
Energy (calories)	50.00

Table 2: Nutritional composition of pineapple fruit (per 100 g pulp).

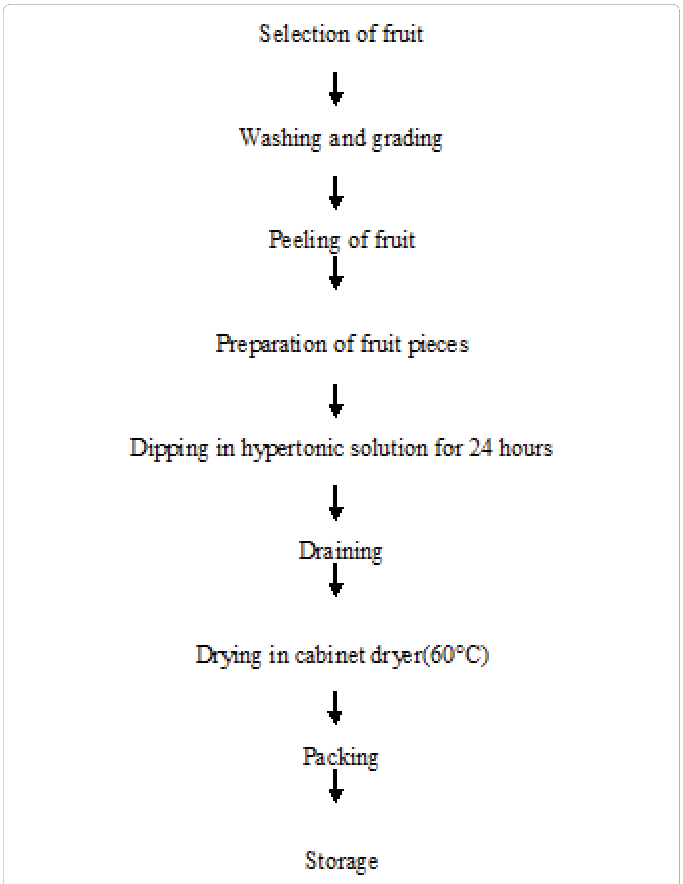

Figure 1: Process flow chart for the preparation of osmo-dehydrated pineapple pieces.

[24]. Osmotic dehydration has received greater attention in recent years as intermediate step for drying of several fruits and vegetables [25]. Being a simple process, it has potential advantage for the processing industry for dehydration of fruits with longer shelf life [26-29].

Osmotic dehydration is a useful technique for the production of safe, stable, nutritious, tasty, economical & concentrated food obtained by placing the fruit slices in an aqueous solution of sugar with high osmotic pressure. The interest in inducing osmotic process in conventional dehydration has two objectives.

Quality improvement

Energy savings: In the osmotic dehydration process, partial dehydration of the fruit pieces by dipping in concentrated sugar syrup (hypertonic) for 20 hr to 24 hr followed by hot air dehydration at 50°C to 60°C temperature is done [28]. Because, generally osmotic concentration process will not give a product of low enough moisture content to be considered shelf-stable. The product must be dried further by air or freeze-drying methods for a reasonable shelf-stable product [30]. In this method, considerable energy is saved as compared to other methods such as osmo-convective, osmo-vac or osmo-freeze dehydration. Osmotic dehydration is one of the ways of processing fruits a relatively simple preservation technique that does not require any sophisticated equipment's [31-33] and it is also one of the potential preservation techniques for producing high quality products [32]. Even at rural places and remote areas without much technological know-how, the growers can be used the technique and converted the excess production into dehydrated form and the product can be marketed for either use in fruit salads during off-seasons or can be used as a substitute for chocolates or candies. Osmotic dehydration is a food preservation technique that relies on the reduction of water activity and humidity of the product, which has advantages over other dehydration techniques because it preserves the sensory and nutritional characteristics of food [34,35] as it provides minimum thermal degradation of nutrients due to low temperature water removal process reported by some recent studies [36-40]. Its process involves simultaneous water loss and solute gain [41] in which the mass transfer depends on variables such as type and concentration of osmotic agents, temperature, agitation/circulation of solution, solution to sample ratio, thickness of food material and pre-treatment suggested by Rosa and Giroux [42]; Corzo and Gomez [43]; Kumar and Sagar [44] and fruit/syrup ratio by Fernandes et al. [45]. Osmo-dehydrated products are also called as intermediate moisture products. Osmo-dehydrated products stored at low temperature remain more acceptable compare to room temperature [1,43]. Osmotic dehydration process has several advantages, *viz.,* (1) Quality improvement, (2) Energy efficiency, (3) Reduction in packaging and distribution costs, (4) Avoiding chemical treatment and (5) Product stability during storage [40].

Suitable pineapple varieties for osmotic dehydration

Kew: The average fruit weighs 1.5 kg to 2.5 kg and oblongs in shape. Eyes are broad and shallow. The fruit is yellow, almost fibreless and very juicy with 0.6% to 1.2% acidity; TSS varies from 12° to 16° Brix. Queen or Common Queen: The average fruit weight of pineapple is 0.9 to 1.3 kg. Eyes are small and prominent. When fully mature, the fruit is golden-yellow. The flesh is less juicy, crispy, less fibrous, and transparent with pleasant aroma and flavor. The TSS content varies from 15° to 16°. Brix and acidity between 0.6% to 0.8% [44-47]. Singapore Spanish: The fruit is cylindrical in shape; the average weight is about 1.6 kg to 2.3 kg. The ripe fruit is reddish orange and flesh is golden-yellow, fibrous and good flavoured.

Osmo-dehydrated pineapple

Processed and value-added products are gaining importance in the worldwide markets. According to Silva et al. [48], to prolong the post-harvest life of agricultural products, one alternative is water removal. Pineapples, for instance, can be peeled, cut into pieces and dried (Figure 1). Conventional drying is an expensive operation due to the phase change of the water from liquid to vapour. Thus, a pretreatment such

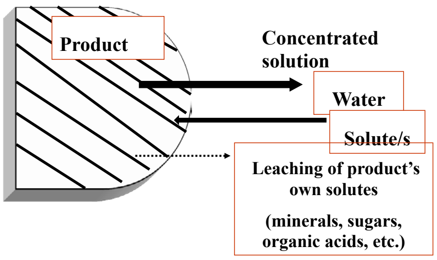

Figure 2: Schematic drawing of mass transfer during soaking process [39].

Particulars	Raw pineapple	Osmo-dehydrated pineapple
Moisture (%)	83.60	12.72
Acidity (%)	0.66	1.50
Ascorbic acid (mg/100 g)	33.57	25.77
Carotinoids (µg/100 g)	945.42	603.75
Total sugar (%)	13.76	65.64
Reducing sugar (%)	6.44	38.34
Non-reducing sugar (%)	7.32	27.33
Sugar: acid ratio	20.85	43.85

Table 3: Physico-chemical composition of raw and osmo-dehydrated pineapple [43].

Osmotic agent	Remark	Reference
Sucrose/ Sugar	Dry sugar is unsuitable because of oxidative browning during osmosis. Difficulty in disposing sugar syrup. Sugar solution is best as it reduces browning by preventing the entry of oxygen. Sweetness hinders its use in vegetable processing.	Farkas and Lazer [1]; Pointing et al. [7]; Flink [15]
Calcium chloride	Increases the firmness of apple slices and preserves the texture during storage. Prevents browning because of synergistic effect with ascorbic acid or sulphur dioxide. Imparts better taste to the product if used above 0.5% level.	Pointing [4]
Ethanol	Decreases viscosity and freezing and freezing point of the osmotic solution in cooling and freezing processes.	Biswal and Le Maguer [7]
Invert sugar	Theoretically more effective than same concentration of sucrose because when completely inverted, it has twice as many molecules per unit volume. Practically little difference in the rate of osmotic dehydration of fruit by sucrose or invert syrups of the same concentration and temperature.	Pointing et al. [7]
Fructose	Increases the dry matter content by 50% as compared to sucrose due to higher penetration rate. Water activity of the final product is also lower. However, sucrose is preferred over fructose.	Bolin et al. [10]
Starch/corn syrup	Favours similar final water content with minimal solid gain as that obtained with sucrose.	Flink [15]
Lactose	It has much lower level of sweetness than sucrose. Low solubility in aqueous solution.	Hawkes and Flink [17]
Malto dextrin	It can be used as an osmosis solute at higher total solids concentration, or in mixed systems. Less effective than sucrose at the same concentration.	Hawkes and Flink [17]
Sodium chloride	NaCl: Mostly used for vegetables as it retards oxidative and non-enzymatic browning. Increases the driving force for the drying owing to the lowering capacity of the salt. Sometimes blanching effect on coloured products can be prevented using mixture of salt and sugar. Organoleptic should be 10-12 per cent. Hinders shrinkage at the surface layers.	Hawkes and Flink [17]; Lenart and Flink [22]

Table 4: Different osmotic agents and their effects in osmotic dehydration process.

as osmotic dehydration is normally used [41] and it showed that water loss from pineapple pieces increased with the increase of sugar solution temperature and concentration. Osmo-dehydrated pineapple pieces using 60° Brix sugar syrup concentration with 60°C drying temperature produced better quality product with respect to physico-chemical as well as sensory quality up to six months of storage period [43]. Kumar and Sagar [24] suggested that tissue damage due to too high temperature and high solute concentration causes a dramatic decrease in solid gain efficiency. To improve the quality of osmo-dehydrated product pre-treatment with potassium meta-bisulphite at 1.5% for 8 h was proved to be best reported by Ahsan et al. [2]. The sugar gain increased up to 50°C and then fell rapidly and it also increased with the increase in solution concentration. Pokharkar and Prasad [38] determined that osmotically concentrated pineapple slices at 30°C and 0.5 water activity gave a moisture content of 12.5% (dry basis). The schematic drawing of mass transfer during soaking process of osmodehydration is illustrated in Figure 2 [42].

Mehta et al. [33] reported decreasing trend in acidity (%), total sugar (%) SO_2 (ppm), reconstitution ratio and increasing trend in reducing sugar (%), moisture (%) and dehydration ratio of pineapple rings during six months of storage period. Physico-chemical composition of raw and osmo-dehydrated pineapple pieces is mentioned in Table 3 [43].

Discussion

In order to prevent absorption of moisture from atmosphere and to prevent spoilage due to contamination of osmo-dehydrated pineapple pieces, different packaging materials are used such as aluminum foil laminated polyethylene pouches, high density polyethylene pouches (HDPE). Kumar et al. (2008) suggested that COEX nitrogen package followed by storage at low temperature (7°C ± 1°C) was found to be best for packing conditions judged at six months of storage. It retained higher carotene, ascorbic acid, sugar, rehydration ratio, less moisture, sensory score and non-enzymatic browning (NEB) in the product after six months of storage. The samples packed in laminated aluminum pouches were also found acceptable after storage of six months [2]. The different osmotic agents and their effects in osmotic dehydration process are presented in Table 4.

Conclusion

Review of osmo-dehydrated pineapple reveals that to prolong the post-harvest life of agricultural products water removal is one of the alternative. Osmo-dehydrated pineapple pieces using 60° Brix sugar syrup concentration with 60°C drying temperature produced better quality product with respect to physico-chemical as well as sensory quality up to six months of storage period, as too high temperature and high solute concentration causes a dramatic decrease in solid gain efficiency due to tissue damage. Potassium meta-bisulphite pre-treatment at 1.5% for 8 h before osmosis improve the quality of osmo-dehydrated product. COEX nitrogen package followed by storage at low temperature (7°C ± 1°C) is recommended for better quality. Considerable energy can be saved by osmo-air dehydration as compared to other methods such as osmo-convective, osmo-vac or osmo-freeze dehydration.

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