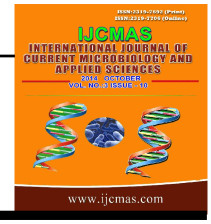

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Original Research Article

Osmotic dehydration characteristics of Sapota (Chickoo) slices

Kedarnath[1], Kiran Nagajjanavar[2] and S.V.Patil[2]

[1]Department of Agricultural Engineering, GKVK, UAS, Bangalore, India
[2]College of Horticulture, Sirsi, 581401, University of Horticultural Sciences, Bagalkot Karnataka, India
**Corresponding author*

A B S T R A C T

Keywords

Sapota, Concentration Temperature, Duration, Osmotic dehydration.

Sapota slices were immersed in a solution containing sugar solution of 30, 40 and 50 ^{o}Brix for about 1 h, at three different osmotic solution temperatures 30, 40 and 50^{o}C. The effect of process parameters (such as duration of osmosis, syrup concentration and syrup temperature) on mass transport data (such as water loss, solid gain and mass reduction) during osmotic dehydration was studied. After 1 h of osmotic dehydration, the minimum and maximum mass reduction, water loss and sugar gain were in the range of 13.54 to 30.25; 23.84 to 36.66 and 3.80 to 6.40 per cent corresponding to low levels (30 ^{o}Brix, 30^{o}C) and high levels (50 ^{o}Brix, 50^{o}C) of syrup concentration and temperature respectively.

Introduction

Sapota (*Achras sapota*) is native to Central and South America, specifically from the Yucatan Peninsula of Mexico to Costa Rica, where the largest population of native trees still exists(Gilly, 1943). India is the largest producer of sapota with 30 to 40 thousand hectares area and is one of the best loved fruit of country. In India, Maharashtra will lead the table with highest area, production and productivity of sapota followed by Karnataka and others states (National horticultural board, 2008). Raw sapota fruits are astringent, while ripe fruits are sweet. Mature fruits are used for making mixed fruit jams and provide a valuable source of raw material for the manufacture of industrial glucose, pectin and natural fruit Ripe sapota is eaten as dessert fruit and also is canned. Only the pulp is usually consumed, although skin is richer in nutritive value than pulp (Gopalan *et al.*, 1985). Like other fruits, ripened sapota cannot be stored for more than a day or two and no published data are available on the percentage of spoilage of sapota due to over ripening (Jain and Jain, 1998).

Many researchers have studied osmotic dehydration of various fruits and vegetables, such as apple, banana, carrot, cherry, citrus fruits, grape, guava, mango, *etc.* (Torreggiani and Bertolo, 2001; Jain *et al.*, 2003). The osmotic dehydration process has been studied and used as a pre-treatment prior to further processing such as convective-drying (Pisalkar *et al.*, 2011) and (Mehta *et al.*, 2013). Very few attempts have been made to study osmotic dehydration characteristics of sapota. Therefore, a study was proposed to investigate osmotic dehydration characteristic of sapota.

Osmotic dehydration is one of the less energy intensive techniques than air or vacuum drying process because it can be conducted at low or ambient temperature. It is the process of water removal by immersing water containing cellular solids in concentrated aqueous solution. The driving force for water removal is the concentration gradient between the solution and the intracellular fluid. If the membrane is perfectly semi-permeable, solute is unable to diffuse through the membrane into the cell. However, it is difficult to obtain a perfect semi-permeable membrane in food systems due to their complex internal structure and there is always some solid diffusion process. The water and acid diffuse at faster rates initially and get reduced at later stage, while solute from concentrated solution diffuses in opposite direction. The solute penetration in food material is less at first, but increases with respect to time. The solute (sugar) penetration in the fruit directly affects the quality *i.e.* both flavour and taste of the end product.

Materials and Methods

A widely grown fruit sapota (*cv Kalipatti*) was selected for the osmotic dehydration experiment. Food grade sugar was used as an osmotic agent being cheap and easily available. Ripened sapota of uniform size, colour and firm texture were taken for experiment. Selected fruits were thoroughly washed under tap water to remove adhering impurities before slicing the fruit. The outer skin of the ripened fruit was carefully peeled off manually using a sharp stainless steel knife without damaging the pulp. The peeled sapota fruits were cut into about 4-5 mm thick slices for the experiment. Sugar syrups of various concentrations were prepared by dissolving required amount of sugar in distilled water.

Sugar syrup of 30, 40 and 50 ^{o}Brix concentration was prepared by adding the required amount of sugar in distilled water and the total soluble solids of prepared syrup were determined by hand refractometers of various ranges (0-32, 28-62 and 58-92 ^{o}Brix). The moisture content of the fresh as well as osmotically dehydrated sapota samples was determined by oven drying at 70^{o}C for 18 h (Ranganna, 2000).

Experiments were conducted at nine combination of three concentrations (30, 40, and 50^{o} Brix) and three temperatures (30, 40 and 50^{o}C). The prepared samples (sapota slices) were weighed approximately 40 g for every experiment and immersed in the sugar syrup (30, 40 and 50 ^{o}Brix) contained in a 250 ml glass beaker. The beakers were placed inside the constant temperature water bath. The syrup in the beakers was manually stirred at regular intervals to maintain uniform temperature. One beaker was removed from the water bath at designated time and placed on tissue paper to remove the surface moisture. The samples were weighed and their moisture contents were determined. The water loss and solid gain were calculated based on mass balance. All the experiments were replicated thrice and results reported are from average value of three replications.

Water loss

Water loss is the quantity of water lost by food during osmotic processing. The water loss (WL) is defined as the net weight loss of the fruit on initial weight basis and is estimated as follows.

$$WL = \frac{W_i . X_i - W_\theta . X_\theta}{W_i} \quad \text{... (1)}$$

Mass reduction

The overall exchange in the solid and liquid of the sample do affect the final weight of the sample. The mass reduction (MR) can be defined as the net weight loss of the fruit on initial weight basis.

$$MR = \frac{W_i - W_\theta}{W_i} \quad \text{... (2)}$$

Solid gain

The solids from the osmotic solution get added in the sample of sapota slices during osmotic dehydration. The loss of water from the sample takes place in osmotic dehydration consequently it increases the solid content. The solid gain is the net uptake of solids by the sapota slices on initial weight basis. It is computed using following expression:

$$SG = \frac{W_\theta (1-X_\theta) - W_i (1-X_i)}{W_i} X\ 100 \quad \text{... (3)}$$

From Equations (3.2) and (3.3), the solid gain (SG) can be correlated with mass reduction (MR) and water loss (WL) as,

$$SG = WL - MR \quad \text{... (4)}$$

Where, WL= Water loss (g per 100 g mass of sample)
SG = solid gain (g per 100 g mass of sample),
MR= Mass reduction (g per 100 g mass of sample),
W_θ = mass of slices after time θ, g,
W_i = initial mass of slices, g,
X_θ = water content as a fraction of mass of slices at time θ.
X_i = water content as a fraction of initial mass of slices, fraction.

Results and Discussion

Water loss

The water loss increased from 0 to 23.84, 28.04 and 32.83 per cent when duration of osmotic dehydration increased from 0 to 1 h for 30 ^{o}Brix at 30, 40 and 50^{o}C temperatures respectively. For 40^{o}Brix, the water loss was found to vary from 0 to 25.18, 32.26, and 35.17 per cent and similarly at 50 ^{o}Brix was found to vary from 0 to 27.18, 32.68 and 36.66 per cent at 30, 40 and 50^{o}C respectively.

Figure 1 revealed that a low temperature-low concentration condition (30^{o}C - 30 ^{o}Brix) resulted in a low water loss (23.84 per cent after 1 h of osmosis) and a high temp-high concentration condition (50^{o}C - 50 ^{o}Brix) resulted in a higher water loss (36.66 per cent after 1 h of osmosis). This indicates that water loss can be increased by either increasing the syrup temperature or concentration of solution. Similar results have been reported for osmotic dehydration of bananas by Sagar (2001). Such effects have also been reported in various fruits and vegetables (Ertekin and Cakaloz, 1996; Karathanos *et al.,* 1995; Lazarides *et al.,* 1995; Pokharkar and Prasad, 1998).

Figure 2 shows the variation in water loss in 30, 40 and 50 °Brix concentrations at temperatures 30, 40 and 50°C. The water loss was found increasing with increasing osmotic solution concentrations at all the three solution temperatures *i.e.* at 30, 40 and 50°C.

These findings were in confirmation with the results obtained. In all the experiments, the rate of water loss was more in the beginning of process and decreased gradually with the increase of duration of osmosis and approaches equilibrium. The similar results were quoted in case of the osmotic dehydration of green beans (Biswal and Bozorgmehr, 1991) and banana slices (Pokharkar and Prasad, 1997). Increased water loss with increase in syrup concentration at a particular temperature of syrup may be due to increased osmotic pressure in the syrup at higher concentrations, which increased the driving force available for water transport. This is in agreement with Nieuwenhuijzen *et al.,* 2001.

Sugar gain

The sugar gain was increased from 0 to 3.80, 4.20 and 4.74 per cent when duration of osmotic dehydration increased from 0 to 1 h for 30 ^{o}Brix concentration at 30, 40 and 50^{o}C syrup temperatures respectively. For 40 ^{o}Brix concentration, the sugar gain was found to vary from 0 to 4.71, 5.10 and 5.71 and for 50 ^{o}Brix it varied from 0 to 5.60, 6.03 and 6.40 per cent for 30, 40 and 50^{o}C syrup temperature.

Figure 3 shows that sugar gain increased with duration of osmosis and approaches the equilibrium after 1 hour of osmotic dehydration. The sugar gain also increased when the concentration of the syrup was increased. This is because of the increased concentration difference between samples. The sugar gain also increased with increase in syrup temperature. It may be due to collapse of the cell membrane at higher temperatures. Similar results have been reported by Ertekin and Cakaloz (1996) and (Nsonzi and Ramaswamy, 1998).

Figure 4 shows the variations in sugar gain at various temperatures at 30, 40 and 50 º Brix concentrations. A low temperature-low concentration condition (30^{o}C-30 ^{o}Brix) gives a low sugar gain (3.80 per cent after 1h of osmosis) and a high temp-high concentration condition (50^{o}C-50 ^{o}Brix) gives a higher sugar gain (6.40 per cent after 1 h of osmosis). The low temperature-high concentration condition 30^{o}C-40 ^{o}Brix and 30^{o}C-50 ^{o}Brix gives a slightly lower sugar gain of 4.71 and 5.60 after 1 h of osmosis than high temperature-high concentration condition 50^{o}C-40 ^{o}Brix and 50^{o}C-50 ^{o}Brix as 5.71 and 6.40 per cent sugar gain after (1 h of osmosis) indicates a pronounced effect of temperature on sugar gain.

This indicates that sugar gain can be increased by either increasing the syrup temperature or concentration of solution. However, an increase in temperature of sugar solution by 10°C has more influence on sugar gain than an increase in concentration by 10 °Brix, may be because of higher temperature causes destruction of cell membrane structure. Similar results have been reported by Lazarides *et al.* (1995) with osmotic dehydration of apple slices in a temperature range of 20-50^{o}C.

Mass reduction

The mass reduction after osmotic dehydration was found to be in the range of 13.54 to 30.25 per cent, corresponding to experiments at low level (30 ^{o}Brix, 30^{o}C after 1 h) and at high level (50 ^{o}Brix, 50^{o}C after 1 h) (Fig. 5).

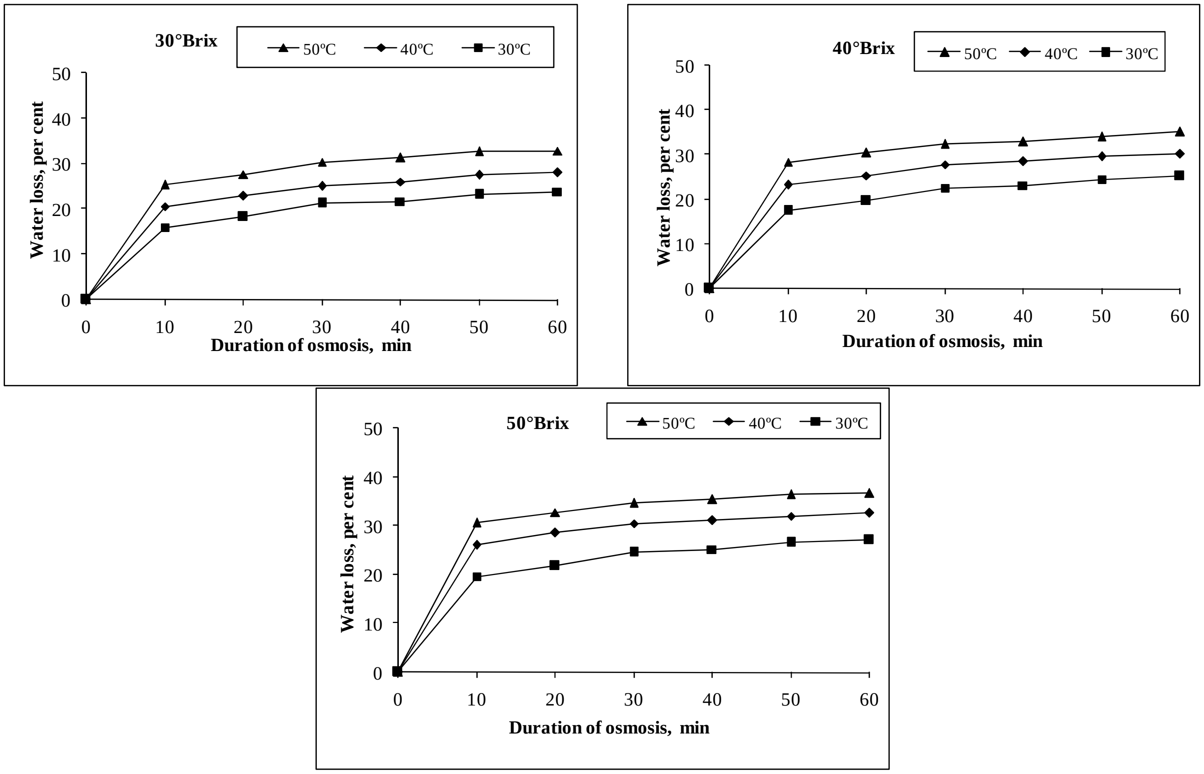

Fig.1 Variation in water loss with syrup concentration at 30, 40 and 50^{o}C temperature

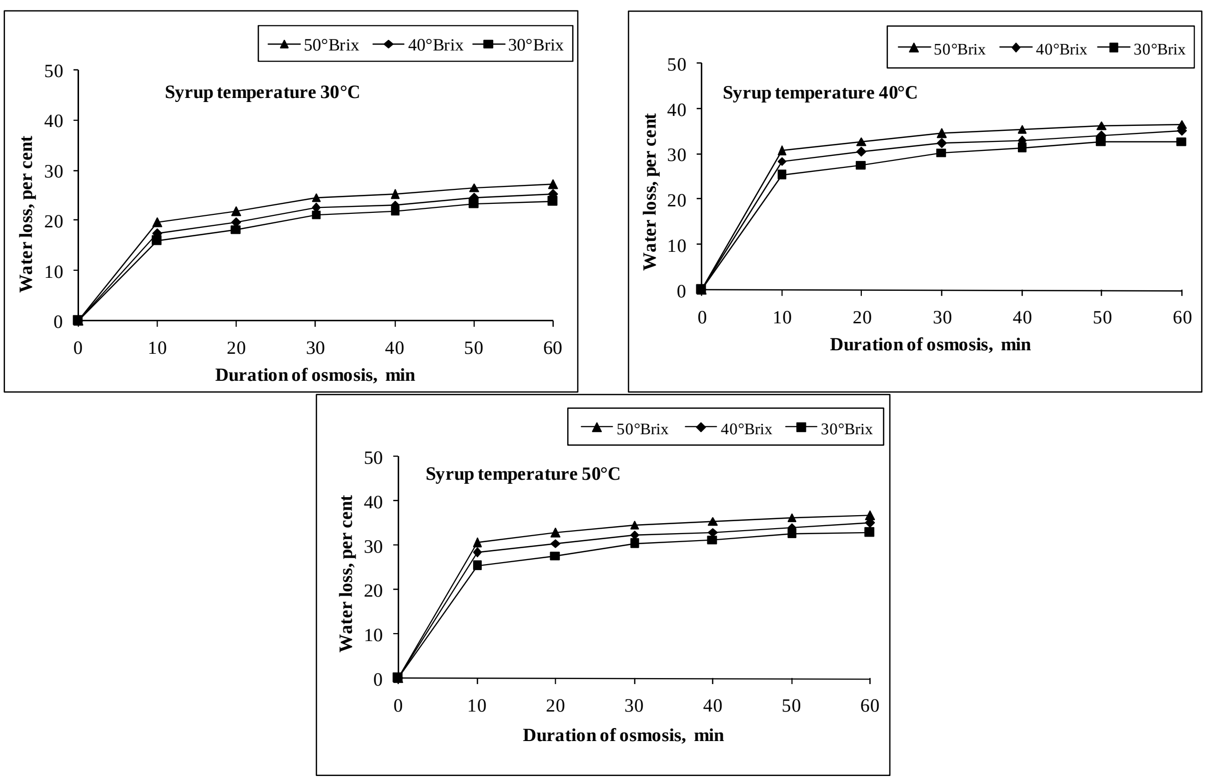

Fig.2 Variation in water loss with temperature at 30, 40 and 50 ^{o}Brix concentration

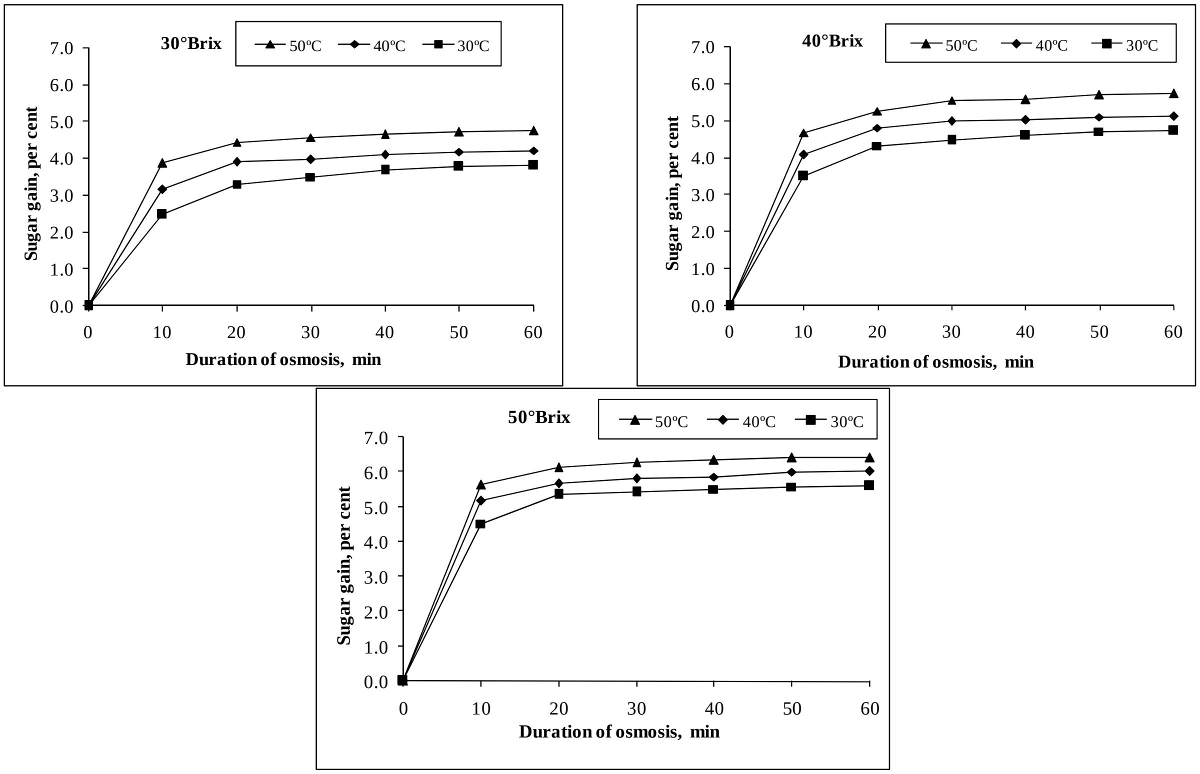

Fig.3 Variation in sugar gain with syrup concentration at 30, 40 and 50^{o}C temperature

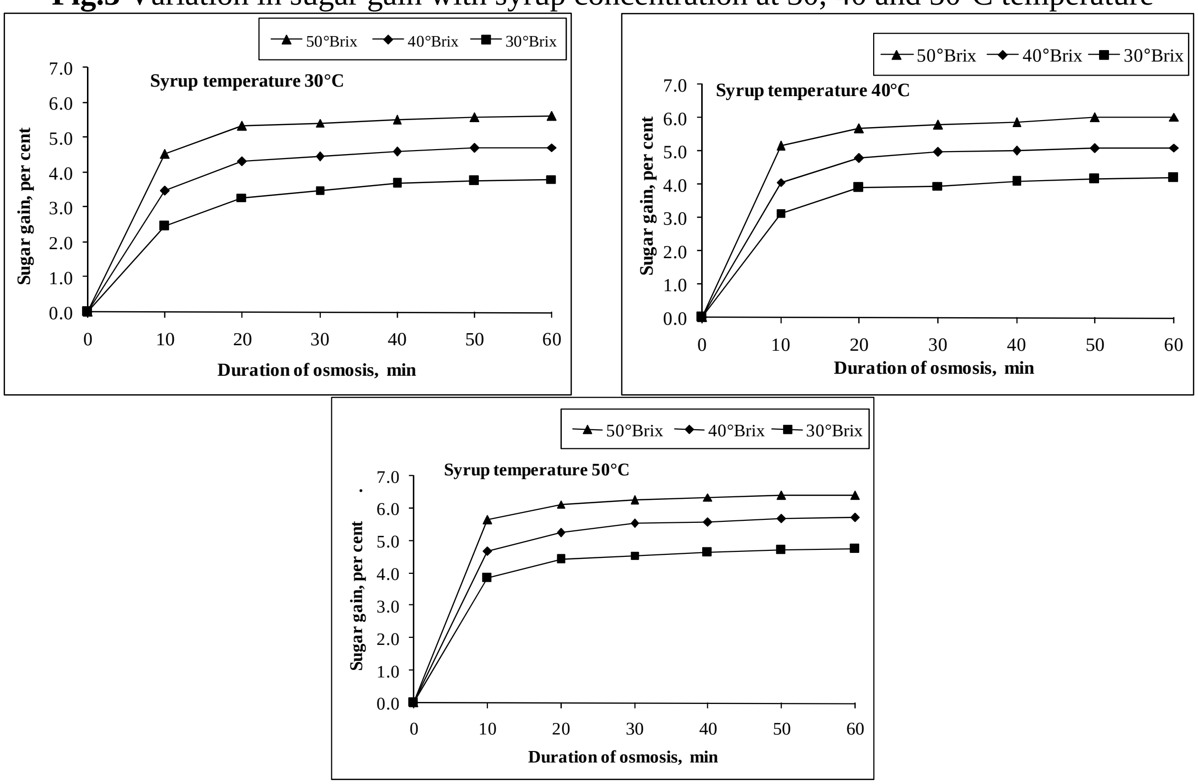

Fig.4 Variation in sugar gain with temperature at 30, 40 and 50 ^{o}Brix concentration

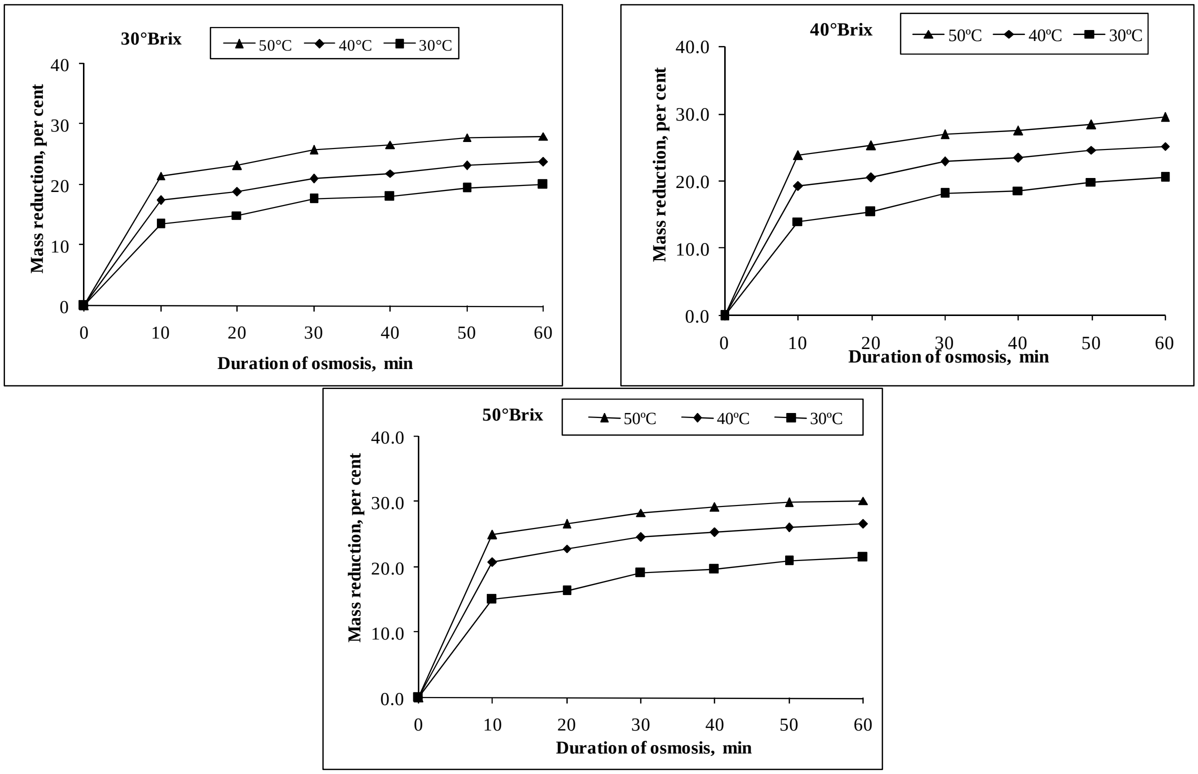

Fig.5 Variation in mass reduction with syrup concentration at 30, 40 and 50°C temperature

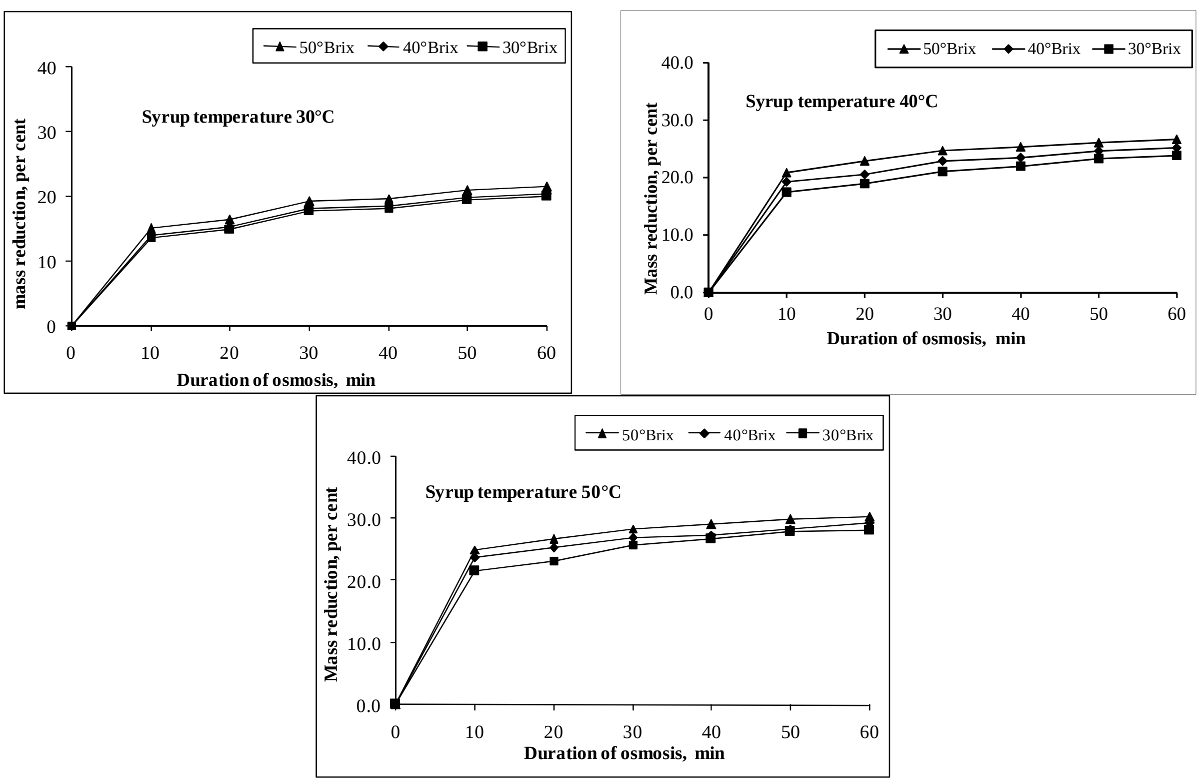

Fig.6 Variation in mass reduction with temperature at 30, 40 and 50 °Brix concentration

The mass reduction increased from 0 to 20.04, 23.84 and 28.08 percent when duration of osmotic dehydration increased from 0 to 1 h at 30, 40 and 50°C temperatures respectively for 30 °Brix while for 40 °Brix, the mass reduction was found to vary from 0 to 20.46, 25.16 and 29.49 per cent and from 0 to 21.57, 26.65 and 30.25 per cent at 30, 40 and 50°C respectively.

Figure 5 reveals that a low temperature-low concentration condition (30°C-30 °Brix) resulted in a low mass reduction (13.54 per cent after 1 h of osmosis) and a high temp-high concentration condition (50°C-50 °Brix) resulted in a higher mass reduction (30.25 per cent after 1 h of osmosis). This indicates that mass reduction can be increased by either increasing the syrup temperature or concentration of solution. Similar results have been reported for osmotic dehydration of onions by Torreggiani and Bertolo (2001).

Figure 6 shows the variation in mass reduction at 30, 40 and 50 °Brix solution concentration at 30, 40 and 50°C temperatures. The mass reduction at all syrup concentrations was affected by the temperature of the syrup. Mass reduction increased with increase in temperatures.

References

Biswal, R.N., Bozorgmehr, K. 1991. Equilibrium data for osmotic concentration of potato in NaCl-water solution. *J. Food Process. Eng.,* 14: 237–245.

Ertekin, F.K., Cakaloz, T. 1996. Osmotic dehydration of peas: 2 Influence of osmosis on drying behaviour and product quality. *J. Food Process. Preserv.,* 20: 105–119.

Gilly, C.L. 1943. Studies in the sapotacae. II. The sapodilla-nispero complex. *Trop. worlds,* 73: 1–22.

Gopalan, C., Ramashastri, B.V., Balasubramanyam, S.C. 1985. Nutritive value of Indian foods. Ansari nagar, New Delhi, India: Indian Council of Medical Research, Pp. 1–59.

Jain, R.K., Jain, S.K. 1998. Sensory evaluation of an intermediate moisture product from sapota (*Achras sapota* L). *J. Food Eng.,* 37: 323–330

Jain, S.K., Verma, R.C., Mathur, A.N. 2003. Osmo-convective drying of papaya. *Beverage Food World,* 30(1): 64–67.

Karathanos, V.T., Kostaropoulos, A.E., Saravacos, G.D. 1995. Air drying kinetics of osmotically dehydrated fruits. *Dry. Technol.,* 13(5-7): 1503–1521.

Lazarides, H.N., Katsanidis, E., Nickolaidis, A. 1995. Mass transfer kinetics during osmotic pre-concentration aiming at minimal solid uptake. *J. Food Eng.,* 25: 151–166.

Mehta, B.K., Jain, S.K., Mudgal, V.D., Chatterjee, K. 2013. Osmotic dehydration characteristics of button mushroom slices (Agaricus bisporus). *J. Environ. Ecol.,* 31(1): 148–153.

National horticultural board, 2008.

Nieuwenhuijzen, N.H., Zareifard, M.R., Ramaswamy, H.S. 2001. Osmotic drying kinetics of cylindrical apple slices of different sizes. *Dry. Technol.,* 19(3&4): 525–545.

Nsonzi, F., Ramaswamy, H.S. 1998. Osmotic dehydration kinetics of blueberries. *Dry. Technol.,* 16(3-5): 725–741.

Pisalkar, P.S., Jain, N.K., Jain, S.K. 2011. Osmo-air drying of aloe vera gel cubes. J. Food Sci. Technol., 48(2): 183–189.

Pokharkar, S.M., Prasad, S. 1997. A model for osmotic concentration of banana slices. *J. Food Sci. Technol.,* 34(3): 230–232.

Pokharkar, S.M., Prasad, S. 1998. Mass transfer during osmotic dehydration of banana slices. J. Food Sci. Technol., 35(4): 336–38.

Ranganna, S. 2000. Handbook of analysis and quality control for fruits and vegetable products. Tata McGraw Hill Publishing Co. Ltd, New Delhi.

Sagar, V.R. 2001. Preparation of onion powder by means of osmotic dehydration and its packaging and storage. *J. Food Sci. Technol.,* 38(5): 525–528.

Torreggiani, D., Bertolo, G. 2001. Osmotic pre-treatments in fruit processing: chemical, physical and structural effects. *J. Food Eng.,* 49(2-3): 247–253.