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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(1): 959-969

www.thepharmajournal.com
Received: 23-11-2021
Accepted: 25-12-2021

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Osmo-convective drying characteristics of sapota (Chikko) slices

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Abstract
The drying behaviour was investigated for Osmo-dehydrated sapota slices at air temperatures of 50, 60, 70, and 80 °C with an airflow velocity of 1.0, 1.5, and 2.0 $m.s^{-1}$. The moisture content reduced exponentially with drying time, and no constant drying rate was recorded. Depending on the air temperature (50–80 °C) and velocity (1-2 $m.s^{-1}$), The moisture diffusivity varied in the range of 1.6227×10^{-10} to 4.868×10^{-10} $m^2.s^{-1}$, and drying time varies from 300 to 510 min. for all air velocities, minimum drying time recorded as 80°C and maximum time for 50 °C. It is also seen that increasing the air velocity from 1 to 2 $m.s^{-1}$ in the temperature range of 50 to 80 °C did not change the drying rate appreciably. The quality of dehydrated samples was also analyzed based on color, sensory, and rehydration ratio. The Osmo-convectively dried samples were found more acceptable at 60 °C. The rehydration trend decreased as the concentration of the sugar solution increased from 0 to 20 °Brix for the period of 5h. The Osmo-dehydrated product absorbed less water in a sugar solution, resulting in a product of crispier texture.

Keywords: dehydration, fruits and vegetables, convective drying

1. Introduction

Sapota is India's highly productive, nutritious, and tropical fruit, contributing thousand million tonnes production from 83-thousand-hectare area during 2019-20 (Anonymous, 2020) [1]. In India, sapota is generally consumed fresh. However, it is easily spoiled in a short span and becomes unfit for consumption. If sapota ripens it can't be stored for more than a day (Sarkar *et al*., 2018). Post-harvest losses of sapota ranged from 25-30 percent (Sarkar *et al.*, 2018). These losses occur mainly due to high ethylene evaluation and metabolic activity. Wastage of sapota fruits before reaching the consumer is mainly due to poor supply chain and storage facilities. One effective method of reducing this considerable loss would be converting it into various commercial sapota products like slices, powder, juice, concentrate (Ganjyal *et al.*, 2005) [13]. Processed Products have inbuilt advantages for prolonged shelf life, a higher degree of resistance to bacterial attack, and lower transportation, handling, and storage costs. Therefore, producing the final product with wholesome and acceptable consumer quality is necessary. Hence, the product needs to be dehydrated, canned, and refrigerated. Among all these preservation methods, dehydration is energy efficient (Xu *et al*., 2021) [47].

Nevertheless, high temperature in convective hot air-drying leads to physical and biochemical changes in the product. These changes are frequently disastrous for the product quality aspects like browning reaction and vitamin destruction (Solanki *et al.*, 2018). So, to improve the product quality, it is essential to opt for the proper drying methods and also need to optimize the drying conditions. Osmotic dehydration is a complementary treatment and food preservation technique in food processing. It reduces the damage due to heat to the flavour, color, inhibiting the browning of enzymes (Shete *et al*., 2018) [41]. It is less energy-intensive than the air or vacuum drying process since it can be conducted at low or ambient temperatures. The osmotic dehydration process may not yield a product of low moisture content enough to make it shelf-stable, and therefore, further processing, such as air drying, vacuum drying, or freeze-drying, is necessary [Ponting *et al*. (1966); Haneef *et al*. (2022)] [34, 14]. Hence, a new method of drying in the combination of osmosis (in which partial dehydration of the fruit) has received attention in recent years as a technique for production of intermediate moisture foods and shelf-stable foods or as a pre-treatment prior to drying in order to reduce energy consumption and heat damage.

Therefore to obtain quality dried products, an investigation was proposed to investigate osmotic behaviour and drying characteristics of sapota slices under the Osmo-convective drying process.

2. Materials and Methods

The principles employed in the production of Osmo-convective dehydrated sapota slices, the kinetics of osmotic dehydration and air-drying, and the procedure involved for the quality of the Osmo-convective dehydrated product was elaborated in this section.

2.1 Raw Materials

Freshly harvested sapota (*cv. Kalipatti*) fruits were brought from Navsari farm (Navsari Agricultural University). Fruits of similar size were selected and were allowed at room temperature to get ripeness. Commercial sugar readily available was considered an osmotic agent.

2.2 Sample and Solution Preparation

The ripened sapota of uniform size, color, and firm texture has been taken for the experiment. Before cutting, the fruits were thoroughly washed to remove adhered impurities under tap water. The outer skin of the ripened fruit was peeled off manually using a knife without damaging the pulp (Fig.1). The peeled sapota fruits were cut into halves, quarters, and about 4-5 mm thick slices for the experiment (Ganjyal *et al.*, 2005) [13]. Sugar syrups for different concentrations were prepared by dissolving the required amount of sugar in distilled water.

2.3 Experimental set up for osmotic dehydration

A small-capacity laboratory osmotic dehydration unit is used (Fig. 2), which consisting of an osmotic dehydration chamber, temperature indicator, and electric pump. A small dehydration unit consisting of a chamber for the sugar solution has a rack with sliding shelves and a solution distribution system.

The osmotic solution chamber of size 30 cm x 20 cm x 20 cm (approximate capacity, 5 liters) is made of a stainless steel sheet with a suitable cover (Fig. 2) used in the study. A rack of size 28 cm x 28 cm x 18 cm and four sliding stainless steel shelves are also provided with nearly the same dimension as the osmotic chamber. As a result, the samples held on the sliding shelves were completely immersed when the whole rack assembly was lowered into the sugar solution. Three valves are attached for regulating the flow and for cleaning in place. A digital temperature indicator (least count 0.5 ^oC) is also provided with the unit.

2.4 Osmotic Dehydration

The chopped sapota slices were weighed approximately 40 g and immersed in the sugar syrup (50 ^{o}Brix) contained in a 250 ml glass beaker. The beakers were placed inside the constant temperature (50 ^oC) water bath. The syrup in the beakers was manually stirred at regular intervals to maintain a uniform temperature. The beaker was removed from the water bath at a designated time (1 hour) and placed on tissue paper to remove the surface moisture. The samples were weighed, and their moisture contents were determined. The temperature and concentration as 50 ^oC and 50 ^{o}Brix with the ratio of syrup to sapota slice 5:1, osmosis for one hour have opted for osmotic dehydration. Moreover, this has been suggested as the best combination for osmo-dehydration of sapota and various fruits/vegetables [Kedarnath *et al.* (2014) [18]; Kour *et al.* (2021) [20]; Ponting *et al.* (1966) [34]; Islam and Flink (1982) [15]; Rahman and Lamb (1990) [35], Pisalkar *et al.* (2011) [29]; Kour *et al.* (2021) [20] and Choudhary *et al.* (2021)] [34] for various fruits/vegetables.

2.5 Moisture Content

The moisture content of the fresh and osmotically dehydrated sapota samples was determined using AOAC (1984) method by taking a small sample of sapota slice and the moisture content was estimated by recording the weights using below equation

$$Per\ cent\ moisture\,(d.b.) = \frac{W_1 - W_2}{W_2} \times 100 \quad \text{..............} \ (1)$$

Where,
W_1 = mass of original sample, g
W_2 = mass of the sample after drying, g

2.6 Total soluble solids

The total soluble solids of syrup were measured using a different range of refractometers (0-32, 28-62, and 58-92 ^{o}Brix), which gave the reading directly in ^{o}Brix (Ranganna, 2000) [37].

2.7 Quality evaluation

The dehydrated product quality was evaluated using color, rehydration characteristics, and sensory evaluation.

2.8 Convective Drying

This experiment was conducted in the laboratory scale convective tray dryer at different temperatures 50, 60, 70, and 80 ^oC. The air velocity was kept at 1.0, 1.5, and 2 $m.s^{-1}$. 100 g osmosed samples were weighed and spread uniformly on the upper tray. During drying sapota, slices were weighed initially at 5 minutes intervals for the first half an hour, at 10 minute intervals for the next half hour, and at 30 minute intervals until completion of an experiment.

2.9 Experimental Set-up

A laboratory model convective tray dryer was used in all the dehydration experiments in this study (Fig.3). The dryer comprises a drying chamber, a heating unit, and a fan.

a) The drying chamber

The drying chamber has comprised of an insulated box with a single door opening at the front. A fan with a speed regulator is provided on the left side of the drying chamber. A heating unit for increasing the temperature of the air is also provided. The air enters the dryer due to suction, transfers heat to the wet product for drying, and simultaneously absorbs moisture. The moisture-laden air leaves the dryer by another opening of the drying chamber. The sample trays of 340 x 270 mm made of stainless steel were used in the dryer. The trays were comprised of SS wire mesh which permitted an excellent flow of drying air through the product. The trays were arranged one over the other in a single column. The sample tray size permitted the spread of 100 g of sapota sample uniformly in a single layer. The slices of sapota were uniformly spread over the tray, thus resulting in a loading density of 1.089 $kg.m^2$.

b) Heating unit

It consisted of an electric heater (2.5 kW) placed on the inner right wall of the drying chamber. A thermostatic controller was used with the heating unit to control the drying air temperature inside the dryer. The maximum temperature of the drying air, which could attain the highest air velocity of 1.5 m.s^{-1}, was 92 °C.

c) Fan
A fan provided at the inner left side of the drying chamber sucked the filtered atmospheric air inside and then through the heating unit, forcing it to pass through the wet product placed in trays. The fan has operated by a single-phase, 50 Hz, 0.375 kW AC motor. It helps to quick and effective drying of the product. The drying chamber temperature was pre-set through a temperature indicator cum controller provided on the control panel of the dryer. A thermostat-controlled and maintained the temperature by switching ON or OFF the heating unit. As measured by an anemometer, the velocity of drying air was changed at different temperatures for different experiments.

2.10 Drying Characteristics

a) Moisture content during drying
Moisture content of sapota slices during drying experiment was determined on the basis of dry matter using equation 2.

$$Per\ cent\ moisture\ content\ (d.b.) = \frac{W_\theta - DM}{DM} \times 100 \quad .... (2)$$

Where,
W_θ = Weight of the sample at time θ, g
DM = Dry matter of the sample, g

b) Drying Rate
The moisture content of the experiments was analyzed to determine the moisture lost from the sample of sapota slices in a particular time interval. The drying rate of the sample was calculated by following the mass balance equation [Brooker *et al.* (1974); Rasooli and Sharabiani (2021)].

$$R = \frac{\text{WML (kg)}}{\text{Time interval (min)} \times \text{DM (kg)}} \times 100 \quad .... (3)$$

Where,
R = Drying rate at time θ
WML = Initial weight of sample – Weight of sample after time θ

c) Dry matter
It is the matter left after removing moisture from the product. As described earlier, the oven-drying method determined the initial moisture content of un-osmosed and osmosed samples. The dry matter percentage and weight of dry matter in the sample were calculated (Brooker *et al.*, 1974) [4].

DM (%) = 100 – IMC (% w.b.) ... (4)

$$WeightofDM = Initialmassofsample \times \frac{DM(\%)}{100} \quad ... (5)$$

d) Moisture Diffusivity
In drying, Diffusivity indicates the flow of moisture to the material or moisture out of material. Diffusivity depends on shrinkage, case hardening, moisture content, and material temperature during drying. In the falling rate period of drying, moisture is transferred mainly by molecular diffusion. The sample's moisture diffusivity is estimated using the simplified mathematical Fick's second diffusion model. The solution of Fick's second law in slab geometry, the solution of Fick's second law in slab geometry, with the assumption that moisture migration was caused by diffusion, negligible shrinkage, constant diffusion coefficients, and the temperature was as follows [Crank (1975); Rajoriya *et al.* (2021)] [8, 36].

$$M_R = \frac{M - M_e}{M_0 - M_e} = \frac{8}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{(2n+1)^2} \exp\left[\frac{-(2n+1)^2 \pi^2 D_{eff} t}{4H^2}\right] \quad ... (6)$$

For long drying periods, Equation (7) can be further simplified to only the first term of the series as,

$$\ln\left(\frac{M - M_e}{M_0 - M_e}\right) = \ln\frac{8}{\pi^2} - \left(\frac{\pi^2 D_{eff} t}{4H^2}\right) \quad ... (7)$$

Where,
M_R = Moisture ratio, dimensionless
M = Moisture content at any time, g H_2O/g dry matter
M_0 = Initial moisture content, g H_2O/g dry matter
M_e = Equilibrium moisture content, g H_2O/g dry matter
D_{eff} = Effective diffusivity in m^2/s
H = Half thickness of slab in sample in, m
n = Positive integer
t = Time (s)

A general form of Eqn (7) could be written in semi-logarithmic form, as follows.

$$\ln(M_R) = A - Bt \quad … (8)$$

Where
A is constant and B is slope.
From Eqn (8), a plot of ln (M_R) versus the drying time gives a straight line with a slope of B as,

$$Slope = \frac{\pi^2 D_{eff}}{4H^2} \quad … (9)$$

The effective diffusivity can now be determined by substituting value of slope B and half thickness H from equation (9).

2.11 Quality Evaluation

Quality parameters like color, rehydration characteristics, and sensory evaluation are described below.

a) Colour
The Colour of the dried sapota powder was measured using a Hunter Lab Colorimeter (Model CFLX/DIFF, CFLX-45). A cylindrical glass sample cup (63.5 mm in diameter x 40 mm height) was placed at the light port (31.75 mm diameter). The instrument was initially calibrated with a black and standard white plate supplied with the equipment. The 3-dimensional scale *L**, *a**, and *b** is used in a Hunter Lab colorimeter. The *L** is the lightness coefficient, ranging from 0 (black) to 100 (white) on a vertical axis. The *a** is purple-red (positive *a**

value) and blue-green (negative *a** value) on a horizontal axis. A second horizontal axis is *b**, which represents yellow (positive *b** value) or blue (negative *b** value) color. *L**, *a**, and *b** can be converted to Chroma (*C**) values, analogous to color saturation or intensity (Mc Guire, 1999).

b) Rehydration characteristics

Every dried product cannot be served directly. Some products need rehydration by soaking in water prior to consumption. For rehydration capacity, weighed samples were soaked in ample water for 5 hours at room temperature. This steeping is known as rehydration. The ratio of the mass of rehydrated and dehydrated samples can be used to find the following rehydration characteristics [Pokharkar *et al.* (1994) [31]; Pokharkar *et al.* (1998a, b)] [32-33]

c) Sensory Evaluation

Sensory evaluation was done based on the nine-point hedonic scale for taste, flavor, color, texture, and overall acceptability. A sample of the dehydrated product was served for evaluation to 12 panelists at a time (Castillo-Gironés *et al.*, 2021) [5].

2.12 Water activity (a_w)

Water activity (a_w) is the ratio of the vapor pressure exerted by the food to the saturated vapor pressure of water at the same temperature. Water activity was determined to measure storage stability using a Hygrolab-3 water activity meter. The sample cup was filled with 2 g material and kept in contact with the sensor probe of the water activity meter and recorded values.

3. Result and Discussion

3.1 Convective drying of sapota slices

Osmo-dehydrated sapota samples dried at different air temperatures (50, 60, 70, and 80 ^oC) with different velocities of air (1.0, 1.5, and 2.0 $m.s^{-1}$). The variation in moisture, drying time, drying rate, and adequate moisture diffusivities were calculated and presented in these sections. During drying, the weight of the sample was recorded after 5 minutes intervals for the first half an hour, at 10-minute intervals for the next half hour, and at 30-minute intervals until the sample attained constant weight. As the initial moisture content of sapota slices was known, the moisture content, amount of water removed, and the mass balance equation determined the drying rate at various intervals.

3.2 Variation in moisture content with time

The typical curves (Fig. 5) show variation in moisture content with drying time for different air temperatures (50, 60, 70, and 80 ^oC) and air velocity (1.0, 1.5, and 2.0 m/s), respectively. The initial moisture content of the osmotically dehydrated sapota samples was 103.376% (d.b.) for all the samples investigated. The moisture content was reduced from 6.3 to 16.5% (d.b.) (Fig. 5). After a drying time of 300 min. from these curves, it was observed that the moisture content of sapota samples decreased exponentially with drying time under all drying conditions. Similar types of results have been reported by various researchers' *viz*. Kahraman *et al*. (2021) [17]; Von-Gersdorff *et al.* (2021) [46]; Pokharkar (1994) [31]; Maskan *et al.* (2002) [25]; Jain (2011) [16]; Pisalkar (2011) [29]. For air-drying of osmotically dehydrated pineapple, papaya, aloe vera, and banana slices, respectively.

In general, it took 5-8 hours of air drying to reduce the moisture content of sapota slices to a safe storage level for all osmosed slices. It also found that the reduction in moisture content was faster in the initial drying period. Many investigators reported this is the general trend found in air-drying. In this period, the resistance of water diffusion was less due to a higher drying rate, and more amount of water could be removed from the food material.

3.3 Drying rate curve

In a convective tray dryer, the weight of slices after subsequent time intervals was determined. The drying rate at various time intervals was determined using moisture content, amount of water removed, and the mass balance equation. The drying rate data plotted against the moisture content (Fig. 6) show that the complete drying of sapota slices after the osmotic dehydration took place in the falling rate period. The constant rate period was absent in the try drying carried for all the samples. The drying in the falling rate period indicates that internal mass transfer has occurred by diffusion. Results support the drying studies conducted for onion slices, apricots and freshwater fishes. [(Rapusas & Driscoll (1995); Doymaz (2011); Pai *et al*. (2021); Khan *et al.* (2021)) [38].

From the curve (Fig. 6), the drying rate was higher in the initial drying period and subsequently reduced with decreased moisture content. As the drying proceeded, the sample's moisture content decreased, and the drying rate also decreased. It can also be seen from the figure that the rate of drying was higher for the high temperature of drying air. The high drying temperature will remove moisture quickly from the sample, resulting in a high drying rate.

3.4 Moisture Diffusivity of sapota slices

The moisture ratio (MR) at various time intervals was determined and plotted (Fig . 7 and Table 1) with drying time to determine moisture diffusivity. From Fig. 7, the initial condition of drying, when the moisture content of the product is high, the various points for different air drying temperatures coincided with one another. However, in the latter part of drying, the points are far apart, which is the effect of temperature variation. The *ln*(MR) value varies from 0 to (-) 5.5846 as the drying increases from 0 to 510 min (Fig. 9). The variation in *ln*(MR) with drying time for each case was linear with an inverse slope. The slope became steeper with an increase in drying air temperature. Moisture diffusivities were calculated from the slopes of these straight lines [(Zhao *et al.* (2021) [48]; Tagnamas *et al.* (2021) [43]; Maskan *et al*. (2002) [25]; Doymaz (2011)] [11]. The moisture diffusivity value of food material was affected by moisture content and temperature. The diffusivity is less than that of high moisture content at a lower moisture content level. Also, it was observed that moisture diffusivity increased with drying air temperature in Osmo-convective drying processes (Liu *et al.* (2021); Elangovan *et al*. (2021) [12]; Rahman & Lamb (1991) [35]; Pokharkar & Prasad (1998a&b) [32-33]. The moisture diffusivity varied in the range of 1.6227×10^{-10} m²/s to 4.8683×10^{-10} m²/s during air drying of osmosed sapota samples, depending on the drying air temperature. These values are within the general range of 10^{-08} to 10^{-12} m²/s for drying food materials [(Delfiya *et al*. (2021) [10]; McMinn & Magee (1999)] [26].

The non-linear shape of the drying curve (Fig.7) indicated variable moisture diffusivity under different conditions of temperature and velocity of drying air. The moisture diffusivity varies considerably with moisture content and could be estimated by analysis of the drying data without considering the shrinkage of the drying sample. The non-linearity of the drying curve may be due to infusing of sugar in sapota samples, blockage of internal and surface pores, and reduction in surface area.

3.5 Quality Evaluation of Dehydrated Sapota Slices
Quality parameters such as color, rehydration ratio, and sensory evaluation were determined for dried samples.

a) Colour

The color of dried sapota slices was measured in L-value (brightness/darkness) and (Table 2)The L-values of Osmo-convectively dried sapota slices at various experimental conditions ranged from 17.52 to 28.82 (Table 2). As regards the individual effect of drying air temperature, it revealed from this table that as the temperature increased L-value of color was increased, which means the sample became lighter in color from 50 °C to 70 °C and thereafter decreased at 80 °C, which may be due to discoloring the sample slightly because of elevated temperature. It is clear with respect to individual effect of temperature that the sample dried with drying air temperature 70 °C was found better and recorded the highest color (L-value=28.82) significantly. An increase in velocity also resulted in increased color (L-value) slightly. The sample dried with 2 $m.s^{-1}$ drying air velocity was significantly superior in recording better color (Lyu *et al*., 2022) [23].

b) Sensory evaluation

Sensory evaluation was conducted based on color, taste, appearance, and overall acceptability. A panel of 12 judges tested the dried samples. The score ranged from 1 to 9, ranging from “Like extremely” to “Dislike extremely. From Table 3 it was observed that the mean sensory score on color, taste, appearance and overall acceptability was highest for 60 °C with 1.5 $m.s^{-1}$ velocity.

c) Rehydration characteristics

The reconstitution qualities of dehydrated sapota samples were determined by conducting rehydration tests. The dehydrated products were immersed in water, 5, 10, 15, and 20°Brix sugar solution, and the products' mass after five hours was measured. The dehydrated sample absorbed water during rehydration and became soft. The maximum rehydration ratio (Table 4) was obtained for sapota slices immersed in water for 5 h. The rehydration ratio was decreased as the concentration of sugar syrup solution increased from 5 to 20°Brix for all levels of air velocity. The results match the study of Osmo-dehydrated plum by Pervin *et al*. (2021) [28] and dehydration of apple cubes by Manzoor *et al*. (2021) [24].

3.6 Water activity
Water activity was determined as a measure of storage stability using a Hygrolab-3 water activity meter at a temperature of 24.5 °C for all samples. Water activity is related to moisture content. All samples in this study were set to reach a safe level of final moisture content, so the results did not show any difference in water activity (Table 5). Water activities of Osmo-convectively dried samples with all combinations of temperatures and velocities ranged between 0.263 and 0. 471. Regarding the personal effect of temperature, it revealed that as the temperature increased, water activity decreased significantly [Tapia *et al.* (2020); Rodríguez *et al*. (2018)] [24, 40]. The sample dried at 80 °C drying air temperature had the lowest (0.263) water activity. Similarly, water activity decreased significantly as air velocity increased, but the rate was comparatively less. similar report alos given by [Das & Arora (2018); Taşeri *et al*. (2018); Boateng *et al*. (2021)] [9, 45].

Table 1: Effective moisture diffusivity of sapota slices during osmo-convective drying.

Osmo convective dried slices (°C)	Air velocity (m/s)	Equation of straight-line y= mx+c	Slope (m)	Diffusivity (m^2/s)	R^2
50	1	y = -0.0001x + 0.0944	-0.0001	1.622×10^{-10}	0.983
	1.5	y = -0.0001x + 0.1053	-0.0001	1.622×10^{-10}	0.985
	2	y = -0.0002x + 0.0844	-0.0002	3.245×10^{-10}	0.9808
60	1	y = -0.0001x + 0.0443	-0.0001	1.622×10^{-10}	0.9936
	1.5	y = -0.0002x + 0.0713	-0.0002	3.245×10^{-10}	0.9933
	2	y = -0.0002x + 0.0117	-0.0002	3.245×10^{-10}	0.9937
70	1	y=-0.0002x – 0.0287	-0.0002	3.245×10^{-10}	0.9944
	1.5	y = -0.0002x – 0.0034	-0.0002	3.245×10^{-10}	0.9954
	2	y = -0.0002x – 0.0969	-0.0002	3.245×10^{-10}	0.996
80	1	y = -0.0003x – 0.1762	-0.0003	4.868×10^{-10}	0.9971
	1.5	y = -0.0003x – 0.1426	-0.0003	4.868×10^{-10}	0.997
	2	y = -0.0003x – 0.0616	-0.0003	4.868×10^{-10}	0.9954

Table 2: Lightness (L* values) of convective dried sapota slices

Osmo convective dried sapota slices (°C)	Air velocity (m/s)	Colour index L-values
50	1	20.73
	1.5	22.72
	2	24.95
60	1	23.08
	1.5	24.91
	2	26.63
70	1	26.28
	1.5	25.14
	2	28.82
80	1	17.52
	1.5	20.40
	2	20.95

Table 3: Mean sensory score of osmo convective dried sapota slices.

Osmo convective dried sapota slices (ºC)	Air velocity (m/s)	Colour	Taste	Appearance	Overall acceptability
50	1	6.2	7.1	7.4	6.9
	1.5	6.7	7.3	7.1	7.0
	2	7.1	6.8	7.3	7.0
60	1	7.4	7.6	7.7	7.5
	1.5	7.7	7.9	7.6	7.7
	2	7.5	7.5	7.5	7.5
70	1	7.4	6.6	7.7	7.2
	1.5	6.7	7.7	7.4	7.2
	2	6.6	7.1	6.9	6.8
80	1	6.2	6.9	7.1	6.7
	1.5	6.3	6.6	6.9	6.6
	2	6.6	6.4	6.7	6.5

Table 4: Reconstitution characteristics of osmo-convective dried products

Osmo convective dried sapota slices (ºC)	Air velocity (m/s)	Rehydration ratio (RR)				
		Distilled water	5 ºBrix	10 ºBrix	15 ºBrix	20 ºBrix
50	1	4.571	4.349	4.327	4.124	4.084
	1.5	3.972	3.932	3.893	3.872	3.852
	2	4.082	4.014	3.946	3.781	3.481
60	1	4.229	4.088	4.063	3.948	3.898
	1.5	3.924	3.809	3.695	3.649	3.599
	2	3.871	3.802	3.790	3.734	3.709
70	1	4.019	3.778	3.773	3.538	3.527
	1.5	4.029	3.997	3.965	3.765	3.565
	2	3.739	3.680	3.622	3.427	3.116
80	1	4.113	3.883	3.806	3.653	3.499
	1.5	3.518	3.509	3.508	3.502	3.494
	2	3.512	3.446	3.431	3.375	3.344

Table 5: Water activity (a_w) of osmo-convective dried products

Osmo convective dried sapota slices (ºC)	Air velocity (m/s)	Water activity (a_w)
50	1	0.471
	1.5	0.456
	2	0.439
60	1	0.436
	1.5	0.395
	2	0.359
70	1	0.398
	1.5	0.382
	2	0.356
80	1	0.273
	1.5	0.266
	2	0.263

Fig 1: Samples of sapota slices

Fig 2: Schematic diagram of osmotic dehydration unit

Fig 3: Experimental tray dryer

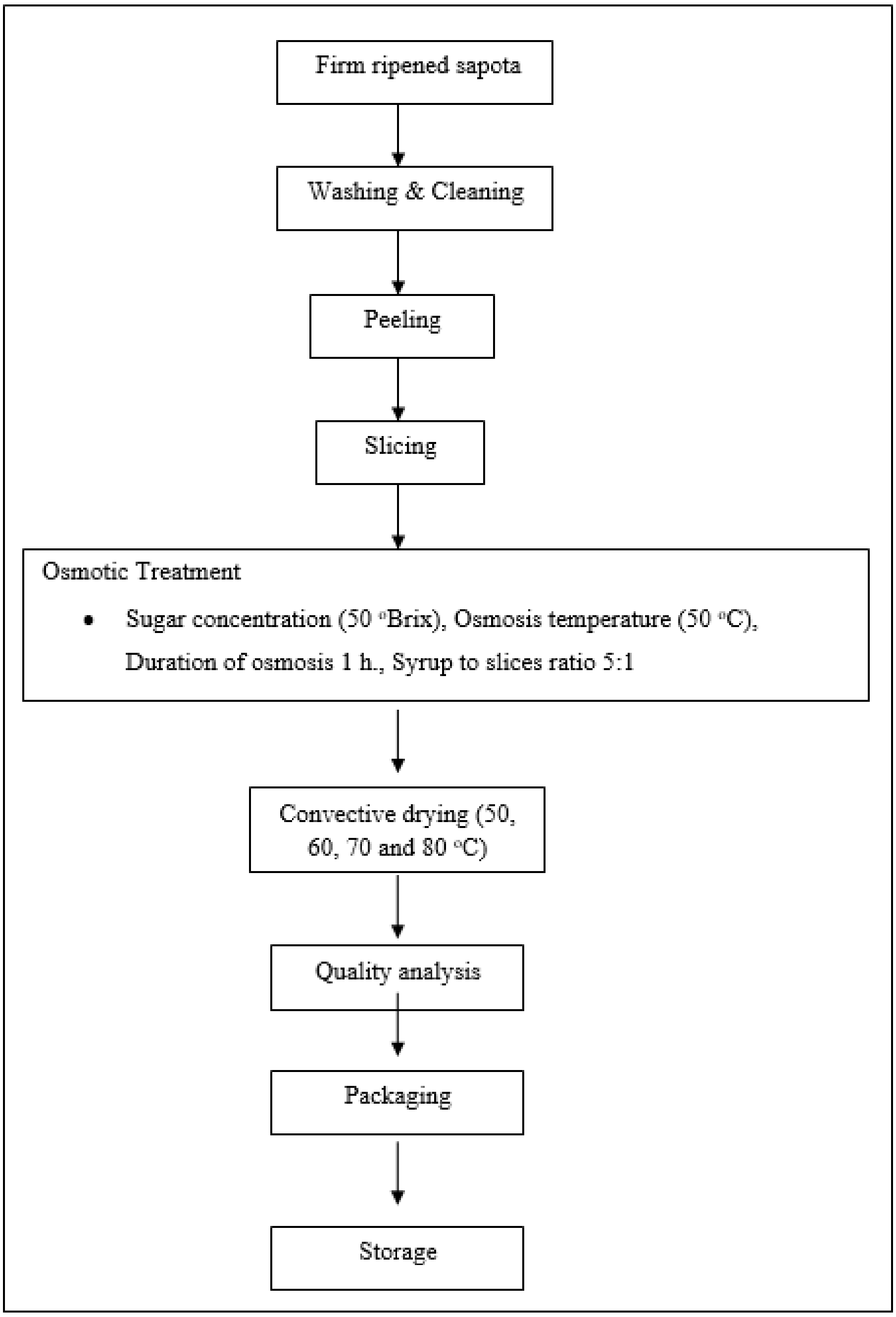


Fig 4: Process flow chart for the osmo-convective drying of sapota slices.

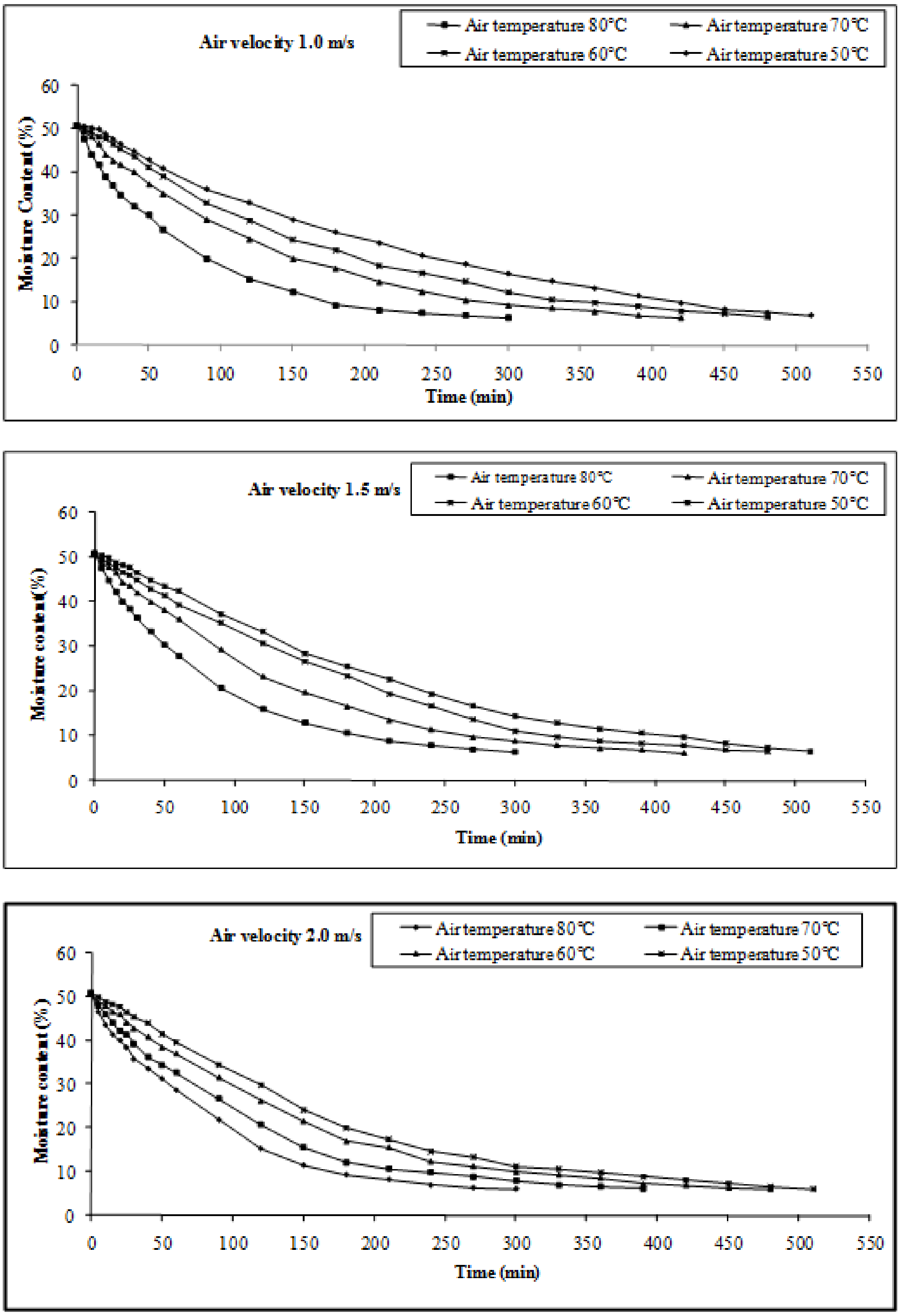
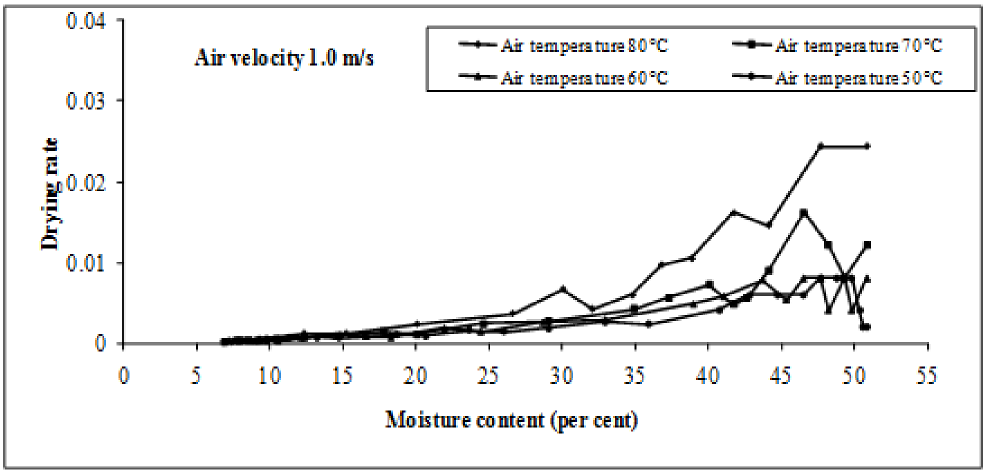


Fig 5: Effect of drying air temperature on moisture content with drying time at various drying air velocities



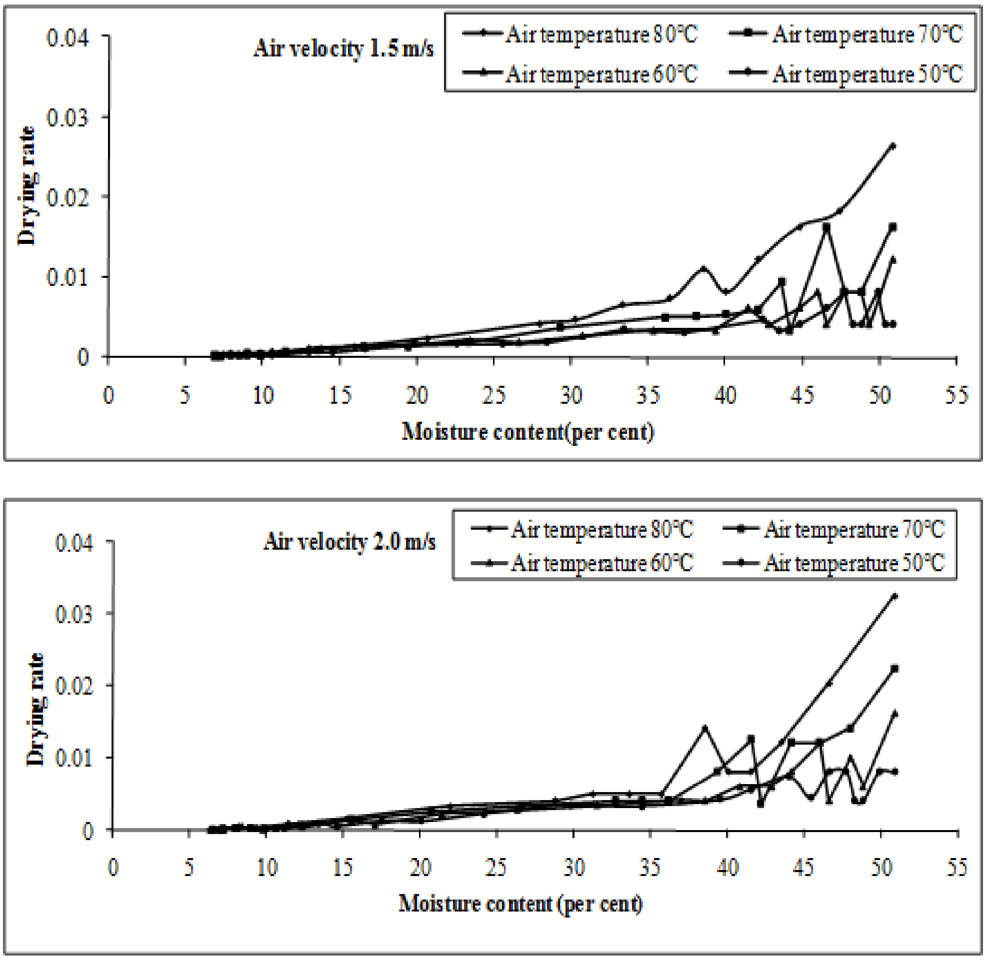
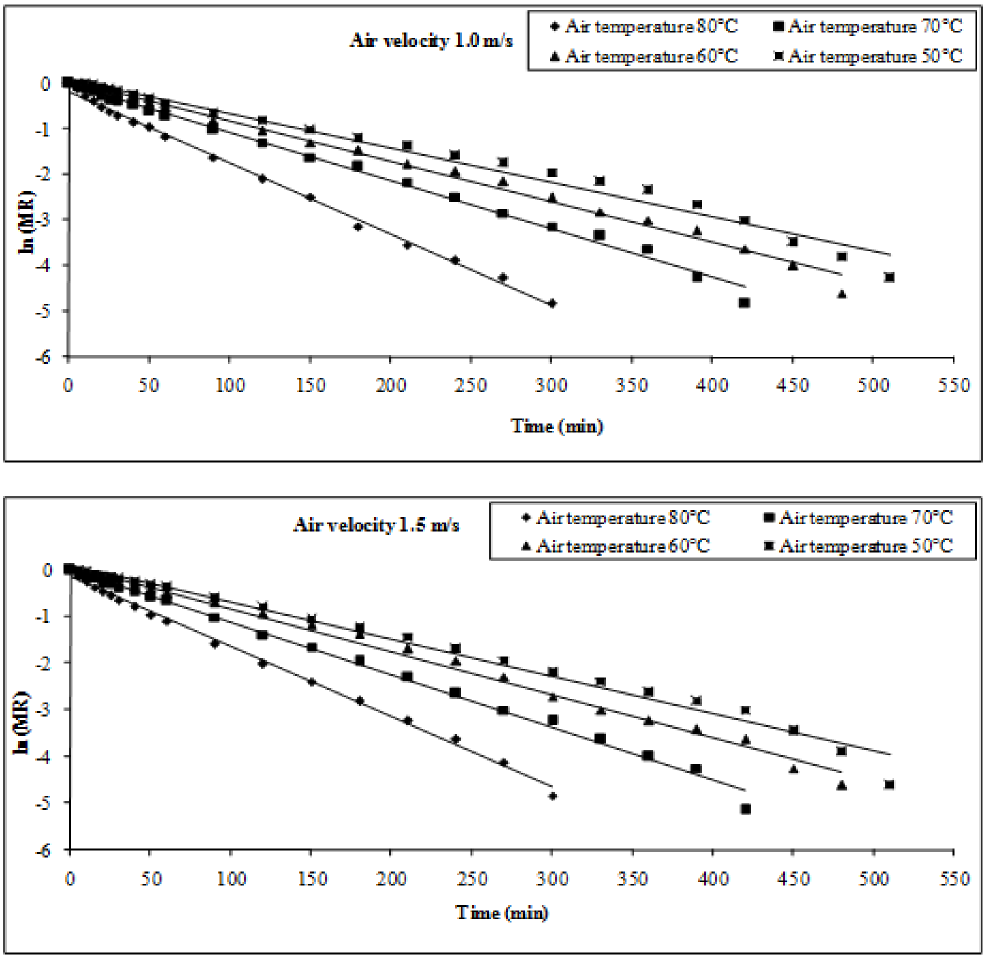


Fig 6: Variation in drying rate for osmo convective dried sapota samples Moisture Diffusivity of sapota slices



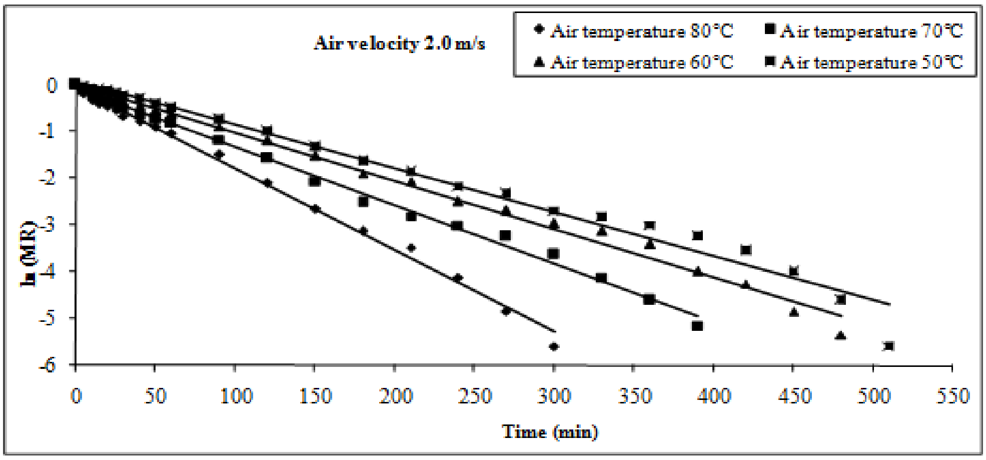


Fig 7: Variation in (MR) versus time for osmo convective dried sapota samples

4. Conclusions

It was concluded that the moisture content of the product was reduced exponentially with drying time, and no constant rate period was observed. It was also seen that increasing the air velocity from 1 to 2 m/s in the temperature range of 50 to 80 °C did not change the drying rate appreciably. This indicated that the total mass transfer resistance was primarily due to the internal moisture diffusion within the sample. It was found that the mean sensory score on color, taste, appearance, and overall acceptability was highest at 60 °C with 1.5 m/s air velocity. The moisture absorption during rehydration was found to decrease with an increase in sugar concentration. The Osmo-dehydrated product absorbed less water in a sugar solution, resulting product was crispier texture.

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