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PRESERVATION OF FOOD AND NUTRITION BY OSMOTIC DEHYDRATION TECHNOLOGY

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Abstract

Fruits and vegetables are good sources of minerals and vitamins. They mostly go waste due to mishandling and lack of storage facilities. Osmotic dehydration technology is a resourceful technique for preserving horticultural crops. It helps in preserving natural properties of fruits like color, aroma, texture and nutritional composition. In comparison to air or vacuum drying is energy efficient since it can be practiced at normal conditions. It has prospective advantages for the processing food industry like quality maintenance. It involves dehydration of the product i.e. removal of moisture content as an osmotic agent and consequent dehydration. This is a valuable technique to outspread the shelf life, decreases cost of energy and improves the sensorial, nutritional and organoleptic properties of foods. Thus, osmotic dehydration is gaining more popularity in present flourishing food processing industry.

***Keywords*: **Food, fruits, osmotic dehydration organoleptic, preservation, technology.

Introduction

Fruits and vegetables are indispensable for providing basic and primary nutrients in the diet of human beings. The global fruit and vegetable production is expected to be 434.7 million MT and 90.0 million MT, respectively. Post-harvest losses are very high in the developing countries like India. The estimated losses were up to the tune of more than 30 per cent. Several processing practices can be practiced to safe guard fruits etc. Drying and dehydration are extensively adapted because of appreciable saving in storage and packaging etc.

In recent years osmotic dehydration has grabbed good attention being an efficacious method for preservation of horticultural produce like fruits and vegetables. It simplifies the processing of product/produce such as mango, sapota, pineapple and banana along with various kinds of vegetables (leafy) etc. with maintenance of primary and basic characteristics viz., aroma, colour and nourishing constituents being simple activity (Pokharkar and Prasad, 1998). Energy requirements are very less than vacuum or air-drying processes as it is able to practice temperature at room. There are many benefits regarding trade in processing to sustain value of food with the health of the food. It includes produce dehydration in two phases, exclusion of water (to be used as an osmotic mediator and consequent reduction of moisture content to make the produce/product more stable (Ponting, 1973). It was explored that modern developments in the control of mass transfer have unlocked new traditions for optimization of the technique and the development of new applications, which have, in turn, generated new research areas for the forthcoming. These are principally associated to the microbiological validation of the process and management of concentrated solutions. In osmotic concentration water is removed from vegetables and fruits as their membranes of cells have semi-permeable property and water is allowed to pass quickly through them than sugar. It is an energetic procedure; sugar dissemination rate is very sluggish at first but increases with the time (Raoult-Wack, 1994 and Rastogi *et al*., 2002). Therefore, characters of the product may be transformed by controlling conditions, time of osmosis sugar, concentration of osmosis solution and syrup concentration, etc. These factors may affect the speed of the osmotic process.

Brief history of osmotic dehydration

Osmosis technique reduces 50% of original weight of the product, after that freezing or vacuum dried has been done. Apple monograph was reflected by drying osmotic dehydration rate (Farkas and Lazor, 1969). OD techniques were studied in kiwi and papaya in solutions of sucrose and glucose (Vial *et al.,* 1991 and Heng *et al*., 1990) The stability of osmotically managed cherry fruit was studied [8], the evaluation regarding sugar content, organoleptic, color, vitamin C, pH and acidity was done. Mass movement during OD technique in pineapple was observed (Beristain, 1990). Lot of research papers or review articles are published (Torreggiani, 1993) dealing with many parameters, such Osmotic Dehydration mechanism etc. including water loss and modeling of solid gain (Rastogi, 2002).

System of osmotic dehydration

Minimum dehydration is the basis of this technique. Physical phenomena and liquid movement is motivated by variation in solute concentration of both, solvent and solute which is disconnected or alienated by semi-permeable membrane and resulting in movement from less solute to more concentration through membrane. When water comprehending cell-tissue was enveloped in hypertonic concentration solution (low in molecular elements such as salts and sugars) the movement of contents of solutes from solution to substantial and it is contingent on alteration of concentration and solution which gave up two instantaneous counter flows and water efflux from solid to solution (Shi and Le Maguer, 2003). It is also dependent on the properties of cell membrane (non-selective), the own solvable contents of product such as sugars, organic acids and minerals also moved towards the product along with movement (outward) of water. That's why this movement might be quantitatively significant to main types of mass transference; it resembles with nutritional and sensory property of concluding product (Raoult-Wack (1994), Azoubel and Murr (2002) Sunkja and Ragharan (2004). Transference of mass happens till equilibrium is achieved regarding osmotic dehydration. It is suggested that through capillary flow and diffusion, subtraction of water occurs whereas uptake of solute to the product and release of the soluble solids of the product is through the diffusion (Shi, 2009). During osmotic action, food particles were confined to two stage activities in terms of solutes and water transfer. The dewatering of article (food item) is known to take place at high rate and require more than few hours. Afterward water loss rate is declined slowly in succeeding hours and finally stops. On the other hand, solute impregnation into solid was not suggestive at the start of osmotic activity, when dewatering rate was dropping down than improved the solute rate into the material (Rault, 1994). Work done earlier on the osmotic action in food substantial was described (Pointing, 1966) and the procedure was detailed as a sensible, non-thermal method of dehydration to obtain distinction (better) dehydrated product while declining the real weight of the product to 50 %. Different osmotic behaviors of plant and animal should be clearly demarcated in terms of configurations and assemblies. Literature review concerning osmotic action regarding meat products was also described (Collignan, 2001). Osmotic technique has several benefits over conservative advances; much of these methods include simplicity (mechanical), elasticity (processing method) and reduced the cost of energy because water movement occurs without any change. This procedure is to be adopted at ambient temperature to avoid degradation of texture, color and nutritional standards. During this procedure loss of unstable compounds and oxidative changes was lessened (Rastogi, 2002; Marani, 2007).

Applications of Osmotic in Processing of Food

The procedure of Osmotic dehydration includes variables like temperature conditions of sugar solution, pre-treatment and additives regarding transfer of mass in different fruits was considered (Pointing, 1966) and revealed that the slices of apple could be diminished to 50 % of their real weight by treating with 60-70 °C brix solution (sugar) and quality was also upgraded. According to this study the need of SO_2 treatment was also abolished to avert colour loss. Air-dried products from Osmotic method were much superior in terms of quality and this technique helps in removing water droplets from fruit slices extent of 50% of the weight, however it is inadequately sufficient for preservation. So, removing water to safe extent by supplementary drying is mandatory. It was proved that temperature conditions more 60 °C adjusts the tissue features favoring phenomena of impregnation and good consequences were attained (Bongirwar, 1977). Distribution of sucrose is a role of absorption of solute and temperature conditions. Coefficient of distribution is reduced along with the enhancement of enough material in period of osmosis process and enhanced with temperature of quality air (Rahman, 1991).

Osmotic Process Affecting Parameters

The variables like variety, temperature conditions pre-treatments, maturity, agitation, mediator, additives, geometry, their physico-chemical characteristics, structure and prevailing pressure during osmotic process plays a very important and significant role. Effect of different variables on product quality and mass transfer have been detailed by different research workers like Pointing (1966), Torreggiani (1993), Raoult-Wack (1994), Pokharkar (1994), Lewicki and Lenart (1995), Sudheer and Dash (1999,) Panagiotou *et al.*, (1998).

Characters of Raw Materials for Osmotic Dehydration Technique

1. Raw material

Water and solid expansion in the osmosis technique is because of the maturity of fruits with variety. In various fruits variation is primarily effective to soluble solids content, the tissue compactness and early insoluble, inter-cellular spaces in tissues and enzymatic action. The rate (kinetic) of solid gain does not relay upon temperature conditions or concentration of the solute. Among various cultivars of mango ripened fruits of Dashehari and Totapuri were fit for OD process (Tiwari and Jalali, 2004).

2. Fruit /vegetable pieces thickness and form

Extraction of water advances with spread the surface area of the produce. It was discovered that fruit sample size had an undesirable influence towards water loss during osmotic method (Panagiotou *et al.*, 1998). Supply coefficient of water was declined with increase in temperature and surface area and it enhanced with increase in concentration of solution including thickness of minimum geometric quantity. For instance, a sample size of 3 mm to an extreme of 10 mm in rectangle, cube shape or ring was considered suitable for the use in this dehydration method (Rahman, 1992).

Parameters of Osmotic Process

A. Pre-treatments

Any kind of pre-treatment such as freezing or blanching prior to osmotic water discharge was disadvantageous to the product value. Immersion in 1 percent solution of citric acid preceding to OD might be used to avert enzymatic browning of produce. Dipping of produce in solutions (alkaline /acid medium) of oleate esters preceding to this process affects the anticipation of staining (Hussian *et al.*, 2004, Sunkja *et al.*, 2004). Pre-treatment with certain chemicals like SO_2 or application of blanching preceding to drying influenced the loss of discoloration (Torreggiani, 1993). Dipping the mango and papaya cuts/slices in 0.4 per cent ascorbic acid or 0.4 % ascorbic acid + 0.1 % solution of KMS for 30 minutes preceding to osmosis progression helped to attain a highly accepted target product.

B. Dipping time

Maintaining solution's concentration persistent, rise of the dipping time caused the improved water removal, but diminished its frequency. Experiments on the optimization, osmosis technique extent evidenced that mass conversation occurred at extreme pace within the initial 2 hours of the osmotic technique. Throughout OD pineapple and mango, incline in osmotic extent (exposure time) caused rise in weight loss (Tiwari *et al.*, 2004). When apple and banana fruit slices were immersed in 70 and 50 ^{0}Brix correspondingly, temperature of osmotic solution (50 °C for 3 hours immersion) resulted in optimal water loss (Gaspartero *et al.*, 2003), Mauro *et al.*, 2004).Osmotic dehydration technique trailed by air-drying (60^0C) temperature conditions with the air speed of 2 m/s resulted in a persistent mass.

C. Temperature conditions

The osmotic solution has significantly affected the osmosis rate. Although the rate was enhanced with temperature and limited up to 60 ^{0}C as advanced temperature overwhelmed the cell membranes. It was explained that the temperature element of the osmotic solution had exaggerated due to various factors like sugar rise of osmosis method (Pokharkar *et al.*, 1998).

D. Osmotic Mediators

Various experiments were carried out to discover the inducement of various osmotic mediators on OD technique. Generally, in use osmotic mediators are sodium chloride for most of vegetables and glucose/sucrose for several fruits (Leistner, 1995). Other osmotic mediators may include Calcium chloride ($CaCl_2$), polyhydroxy compounds and monohydroxy ethanol lactose, corn syrup, malt dextrin and combinations of above substances.

E. Concentration of osmotic solution

Water loss along with sugar gain improved directly with the rise of temperature and concentration of sugar. Sugar diffusion rate was a function of temperature and its concentration (Rahman *et al.*, 1991). Solution concentration is a fundamental aspect in OD process and various scientists have considered the influence of osmotic solution concentration on mass transference. Generally, strength of the syrup in the range of 60-70 °Brix has been considered optimal (Chaudhari, 1993; Kumbhar *et al.*, 1993). Advanced concentration resulted in more rapid osmosis rate. Use of advanced concentration in osmosis procedure for more than 50 % of product weight lessening is not appreciated because there was decline in rate (osmotic) with passing of time (Torreggiani, 1993).

F. Movement/ Agitation

When vegetables/fruits are put and agitated in syrup etc., osmosis rate will be higher due to lessened mass transfer confrontation at the surface by averting localized thinning procedure. But, impairment to the sample might be caused. Agitation speed had an optimistic influence on water removal throughout OD procedure (Panagiotou *et al.*, 1998 and Tiwari, 2005).

G. Osmotic Solution Ratio to Fruit Slices

When there was a rise in sample ratio of solution, osmosis rate improved up to a definite level. Though, it is necessary to use an ideal ratio since wide ratios exhibit real-world complications in managing syrup combination (of fruits/vegetables) during processing. Normally a ratio of 1:2 or 1:3 is suitable for practical/real world handling (Tiwari, 2005).

Kinetics of Osmotic Dehydration

Osmotic dehydration kinetic is accessed by calculating solid gain and water exclusion rate. Commonly advanced water removal rates might occur within initial hour of osmosis process due the higher driving energy between the watery fruit juice etc. and osmotic solution (Sharma *et al.*, 2004).

Mass Transfer Phenomena throughout OD Process

There are three types of counter current mass transfer in concentration of osmotic action (Karthiayani, 2004) and Tiwari, 2005).

1. Water flow from material to solution.
2. Solute movement to the product; it makes likely to acquaint the anticipated quantity of a dynamic principle, a preserving agent, any solute, a sensual value enhancement of the produce.
3. Own solutes of the product (Like sugar, vitamins, minerals, organic acids etc.) discharge, which is quantitively insignificant when compared with the both kinds of alteration mechanism, but requisite with regard to the configuration of concluding produce.

Drying Behavior of Osmotically Concentrated Fruits

In very little time drying process was conceivable for osmo-dried foodstuffs with the high temperature as those having little quantity of moisture. Normally osmotic concentration would conclusion little moisture contented to be warehoused for longer period. Osmo-dried foodstuffs need to be processed supplementary by various approaches (vacuum drying or air drying, etc.) to attain shelf-stable products (Ponting, 1973). The osmo-dried mango and papaya pieces/slices are to be dried at temperature 60 °C for 6 hours to acquire 16 % moisture contented (Guru Meenakshi *et al.*, 2005).

Packaging in case of O D Foodstuffs

To avoid absorption of humidity from surroundings and to avoid decomposition caused by infestation and food grading, airtight packing can be used to stock such osmotically dried nourishments. Plastic-coated (laminated) polypropylene bags and aluminum foils etc. are recommended as ideal and perfect packing materials (Sagar and Khurdiya, 1999). An experiment was conducted successfully by using HDP bags for osmo-dried fruit of papaya (Ahmed and Choudhary, 1995). Such dehydrated products/foodstuffs were to be kept at standard temperature conditions for duration of six months or so and were acknowledged with slight fluctuations.

Storing aspect of Osmotically Dehydrated Foodstuffs

The storing constancy of such products diverges have duration ranges from six months to one-year. Dried papaya artifact/product achieved through OD technique remains steady up to six months of storage at normal temperature (Ahmed and Choudhary, 1995). Banana products, osmotically dehydrated can be stored up to one year or more, liable to the storage circumstances, temperature and packaging ingredients used (Bongirwar and Sreenivasan, 1977). Experiment conducted on storage concerning osmo-dehydrated pieces of mango exhibited that sustaining R.H. between 64.8-75.5 per cent would be beneficial for keeping colour, taste, flavor and texture as such.

Infectious Evaluations of Osmo-dehydrated Foodstuffs

Microbial superiority of transitional moisture content banana stored at 0 °C - 37 °C, the total plate sum total was 250 to 300 colonies/g but at ambient temperature and 37 ^{0}C, it was lowest, product was micro-biologically harmless for straight consumption (Ramarjuna and Jayaraman, 1980). Average plate count of fig toffee was deliberated after six months of storage duration. Sodium benzoate treated toffees were testified to be low in microbial count (11 x 103/g) as compared to untreated ones (23 x 103/g) one (Khandekar *et al*., 2005).

Advantages and parameters of Osmotic Dehydration

Various parameters of OD in food industry are there. Let's consider few important parameters-

1. Quality

Osmotic dehydration's concentration is a major tool to lessen the moisture content in the quality of fresh foodstuffs/products. This is done by treating the product at lower temperature (35-50°C) (as low temperature had no influence on the characteristics on membranes of the cell, obligatory for osmotic occurrence (Lazarides, 1982). Tissue of the plant is engrossed in osmotic standard solution. As oxygen availability was not there so need not to use antioxidant to guard against oxidative discoloration and enzymatic activities (Dixon *et al*., 1976). Dipping the product in osmotic solution beforehand application of air-drying method was useful for refining quality features since acidity was reduced and browning (oxidation) was prevented (Ponting, 1973). Osmotic methods were applied before freezing was done to generate different kinds of fruits that are stored for longer period with the enhancement/improvements of flavor and color texture after thawing (Sormani *et al*., 1999) and decreased the drip loss on freeze (Lazarides and Mavroudi 1995).

2. Saving Energy

Various kinds of OD applications are used for processing of fruits and vegetables products. However, this method is not able to yield the product of less moisture level which has extended shelf life and stableness. So, OD is used along with other drying approaches such as vacuum freeze, or convective drying method to obtain final good quality product. Cost reduction is main aim to combine different methods. Water was removed from product without using external energy (Lazarides, 1982).

Beside these, there are several benefits of the OD technique, like

1. It diminishes the effect of temperature conditions on nutrient composition of foodstuff and preserves the integrity, as not very high temperature conditions are required for the process.
2. Minor heat action favors, flavor and colour retaining along with resulting better organoleptic characteristics of the product.
3. It enhances resistance to the temperature.
4. The method is not complicated and economical. Because prerequisite of energy is 2-3 times less in comparison to the traditional drying.
5. Enzymatic browning is avoided and prevents actions of polyphenol oxidases.
6. It results in betterment of rehydration features and the texture.
7. The blanching procedure may be get rid of by osmotic dehydration, which cuts cost of technique.
8. Acid elimination and sugar withdrawn by vegetables and fruits alters their configuration and advances the taste and acceptableness and the effect is known as candying.
9. This method could verify to be decent enough for the creation of ready to eat foodstuffs such as raisins etc.
10. This technique cuts down volume of the foodstuffs thereby redeeming processing cost, storage and charges of transport etc.
11. Continual dipping product in osmotic mediators prevents the exposure to O_2; the product holds better features like color etc.
12. It guards the composition of the product (fruit/vegetable) against collapse during subsequent drying process. It sustains the shape etc. of the dehydrated products as such.

Alternative technique named; vacuum osmotic dehydration method leads to some additional benefits in contrast to atmospheric osmotic dehydration (OD) technique. The outcome of vacuum method is very significant in mass transfer phenomena for the kinetics, predominantly regarding weight lessening of food and water loss during osmotic managing. This influence of vacuum application cannot be elucidated only on the basis of osmotic transport means and diffusional. So, a hydrodynamic technique has been anticipated and practically evaluated. Taking this new mechanism into consideration, a much precise method to demonstrating of the vacuum osmotic dehydration may (OD) be used (Fito, 1994).

Effect on the physiognomies of the osmosed apples was assessed with different kinds of osmotic solutions, with or without little quantities of added sodium chloride which was used during experiment. It was concluded that water loss of the final product and water activity were influenced not only by activity of the osmotic agent, but also by the put-on objects in the prototypical. Gain in solid objects depends on the syrups configuration and the sample form. Adding small amounts of sodium chloride to osmotic solutions has improved the energetic force of the drying technique (Lerici *et al*., 1985). Osmotic dehydration is gaining acceptance, as it is energy effective and has quality correlated advantages. Moreover, it is a gracious processing stage in the sequence of coalesced food dispensation. Because osmotic dehydration is a sluggish technique, hence new supplementary ways are needed for increasing the mass transference without disturbing the quality. Certain restraints are still there for the extensive industrial acceptance of osmotic dehydration. In order to associate the outcomes of various studies, there is a need to validate experimental results in terms of vital aspects like coefficient of diffusion. Several approaches to increase mass transfer, e.g. electrical field pulses, ultrasound, vacuum including centrifugal force application of higher hydrostatic pressure are also accessible (Rastogi *et al*., 2002). Enhanced solution concentration caused higher water loss. An increase of sucrose in osmotic solutions declined the activity of driving force (Azoubel and Murr, 2004). When When OD is conducted less than 30 minutes, it reduces the water diffusivity because of sugars attainment but also increases the same diffusivity when carried out for longer duration i.e. more than one hour, due to break down of cells and lessening the confrontation to water diffusion. Ultrasound treatment advances diffusivity of water due to microscopic transmission composition which offers non-significant confrontation to water diffusion process. (Dalla Rosa and Giroux 2001).

Problems in Implementation of Osmotic dehydration

This technique for animals' or plants material in intense solutions has resulted the several factors due to execution of the concentrated sugar or salt solutions. Actual problem occurs in handling its dilution proportion. Solution proportion has been controlled by the constant rate of the conversation of solution or solvent (Dalla Rosa and Giroux, 2001). Several technologies have been tried to control dilution ratios (Dalla Rosa *et al*., 1992). Additional problem accompanying the application of osmotic treatment was loss of particles from food (aromas, acids, pigments and proteins etc.) along with solute loss and which penetrated into solution. Foremost problem happened in water movement as well as in viscosity, color and adjustment of pH, flavor deviations during its consumption (Dalla Rosa and Giroux, 2001). When solution has been used again, then restoration of solute can also be managed. Several methods have been tried to achieve the goal, including evaporation at low or high temperature with the application of vacuum method, adding solute to save the energy cost, cryo-concentration and concentration of membrane. Microbial adulteration by yeasts, and molds etc. was most widespread during processing method. Application of CCP and HACCP methodology for governing development is mandatory when the osmotic dehydration is to be done without any subsequent course set up to obtain the reliability of concluding produce (Dalla *et al.,* 1992, Singh and Oleviera, 1994).

Conclusion

OD method is a modest technique which enables us processing of several tropical/subtropical fruits and vegetables such as mango, pineapple, sapota, banana, guava, papaya, pumpkin, carrot etc. along with retention primary, elementary physiognomies viz., colour, aroma, and nutrients etc. During osmotic dehydration technique adds healthier and nourishing value, results in wholesome and ensures its availability round the year.

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