Osmotic dehydration of fruits & vegetables

Pant P. and Saini H.

Introduction

India is the second largest producer of fruits & vegetables after China, with a production of 44.04 million tonnes from an area of 3.72 million hectares and an annual production of 87.53 million tonnes vegetables from 5.86 million hectares having a share of 14.4 % to the world production. Fruits & vegetables are an important supplement to the human diet as they provide the essential minerals, vitamins and fibre required for maintaining health. The varied agro climatic conditions available in our country make it possible for us to produce several types of tropical, subtropical and temperate fruits and vegetables.

A large variety of fruits are grown in India, of which mango, banana, citrus, guava, grape, pineapple are the major ones. In case of vegetables, potato, tomato, onion, cabbage and cauliflower account foe around 60 % of the total vegetable production in country.

Only 2 % of these crops are produced into value added products. There are over 4000 processing units functioning in India. But a marginal quantity of 1.0 to 2.0 % of the produce is processed and packaged in contrast with developed and developing countries i.e., 70 to 80 %.

Many processing techniques can be employed to preserve fruits & vegetables as drying and dehydration, one of the most important operations that are widely practiced because of considerable saving in packaging, storage etc.

Osmotic dehydration has received greater attention in recent years as an effective method for preservation of fruits and vegetables. Osmotic dehydration is a food preservation technique or the processing of dehydrated foods since it presents some benefits such as reducing the damage to the flavour, colour, inhibiting the browning of enzymes and decreasing the energy costs.

History of osmotic dehydration

Pointing and coworkers in 1966 were pioneering the research on OD of foods (Pointing et al., 1966), and since after that a continuous stream of publication was appeared (Rastogi et al., 2002). By using of osmosis process 50% of original weight of fruit was reduced, after that it was subjected to freeze or vacuum dried. Monograph of apple was calculated the drying rate of osmotic dehydration provided by Farkas and Lazar (1969). Vial et al.(1991) and Heng et al.(1990) studied the OD (kinetics) of papaya and kiwi in sucrose and glucose solutions.

The constancy of osmotically processed cherry studied by Torregianni et al.(1987), to analyze the sugar content, colour, acidity, vitamin C, pH and organoleptic distinctiveness. The transfer of mass during OD of pineapple was reported by Beristain et al.(1990). Many research papers or review papers were published (Torregianni, 1993) dealing with a variety of parameters, such OD mechanism and modeling of solid gain and water loss (Rastogi et al., 2002).

What is Osmotic Dehydration?

Osmotic concentration is the process of water removal from fruits and vegetables, because the cell membranes are semi-permeable and allow water to pass through them more rapidly than sugar. During osmosis small quantity of fruit acid is removed along with water. It is a dynamic process, in which water and acid are removed at first and then move slowly, while sugar penetration is very slight at first but increases with the time. Therefore, the characteristics of the product can be varied by controlling temperature, sugar syrup concentration, concentration of osmosis solution, time of osmosis etc. to make osmotic concentration process faster.

Application of Osmosis in Food Processing

The osmotic dehydration process and influence of its process variables such as pretreatment, temperature of sugar solution and additives on the mass transfer in osmotic dehydration of various fruits was studied by Ponting et al. (1966) and reported that the apple slices reduced to 50 per cent of original weight by using 60 – 70^0 Brix sugar solution and superior quality. The study also indicated that there was no need of sulphur dioxide treatment to prevent loss of colour. The osmotic air-dried products were high in superior quality and reported that the osmosis process removed water from fruits and vegetables slices to the extent of 40 – 50 per cent of the weight, but not enough for storage. Therefore, to remove water up to safe levels further drying is needed. Bongirwar and Sreenivasan (1977) indicated that the high temperature above 60 ℃ modifies the tissue characteristics favouring impregnation phenomena and thus solid gain. Rahman and Lamb (1991) reported the rate of sucrose diffusion is a function of solute concentration and temperature. The diffusion coefficient decreased with the increase in solid content during the osmosis and increased with the drying air temperature.

Kinetic of Osmotic Dehydration

The kinetic 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 the large driving force between the dilute fruit sap and osmotic solution (Sharma et al., 2004).

Raw Materials Characters for Osmotic Dehydration

Quality of raw material

The variety and maturity of fruits and vegetables mainly control water loss and solid gain in the osmosis process. Among different fruits variability is mainly related to the tissue compactness, initial insoluble and soluble solids content, inter cellular spaces and enzymatic activity of the fruit. The kinetic rate of solid gain did not depend significantly on solute concentration or process temperature. Among different varieties of mango Dashehari and Totapuri at ripe stage were found suitable for osmotic dehydration (Tiwari &Jalali, 2004).

Shape, size and thickness of the fruit pieces

Water loss increases with increase in the surface area of fruit pieces. Panagiotou et al. (1998) observed that the size of fruit samples had a negative effect on water loss during osmotic treatment and also observed that the distribution coefficient of water decreased with increasing temperature and surface area and it increased with the increase in syrup concentration and thickness of minimum geometric dimension. In general, a sample size of 3 mm to a maximum of 10 mm in rectangle, ring or cube shape was suggested for the use in osmotic dehydration process.

Process parameters of osmotic dehydration

Transfer of mass during osmotic dehydration inclined by temperature, size and geometry, concentration of osmotic solution, material to solution ratio, agitation, degree of solution, and methods of pre drying. Temperature was much important factor which involved in breaking the integrity of plant material and membrane; for example plasma membrane started to undergo irreversible damage at 50°C (Thebud and Santarius, 1982). With increasing the level of agitation there was increasing the rate of dehydration. The sufficient level of agitation ensured the minimization of mass transfer affected on liquid side (Rastogi et al.,2002). When the time spent over, then membrane did not provide barrier for the solute, which penetrated to the cell (Mauro et al., 2002). The product mass ratio and solution was brought on different effects in the solution of

dehydrated process. The driving force decreased to release of water when osmotic solutions become dilute. The shape of material was another factor in OD. If the size of solid material was bigger then dehydration rate would be slowed because the length of diffusion path was higher. So process dependent on the food nature, structure and weight of osmotic solute and pressure was also affected on transfer of mass (Rastogi et al.,2002).

Mass transfer phenomena during osmotic dehydration

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

1. Important water out flow from product to solution.
2. Asolute transfer, from the solution to the product; it makes thus possible to introduce the desired
amount of an active principle, a preservative agent, any solute or nutritional interest, or a sensory quality improvement of the product.
3. Leaching out of products own solutes (sugar, organic acids, minerals, vitamins etc.), which is quantitatively negligible when compares with the first two types of transfer, but essential with regard to the composition of final product.

Benefits of osmotic dehydration

There were two important parameters of OD in food industry (1) quality feature of texture, colour, flavor, stability of product, nutrients retention during storage and (2) energy competence.

Quality issues

The concentration of OD was an important tool to reduce the water content with little bit damage on the quality of fresh products. This was done with the mild treatment of product at low temperature (30-50°C); so that temperature did not affect the properties of cell membranes, which was necessary to maintain the osmotic phenomenon (Lazarids, 2001). The plant tissue was continuously immersed in the osmotic medium because oxygen was not exposed so that there was no need of use of antioxidant to protect against enzymatic and oxidative discoloration (Dixon et al., 1976).

The immersion of food in osmotic medium before air drying was helpful for improving the final product quality since acidity of fruit reduced and prevents the oxidative browning (Pointing, 1973). Osmotic treatments before freezing were done to generate different types of fruits that stored for longer periods with the improvement of texture, flavor, and colour after thawing (Sormani et al., 1999) and reduced the drip loss on freeze (Lazarides and Mavroudis, 1995).

Energy saving

Different types of OD applications were using in the processing of fruits and vegetables. However OD was not able to produce the product of low moisture content which has longer shelf life and stability. So osmotic dehydration was using with other drying methods such as freeze, vacuum or convective drying step to get the stable product. So that OD and drying methods were used in combination to reduce the cost of production. Water was removed in liquid form without using external energy (Lazarids, 2001).

DryingBehaviour of Osmotically Concentrated Fruits

The high temperature short time drying process was possible for osmo-dried products as those having low moisture content. Generally osmotic concentration would not give low moisture content to be stored for long time. Osmo-dried products should be processed further (air drying, vacuum drying etc.) to obtain shelf-stable products (Pointing, 1973). The osmo dried papaya and mango slices were dried in a cabinet dryer at 60^0 C for 6 hrs to obtain 16 per cent moisture content (Gurumeenakshi et al., 2005).

Packaging of Osmotically Dehydrated Products

In order to prevent absorption of moisture from atmosphere and to prevent spoilage due to contamination, air tight containers of good quality and food grade and can be used to store osmotically dried foods. Aluminum foil, laminated polypropylene pouches are suggested as ideal packing materials (Sagar&Khurdiya, 1999). Ahemed and Choudhary (1995) used high-density polyethylene pouches for osmo-dried papaya. Dried products were kept at room temperature for six months and it was accepted with little changes.

Storage of Osmotically Dehydrated Products

The storage stability of osmotically dehydrated products varies from six months to one year. The papaya product obtained from osmotic dehydration process remains stable up to six months of storage at room temperature (Ahemed&Choudhary, 1995). Bongirwar and Sreenivasan (1977) reported that the osmotically dehydrated banana products can be preserved up to one year or more depending upon the storage conditions and packaging materials used. Storage studies on osmo-dehydrated mango slices showed that the keeping relative humidity between 64.8 to 75.5 per cent would be conducive for the retention of colour, flavour, texture and taste.

Advantages of Osmotic Dehydration

There are number of advantages of the osmotic dehydration process.

1. It minimizes the effect of temperature on food quality and preserves the wholeness of the food, as no high temperature/phase change is required in the process.
2. Mild heat treatment favourscolour and flavour retention resulting in the product having superior organoleptic characteristics. It is more when sugar syrup is used as osmotic agent.
3. It increases resistance to heat treatment.
4. The process is quite simple, economical (energy requirement is 2-3 times less as compared to the conventional drying.
5. It prevents the enzymatic browning and inhibits activities of polyphenol oxidases.
6. It improves the texture and rehydration properties.
7. The blanching process may be eliminated by this process, which reduces cost of processing.
8. Acid removal and sugar uptake by fruits modifies the composition and improves the taste and acceptability which is called candying effect.
9. The process could prove to be good for production of the ready to eat foods such as raisins etc.
10. The process reduces volume of the products thereby saving in the cost of processing, storage and transport.
11. Constant immersion of product in osmotic agents avoids the O_2 exposure, the product retains better colour.
12. It protects against the structural collapse of the product during subsequent drying. It helps to retain the shape of the dehydrated products.

Drawbacks of Osmotic Dehydration

The reduction in acidity level reduces the characteristic taste of some products. This can be overcome by adding fruit acid in the solution. Solute uptake and leaching of valuable product constituents often lead to substantial modification of the original product composition with a negative impact on sensory characteristics and nutritional profile. Sugar coating is not desirable in certain products and quick rinsing may be necessary after the treatment. Sugar uptake results in the development of a concentrated solids layer under the surface of the fruit, upsetting the osmotic pressure gradient across the fruit interface and decreasing the driving force for water flow. In terms of final product characteristics, sugar uptake affects both rehydration and flavour retention due to lower rehydration of sugar in the fruit, compared with fruit tissue itself (Chaudhariet al., 1993; Ghosh et al., 2004).

Conclusions

Osmotic dehydration process being a simple process, facilitates processing of tropical fruits and vegetables such as banana, sapota, pineapple, mango, guava, carrot, pumpkin, papaya etc with retention of initial fruit characteristics viz., colour, aroma and nutritional compounds. In preservation of fruits and vegetables osmotic dehydration process add value to the finished product, which is wholesome, nutritious and available round the year.

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