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Effect of Different Process Parameters on Osmotic Dehydration of Sapota Slices

*P.D. Jawake[1], V.D. Mudgal[2] and P. S. Champawat[2]

[1]Senior Research Fellow, *AICRP on PHET, CTAE, MPUAT, India*
[2]*Professor and PI, AICRP on PHET, CTAE, MPUAT, India*
[3]*Associate Professor and* Head, *Deptt. of PFE, CTAE, MPUAT, India*
Corresponding author: P.D. Jawake (jawake.pravin1@gmail.com)

Abstract**:** *Osmotic dehydration has received greater attention in recent years as an effective method for preservation of fruits and vegetables. Being a simple process, generally used as a pretreatment prior to drying of the fruit and vegetables in order to reduce energy consumption and heat damage so it can help to retention of maximum initial fruit characteristics viz., colour, aroma, texture and nutritional composition. To study the effect of process parameters such as syrup temperature, syrup temperature and duration of osmosis on responses of osmotic dehydration viz., mass reduction, water loss and sugar gain, the experimental trials on osmotic dehydration performed by immersing the fruit slices of ripen sapota in different sugar syrup concentrations (50, 60 and 70^{o}Brix) at different syrup temperatures (30, 40 and 50^{o}C) for 180 min. Mass reduction, water loss and sugar gain was observed increased with increased of syrup concentration and temperature. The mass reduction, water loss and sugar gain was found to be in the range of 17.70 to 29.23, 21.89 to 36.01 and 4.19 to 6.78 per cent, respectively. The maximum mass reduction, water loss and sugar gain was observed 29.23, 36.01 and 6.78 per cent for 70^{o}Brix syrup concentration and 50^{o}C syrup temperature, respectively, for 180 min duration of osmosis of sapota slices*

Keywords**:** *Mass reduction, osmotic dehydration, sapota, sugar gain, water loss*

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I. Introduction

Sapota fruit (*Achras sapota* L.) fruit commonly known as Chikoo, is one of the delicious fruit. The fruit pulp is usually consumed, although skin is richer in nutritive value than pulp [1]. Sapota is grown throughout the tropical regions of the world, including Central and South America, West Indies, India and Florida. Among these tropical regions, India ranked first in production with 1294 thousand metric tonnes from 107 thousand hectares area in year of 2015-16 [2]. Kalipatti cultivar is mainly grown in Maharashtra and Gujarat states [3].

Sapota fruit is rich in protein (0.70 per cent), fat (1.10 per cent), carbohydrates (20 per cent) and minerals such as phosphorous (0.072 per cent), calcium (0.028 per cent) and iron (0.0013 per cent). Sapota also has fiber (2.60 per cent), moisture content (73-78 per cent) *etc.* In addition sapota contains carotene (0.097 per cent) which is known as antioxidant and consumed for laxative property. Sapota is a good source of fiber supplement and sugar, provide quick energy and an excellent means of recovery from fatigue [4].

The post harvest losses of sapota during the peak season reaches about 30 per cent. The spoilage of sapota is due to highly perishable in nature, improper transportation and poor storage facilities [5]. These losses can be overcome through proper post harvest management *i.e* developing value chain from production to consumption. The development of value added products from sapota fruits can also be an effective method for reducing post-harvest losses. Dehydration is the most important unit operation for self life enhancement and save about 86% in shipping, 77% in storage space and 82% in handling and transport cost. Minimum labour requirements in processing, packaging and reduced distribution cost are the other advantages of dehydrated products [6]. The drying process has no exception to the use of energy but we have to adopt the such drying technique which can be consume less fossil fuels and electricity, as well as it can maintained the quality of product. The applications of osmosis in food processing as a dehydration process have been primarily motivated by economical factors and the quality improvement of the final product. Osmotic dehydration (partial dehydration of the fruit and to a lesser extent to vegetables) process received attention in recent years as pretreatment for removal of excess water prior to drying in order to reduce energy consumption and heat damage [7] [8] [9]. The studies on osmotic dehydration process of many fruits *viz.*, apple [10];[11] , strawberry [12], pineapple [13] [14], grapes [15], papaya [16] [17], Banana [18] [19], mango [20] [21] [22], Sapota [23] and Yacon [24] have been reported by several researchers. As the little work has been reported on osmotic dehydration of sapota fruit, the present study was conducted to study the effect of different process parameters on osmotic dehydration of sapota slices.

II. Materials And Methods

2.1 Sample and Solution Preparation

Sapota (var. *Kalipatti*) was procured from local market (*Krishi Upaj Mandi*, Udaipur). Grading was performed manually by hand picking on the basis of its physical dimensions, colour and absence of surface defects. The graded sapota were stored in cardboard box at ambient temperature for ripening. Ripen sapota were used for experimentation. The commercial sugar (sucrose) used as an osmotic agent, was procured from the local market of Udaipur. The graded sapota were thoroughly washed under tap water and the surface moisture was removed using blotting paper. Washed sapota fruits were peeled and sliced (5±0.5 mm thick) manually using stainless steel knife. The total soluble solid of sapota was determined by using digital refractometers [25]. Sapota fruit itself had initial concentration 23.60^{o}Brix so in view to keep higher concentration gradient between the osmotic solution and the intercellular fluid of sapota slices, sugar syrups of 50, 60, and 70^{o}Brix concentration were prepared for conducting trials on osmotic dehydration.

2.2 Experimental Set up and Procedure for Osmotic Dehydration

A small capacity laboratory temperature controlled water bath of size 30 cm × 20 cm × 20 cm (5 litres capacity) was used as osmotic dehydration unit. The unit consist of osmotic dehydration chamber, temperature indicator and electric pump. The heating chamber made of stain less steel sheet, has an immersion heater (500W) connected to the bottom of the osmotic chamber. The temperature of the osmotic solution in the chamber was controlled with the help of a thermostat. A water level indicator was also provided. Temperature sensor was also provided to determine the temperature of the sugar solution.

Experiments were conducted with three different syrup concentrations (50, 60 and 70^{o}Brix) and temperatures (30, 40 and 50^{o}C). The slice thickness of 5±0.5 mm and sample to solution ratio (1:5) were used through out study. Weighed sugar syrup (200g) and sapota samples (40g) were placed in a 500 ml beaker which was further placed into the constant temperature water bath for osmotic dehydration. The syrup in the beakers was stirred continuously at 40 rpm by electric operated stirrer to maintain uniform temperature and concentration of syrup. One beaker was removed from the water bath at designated time (after every 10 min intervals for first half hour and 30 min intervals for next two and half hour), samples were taken out and rinsed in flowing water, placed on tissue paper to remove the moisture and excess syrup from the surface and weighed for determining the moisture contents by [25]. All experiments replicated thrice and the averages of these three replication were taken for calculation.

2.3 Calculation for Mass transport parameters of osmotic dehydration

The water loss (WL), sugar gain (SG) and mass reduction (MR) were calculated on wet basis by equations 1, 2 and 3, respectively [27] [13] [28]. Variation in WL, SG and MR with progress in duration of osmosis at selected temperature and concentration were plotted x-y axis for studying the effect of temperature and concentration on WL, SG and MR.

Water loss: Water loss is the quantity of water removed from food during osmotic dehydration. The water loss (WL) is defined as the net weight loss of the fruit on initial weight basis and was estimated as

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

Sugar gain: Sugar gain is the net uptake of sugar by the slices on initial weight basis and computed using following expression:

$$SG = \frac{W_\theta(1 - X_\theta) - W_i(1 - X_i)}{W_i} \times 100 \quad \text{… (2)}$$

Mass reduction: Mass reduction (MR) is nothing but difference between water loss and solid gain. Also it can be defined as the net mass reduction of the fruit on initial weight basis.

$$MR = \frac{W_i - W_\theta}{W_i} \quad \text{... (3)}$$

Where,

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

2.4 Statistical analysis

The data obtained in three replications were subjected to statistically analyze to study influence of process factors (syrup temperature and concentration) on different responses of osmotic dehydration process viz. water loss, sugar gain and mass reduction were analyzed using analysis of variance (ANOVA) technique with Completely Randomized Design (CRD) as suggested by [29]. The critical difference value at 1% level of probability was used for comparison among all treatments.

III. Results And Discussion

3.1 Effect of Different Temperatures and Concentrations on Water Loss

The effect of temperature and concentration of syrup solution on water loss has been illustrated in Fig. 1, 2 and 3. The water loss of 21.89, 25.85 and 28.36 per cent found for 50 ºBrix at 30, 40 and 50ºC temperatures, respectively when duration of osmotic dehydration increased from 0 to 180 min (Fig.1). Also for 60ºBrix, the water loss was found 26.12, 30.28, and 33.18 per cent at 30, 40 and 50ºC, respectively (Fig.2). Similarly for 70ºBrix concentration, the water loss was found 28.83, 33.23, 36.01 per cent at 30, 40 and 50ºC syrup temperatures, respectively (Fig.3). It was found that a low temperature-low concentration condition (30ºC-50ºBrix) resulted in a low water loss (21.89 per cent after 180 min of osmosis) and a high temperature-high concentration condition (50ºC-70ºBrix) resulted in a higher water loss (36.01 per cent after 180 min of osmosis).

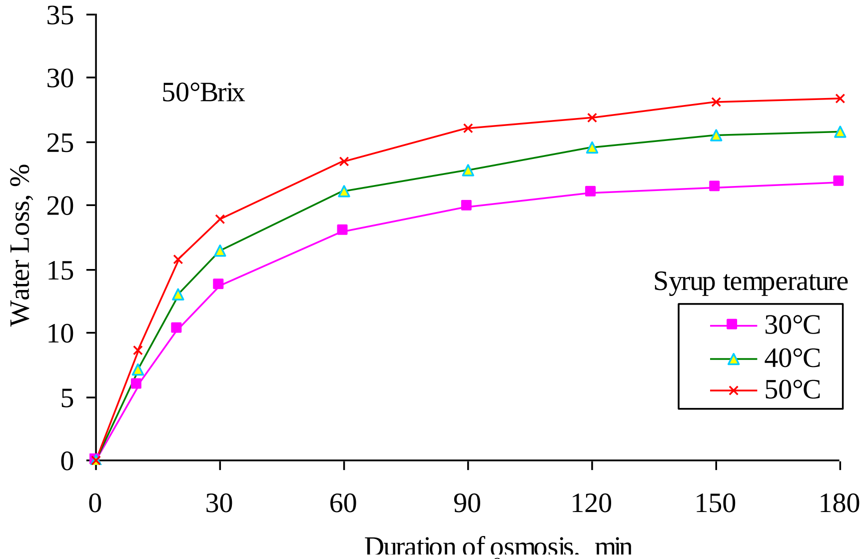

Fig. 1 Variation in water loss with duration of osmosis at 50°Brix syrup concentration at three different syrup temperatures

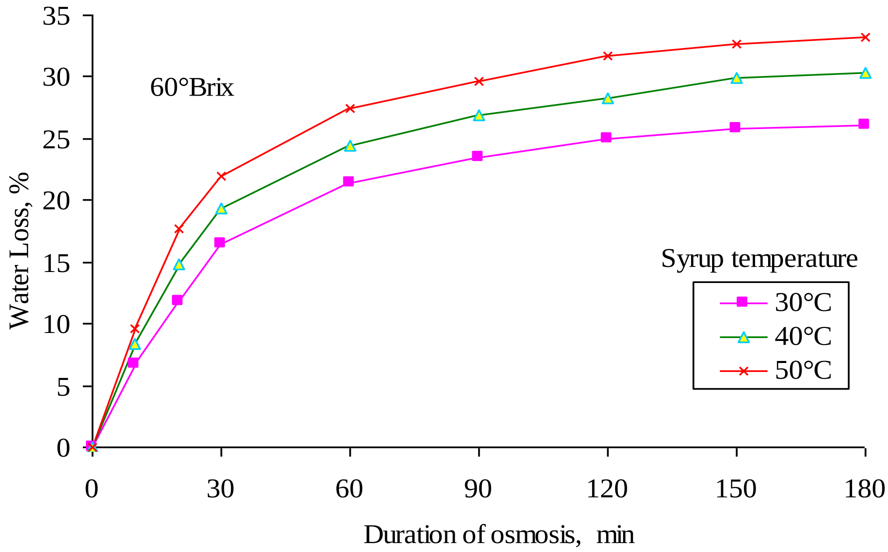

Fig. 2 Variation in water loss with duration of osmosis at 60°Brix syrup concentration at three different syrup temperatures

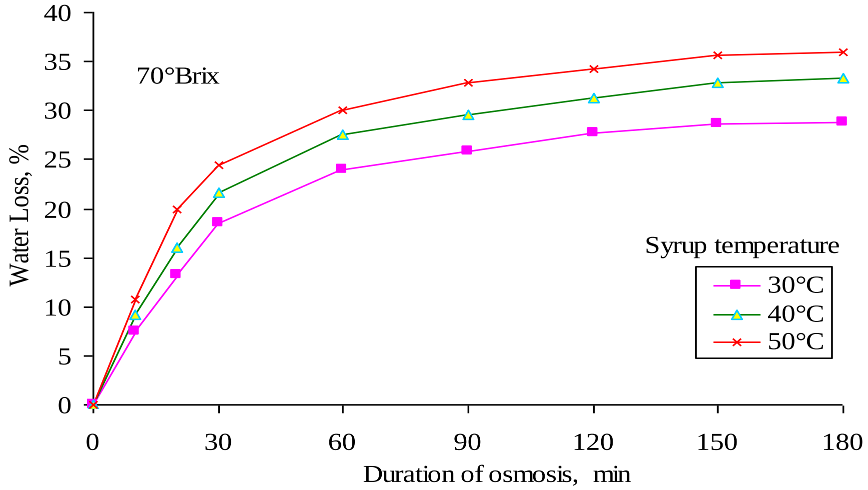

Fig. 3 Water loss with duration of osmosis at 70^{o}Brix syrup concentration at three different syrup temperatures

This indicates that water loss can be increased by either increasing the syrup temperature or concentration. The water loss at any concentration was affected by the temperature of the syrup as it was increased with increase in syrup temperature. This may be due to changes in semi-permeability of the cell membrane of the ripen sapota fruit, allowing more water to diffuse out in a shorter period. Also increase in water loss with increase in syrup concentration may be due to increased osmotic pressure in the syrup at higher concentrations, which increased the driving force available for water transport. Similar trends were also reported by [30] [31] [32] for osmotic dehydration of pineapple, guava and papaya, respectively.

3.2 Effect of Different Temperatures and Concentrations on Sugar Gain

The effect of temperature and concentrations of syrup on sugar gain has been illustrated in Figs. 4, 5 and 6. The sugar gain of 4.19, 4.78 and 5.16 per cent was found for 50 ºBrix at 30, 40 and 50ºC syrup temperatures respectively when duration of osmotic dehydration increased from 0 to 180 min (Fig.4). Also for 60ºBrix, the sugar gain was found 4.80, 5.46, 5.98 per cent at 30, 40 and 50ºC syrup temperature respectively (Fig.5). Similarly for 70ºBrix concentration, the sugar gain was found 5.28, 6.18, 6.78 per cent at 30, 40 and 50ºC syrup temperatures respectively (Fig.6). It was found that a low temperature-low concentration condition (30ºC-50ºBrix) resulted in a low sugar gain (4.19 per cent after 180 min of osmosis) and a high temperature-high concentration condition (50ºC-70ºBrix) resulted in a higher sugar gain (6.78 per cent after 180 min of osmosis). This indicates that sugar gain in ripen sapota can be increased by either increasing the syrup temperature or concentration. Also it can be seen that sugar gain was increased with duration of osmosis and did not approach the equilibrium even after 3 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 of ripen sapota fruits at higher temperatures. Similar results have also been reported by [33] [34] [19].

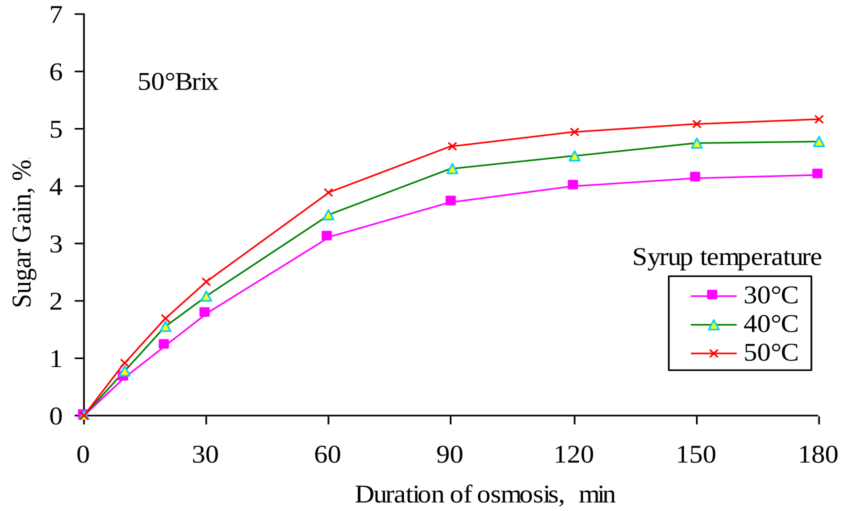

Fig. 4 Sugar gain with duration of osmosis at 50^{o}Brix syrup concentration at three different syrup temperatures.

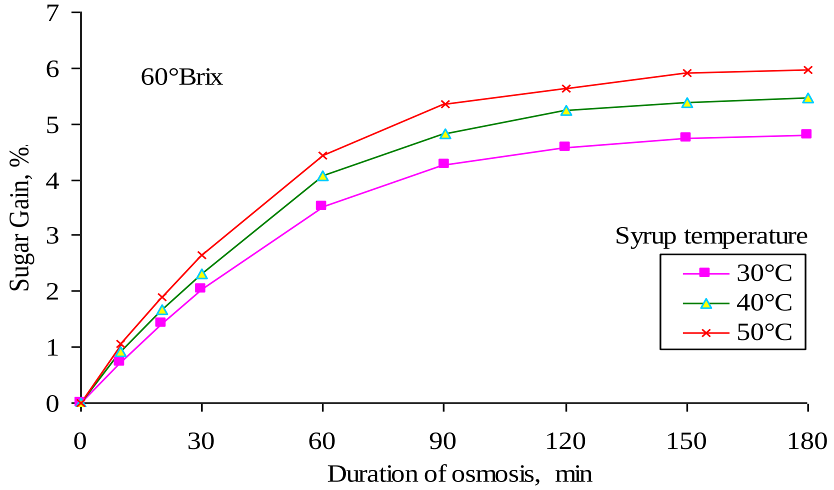

Fig.5 Sugar with duration of osmosis at 60°Brix syrup concentration at three different syrup temperatures.

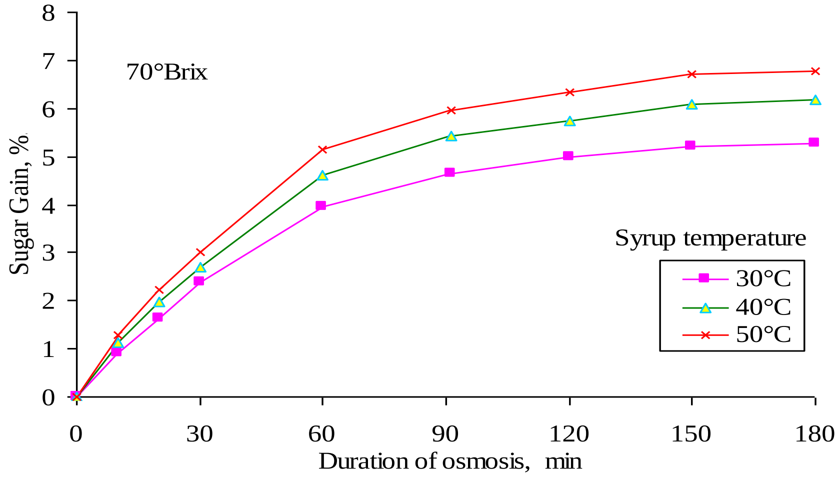

Fig. 6 Sugar gain with duration of osmosis at 70°Brix syrup concentration at three different syrup temperatures.

3.3 Effect of Different Temperatures and Concentrations on Mass Reduction

The effect of temperature and concentrations of syrup on mass reduction has been illustrated in Figs. 7, 8 and 9. The mass reduction was found 17.70, 21.06 and 23.21 per cent for 50°Brix at 30, 40 and 50°C temperatures respectively when duration of osmotic dehydration of ripen sapota increased from 0 to 180 min (Fig.7).

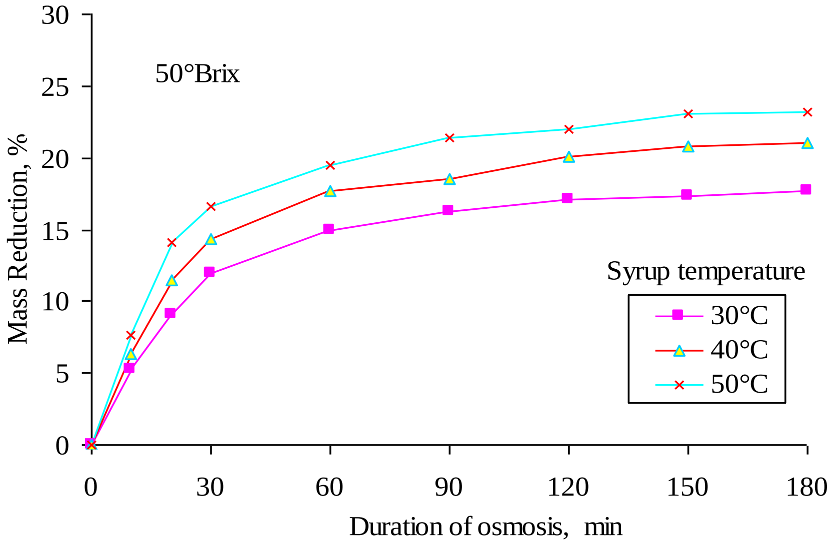

Fig.7 Mass reduction with duration of osmosis at 50°Brix syrup concentration at three different syrup temperatures.

Also for 60ºBrix, the mass reduction was found 21.32, 24.82 and 27.20 per cent at 30, 40 and 50ºC respectively (Fig.8). Similarly for 70ºBrix concentration, the mass reduction was found 23.56, 27.05 and 29.23 per cent at 30, 40 and 50ºC syrup temperatures respectively with increase in duration of osmosis of ripen sapota from 0 to 180 min (Fig.9). It was found that a low temperature-low concentration condition (30ºC-50ºBrix) resulted in a low mass reduction (17.70 per cent after 180 min of osmosis) and a high temperature-high concentration condition (50ºC-70ºBrix) resulted in a higher mass reduction (29.23 per cent after 180 min of osmosis). This indicates that mass reduction can be increased by either increasing the syrup temperature or concentration. Similar results have also been reported by [33] [34] [19].

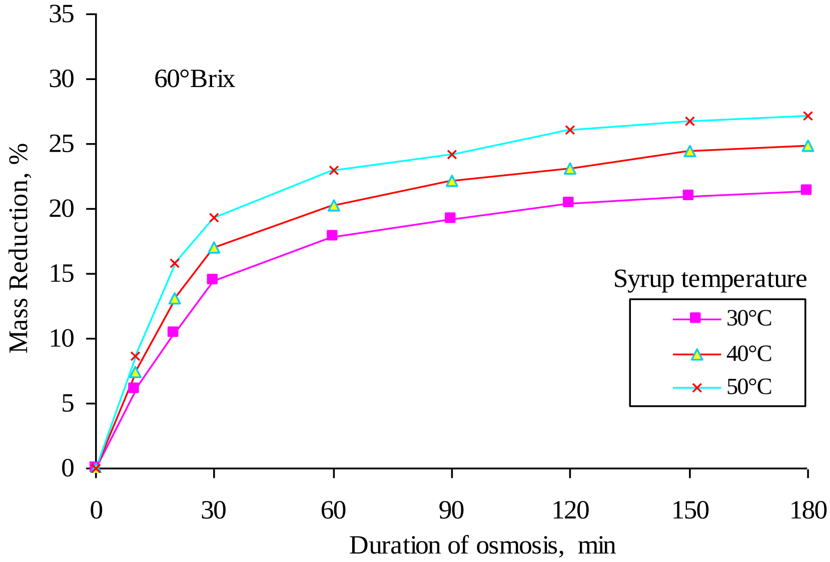

Fig.8 Mass reduction with duration of osmosis at 60°Brix syrup concentration at three different syrup temperatures.

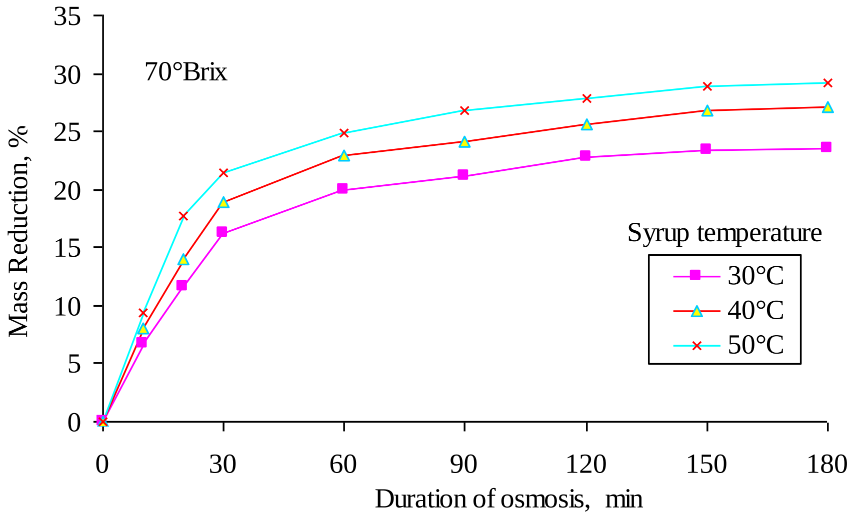

Fig.9 Mass reduction with duration of osmosis at 70°Brix syrup concentration at three different syrup temperatures.

3.4 Statistical analysis

The standard statistical technique 'Analysis of Variance' (ANOVA) was applied for the water loss, sugar gain and mass reduction data from three replicates of 180 min osmotically dehydrated sapota samples to study the effect of process variables, osmotic concentration and temperature on water loss characteristics. Critical difference and co-efficient of variances (CV) was evaluated for water loss and presented in Table 1, 2 and 3.

It is the revealed effect of temperature of syrup on water loss, sugar gain and mass reduction were significant with critical difference of 1.183, 0.511 and 0.757. Also effect of syrup concentration on water loss, sugar gain and mass reduction were significant at 1 per cent with critical difference of 1.183, 0.511 and 0.757. The co-efficient of variances (CV) were 2.973, 6.965 and 2.333 for water loss, sugar gain and mass reduction respectively. The combine effect of temperature and syrup concentration on water loss, sugar gain and mass reduction were not significant with critical difference of 2.049, 0.885 and 1.312.

Table: 1 ANOVA for the effect of process variables on the water loss

S. No.	Source	DF	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	A	2	217.365	108.683	143.204**	0.29	1.183
2.	B	2	245.355	122.678	161.644**	0.290	1.183
3.	A x B	4	0.459	0.115	0.151(ns)	0.503	2.049
4.	Error	18	13.661	0.759			
CV = 2.973, ** Significant at 1%., ns= Non significant							

Table: 2 ANOVA for the effect of process variables on the sugar gain

S.No.	Source	DF	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	A	2	6.696	3.348	23.664**	0.125	0.511
2.	B	2	8.421	4.211	29.761**	0.125	0.511
3.	A x B	4	0.228	0.0570	0.403 (ns)	0.217	0.885
4.	Error	18	2.547	0.142			
CV = 6.965, ** Significant at 1%. ns= Non significant							

Table: 3 ANOVA for the effect of process variables on the mass reduction

S. No.	Source	DF	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	A	2	147.832	73.916	237.63**	0.186	0.757
2.	B	2	163.556	81.778	262.91**	0.186	0.757
3.	A x B	4	0.115	0.029	0.093(ns)	0.322	1.312
4.	Error	18	5.599	0.311			
C.V = 2.333, ** Significant at 1%. ns= Non significant							

IV. Conclusion

Syrup concentration, temperature of solution and duration of osmosis had definite effect on the kinetics of osmotic dehydration of sapota slices. Water loss from the sapota slices was very rapid for the first half hour of osmosis and reduced subsequently with duration of osmosis. The water loss sugar gain and mass reduction were observed increased with increased in sugar concentration and temperature during osmotic dehydration. The highest of mass reduction, water loss and sugar gain was observed 29.23, 36.01, 6.78 per cent for 70^{o}Brix concentration and 50^{o}C temperature of syrup. Osmosis can be use as a pretreatment prior to any drying can be used to remove the moisture from sapota slices and increase the sugar per cent in sapota slices.

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