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RESEARCH PAPER

Convective Hot Air Drying of Sapota (*Achras sapota L.)* Slices and Its Quality Evaluation

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ABSTRACT

In this paper the peeled ripe sapota slices 5(mm) of *kalipatti* variety was exposed for convective hot air drying temperature 40°C, 50°C, 60°C and 70°C drying took place 69h, 60h, 54h and 52h respectively. The quality of dried product i.e. TSS, acidity, pH, reducing sugar, non reducing sugar, total sugar, carbohydrate, protein, fat, ash and colour (*L*, *a* and *b*) was evaluated. Variance drying models i.e. Newton, page, modified page, Thompson modified page equation was fitted to the experimental data. The page model was fitted well at $R^2 = 0.978$: MSE = 8.869: $k = 0.0467$; $n = 0.636$; $\chi^2 = 0.133$ for all the temperature of the drying. The effective diffusivity value was in the range of 2.92×10^{-9} to 3.60×10^{-9} m^2/s. And increase as the drying temperature increases from 40°C to 70°C. The activation energy for the drying of sapota slices was 88.59 kg/ mole. The quality parameter was TSS 60 to 65 (°B); acidity is 0.14 to 0.17(%); pH is 60 to 65(°B); reducing sugar 27.04 to 33.76(%); non reducing sugar 39 to 43(%); total sugar 68.09 to 79.02(%); carbohydrate 0.21 to 0.29(%); protein 0.78 to 0.89(%); fat 0.91 to 1.9(%); ash content 1.1 to 1.8(%) and colour value *L* 61.22 to 55.30; a value varies from 9.13 to 16.64; *b* value varies from 24.03 to 31.27 respectively.

Keywords: Convective hot air drying, sapota slices, physic-chemical properties, page model etc.

Drying is simultaneous heat and mass transfer process. Cost-effective and hygienic way of preserving foods is of great importance given the prevailing inconsistency in food supplies throughout the world. The utilization of dryers can reduce crop losses and improve the quality of the dried product significantly when compared to the traditional methods of drying such as sun or shade drying (Akpinar *et al.* 2003).

Heat and mass transfer in the tray dryer is carried out by convection and partly conduction method. Hot air is used to supply heat to the food surface which heat up the food and increase its temperature, which result in evaporation of water from the food. Several factors can influence hot-air drying of food i.e. velocity and temperature of air, water diffusion through material, load density, thickness of bed and shape of the product to be dried. However, the sudden removal of water decreases the nutritional and sensorial value of food and results in to shrinkage and hardening (Vega *et al.* 2007).

Sapodilla, (*Manilkara zapota L.*) which belongs to the family *sapotaceae*, is underutilized tropical fruits commonly known as "*sapota*" in India and "*chiku*" in Malaysia. Immature fruits are hard, gummy and rich in tannin (astringent), while the ripe fruits are

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soft and juicy, with a sweet taste an attractive range colour, which makes them wonderful dessert fruit. (Sallesh, 2016). In India it is grown in an area of 82000 ha with 8 tones production at 14.19 tonnes per hectors productivity. Sapota is grown on a commercial basis in India, the Philippines, Srilanka, Malaysia, Mexico, Venezuela, Guatemala and other central American countries (Ganjyal *et al*. 2003).

In Maharashtra, Gujarat, Tamilnadu and Karnataka states sapota is grown commercially (Shirol *et al.* 2009). Raw fruits of sapota are astringed, while ripe fruits are sweet. It is mainly used on dessert fruits bedside many processed products are prepared from sapota namely Halwa, Juice, Milk Shake, Shrikhand, fruit Jam. Mature fruits are used for making mixed fruits jams and provide a valuable source of raw materials for manufacture of industrial glucose, protein and natural fruits jellies. They also are canned as slices. (Gopalan *et al*. 1985).

Mature fruit contain about 72 to 78% moisture (wb) and TSS ranges from 12 to 18˚brix. The most common cultivars grown are Kalipatti, Chaatri, Dhola Diwani, Long, Bhuri Bhurpatti, Jingar, Venjet, Pala, Cricket ball, Oval, Banglore and Calcutta round. India is the largest producer of sapota followed by Mexico, Guatemala and Venezuela. In the last ten years area under the crop has shown a tremendous increase of over 136 per cent (Maya *et al*. 2003). In India production of sapota was 4.17 thousand hectares during the year 2005-2006 and 4.00 thousands hectares during the year 2010-2011. The growth rate is 4.08% and the production during 2005-2006 is 49.02 thousand tonnes and 43.58 thousand tonnes during 2010-2011. By exporting to different countries about 2.693 thousand tonnes of sapota, India earned about ₹ 4, 28, 34,567 in the year of 2011-12.

Sapota fruits is reported to contain sugar, (Siddappa and Bhatia, 1954), acids (Shanmugavelu and Srinivasn, 1973), protein, amino acid (Selvaraj and Pal, 1984), phenolics viz, galic acid, catechin, chlorogenic acid, leucodelphinidin, and leucodelargonidin and Leucopelargonidin (Matthew and Lakshminarayana, 1969), carotenoids, ascorbic acids, and minerals like potassium, calcium and iron (Selvaraj and Pal, 1984). Fruits contains carbohydrate (50.49 -100 g), protein (0.7 g – 100g), fat (1.1 g – 100g), fibre (2.6g -100g), and minerals nutrient viz. calcium (28mg -100g), iron (2.0mg -100g), phosphorus (27mg -100g), ascorbic acid (6.0mg -100g), Golpalan *et al*. (1977).

An average sapota tree yields between 250-2500 fruits depending on its age. It has been observed that when there is bumper production of sapota the fruits go a waste for want of suitable preservation facilities. Considering the fast increasing area under sapota cultivation, preservation and processing technology needs to be developed in order to prevent huge post-Harvest losses and regulate price during glut period and thus protecting the interest of the growers. Sapota is traditionally preserved by sun drying. Although sun drying is the most common method used to preserve agricultural products, this technique is weather dependent, and has the problem of contamination with foreign matter, more surface area requirement, and labour requirement. Also, the time required for drying can be quite long. Therefore, an effective means to overcome these problems are to dry the sapota slices by convective hot-air dryers.

Drying is a classical method of food preservation, which provides longer shelf life, lighter weight for transportation and small space for storage. It is defined as a process of moisture removal due to simultaneous heat and mass transfer. It can be done by solar dryers, cabinet dryer, freez dryer *etc.* There is a strong demand for convenience foods. This study was conducted to investigate convective hot air drying of sapota slices and to determine the quality of dried product powder. Sapota remains a mostly unexplored fruits, although research has been reported on aspects of its post-Harvest treatment. Studies have been reported on the extension of shelf-life of the fruit by chemical treatments. Drying characteristics of sapota slices are available in the literature. One way to increase the shelf-life of sapota would to process it in to powder, as is done with various other fruits. Dried sapota slices powder can be stored much longer than fresh fruit.

Various researchers have reported the drying characterization of fruits and vegetables by using convective hot air dryer for carrots, white mulberry, okra, tomatoes, sweet potato cube, azarole red and yellow fruit, kale, sweet cherry, figs, kiwifruit, uryani plum, red pepper, bay leaves, red bell pepper, single apricot, apple, anola shreads, potato, etc. (Doymaz, for 2004a, 2004b, 2005 , 2007. Singh and Pandey 2012; Koyuncu *et al.* 2007; Mwithiga and Olwals, 2005; Doymaz and Ismail, 2011; Babalis *et al.* 2006; Orikasa *et al.* 2008; Sacilik *et al.* 2006; Doymaz and Pala, 2002; Akpinar, *et al*. 2003; Gunhan *et al*. 2005; Vega *et al*. 2007; Togrul and Pehlivan, 2003; Sacilik and Elicin, 2006; Prajapati *et al*. 2011; Nema and Dutta, 2004). No reports are available on the convective hot air drying characteristics of sapota slices. Present study was undertaken to study the convective hot air drying characteristic of sapota and to study its quality parameter.

MATERIALS AND METHODS

Moisture Content Determination

Sapota *(cv.kalipathi)* fruits were procured from the Dapoli market. Under ripe and over ripe fruits were discarded. Fruits were cleaned by removing unwanted portion like leaf and stalk material etc. and then washed in tap water. The cleaned fruits after removing surface moisture after removal of peel were cut into two halves. The peel and seed portion separated manually by knife. Initial moisture content of the sapota was calculated by using hot air oven at 105°C ±1 for 24 h. The final weight of sapota slices after 24 h was recorded. The moisture content of the sapota slices was determined by following formula (Chakraverty, 1994).

$$\text{Moisture content (db) \%} = \frac{W_1 - W_2}{W_2} \times 100 \qquad \text{... (1)}$$

Where,

W_1 = weight of sample before drying, gram

W_2 = weight of bone dried sample, gram

Experimental setup

Tray drying of sapota slices was performed at Department of Post-Harvest Engineering, Post-Graduate institute of Post-Harvest Management, Killa-Roha. The drying was carried out in the tray dryer (Make: M/s. Aditi Associates; India Model. ATD-124) having capacity of 5 kW. There were nine numbers of trays inside the trays dryer. The size of the tray was 81cm × 41cm × 3.4 cm, the sapota slices of 5mm thick size were dried in thin layer drying. The slices were spread on the tray in single layer. The mesh (square) size of the tray was 1×1 mm, the temperature of the drying was 40°C, 50°C, 60°C and 70°C the air velocity inside the dryer was 2-3 m/s. The weight loss with respect to the time was recorded from trays at different location in the tray dryer. The weight loss of the sample was measured at various time interval, ranging from 10 min at beginning of the drying up to 180 min and after each 30 min till the constant weight was observed recorded. Weight loss was recorded by a digital balance of 0.001 g accuracy. Each experiment was performed in triplicate. The moisture content with respect to the time was calculated from drying data. The drying data i.e., initial moisture content, weight loss, with respect the time, final moisture content of the sapota slices were also is recorded. Three replications were taken for each experiment. Fig. 1 shows the drying of sapota slices in convective hot air drying.

Fig. 1: Drying of sapota slices in tray dryer

Drying Characteristics

Moisture content (% db) versus drying time (min) and drying rate (g. of water removed/ 100g bone dry material/min) with respect to moisture content was determined for tray drying of sapota slices. Moisture ratio versus drying time (min) was also determined from the experimental data. Various mathematical models listed in Table 1.were fitted to the experimental data on moisture ratio versus drying time in minutes of sapota slices with tray drying. The moisture ratio determine the unaccomplished moisture changes, defined as the free from water still to be removed, over the initial total free water (Henderson and Pabis, 1961).

1. Drying rate

The drying rate of sapota slices was calculated on dry basis using following formula;

$$R = \frac{W_r}{T \times W_d} \times 100 \quad \text{... (2)}$$

Where,

R = Drying rate (g/min)

W_r = Amount of moisture removed (g)

T = Time taken (min)

W_d = Total bone dry weight of sample

2. Moisture ratio

For an investigation of drying characteristics of sapota slices, it is important to model drying behaviour effectively. In this study, the experimental drying data of sapota slices at different temperature were fitted using five models given in Table 1. In this model, MR represents the dimensionless moisture ratio. The moisture ratio (MR) and the drying rate of sapota slices during experiments were calculated using the following equation. The moisture ratio of sapota slices was calculated on wet basis using following formula (Chakraverty, 2003).

$$MR = \frac{M - M_e}{M_0 - M_e} \quad \text{... (3)}$$

Where,

MR = Moisture ratio

M = Moisture content at any time θ, %(db)

M_e = EMC, % (db)

M_0 = Initial moisture content, %(db)

Non-linear regression analysis was performed to the experimental data by using SAS 6.0. (Root Mean Square Error) (Togrul and Pehlivan, 2004). The Root Mean Square Error were calculated by using equations (4), N and n are the number of observations and the number of constants respectively;

$$RMSE = \left[\frac{1}{N} \sum_{i=1}^{n} \left(MR_{\exp} - MR_{pre} \right)^2 \right] \quad \text{... (4)}$$

Where,

MR_{exp} = experimental moisture ratio

MR_{Pre} = predicted moisture ratio

3. Correlation regression coefficient and error analysis

The goodness of fit of the tested mathematical models to the experimental data was evaluated with the correlation coefficient (R^2), chi-square (χ^2) and the root mean square error (*RMSE*). The higher the r^2 value and lower the chi-square (χ^2) and RMSE values, the better are the goodness of fit (Ozdemir and Ozdemir and Devers., 1999; Ertekin and Yaldiz., 2004; Wang *et al.* 2007). According to Wang *et al.* (2007 a) chi-square (χ^2) and can be calculated as follows;

$$\chi^2 = \frac{\sum_{i=1}^{n} \left(MR_{\exp.i} - MR_{pre.i} \right)^2}{N - Z} \quad \text{... (5)}$$

Where,

$MR_{exp,i}$ = is the i^{th} experimental moisture ratio,

$MR_{pre,i}$ = is the i^{th} predicted moisture ratio ,

N = is the number of observation, and

z = is the number of constant.

Calculation of Effective Diffusivity

Effective diffusivity was calculated by using Fick's

Second law of diffusion (Doymaz, 2004) as given in equation. This equation assumes that effective diffusivity is constant and shrinkage of the sample is negligible.

$$\frac{\partial M}{\partial t} = D_{eff}.\nabla^2 M \quad \text{... (6)}$$

Where,

M = moisture content (kg water/kg dry matter)

t = is the time / s

D_{eff}= effective moisture diffusivity, m^2/s.

The solution of Fick's second law in slab geometry, with the assumption that moisture migration was caused by diffusion, negligible shrinkage, constant diffusion coefficient and temperature was given by Crank (1975) as follows:

$$\text{MR} = \frac{8}{\pi^2}\sum_{i=}^{n}\frac{1}{(2n-1)^2}\exp\left(\frac{-(2n-1)2\pi^2 D_{eff}t}{4H^2}\right) \text{... (7)}$$

Where, H is the half thickness of the slab m; n = 1, 2, 3 … the number of terms taken into consideration. For long drying time Equation (8) can be simplified further (Lopez *et al.* 2000; Doymaz, 2004) as:

$$In(MR) = In\frac{8}{\pi^2} - \frac{\pi^2 E_{eff}t}{4l^2} \quad \text{...(8)}$$

The diffusivities are typically determined by plotting the experimental drying data in the terms of Ln (MR) vs. drying time (t) in Equation (9), because the plot gives a straight line with the slope as follows.

$$\text{Slope} = \frac{\pi^2 D_{eff}}{4L^2} \quad \text{...(9)}$$

Where,

L = half thickness

Determination of Effective Moisture Diffusivity and Activation Energy

The effective moisture diffusivity of the dried sapota samples was estimated by using the simplified mathematical Fick's second diffusion model (Equation 6). The activation energy of the samples was obtained by plotting the natural logarithm of D_{eff} against the reciprocal of absolute temperature, then determining the slope of the straight line by using Equation (10). Activation energy was obtained by plotting the natural logarithm of D_{eff} against the reciprocal absolute temperature. Lopez *et al.* (2000) and Simal *et al.* (1996) related temperature with Arrhenius expression as.

$$D_{eff} = D_0 Exp\left(\frac{-E_a}{R(T+237.15)}\right) \quad \text{... (10)}$$

Where,

D_o= is the pre-exponential factor of the Arrhenius equation, (m^2/s)

E_a= is the activation energy (kJ/mol)

T = is the temperature of air, (°C)

R = is the universal gas constant, (8.134kJ/mol· K),

Rearranging Equation (10) gives Equation

$$InD_{eff} = InD_0 - \frac{E_a}{R(T+27315)} \quad \text{... (11)}$$

Energy of activation can thus be calculated from Equation (11), which gives a relationship between temperature and effective moisture diffusivity. The plot of versus 1/ (T+273.15) gives a straight line (slope of k_L= E_a/ R). Linear regression analyses were used to fit the equation to the experimental data to obtain the coefficient of determination (r^2).

Table 1: Mathematical models tested with the moisture ratio of sapota slices at tray drying

Sl. No.	Model	Equation	Reference
1	Newton	$MR = exp\ (-kt)$	Westerman, *et al.* 1973
2	Page	$MR = exp\ (-kt^n)$	Page (1949)
3	Modified Page	$MR = Exp - (kt)^n$	Overhult *et al.* (1973)
4	Thompson	MR = $a\ exp\ (-kt^n) + b_t$	Sacilik *et al.* 2006
5	Modified Page equation	$MR = exp\ (-kt^n)$	Zhang and Litchfield, 1991

Evaluation of Quality parameters for the sapota powder Product

1. Total soluble solids (°B)

Total soluble solids dried sapota slices before and after drying at 40, 50, 60 and 70°C was determined using Refractometer (M/s. Atago, Japan) and the values were corrected at 20°C. The equipment was calibrated with distilled water and the TSS of the sapota slices was determined. The experiment was replicated three times average reading was reported.

2. Titratable acidity (%)

The Titratable acidity of sapota slices before and after drying at 40, 50, 60 and 70°C was determined by Ranganna (1997). 15 gm of sample was blended in mortar and pestle with 20-25 ml distilled water. It was then transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10ml) was titrated against 0.1N sodium hydroxide (NAOH) solution using phenolphthalein as an indicator (Ranganna, 1997). The acidity was calculated as given below and the results were expressed as percent anhydrous citric acid. The three replications were carried out and the average reading was reported.

$$\text{Titratable acidity (\%)} = \frac{N \times T \times E}{W \times V \times 1000} \times 100 \quad \text{... (12)}$$

Where,

N = normality of alkali

T = titrate reading

E = equivalent mass of acid, g

W = weight of the sample, g

V = total volume of the sample, g

3. pH

pH of Sapota dried slices before and after drying at 40, 50, 60 and 70°C was measured using digital pH meter. The digital pH meter is firstly calibrated by using 4 pH and 7 pH buffer solution. The electrode was washed with distilled water and blot led with tissue paper. 10 ml of sapota slices was taken in beaker, and then the tip of electrode and temperature probe was then submerging in to the sample. The pH reading display on the primary LCD and temperature on secondary one. The pH of fresh sapota slices was determined for three replication average reading was reported.

4. Reducing sugars (%)

The reducing sugars sapota slices before and after drying at 40, 50, 60 and 70°C was estimated by using Lane and Eynon Method with modifications suggested by Ranganna (1997). A 15 gm of sapota slices were crushed with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to de-lead the solution. This lead free extract was used to estimate reducing sugars titrating against standard Fehling mixture (Fehling ‘A’ and ‘B’ in equal proportion) using methylene blue as an indicator to brick red end point. The three replications were carried out and the average reading was reported.

Reducing sugar =

$$\frac{100}{\text{Buttereading}} \times \frac{\text{Volume prepared}}{\text{Inital volume}} \times Gv \text{ off chlings soln.} \quad \text{...(13)}$$

Where,

GV = Glucose value.

5. Total sugars (%)

Total sugars sapota slices before and after drying at 40, 50, 60 and 70°C was estimated by same procedure of reducing sugar after acid hydrolysis of an aliquot of deleaded sample with 50 percent of hydrochloric acid followed by neutralization with sodium hydroxide (40%) and calculated as below (Eq. 14). The experiment was repeated three times to get the replication the average reading was reported.

$$\text{Total sugar} = \frac{\text{Factor} \times \text{Dilution}}{\text{Titerading} \times \text{weight of sample}} \times 100 \quad \text{...(14)}$$

6. Carbohydrate (%)

The carbohydrate of sapota slices before and after drying at 40, 50, 60 and 70°C was estimated by anthrone method in which prepared a series of Glucose solution and distilled water in the ratio (0:1; 0.2:0.8; 0.4:0.6; 0.6:0.4; 0.8:0.2; and 1:0) by using spectrophotometer. One gram ground sapota pulp was mixed with 5 ml of 2.5 N HCL and then heated for 3 h in water bath. The mixture was allowed to cool for 1.3 h, and it is added with sodium carbonate till effervescence stops. It is seen by naked eyes. After filtration, anthrone reagent (2 g anthrone powder 100 ml H_2SO_4) was added in filtered solution. The mixture was heated for 8 min and allowed to cool. The solution was taken in the curvetted of spectrophotometer, and absorbance was recorded at 630 nm. A graph was plotted, i.e., absorbance versus concentration (glucose stock: distilled water), and concentration of unknown sample was measured by using formula,

$$\text{Concentration \%} = \frac{\text{Absorbance of unknown} - \text{Concentration of standard}}{\text{Absorbance of standard}} \quad \ldots(12)$$

7. Protein (%)

The protein content of sapota powder before drying and after drying at 40, 50, 60 and 70°C was determined by Lowry's Method (Lowry *et al.* 1951) using spectrophotometer (Make: Systronics- UV Visible spectrophotometer; Ahmadabad; Model No: 106). In this method, 1 g sapota pulp was mixed with 5 ml of alkaline solution which was prepared from 50 ml of Part one (2% sodium carbonate in 0.1 N NaOH) solution and 1 ml of part two (0.5% copper sulphate in 1% sodium potassium tartarate) solution. Mixed solution i.e. part one and part two was rapidly diluted with folin-ciocalteu reagent. After 30 min, sample was loaded in the cuvet of spectrophotometer upto>3/4 of its level. The absorbance was read against standard protein solution at 750nm. Absorbance is recorded as protein content.

8. Fat (%)

Fat of sapota powder before drying and after drying at 40, 50, 60 and 70°C was determined using soxhlet fat extraction system (AOAC, 2010) by using Soxhlet apparatus (Make: Elico, Hyderabad). In this method, initially weight of empty flask was weighed. 2 g sapota pulp wrapped in filter paper was siphoned for 9-12 times with the petroleum ether in soxhlet apparatus. After removing assembly, evaporation of petroleum ether was allowed by heating. Residue remained at the bottom of the flask and was reweighed with flask. The quantity of residue was determined as fat content of sapota powder.

9. Ash (%)

Ash percentages of the sapota slices before and after drying at 40, 50, 60 and 70°C were determined by using the procedure as described (AOAC, 2000). 2 g of the dried sapota powder sample was weighed accurately in the crucible. The crucible was heated gently on a burner for 5 min at first and then strongly in a muffle furnace at 550 ± 20°C for 2 hours, till grey ash was obtained. Cool the crucible in desiccators and weigh. The % ash (w/w) was calculated by using following equation (13).

$$\text{\% Ash (w/w)} = \frac{\text{Weight of sample portion, g} - \text{weight loss on ashing, g}}{\text{Weight of sample portion, g}} \times 100 \quad \ldots(13)$$

10. Colour

The sapota slices before and after drying at 40, 50, 60 and 70°C was used to measure the colour value by using colorimeter (M/S Konica minotta, Japan Models:Meter CR-400). The equipment was calibrated against standard white tile. Around 20 g sapota dried slices powder was taken in the glass cup, the cup was placed on the aperture of the instrument. The colour was recorded in terms of *L*= lightness (100) to darkness (0); *a* = Redness (+60) to Greenness (-60); *b*= yellowness (+60) to blueness (-60).

RESULTS AND DISCUSSION

Drying Kinetics

Fig. 2 shows moisture content (db) % w.r.t. time (min) of dried sapota slices tray drying. The sapota slices was dried from an average initial moisture content of 271.333(db) % (db) to 10.28% (db); from 271.33 (db) % to 6.99(db); 271.33% (db) to 8.87% (db) and 271.33% (db) to 10.10% (db) It took around 69 h, 60 h, 54 h, and 52 h at 40°C, 50°C, 60°C and 70°C respectively as the temperature increases from 40°C to 70°C the drying time decreases from 69 h to 52 h.

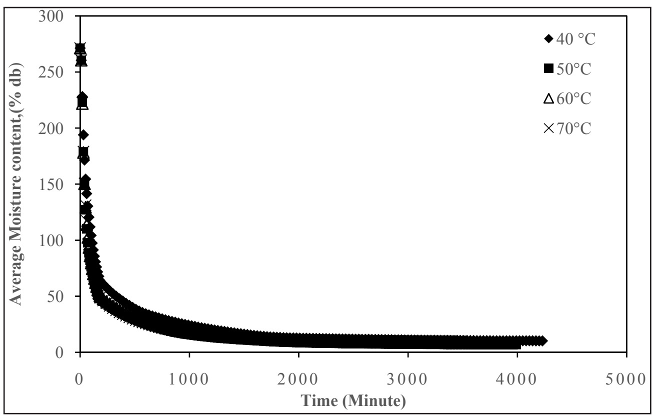

Fig. 2: Moisture content % (db) versus Time (min) by convective tray drying at 40°C, 50°C, 60°C and 70°C

Fig. 3 shows the drying rate (g water removed/100 g of bone dry material; /min) with respect to moisture content % (db) of sapota slices dried by tray drying at 40°C, 50°C, 60°C and 70°C. The initial drying rate of sapota slices was 0.4091 g of water removed / 100 g of bone dry matter per minute and decreases up to the 3.23×10^{-6} g of water removed / 100 g of bone dry matter per minute at 40°C; 0.5455 g of water removed / 100 g of bone dry matter per minute and decreases up to the 1.06×10^{-6} g of water removed / 100 g of bone dry matter per minute at 50°C; 0.5972 g of water removed / 100 g of bone dry matter per minute and decreases up to the 2.97×10^{-6} g of water removed / 100 g of bone dry matter per minute at 60°C and 0.6577 g of water removed / 100 g of bone dry matter per minute and decreases up to the 7.45×10^{-6} g of water removed / 100 g of bone dry matter per minute at 70°C. From Fig. 3 it is clear that the drying took place in falling rate period. As the temperature of drying increases from 40°C to 70°C the drying rate also increases.

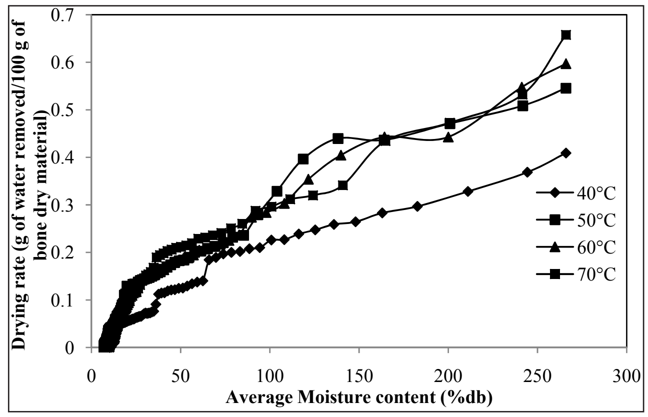

Fig. 3: Drying rate (g water removed / 100 g bone dry material / min.) versus moisture content % (db) of sapota slices by convective try drying method 40°C, 50°C, 60°C and 70°C

Moisture removal inside the sapota slices at 70°C was higher and faster than the other investigated temperature. Migration of surface moisture and evaporation rate from the surface to the air decreases with decrease of the moisture in the product. The shorter time of drying was observed at higher temperature thus increased drying rate (Zhu and Shen, 2014). This increase in drying rate because of the increased heat transfer potential between the air and sapota slices which favours the evaporation of water from sapota slices. Similar observations reported in the literatures for Parsley leaves, Asian white radish and orange slices by the Akpinar *et al*. (2006), Lee *et al*. (2009) and Rafiee *et al*. (2010). The drying rate values are in agreement with the values obtained for Peach slices, Kokum rind and Grape leaves reported by Zhu and Shen, (2014), Hande *et al*. (2014) and Doymaz, (2012) respectively.

Fig. 4 shows variation in moisture ratio with respect to time in minute. During the drying experiment moisture ratio decreases from 1 to 3.23×10^{-6}, 1 to 1.06×10^{-6} , 1 to 2.97×10^{-6} and 1 to 7.45×10^{-6} at the drying temperature of 40°C, 50°C, 60°C and 70°C respectively. The results obtained were in agreements with those reported by Hande *et al.* (2014).

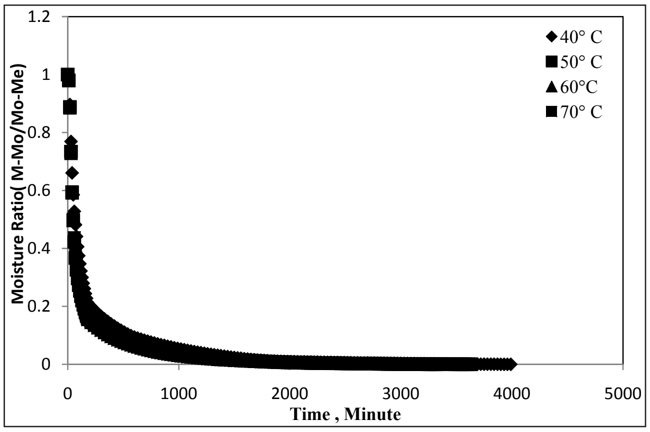

Fig. 4: Variation in moisture ratio with respect to time for sapota dry slices in tray dryer 40°C, 50°C, 60°C and 70°C

Modelling of Drying Curve

Table 2 shows various models i.e. Newton, Page, Modified Page, Exponentials, Modified Page equation were fitted to the experimental data i.e. moisture ratio versus time (min). 2(a) at 40°C, 2(b) at 50°C, 2(c) at 60°C and 2(d) 70°C respectively. The Page model fitted well (r^2 = 0.978: MSE = 8.869×10^{-4}: k = 0.0467; n = 0.636; χ^2 = 0.133) at all temperature. Table (2(a) to (d)) shows the statistical regression results of the different models, including the drying model coefficients and comparison criteria used to evaluate goodness of the fit including the r^2, χ^2 and *RMSE* of sapota slices at different temperature In all cases r^2 values for the models were greater than 0.966 indicating a good fit. The model parameter i.e. '*k*' 0.0467, 0.0356, 0.0375 and 0.0275 at 40°C, 50°C, 60°C and 70°C respectively. Value '*n*' were 0.6365, 0.7452, 0.7306 and 0.8026 at 40°C, 50°C, 60°C and 70°C respectively. The model parameter k decreasing from 0.0467 to 0.0275 as temperature increase from 40°C to 70°C. Similarly n value increase from 0.6365 to 0.8026 as the temperature increase from 40°C to 70°C.

Table 2: Different drying data models fitted for the experimental data at 40^{o}C, 50^{o}C, 60^{o}C by Convective hot air drying of Sapota slices

(a) Temperature (40° C)

Sl. No.	Model Name	Temperature 40°C			
		Model Parameter	**R²**	**MSE**	**χ²**
1	Newton	k = 0.0086	0.9596	0.0016	0.2482
2	Page	k = 0.0467; n = 0.6365	0.9782	0.0008	0.1339
3	Modified Page	k = 0.0081; n = 0.6365	0.97820	0.0008	0.1339
4	Exponential	k = 0.0086	0.95960	0.0016	0.2482
5	Thompson	a = -1.91915E + 02 b = -1.062945692	0.98292	8.25003E + 04	1.24575E + 07
6	Modified Page equation-II	k = 1.79123 L = 1.75122E+01 n = 0.6365	0.97820	0.0008	0.1339

(b) Temperature 50°C

Sl. No.	Model Name	Temperature 50°C			
		Model Parameter	**R²**	**MSE**	**χ²**
1	Newton	k = 0.0116	0.9603	0.0014	0.1989
2	Page	k = 0.0356; n = 0.7452	0.9660	0.0012	0.1702
3	Modified Page	k = 0.0114; n = 0.7452	0.9660	0.0012	0.1702
4	Exponential	k = 0.0116	0.9603	0.0014	0.1989
5	Thompson	a = -1.74052E+02 b = -1.857969719	0.9751	9.93438E+04	1.38088E+07
6	Modified Page equation-II	k = 1.3598 L = 1.14982E+01 n = 0.7452	0.9660	0.0012	0.1702

(c) Temperature 60˚C

Sl. No.	Model Name	Temperature 60°C			
		Model Parameter	R^2	MSE	χ^2
1	Newton	k = 0.0114	0.9618	0.0014	0.1930
2	Page	k = 0.0375 n = 0.7306	0.9686	0.0012	0.1584
3	Modified Page	k = 0.0111 n = 0.7306	0.9686	0.0012	0.1584
4	Exponential	k = 0.0114	0.9618	0.0014	0.1930
5	Thompson	a = -1.71099E+02 b = -2.519816379	0.9708	9.87801E+04	1.26439E+07
6	Modified Page equation-II	k = 2.3798 L = 1.71082E+01 n = 0.7306	0.9686	0.0012	0.1584

(d) Temperature 70˚C

Sl. No.	Model Name	Temperature 70°C			
		Model Parameter	R^2	MSE	χ^2
1	Newton	k = 0.0115	0.9701	0.0011	0.1500
2	Page	k = 0.0275 n = 0.8026	0.9739	0.0010	0.1313
3	Modified Page	k = 0.0113 n = 0.8026	0.9739	0.0010	0.1313
4	Exponential	k = 0.0115	0.9701	0.0011	0.1500
5	Thompson	a = -1.58874E+02 b = -1.232358461	0.9706	9.78395E+04	1.24256E+07
6	Modified Page equation-II	k = 2.2724 L = 1.56324E+01 n = 0.8026	0.9739	0.0010	0.1313

Calculation of Effective Diffusivity

Fig. 5 shown the Ln (MR) versus time (min) for effective diffusivity of sapota slices by convective hot air drying at 40°C, 50°C, 60°C and 70°C respectively. Linear equation obtained from the graph when compared with $y = mx + c$, where m is the slope of the line and the effective diffusivity was calculated from question (6) for sapota slices. Table 3 shows the effective diffusivity attained for various treatments of sapota slices dried by convective hot air drying. The value of diffusivity is reported by the different temperature in the table 3 is following that and result shown in drying temperature are the drying 40°C, 50°C, 60°C, 70°C is effective diffusivity is 2.92×10^{-9}, 3.25×10^{-9}, 3.57×10^{-9} and $3.60 \times 10^{-9} m^2/s$.

The effective diffusivity was in the range at 2.92×10^{-9} m^2/s to 3.60×10^{-9} m^2/s. at 40°C to 70°C. As the temperature of drying increases from 40°C to 70°C the effective diffusivity increases. The effective diffusivity was in the range of 1.973×10^{-10} to 8.059×10^{-11} for fig fruits (Doymaz *et al*. 2011), 3.2×10^{-9} m^2/s to 11.2×10^{-9} m^2/s for red bell pepper (Vega *et al*. 2007), and 4.76×10^{-9} to 8.32×10^{-9} m^2/s for apricot at 50°C, 60°C, 70°C and 80°C (Togrul and Pehivan, 2003). It was observed that D_{eff} values increased greatly with increasing drying temperature. When samples are dried at higher temperature, increased heating energy would increase the activity of the water molecules leading to higher moisture diffusivity (Xiao *et al*. 2010).

Marinos-Kouris and Maroulis (1995) of food materials and Srikiten and Roberts (2003) also reported the moisture diffusivity range for potato, carrot core, carrot cortex and apple as 1.2^{-9} to 9.92^{-8} m^2/s over the range 50°C to 80°C.

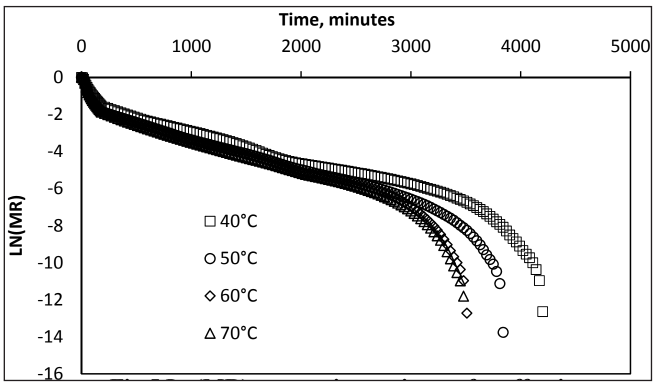

Fig. 5: Ln(MR) versus time, minutes for effective diffusivity of sapota slices dried by convective hot air drying

Fig. 6 shown graph Ln (MR) versus 1/Tabs of the sapota slices dried by convective hot air drying. The graph shows a straight line curved with a slope -736.62 and intercepts -17.203. Based on the slope the activation energy of the drying process was calculated.

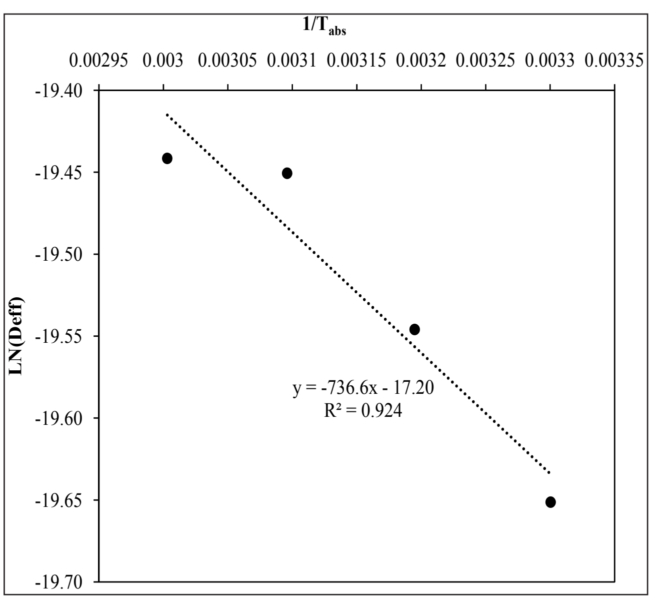

Fig. 6: LN(Deff) versus 1/Tabs of the sapota slices dried by the Convective hot air drying

Table shows pre exponential factor and the activation energy of the Arrhenius equation. The pre exponential factor was 3.379×10^{-8} m^2/s. and activation energy was 88.596 kJ/mole. The energy of activation obtained in our work are comparable with existing literature by Doymaz (2004) for carrot 28.39 kJ/mole, Bone *et al.* (1997) for potato 20.0 kJ/mole, Park *et al*. (2002) for mint 57.0 kJ/mole. Falade *et al*. (2007) for D. Alata 25.26 to 46.46 kJ/mole, and D. rotunda yam 41.75 to 72.47 kJ/mole cultivar.

Table 3: Values of Effective Diffusivity attained for various treatments of Sapota slices dried by convective hot air drying

Drying Temperature	Effective Diffusivity (D_{eff}) × 10^{-9} (m^2/s)
40°C	2.92
50°C	3.25
60°C	3.57
70°C	3.60

Table 4: Pre-Exponential factor D_0 of Arrhenius equation and the activation energy Ea (KJ/mole) at varied temperature of sapota sliced dried by convective hot air drying

Pre-expositional Factor $D_0 \times 10^{-8}$ (m^2/s)	E_a (kJ/mole)
3.37934	88.5967

Nutritional compositions of sapota slices before and after convective hot air drying

1. Moisture content (%wb)

Table 5 (a) shows the moisture content of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The moisture content of sapota slices before drying was 75.2% (wb). As the temperature of drying increases from 40°C to 70°C the moisture content decreases from 10.16% (wb) to 8.78 %(wb). The moisture content of sapota slices were 10.16, 9.60, 9.12 and 8.78 % (wb) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the moisture content decreases.

Table 6 (a) shows the ANOVA for effect of temperature on moisture content of sapota slices after drying at 40, 50, 60 and 70°C by convective hot air drying. It was observed that the decrease in moisture content with increases in temperature was significant at ($p \leq 0.05$).

2. TSS (°B)

Table 5 (b) shows the TSS (˚B) of sapota slices before drying and after drying at at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The TSS of sapota slices before drying was 19^0B and it increases after drying from 60-65 ^{0}B. As the temperature of drying increases from 40°C to 70°C the TSS of sapota slices increases from 60-65 ^{0}B. The TSS of dried sapota slices were 60^0B, 62^0B, 64^0B and 65^0B at 40°C, 50°C, 60°C and 70°C drying temperature respectively.

Table 6 (b) shows the ANOVA for the TSS of sapota slices at varied temperature 40°C, 50°C, 60°C and 70°C. The increase of TSS w.r.t. increases in drying temperature was significant at p≤ 0.05. Ganjyal *et al*. 2005 reported the TSS of sapota slices was in the range of 22 to 28 °B. Relekar *et al*. 2012 reported the TSS of sapota slices was in the range of 40 to 42.03 °B.

3. Acidity (%)

Table 5 (c) shows the acidity (%) of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The acidity of sapota slices before drying was 0.4 (%) and it increases w.r.t. increases in temperature from 40°C to 70°C drying from 0.14 to 0.17 (%). The acidity of dried sapota slices were 0.14, 0.15, 0.16 and 0.17 (%) at 40°C, 50°C, 60°C and 70°C drying temperature respectively.

Table 6 (c) shows the ANOVA for acidity of sapota slices at varied temperature 40°C, 50°C, 60°C and 70°C. The increase of acidity (%) with increase the temperature was significant at(p≤ 0.05). Seema Kumari *et al.* 2016 reported the acidity of sapota slices was range of 0.16 to 0.20(%). Ganjyal *et al.* 2005 reported the acidity of sapota slices was in the range of 0.24 to 0.35 (%) and Relekar *et al.*2012 reported the acidity of sapota slices was range of 0.21 to 0.24 (%).

4. pH

Table 5 (d) shows the pH of sapota slices before and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The pH of spota slices before drying was 5.7 and it temperature increases from 40°C to 70°C the pH increases from 6.1 to 5.8. The pH of sapota slices were 5.8, 5.9, 6.0 and 6.1 at 40°C, 50°C, 60°C and 70°C drying temperature respectively. As the temperature of drying increase the pH content increases.

Table 6 (d) shows the ANOVA for effect of temperature on pH content of sapota slices after drying at 40 °C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the increase in pH content with increase drying temperature was non-significantly at (p≤ 0.05). Convective hot air drying was in agreement with the reported by Costa *et al*. (2009) for the convectively dried cashew apple fruit powder; sweet-bell paper by convective drying (Sharma *et al*. 2014).

5. Reducing Sugar (%)

Table 5(e) shows the reducing sugar (%) of sapota slices before drying after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The reducing sugar of sapota slices before drying was 16.1(%). It increases on the temperature of drying 40°C to 70°C drying from 27.4 to 33.76(%). The reducing sugar of dried sapota slices were 27.4, 33.5, 33.41 and 33.76(%) at 40°C, 50°C, 60°C and 70°C drying temperature respectively.

Table 6(e) shows the ANOVA for the reducing sugar of sapota slices at varied temperature 40°C, 50°C, 60°C and 70°C. The increase reducing sugar with increase drying temperature was significant at (p≤ 0.05). Relekar *et al.* 2012 reported the reducing sugar sapota slices was in the range of 28.14 to 29.61(%).

6. Non Reducing Sugar (%)

Table 5 (f) shows the non-reducing sugar of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The non-reducing sugar of sapota slices before drying was 47.5(%). As the temperature of drying increases from 40°C to 70°C the non-reducing sugar decreases from 39 to 43(%). The non reducing sugar of sapota

Table 5: Nutritional composition of sapota slices before and after drying by convective hot air dryer

Sl. No.	Chemical constituent	Before drying	After drying			
			40°C	**50°C**	**60°C**	**70°C**
1	(a) Moisture (%) wb	75.2±1.6	10.16±0.1	9.60± 0.4	9.12±0.4	8.78±0.2
2	(b) TSS (^{0}B)	191.4	652.3	642.1	62	60
3	(c) Acidity (%)	040.026	0.140.015	0.15	0.160.012	0.17
4	(d) pH	5.7	6.10.1	6.0	5.9	5.8
5	(e) Reducing sugar (%)	16.11.23	27.041.91	33.053.72	33.41	33.76
6	(f) Non-reducing sugar (%)	47.51.58	390.93	41	42	43
7	(g) Total sugar (%)	66.01**±2.12**	68.09**±2.4**	76.20**±2.3**	77.62**±2.5**	79.02**±2.7**
8	(h) Carbohydrate (%)	19.50 ±3.47	21±0.1	23±0.1	27±0.1	29±0.2
9	(i) Protein (%)	0.5±0.13	0.78±0.1	0.81±0.2	0.85±0.2	0.89±0.2
10	(j) Fat (%)	0.49±0.44	0.91±0.02	1.2±0.02	1.7±0.03	1.9±0.03
11	(k) Ash (%)	0.47±0.03	1.1±0.06	1.3±0.06	1.6±0.07	1.8±0.06
12	(l) Colour L	71.102.43	61.221.13	59.24	63.06	55.30
13	(m) a	7.140.02	9.130.12	11.64	14.80	16.64
14	(n) b	40.500.03	16.500.02	26.370.98	31.270.123	24.69

Table 6: ANOVA for the nutritional composition parameter of sapota slices after drying by convective hot air drying

Sl. No.	Parameter	S.E (5%)	C.D (5%)
1	(a) Moisture (%) wb	0.03	0.05
2	(b) TSS(^{0}B)	0.29	0.93
3	(c) Acidity (%)	0.01	0.02
4	(d) pH	0.11**	0.36**
5	(e) Reducing sugar (%)	0.18	0.60
6	(f) Non- reducing sugar (%)	9.25**	30.18**
7	(g) Total sugar (%)	6.31	22.02
8	(h) Carbohydrate (%)	0.02	0.07
9	(i) Protein (%)	0.02	0.07
10	(j) Fat (%)	0.08	0.26
11	(k) Ash (%)	0.06	0.20
12	(l) Colour L	0.41	1.34
13	(m) a	0.34	1.12
14	(n) b	0.36	1.18

*(Sig = significant and Non sig ** = non-significant at (p ≤ 0.05).*

slices were 39, 41, 42 and 43(%) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the non reducing sugar decreases.

Table 6 (f) shows the ANOVA for effect of temperature on non reducing sugar of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the decrease in non reducing sugar with increase drying temperature was non-significantly at 0.05). Cholera *et al.* 2016 reported the non reducing sugar sapota slices was in the range of 40.32 (%). Relekar *et al.* (2012) reported the non reducing sugar of sapota slices was in the range of 31.81 (%).

7. Total sugar (%)

Table 5 (g) shows the total sugar of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The Total sugar of sapota slices before drying was 66.01(%). As the temperature of drying increases from 40°C to 70°C the Total sugar increases from 68.09 to 79.02 (%). The non reducing sugar of sapota slices were 68.09, 76.20, 77.62 and 79.02 (%) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the total sugar increases.

Table 6(e) shows the ANOVA for the Total sugar of sapota slices at varied temperature 40°C, 50°C, 60°C and 70°C. The increase Total sugar with increase drying temperature was significant at ($p \leq 0.05$). Relekar *et al.* 2012 reported the total sugar sapota slices was in the range of 68.61(%).

8. Carbohydrates (%)

Table 5(h) shows the carbohydrates of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The carbohydrates of sapota slices before drying was 19.50(%). After drying the carbohydrate increases As the temperature of drying increases from 40°C to 70°C the carbohydrates increases from 0.21 to 0.29(%). The carbohydrates of sapota slices were 21, 23, 27 and 29(%) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the carbohydrates decreases.

Table 6(h) shows the ANOVA for effect of temperature on of carbohydrates sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the decrease in carbohydrates with increase drying temperature was significant at 0.05). Seema Kumari *et al.* (2016) reported the carbohydrate of sapota slices was in the range of 29 to 23 (%).

9. Protein (%)

Table 5 (i) shows the Protein of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The Protein of sapota slices before drying was 0.5(%). As the temperature of drying increases from 40°C to 70°C the increases protein from 0.78 to 0.89 (%). The Protein of sapota slices were 0.78, 0.81, 0.85and 0.89(%) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the Protein increases.

Table 5 (i) shows the ANOVA for effect of temperature on Protein of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the increases in protein with increase drying temperature were significant at 0.05). Seema Kumari *et al.* (2016) reported the of sapota slices was in the range of 29 to 23 (%).

10. Fat (%)

Table 5 (j) shows the fat of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The fat of sapota slices before drying was 0.49(%). As the temperature of drying increases from 40°C to 70°C the fat increases from 0.9 to 1.9 (%). The fat of sapota slices was 0.9, 1.2, 1.7 and 1.9 (%) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the fat increases.

Table 5(j) shows the ANOVA for effect of temperature of drying on fat of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the increases in fat with increase drying temperature were significant at 0.05). Seema Kumari *et al.* 2016 reported the fat of sapota slices was in the range of 1.2 to 1.1 (%).

11. Ash (%)

Table 5(k) shows the ash of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The ash of sapota slices before drying was 0.47(%). As the temperature of drying increases from 40°C to 70°C the ash increases from 1.1 to 1.8 (%). The ash of sapota slices was 1.1, 1.3, 1.6 and 1.8 (%) at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the ash increases.

Table 5(k) shows the ANOVA for effect of temperature on ash of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the increases in ash with increase drying temperature was significant at 0.05). Abul Fadl (2015) reported the fig a fruit slice in convective drying ash content was in the range is 1.24 (%).

12. Colour

Table 5(l) shows the colour of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The colour *L** value of sapota slices before drying was 71.10. As the temperature of drying increases from 40°C to 70°C the colour *L** increases from 61.22 to 63.06. The colour L* value of sapota slices were 61.22, 59.24, 63.06 and 55.30 at 40°C, 50°C, 60°C and 70°C respectively. The *L** value does not showed any specific trend w.r.t. increase in temperature of drying.

Table 5(m) shows the a* value of colour of sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The a* value of sapota slices before drying was 7.14. As the temperature of drying increases from 40°C to 70°C the colour a* increases from 9.13 to 16.64. The a* value of sapota slices were 9.13, 11.64, 14.80 and 16.64 at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the colour a* increases.

Tables 5(n) shown the b* value of colour sapota slices before drying and after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. The colour b* value of sapota slices before drying was 40.50. As the temperature of drying increases from 40°C to 70°C the colour b* increases from 6.50 to 24.69. The colour b* value of sapota slices were 6.50, 26.37, 31.27 and 24.69 at 40°C, 50°C, 60°C and 70°C respectively. As the temperature of drying increases the colour b* decreases.

Table 6(l) shows the ANOVA for effect of temperature on colour L* value of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the changes in colour *L** value with increase in temperature were significant at 0.05). Table 6 (m) shows the ANOVA for colour a* value of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the increases in colour a* value with increase in temperature were significant at 0.05). Table 6(n) shows the ANOVA for the colour b* value of sapota slices after drying at 40°C, 50°C, 60°C and 70°C by convective hot air drying. It was observed that the increases in colour b* value with decreases in temperature was significant at 0.05).

CONCLUSION

1. From this study it was concluded that tray drying of sapota slices dried from an average initial moisture content of 271.333(db) % (db) to 10.28% (db); from 271.33(db) % to 6.99(db); 271.33%(db) to 8.87%(db) and 271.33% (db) to 10.10 % (db). It took around 69 h, 60 h, 54 h, and 52 h at 70°C, 60°C, 50°C and 40°C.
2. The Page model fitted well (R^2= 0.978: MSE = 8.869×10^{-4}: k = 0.0275; n = 0.6365; χ^2 = 0.133).
3. The value of diffusivity is reported by the different temperature in drying temperature are the drying 40°C, 50°C, 60°C, 70°C is effective diffusivity is 2.92×10^{-9}, 3.25×10^{-9}, 3.57 and 3.60×10^{-9} m^2/s.
4. From the above results it can be concluded that convective drying technique was an effective treatment to sapota slices (5 mm) as it reduces the final drying time and improved the quality of dried sample.
5. The TSS of sapota slices before drying was 19 °B and after drying was 65 to 60°B at 40°C to 70°C, acidity of sapota slices before drying was 0.4 % and after drying was 0.14 to 0.17% , pH of sapota slices was before drying is 5.7 and after drying was 6.1 to 5.8. And reducing sugar of sapota slices before drying was 16.1(%) and after drying 27.4 to 33.76 (%), the non reducing sugar of sapota slices before drying was 47.5(%) and after drying was 39 to 43 (%), Carbohydrate of sapota slices before drying was 19.50 (%) and after drying was 21 to 29 (%).
6. Protein of sapota slices before drying was 0.5 (%) and after drying was 0.78 to 0.89 (%). The fat of sapota slices before drying was 0.49 (%) and after drying was 0.91 to 1.9, The ash content of sapota slices before drying was 0.47 (%) and after drying was 1.1 to 1.8 and Colour of sapota slices of '*L*' value was before drying rang is 54.70 to 72.10

and '*a*' value range is 7.10 to 10.42 and '*b*' value range is 37.26 to 41.91 and after drying the sapota slices of '*L*' value was in range of 71.10 to 55.30. And '*a*' value was in range of 7.14 to 16.64. '*b*' value was in range of 40.50 to 24.69.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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