OSMOTIC DEHYDRATION OF CASHEW APPLE: A REVIEW

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Abstract: *Osmotic dehydration is used for partial dehydration of foods, usually as an upstream processing step, before they are subjected to further processing such as air drying. Osmotic dehydration is a simultaneous mass transfer process which mainly promotes the flow of water molecules from the food to osmo-active solution and some migration of solutes from the solution into the food, thus maintaining good organoleptic and functional properties in the finished product. Osmotic dehydration is a food preservation technique with low energy and capital requirement compared to other conventional methods and results in good quality final product in terms of colour, texture and flavor. The perishable cashew apple generates high amount waste residues and the wastage rate exceeds about 90% of production in India. Economic and efficient methods for handling and processing could help facing this problem through processing and transformation into good quality attractive products with extended shelf life. The problems limiting the acceptability of cashew apple are its astringency, seasonability, poor storability and lack of awareness regarding information on appropriate processing technology. Osmotic dehydration is considered as an answer to these problems, where high quality ready-to-eat products with good shelf life can be produced.*

Keywords: *Osmotic dehydration, Cashew apple, Water loss, Solid gain, immersion time.*

Introduction

The cashew (Anacardiumoccidentale L.), a member of Anacardiaceae family, is a native of North East Brazil in Latin America. Being an evergreen tree of tropics, it is cultivated in more than 28countries for its delightful nutritious kernels, apple and cashew nut shell liquid. Cashew is one of the major horticultural crops of Konkan region, mainly grown on hill slopes as rain-fed perennial crop. (Desai et al., 2010).Major states contributing to the cashew nut production in India are Maharashtra, Andhra Pradesh, Orissa, Kerala, Tamil Nadu, Karnataka, Goa and West Bengal. Area under cashew cultivation in India was 10.27 lakh hectares; the production of cashew nut with shell was 7.25 lakh MT. In Maharashtra area under cashew cultivation was 1.86 lakh hectares, the production of cashew nut with shell was 2.35 lakh MT and the cashew productivity was comparatively higher (DCCD, 2017).

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, Maharashtra, has released and recommended the eight varieties of cashew viz., Vengurla 1, 2, 3, 4, 5, 6, 7 and 8; among which 'Vengurla-4' is one of the preferred variety by farmers of Konkan region because of larger size of cashew nut and higher productivity. Vengurla-4 has fruiting period in February-May months and the colour of apple is red. The Juice percentage was 76 %, number of nuts 140 per kg and mean nut yield 17.2 kg/tree (Anonymous, 2017).

Osmotic dehydration of food got attention due to its importance in food processing industries. It is a process for the partial removal of water from plant tissues such as fruits and vegetables by immersion in an aqueous concentrated solution of soluble salts. A driving force for the diffusion of water from the tissue into the solution is provided by the difference in osmotic pressure or concentration gradient between the food and surrounding osmotic solution. A diffusion of water is accompanied by the simultaneous counter diffusion of solute from the osmotic solution into the tissue. Since the membrane responsible for the osmotic transport is not perfectly selective, other solutes such as sugar, organic acids, minerals, salts, vitamins present in the cells can also be leached into the osmotic solution (Torte *et al*., 2007).

Osmotic dehydration is used for partial dehydration of foods, usually as an upstream processing step, before they are subjected to further processing such as air drying (Fernandes *et al*., 2008, Azoubel*et al*., 2009 and Sosa *et al*., 2011) to make the final product shelf stable.

Osmotic dehydration is one of the energy efficient means of removing moisture from a food product, as the water does not have to go through a phase change to be released from the product. It is stated that some of the advantages of direct osmosis in comparison with other drying processes include minimized heat damage to colour, flavour and less decolourisation of fruit by enzymatic oxidative browning (Saurel*et al*., 1994 and Krokida*et al*., 2001).

Osmotic dehydrationis a food preservation technique with low energy and capital requirement compared to other conventional methods and results in good quality final product in terms of colour, texture and flavour. It involves partial removal of water from fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts. Cashew apple is the succulent peduncle of the cashew fruit containing about 82-85% juice, 10-12% sugar, minerals and high level of vitamin C. The perishable cashew apple generates high amount waste residues and the wastage rate exceeds about 90% of production in India. Economic and efficient methods for handling and processing could help facing this problem through processing and transformation into good quality attractive products with extended shelf life. The problems limiting the acceptability of cashew apple are its astringency, seasonability, poor storability and lack of awareness regarding information on appropriate processing technology. Osmotic dehydration is considered as an answer to these problems, where high quality ready-to-eat products with good shelf life can be produced. Several production factors such as sample size, nature and duration of osmotic treatment etc. affect the efficiency of osmotic dehydration (Mini and Archana, 2016).

Mechanism of Osmotic Dehydration

Raoult *et al.* (1991) termed the osmotic dehydration as ‘Dewatering and Impregnation Soaking Process (DISP)’ is a water removal process which is based on placing foods, such as fruits and vegetables into concentrated solutions of soluble solutes, having higher osmotic pressure. The driving force for water removal is the concentration gradient between the osmotic solution and the intercellular fluid while the cell wall, acts as a semi permeable membrane. Since the membrane is only partially selective there is always some solute diffusion (uptake) into the food. Therefore, osmotic dehydration has at least two major simultaneous counter current flows, water diffusion out of the food into the solution, at a faster rate initially and slowly afterwards and solute penetration in the opposite direction, at a slow rate initially but increasing with time. Considerable amount of solute penetration takes place if the duration of osmotic dehydration is long. There is also some leakage of solute (sugar, organic acid, minerals, salts etc.) across the membrane. Though quantitatively negligible, it may be essential as far as organoleptic or nutritional qualities are concerned (Rahman, 1992 and Fito*et al.,* 2001). The process generally results into a partially dehydrated product.

Thus, osmotic dehydration is a low temperature dehydration technique where partial removal of water is achieved by the direct contact of the solid food, in a hypertonic medium *i.e.* highly concentrated sugar or salts solutions, through a semi permeable membrane until equilibrium is reached. Therefore, the applications of osmosis to food processing as a means of dehydration have been primarily motivated by economical factors and the quality improvement of the final product. This has been often proposed as a first step followed by of drying methods such as air-drying.

Advantages of the osmotic dehydration process

There are number of advantages of the osmotic dehydration process. The main advantage is that it minimizes the damage to the tissues and removes water without phase change, as compared to other methods of drying. Some of the merits of the process as described by various researchers (Dixon *et al.,* 1976; Islam and Flink, 1982; Rahman and Lamb, 1991; Chaudhari *et al.,* 1993; Sankat*et al.,* 1996; Sethi*et al.,* 1999; Fito*et al.,* 2001 and Jain and Verma, 2003) are it preserves the wholesomeness of the fruit, as cell damage is minimum.Mild heat treatment favourscolour and flavour retention resulting in product with superior organoleptic characteristics and textural attributes.The use of artificial preservatives may be avoided.The process is quite simple, economical and does not require any sophistication. As there is no phase change, the energy requirement is 2-3 times less compared to the conventional drying.The process is economically viable for highly perishable fruits as blanching may be eliminated.

Effect of process parameters on osmotic dehydration

Osmotic dehydration is influenced by several parameters *viz.,* variety and maturity of fruit pre-treatment applied to food, chemical composition of osmotic agent, solute concentration, immersion time, geometry and tissue compactness of material and level of agitation (Azoubel*et al.,* 2009 and Rastogi *et al.,* 1997).

The effects of some vital factors have been reviewed in brief below.

Pre-treatment given to product

Various researchers reported that disruption of structure barriers due to product treatment improved water and solute diffusivities within the product, resulting in faster equilibrium in favour of higher solute uptake. Blanching, thawing, sulphating, acidification and higher process temperature all favour solid uptake yielding lower water loss/solute gain ratio. (Ponting, 1973 and Biswal *et al.,* 1991).

Composition of osmotic solution

The choice of osmotic solution and its concentration depends on several factors. It should be tasty, less costly and harmful, higher soluble and should have lower water activity (Lerici*et al.,* 1985). Several studies were conducted on different aqueous media. The most commonly used osmotic agents were sucrose for fruits and sodium chloride for vegetables and fish. Other osmotic agents include calcium chloride, a monohydroxyl ethanol and the polyhydroxyorganics such as lactose, maltodextrin and high fructose corn syrup or mixtures of these items. Ponting *et al.* (1966) reported that the osmotic treatment of apple pieces in the solution of calcium chloride increased firmness and preserved texture during storage. Chenlo*et al.* (2002) reported the physical properties of various osmotic solutions having different compositions and concentrations.

Temperature of osmotic treatment

Ponting *et al.* (1966) and Lenart and Flink (1984) found that the rate of osmosis was markedly affected by the temperature. Although, rate was increased with temperature, there was limit, perhaps 60ºC above which the cell membrane was destroyed and caused internal browning of the fruit pieces on one hand and loss of fruity flavour on the other hand. Consequently, poor results were obtained in further osmotic water removal. Rahman and Lamb (1991) found that the solid concentration became nearly constant above 60ºC. Since water loss is higher at higher temperature, the osmotic equilibrium was achieved by flow of water from the cell rather than solid diffusion. They reported that, solid gain increased up to 50ºC and then fell sharply. They found that it was not normal to find diffusion rates falling with increase in temperature. The reason might be that the cell wall which was composed of cellulose and pectin, increased its permeability at higher temperature. The soluble solid diffusion during osmosis depended mainly on molecular size, ionic state and solubility of the solute in the water.

Duration of osmotic treatment

Most of the studies on osmotic dehydration were conducted in batch system with highly concentrated sucrose solutions. According to Ponting *et al*. (1966) and Lenart and Flink (1984) keeping the concentration of the solution constant, the increase of the contact time resulted in an increase of the weight loss or simply a more effective dehydration. Although the weight loss was increased as a function of time of osmosis, the rate at which it occurred was decreasing.

Osmotic solution to fruit mass ratio

It has been reported that the rate of osmosis was increased up to a certain limit and then levelled off with increase in the solution to fruit ratio. Many workers used 4:1 to 5:1 solution to fruit ratio to study the mass transfer kinetics by changing solution concentrations and other parameters. Some of the studies had also been conducted using higher ratios of 10:1 to 25:1 to avoid the significant dilution of the medium due to water loss from samples and solute uptake by samples and subsequent decrease of the osmotic driving force during the osmotic dehydration (Hawkes and Flink, 1978; Lazarides*et al.,* 1995 and Biswal *et al.,* 1997). The osmotic dehydration of cashew apple (Azoubel*et al*., 2009) was used 10:1 solution to fruit ratio.

Effect of Osmotic Dehydration Parameters on Water Loss and Solid Gain

Lenart and Flink (1984) were first to defined terminology, for mass transport data such as water loss, solid gain and mass reduction during osmotic concentration and same has been used by various researchers such as Shi *et al*. (1995) and Kaleemullah*et al*. *(*2002).

Sharma *et al*. (2004) observed the kinetics of osmotic dehydration is determined by estimating the rate of water removal and solid gain. Generally higher rates of water removal take place within first hour of osmosis due to large driving force between dilute fruit sap and osmotic solution.

Mathematical Modelling of Osmotic Dehydration Process

Azoubel andMurr (2003) reported that osmotic dehydrated cashew apple responses of water loss (%) and solid gain (%) were fitted to polynomials, with multiple correlation coefficients ranging from 0.92 to 0.99. The fitted functions were optimised for maximum water loss and minimised incorporation of solids to obtain a product resembling non-processed fruit. Three optimum sets were selected for each solute and the ascorbic acid content was determined. The ascorbic acid losses were like those reported for osmotic dehydration processes.

Treatments after Osmotic Dehydration

Ponting *et al*. (1966) reported that, relatively high temperature short-time air drying process was possible because the texture of the osmotically dried fruit was more or less open and rigid and the fruit did not collapse and became leathery during drying. Thus, the fruit which had been osmotically dehydrated to about 50 per cent weight reduction can be air dried to low moisture content in short time. Drying rates and effective diffusion coefficient of osmo-air dried fruits using 50-70ºC were significantly decreased with increase in solid gain during osmosis and increased with drying temperature. Drying time was considerably reduced for pretreated samples (Rahman and Lamb, 1991 and Ghosh *et al.,* 2006).

Results of Osmotic Dehydration of Cashew Apple

Mini and Archana (2016) studied the osmo-dehydrated cashew apples could be developed by osmotic treatment of 10 mm thick slices of cashew apples in 60° brix at 50° C for 24 hours followed by drying at 50° C till 15-20% moisture. The product could be stored for six months in vacuum pack with nitrogen in laminated pouch without affecting major chemical quality parameters. Osmotic dehydrated cashew apple is a novel value added product developed from the commonly waste pseudo fruit of Kerala. This is a 'ready to eat' high quality snack food with extended shelf life, preserving natural qualities of cashew apple. By developing this value added products, it is possible to make the seasonal fruit available to the consumers throughout the year.

Azoubel and Murr (2003) reported that Osmotic dehydration of cashew apple in sucrose and corn syrup solids solutions as influenced by temperature (30–50 ^{0}C), sugar syrup concentration (40–60% w/w) and immersion time (90–240min) was studied through response surface methodology. Responses of water loss (%) and solid gain (%) were fitted to polynomials, with multiple correlation coefficients ranging from 0.92 to 0.99. The fitted functions were optimised for maximum water loss and minimised incorporation of solids in order to obtain a product resembling non-processed fruit.

Azoubel*et al.*, (2009) studied the effect of different osmotic pretreatments on cashew apple drying kinetics and product quality were investigated. The osmotic pretreatment was carried out in an incubator at constant temperature and agitation. The drying process was conducted in a fixed bed dryer at different temperatures and constant air velocity. Experimental data were fitted successfully using the Page and the two-term exponential models for dried fresh and pretreated fruit, respectively. It was found that drying rates of osmosed fruits decreased owing to the presence of infused solutes. Evaluation of the final product was performed by means of ascorbic acid content, water activity and sensorial test. The samples pretreated in sucrose solution had the highest acceptance. Osmosed samples had lower drying rates owing to the initial solid content, requiring more time to reach the same final moisture content as fresh cashew apple. Page's model showed a good fit to the experimental data of dried fresh fruit, and the calculated average relative errors were up to 15%. For the pretreated samples, the two-term exponential model had the best fit, with calculated average relative errors lower than 10%.The sucrose osmosed samples had the highest acceptance.

Azoubel*et al.*, (2004) reported Cashew apple slices were osmotically treated in corn syrup solids solutions at different concentrations (40-60% w/w), temperatures (30-50^{o}C) and immersion times (90-240 min). Temperature was the most important factor affecting water loss, while immersion time was the most significant factor affecting solid gain. The model fitted the experimental data observations accurately, with regression coefficients that varied from 0.92 to 0.99. Water loss and solid gain take place in a parallel mode, with the rate of water loss was always higher than the rate of solid gain. Both process temperature and immersion time and solution concentration have a significant effect on water loss and solid gain during the osmotic dehydration of cashew apple slices in corn syrup. Temperatures close to 50°C should be avoided because they lead to disadvantageous modifications in the material structure. Depending on specific process goals one could choose from a range of process conditions to direct product treatment towards dewatering, impregnation or a mixed effect.

Conclusion

Osmotic dehydration is a food preservation technique with low energy and capital requirement compared to other conventional methods and results in good quality final product in terms of colour, texture and flavor. The problems limiting the acceptability of cashew apple are its astringency, seasonability, poor storability and lack of awareness regarding information on appropriate processing technology. Osmotic dehydration is considered as an answer to these problems, where high quality ready-to-eat products with good shelf life can be produced.

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