Original Research Article

OSMO-Microwave Drying of Pineapple (*Ananas comosus*) Slices: Mass Transfer Kinetics and Product Quality Characterization

Abstract

The objective of this present research was to investigate the effect of slice thickness and concentration of the osmotic solution on mass transfer kinetics, the color profile of osmotically dehydrated pineapple slices, and product quality characteristics of osmotically dehydrated microwave-dried (ODMWD) products. Three different slice thicknesses (0.5, 1, and 1.5 cm) and three concentrations of osmotic solution (40, 50, and 60 °Brix) were used. The mass transfer kinetics (moisture reduction behavior, weight loss, and solid gain), physicochemical properties (color, TSS, pH, titratable acidity, vitamin C, and total sugar), and total phenolic content of pineapple slices were analyzed. During osmotic dehydration, the moisture reduction behavior of 0.5 cm slices was faster in all osmotic solutions, whereas water loss and solid gain were higher for all slices treated with 60 °Brix. Both slice thickness and concentration of the solution significantly affected the color of OD pineapple slices. For ODMWD products, total soluble solids (TSS), pH, ascorbic acid content, total sugar, and total phenolic content increased for all slice thicknesses with an increase in osmotic solution concentration, whereas titratable acidity exhibited the opposite result. The rehydration ratio was higher in 0.5 cm slices for all solution concentrations. According to the finding, pineapple fruits can be dehydrated by using 60 °Brix solution concentration with 0.5 cm slices for making dehydrated pineapple fruit, and osmotic dehydration followed by microwave drying of pineapple fruit could be used for value-added processing products.

Keywords: mass transfer, microwave drying, Osmotic dehydration**,** pineapple, product quality

Introduction

Pineapple (*Ananas comosus*), a tropical fruit, is cultivated mostly in both tropical and subtropical climates and is known for its fantastic juiciness, intense flavor, and abundance of medical advantages (Hossain et al., 2017). After bananas and citrus, pineapple is the third-most valuable tropical fruit worldwide. In Bangladesh, pineapple ranks fourth in terms of total growing area and production. Fruit production, especially pineapple, is increasing daily in Bangladesh (Hossian & Abdulla, 2015). In the fiscal year 2018–2019, Bangladesh produced 217,000 tons of pineapples (BBS, 2020). Mature pineapple fruit contains high moisture content, high sugars, soluble solid content, ascorbic acid, the protein-digesting enzyme (bromelain), citric acid, malic acid, and vitamin A and B. Further, pineapple has a considerable quantity of calcium, potassium, vitamin C, crude fiber, and other minerals that are helpful for the digestive system and aid in keeping a healthy weight and balanced diet (Hossain et al., 2017). The pineapple can be eaten in a variety of different ways, including fresh slices, dried, canned, juiced, and in a wide array of foodstuffs such as desserts, fruit salads, jam, yogurt, ice cream, and candies (Debnath et al., 2012; Saxena et al., 2009). Pineapple lowers blood pressure, treats inflammatory diseases, contributes in weight loss, and protect against diabetes and free radical damage (Septembre-Malaterre et al., 2016).

However, pineapple has a relatively short shelf life because of its high moisture and nutrient content, which speeds up microbial activity and causes deterioration. In industrialized countries, post-harvest losses of fruits often account for 20 to 25 percent of total fruit production, and considerably higher in developing countries (Sharma et al., 2009). In Bangladesh, it was estimated that post-harvest losses of pineapple accounted for around 25% of the overall production, with an annual economic loss of TK 550.58 core (Hossain et al., 2017).

Drying is considered one of the oldest techniques of food preservation, and approximately 20% of the world's perishable crops are dried to extend their shelf-life (Chakraverty et al., 2003). Among various pre-treatment prior to drying, osmotic dehydration (DO) preserves the fruits by reducing water activity and results in lower drying time, better textural quality, sensory and nutritional characteristics, flavor enhancement, and color stabilization (Ozdemir et al., 2008; Saputra, 2001). Osmotic dehydration is a simple and low-cost pretreatment technique used before drying foods. It minimizes energy consumption for subsequent drying processes and promotes the final quality of the product (Amami et al., 2008; Arslan & Özcan, 2011). Furthermore, osmotic dehydration is the most effective method for obtaining a product with low water activity and long shelf life. Thus, it improves product stability in a fresh-like state and prevents microbiological deterioration (Yadav et al., 2012). However, Many factors influence the rate of mass transfer during osmotic dehydration, including the food product's specific surface area, temperature, immersion period, solute concentration and composition, mode of solid-liquid phase interaction, pressure, and product-to-solution ratio (Verma et al., 2014).

Microwave drying is becoming more popular over conventional dryings because of its several advantages such as speed of operation, energy efficiency, better process control, and quicker start-up and shut-down times (An et al., 2022). Microwave drying converts electromagnetic energy directly to kinetic energy in water molecules, and the product itself generates heat (Motevali et al., 2011). Microwave drying, on the other hand, may cause non-uniform heating and/or surface overheating (Ahrné et al., 2007). Fruits that have undergone microwave-assisted osmotic dehydration (MWOD) at frequencies between 300 MHz and 300 GHz lose higher moisture, minimize solid gain, and improve energy efficiency (Figiel, 2010; Puligundla et al., 2013). MWOD demonstrated improvements in rehydration properties, porosity, overall dehydration coefficient (ML/SG), drying time, and shrinkage (Li &

Ramaswamy, 2006; Pereira et al., 2007). In comparison to conventional osmotic dehydration (COD), MWOD is a better method for enhancing moisture loss (ML), color change (E), and chroma while reducing solids gain (SG) and hue angle (Manzoor et al., 2021).

Very few of literature is available on osmotic dehydration by using a combination of honey, sucrose, and salt as an osmotic agent. Moreover, few numbers in the literature documented microwave drying of osmotically pre-treated samples. Therefore, the aim of this study was to investigate the dehydration kinetics and quality characteristics in terms of color, rehydration, and physicochemical profile of dehydrated pineapple by using a combination of honey, sucrose, and salt as an osmotic agent.

Materials and methods

Preparation of sample and osmotic solution

Fresh and mature ripe pineapple (variety: *Giant Kew*) were purchased from a local food store in Jashore, Bangladesh, during November and December of 2021 and stored at 3°C before use. The samples were thoroughly washed with running water to remove adhering soil and other debris. Then the pineapples were then peeled and sliced using a sharp knife into three different slice thicknesses of 0.5 cm, 1 cm, and 1.5 cm with an area of 8.5 cm^2. Osmotic solutions were prepared using a mixture of refined sugar (Fresh Refined Sugar), salt (ACI, Bangladeshi Salt), and pure honey (78^0 Brix) at three different concentration levels 40, 50, and 60 ^{o}Brix (Tippanna et al., 2019).

Experimental design

A two-factor (3×3 factorial) completely randomized design (CRD) was employed where the two factors were the slice thickness and concentration of the osmotic solution. The research was divided into two parts: osmotic dehydration of pineapple slices in a mixed osmotic solution (sugar, salt, and honey) up to a certain level and then microwave drying of the osmotically dehydrated product. In the first part, the pineapple slices were immersed in osmotic solutions in beakers at a constant temperature of 50° C for 4-6 h in a water bath for osmotic dehydration. The fruit-to-solution ratio was maintained at 1:10 (Nazaneen et al., 2017). The moisture loss in the samples was checked every 30 min intervals. The dehydrated slices were drained and blotted with absorbent paper to remove the excess solution. In the second part, osmotically dehydrated pineapple slices were again subjected to microwave drying using a microwave oven (MW73AD-B/D2, Samsung, Bangladesh) at 40°C temperature (700 watts operating at a frequency of 2450 MHz) for 2-3 h. The cavity dimension of the microwave oven was (W× H×D) 330 mm x 211 mm x 309 mm. Glass plate rotates for 5 min^{-1}, and the direction of 360° rotation can be changed by pressing the on/off button. Time adjustment is made with the aid of a digital clock located on the oven. One dish containing 100 g of sample was placed on the centre of a turntable fitted inside the microwave cavity and processed until the slices were dried entirely. The pineapple slices were arranged in a thin layer on a rotating, 245 mm-diameter glass plate. At 30-minute intervals, the sample was taken off the glass plate and placed on the digital balance (Radwag, Radom, Poland) to measure the amount of moisture loss in the sample. The final moisture content of the samples was brought down to 14-16% (wet basis). The dried slices were cooled to room temperature and packed in an HDPE pack with sealing. Then it was stored in a refrigerator at 3°C temperature for future quality analysis of the dried product. A schematic flow chart of the whole experiment is presented in **Figure 1**.

Ripe pineapple

↓

Stored at 3°C until used

↓

Washing & Peeling

↓

Cutting into slices

(0.5 cm, 1 cm & 1.5 cm)

↓

Bottling

↓

Osmotic dehydration

(OSC= 40°, 50° and 60° Brix, S: S = 1:10 at TWB= 50°C, 4 h)

↓

Microwave heating/Drying

(MWP= 700 W, TMO= 40°C, 1.5-3 h)

↓

Packaging (HDPE)

Figure 1. Osmotic dehydration followed by microwave drying of Pineapple slices. (OSC= Osmotic solution concentration, S:S =Sample weight to solution ratio, TWB = Temperature in water bath, TMO= Temperature in Microwave oven, MWP = Microwave power, HDPE = High-density polyethylene.

Mass transfer parameters

The mass transfer characteristics of the samples (fresh and treated), including the water loss (WL), moisture content (MC), and solid gain (SG), were determined, according to (Manzoor et al., 2021) by the following equations

Moisture Loss (ML %) = ×100 ….. (i)

Solid Gain (SG %) = ×100 …………(ii)

Moisture content (MC) = ×100 …….... (iii)

Rehydration ratio

Rehydration ratio of dried product was determined by the method used (Nishadh & Mathai, 2014). The rehydration ratio of the samples was estimated using the formula below.

Rehydration ratio = ..…………………………. (iv)

Ascorbic acid (vitamin C), Total Soluble Solids, Titratable acidity, and pH

The ascorbic acid content was determined by the titrimetric (dye reduction) method according to the method described by (Ranganna, 1986). Total soluble solids (TSS) were estimated by using a digital refractometer (HI 96801, refractometer, China) according to the method AOAC (2005). The refractometer was calibrated to zero with distilled water before sample analysis. The titratable acidity of fruit and fruit products is estimated through the titration of the fruit sample with 0.1N NaOH by using phenolphthalein as an indicator according to the method AOAC (2005). The p^H of the samples was determined using a P^H meter (Digital PH meter, China). The pH meter was calibrated with standard buffer solution, such as buffer at p^H 4.0 allowed by p^H 7.0 before analysis of samples.

Color characteristics

The Hunter color lab system (coordinate L*, a*, b*) using a colorimeter (CR400, Konica Minolta) was used for the color determination of fresh and ODMWD pineapple samples. Hue angle and chroma were also calculated from the CIE L*, a*, b* using Equations (v) and (vi).

Hue angle (degrees) = arctan (b*/a*) ………………………………………….. (v)

Chroma = $(a^{*2}+b^{*2})^{1/2}$ ………………………………………….. (vi)

Total phenolic content

The total phenols (TP) of the sample were estimated using the methods outlined by (Igual et al., 2012). Folin-Ciocalteu reagent (1.25 mL), distilled water (15 mL), and pineapple extract (0.25 mL) were mixed for 15 s before being allowed to sit for 8 minutes to conduct the experiment. After this, 3.75 mL of 7.5% Na_2CO_3 and 25 mL of distilled water was added to the mixture to bring it the desired volume. After 120 min of incubation in the dark at room temperature, the blue color absorbance was measured at 765 nm. The TP content in samples was calculated using a gallic acid standard calibration curve and represented as mg GAE/100 g dry weight.

Statistical Analysis

The statistical analysis was carried out using a two-factor (3×3 factorial) experiment in completely randomized design (CRD). Each sample was replicated thrice. Statistical software (SPSS windows version 27) was used with Duncan's Multiple Range Test analysis at 95% confidence level.

Results and Discussion

Moisture reduction behaviour

The moisture reduction behaviour of pineapple slices (0.5, 1, and 1.5 cm) during osmotic dehydration at different concentration levels (40, 50, and 60 °Brix) are shown in Figures 2a, 2b, and 2c, respectively. It was observed that from the figures (2a,2b, and 2c), moisture loss was quicker during the initial period of osmotic dehydration, and then the rate of moisture reduction decreased with increasing dehydration time. During osmotic dehydration, moisture loss after 240 min varied from 34.09% to 42.17% at different concentration levels of osmotic solution. From all the figures, we observed that 0.5 cm slices showed rapid moisture reduction from pineapple fruits, and 60 °Brix solution tended to remove moisture higher than 40 and 50 °Brix solution. The higher solution concentration conditions demonstrated higher moisture reduction due to increased internal moisture pressure during osmotic dehydration.

Similar findings were reported by Selvakumar & Tiwari (2018) on osmotic dehydration of carrot slices was higher when the higher concentred solution was applied for dehydration. In addition, Saputra (2001) pointed out that the moisture reduction behaviour of osmotically dehydrated pineapple is significantly affected by solution type, concentration, temperature, and immersion time. Mahesh et al. (2017) reported that using honey as an osmotic agent increased the osmotic dehydration of pineapple slices. Mirzayi et al. (2018) experimented on osmotic dehydration of banana slices using a combination of salt and sucrose. They pointed out that the higher the percentage of salt results in higher moisture reduction. The results are also supported by a study on osmotic dehydration of kiwifruit (Cao et al., 2006).

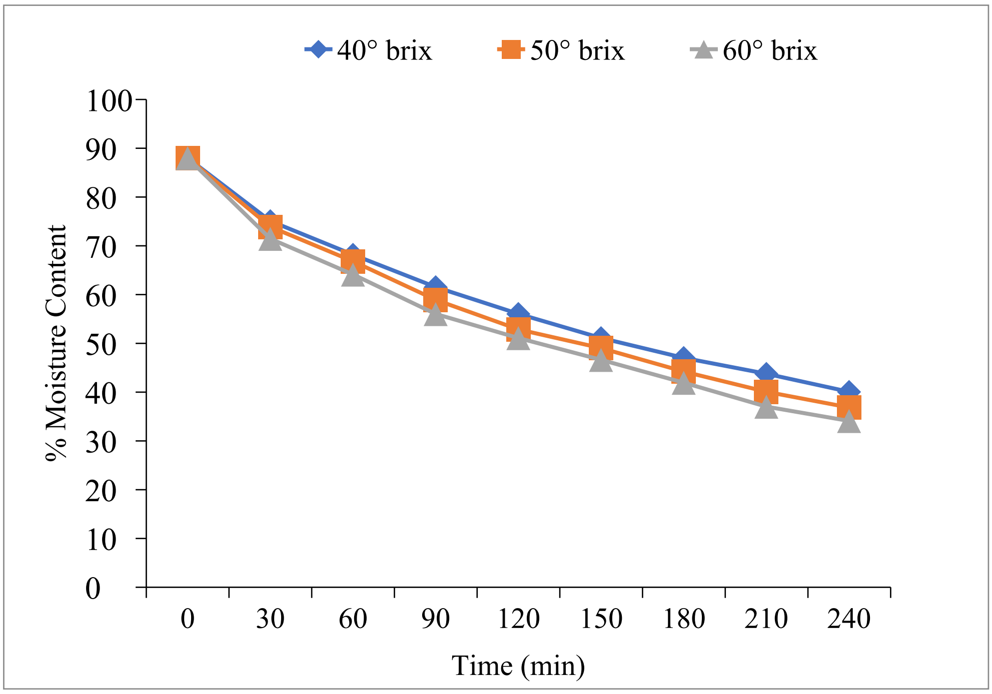

Figure 2 a. Moisture reduction behavior of 0.5 cm thick slice

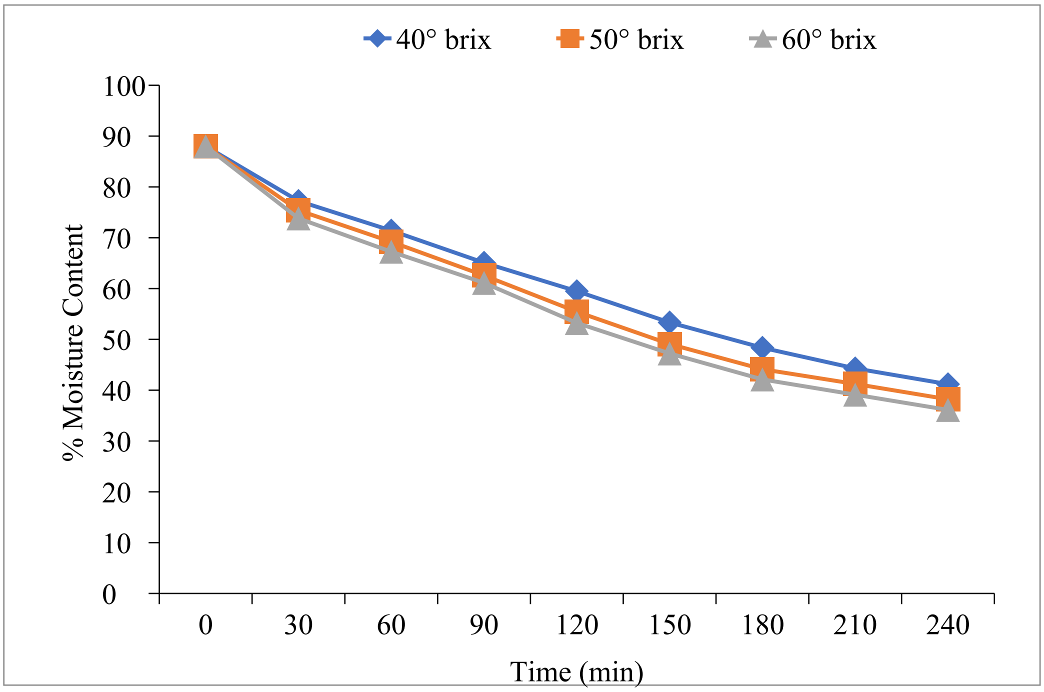

Figure 2b: Moisture reduction behavior of 1 cm thick slice

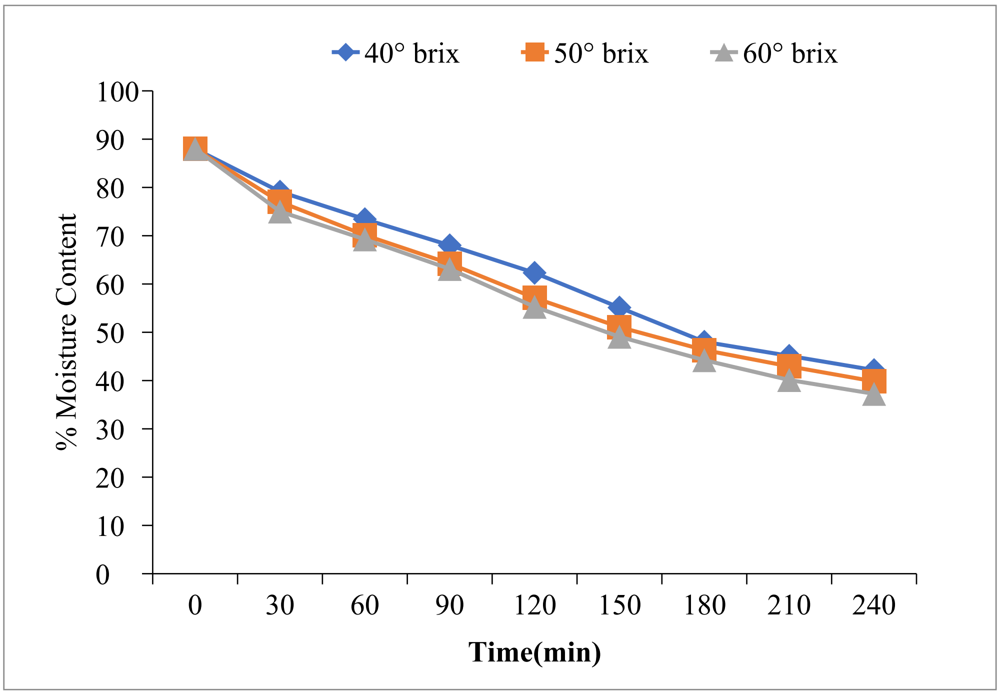

Figure 2c: Moisture reduction behavior of 1.5 cm thick slice

Water loss

The percent water loss (WL) values of the pineapple slices treated with different osmotic solution concentrations are summarized in Figure 3a, 3b, and 3c. The water loss of all samples gradually increased with the increasing dehydration time for all solution concentrations. Initially, the WL of the same thick slice was almost equal in the different solution concentrations, but it was found to increase in higher osmotic solution concentration with the increase in dehydration time. This may be due to increased osmotic driving forces between the sample and solution (Thalerngnawachart & Duangmal, 2016). The rate of WL was higher for the 0.5 cm slice at all different solution concretion than the 1 cm and 1.5 cm slices at the beginning of the osmotic dehydration process. In earlier study, Azoubel & Murr (2004), reported that, water loss and solid gain increased with increase in sugar concentration and immersion time. Tippanna et al. (2019) also found that the rate of mass transfer in the fruit varied with osmotic solution concentration. They also reported that utilizing a 60% sucrose solution resulted in a water loss of 25.22% for pineapple fruit.

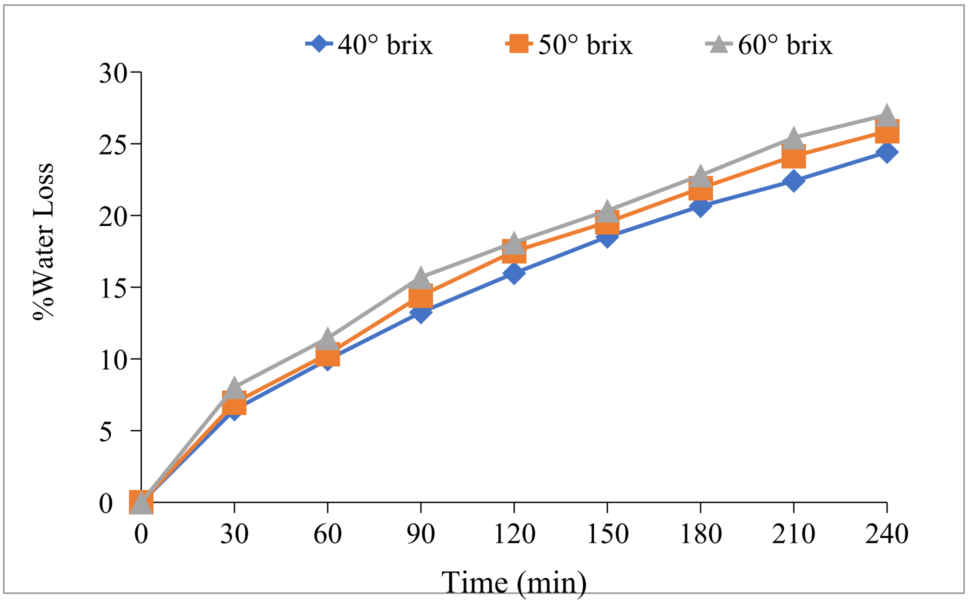

Figure 3a. Water loss (%) during osmotic dehydration of 0.5 cm slice.

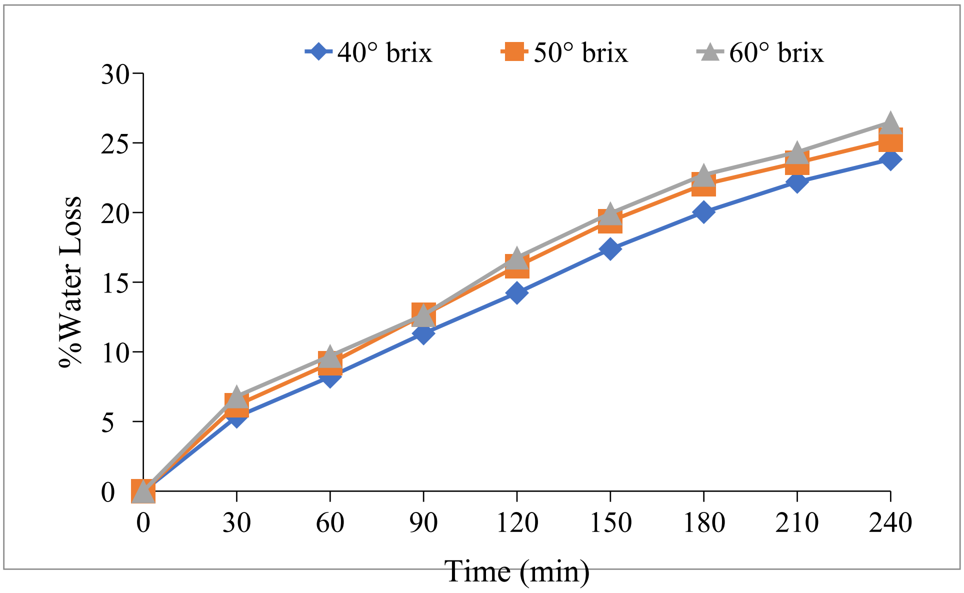

Figure 3b. Water loss (%) during osmotic dehydration of 1 cm slice.

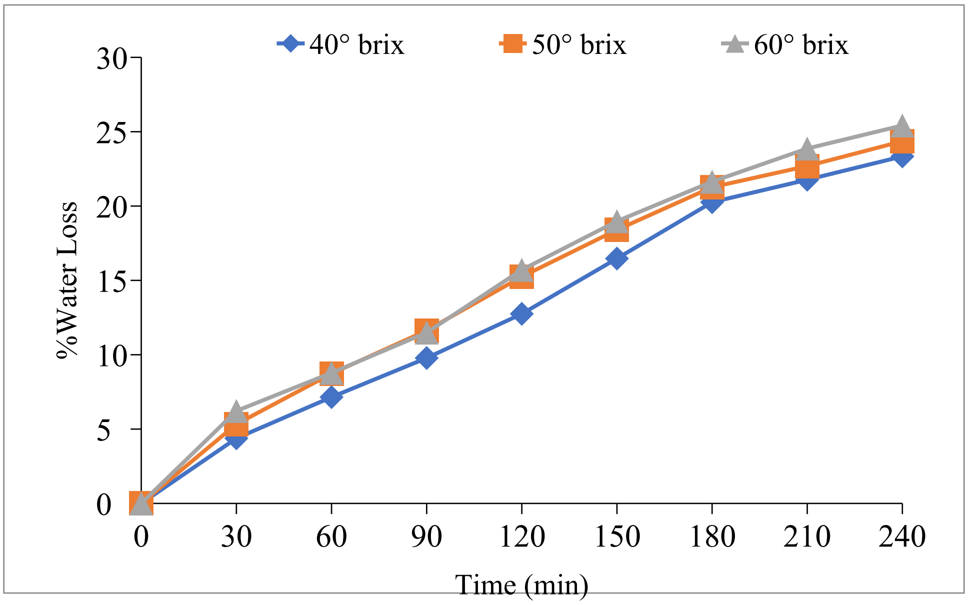

Figure 3c. Water loss (%) during osmotic dehydration of 1.5 cm slice.

Solid gain

The percent Solid gain (SG) of all treatments was found to be increased with increasing solution concentration and dehydration time, depicted in Figures 4a, 4b, and 4c, as reported in previous studies (Corrêa et al., 2011; Manzoor et al., 2021). SG rate of 0.5 cm slice was initially higher than 1 cm and 1.5 cm slices in three different (40°, 50° and 60° Brix) osmotic solution concentration. The 0.5, 1 and 1.5 cm slices exhibited a sharp increase in SG up to 60 min, 120 min and 150 min of OD, respectively and afterwards a gradual increase in SG was observed in all osmotic solution concentration. However, at higher concentrations at 60 °Brix the SG rate was high for three different slice thicknesses. This may be because of the higher chemical potential difference between the sample and the osmotic solution (Manzoor et al., 2021). The end of osmotic dehydration process, a highest SG value of 9.08 % was determined for the sample of 0.5 cm thickness immersed in 60 °Brix solution whereas the least SG (4.61%) recorded for the sample of 1.5 cm thickness immersed in 40 °Brix solution.

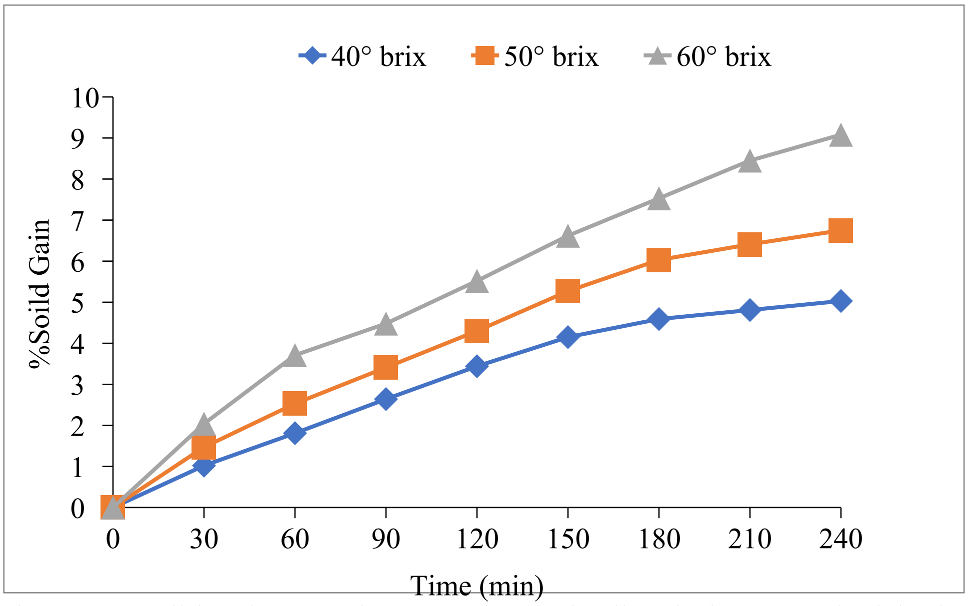

Figure 4a. Solid Gain (%) of 0.5 cm pineapple slice during osmotic dehydration

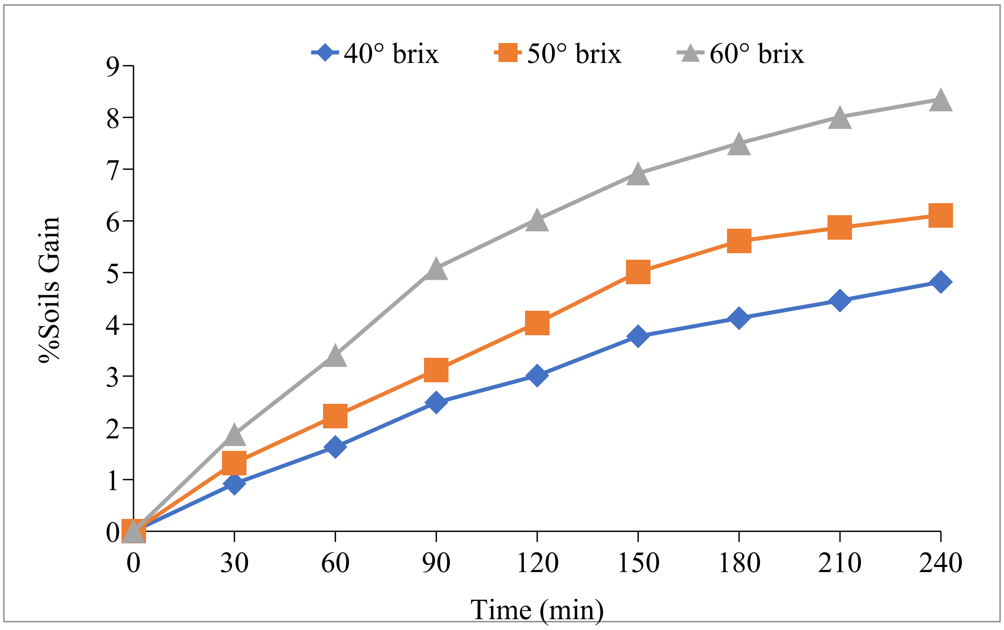

Figure 4b. Solid Gain (%) of 1.0 cm pineapple slice during osmotic dehydration

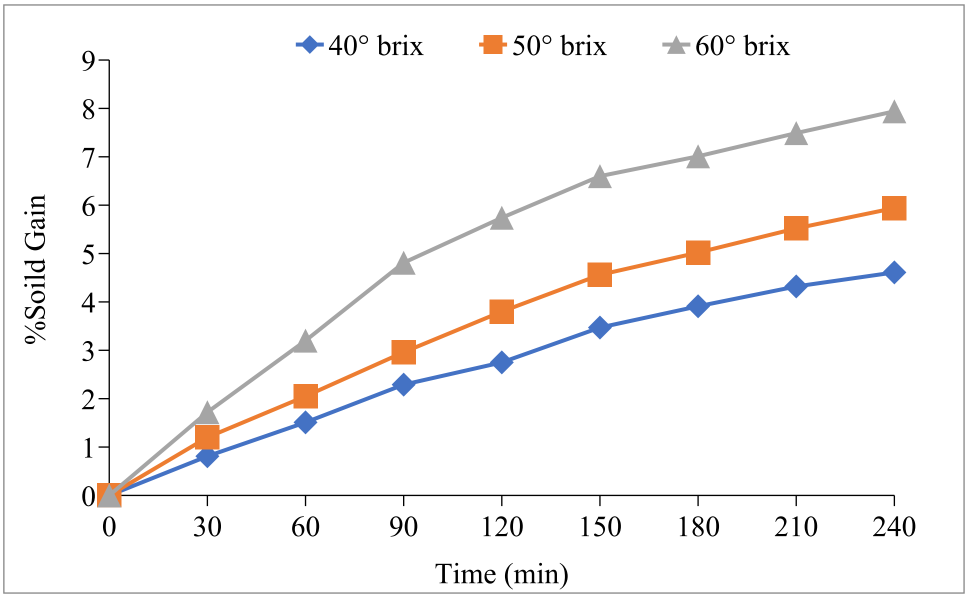

Figure 4c. Solid Gain (%) of 1.5 cm pineapple slice during osmotic dehydration

Color attribute of Osmo-dehydrated pineapple slices

Food products, particularly fruits, are evaluated first and foremost by their color changes, which indicate how well consumers receive them. A significant difference in color parameters (L* -lightness, a*-redness, and b*-yellowness) among the osmotically dehydrated samples was observed in this study, as shown **in Table 1. The** initial L* value of fresh pineapple slices was 50.97. During OD, an increase in L* value was observed in all 0.5 cm slices, whereas a significant reduction was seen in all 1 cm and 1.5 cm slices treated with the same osmotic solution concentrations. This is possibly due to the variation in slice thickness which affects the water loss from the sample. According to Falade et al. (2007), osmotic dehydration causes the cytoplasm to contract due to water loss of fruits and results in a reduction in food brightness. The L* value of all slices increased with an increase in solution concentration. A significant increase in the chromatic coordinate, a*, was witnessed with the increase in thickness and solution concentration. The highest value of a* was found to be 20.03 for the 1.5 cm slices treated with 60 °Brix. The chromatic coordinate of the b* value of fresh was 43.40, which was noticed to decrease with the increase in slice thickness and solution concentration. After OD, a significant decline was observed in the 1.5 cm slices treated with 60 °Brix from 43.40 to 21.47. The hue angle (H) of the slices changed from yellowness towards redness with increasing the slice thickness and solution concentration. The Hue angle of 1.5 cm slice immersed in 60 °Brix experienced the lowest H-value of 46.99. The chroma of treatments corresponded with the b* value. Manzoor et al. (2021 and Chutintrasri & Noomhorm (2007) also reported the variation of color attributes of osmotic dehydrated fruits samples at the different concentration levels of osmotic solutions.

Microwave drying of Osmo-dehydrated pineapple slices

Drying time

The drying time of microwave drying of Osmo-dehydrated pineapple slices is shown in figure 5. The drying time was affected by the pineapple slice's thickness. The final moisture content of the 0.5, 1, and 1.5 cm slices was obtained to 14 -15% (wet basis) in 90, 110, and 180 min, respectively. The drying time increased with the increase in thickness may be due to the increased distance traveled by moisture to the surface (Limpaiboon, 2011). A similar effect of thickness on drying time has been reported by Azimi-Nejadian & Hoseini (2019) for potato slices, whereas Akal et al. (2014) observed a relatively little effect at low microwave power for Kiwi slices.

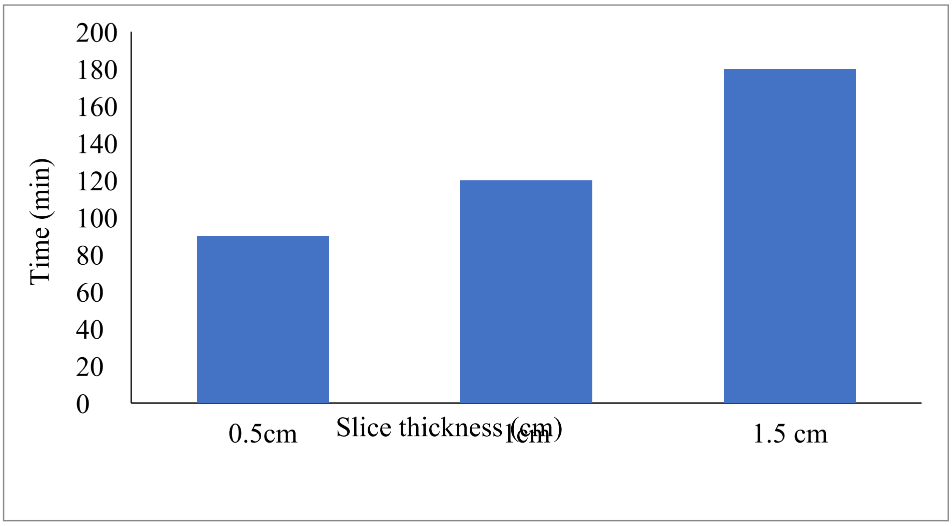

Figure 5. Drying time of osmotically-dehydrated pineapple slices at 50˚C temperature

Physicochemical properties of Osmo-dehydrated microwave-dried (ODMWD) pineapple slices

Total soluble solids, Titratable acidity, and pH

Total soluble solids (TSS), Titratable acidity, and pH of osmotically dehydrated followed by microwave-dried (ODMWD) pineapple slices are summarized in Table 2. The TSS of all treatments increased with an increase in the concentration of the osmotic solution and increased in slice thickness at the same concentration level. The highest TSS value was 14.29% for the 1.5 cm slices treated with 60° Brix solution, whereas the lowest TSS value was 7.63% for the 0.5 cm slice immersed in 40 °Brix solution. Chaudhary et al. (2019) found similar results on the osmotic dehydration of pineapple slices at 40, 50, and 60 °Brix concentration levels.

Titratable acidity (TA), which is significant for the sensory qualities of the fruit, is a measure of the amount of organic acids present in the fruit. The TA of pineapple slices decreased as the concentration of osmotic solution increased. In our study, the highest value of TA (0.22) was found for 1.5 cm slices treated with 40 °Brix solution, whereas the lowest value of TA (0.10%) was obtained for 1 cm slice immersed in 60 °Brix solution. Chaudhary et al. (2019) also reported the same result when they conducted an experiment on the osmotic dehydration of pineapple slices at 40, 50, and 60 °Brix solution concentration levels.

The pH is one of the most important factors that affect the growth of microflora in foods. In this study, the pH of pineapple slices increased as the concentration of osmotic solution increased, and pH decreased as an increase in slice thickness. The highest pH value of 6.84 was obtained in a 0.5 cm thick slice treated with 60 °Brix solution, and the lowest pH value of 6.38 was found in a 1.5 cm thick slice immersed in 40 °Brix solution.

Vitamin C

The vitamin C content of Osmo-dehydrated microwave-dried (ODMWD) pineapple slices is summarized in Table 3. The slice thickness and solution concentration did not show any significant effect on vitamin C content except for the 1.5 cm slice treated with 60 °Brix solution. The vitamin C content of all samples was near about 30 mg/100 g, whereas the 1.5 cm slice immersed in 60 °Brix solution possessed the height vitamin C of 35.60 mg/100 g. The sample treated with 60 °Brix solution retrained the highest vitamin C, most likely due to the sugar effect resulting in a reduction in loss of soluble components, for example, ascorbic acid (Saputra, 2001). A similar effect of osmotic solution concentration on pineapple slices has also been reported by Salazar et al. (2019).

Table 1. Color attributes of osmotically dehydrated pineapple slices treated with different osmotic solution concentrations.

Sample Thicknes s (cm)	Osmotic solution concentration														
	40 °Brix					50 °Brix					60 °Brix				
	L*	a*	b*	C	H	L*	a*	b*	C	H	L*	a*	b*	C	H
Fresh	50.97±4	5.83±3	43.4±2	33.1±3.48	70.03	50.97±4.0	5.83±2.8	43.4±2.6	33.1±3.4	70.03	50.97±4	5.83±2.8	43.4±2.6	33.1±3	70.03±3
0.5	62.40^{a}	7.20^{d}	53.17^{a}	53.66^{a}	82.29^{a}	64.57^{a}	7.60^{d}	51.20^{a}	51.76^{a}	81.56^{ab}	65.97^{a}	9.33^{c}	33.30^{c}	34.58^{c}	74.35^{c}
1.0	42.63^{d}	7.47^{d}	38.03^{b}	38.76^{b}	78.89^{b}	43.50^{d}	8.90^{c}	37.87^{b}	38.90^{b}	76.77^{bc}	47.50^{c}	9.50^{c}	36.57^{bc}	37.78^{b}	75.44^{c}
1.5	37.17^{e}	13.50^{bc}	27.27^{d}	30.43^{d}	63.66^{d}	42.03^{d}	15.63^{b}	24.10^{de}	28.72^{d}	57.03^{e}	43.80^{d}	20.03^{a}	21.47^{e}	29.36^{d}	46.99^{f}

Note: Values represent the mean of three replicates. Different lowercase superscript letters in the same column symbolize statistical differences ($P < 0.05$) between the samples.

Table 2. Chemical properties of Osmo-dehydrated microwave-dried (ODMWD) pineapple slices.

Slice thicknes s (cm)	Osmotic solution concentration											
	40 °Brix				50 °Brix				60 °Brix			
	%TA	pH	%TSS	Vitamin C (mg/100 g)	%TA	pH	%TSS	Vitamin C (mg/100 g)	%TA	pH	%TSS	Vitamin C (mg/100 g)
0.5	0.22^{a}	6.71^{b}	7.63^{c}	28.60^{b}	0.21^{a}	6.81^{a}	9.76^{d}	30.35^{ab}	0.16^{bc}	6.84^{a}	11.60^{c}	31.40^{ab}
1.0	0.17^{b}	6.68^{b}	9.13^{c}	31.50^{ab}	0.13^{d}	6.71^{b}	11.27^{d}	31.95^{ab}	0.10^{e}	6.80^{a}	11.57^{c}	32.73^{ab}
1.5	0.22^{a}	6.38^{c}	9.23^{a}	31.97^{ab}	0.17^{b}	6.49^{b}	12.23^{b}	32.93^{ab}	0.14^{cd}	6.67^{b}	14.29^{a}	35.60^{a}

Note: Values represent the mean of three replicates. Different lowercase superscript letters in the same column symbolize statistical differences ($P < 0.05$) between the samples.

Total Sugar Content

The total sugar content of ODMWD pineapple slices is depicted in Figure 6. In our study, the total sugar content of samples was not affected by slice thickness, whereas the concentration of Osmo-solution showed an effect. Total sugar content increased with the increase of concentration of the osmotic solution. The highest total sugar content was found in the 0.5 cm thick sample treated in 60 °Brix solution. The sample with 1.4 cm in thickness and 40 °Brix solution treatment had the lowest total sugar concentration. An increase in total sugar content after microwave drying could be attributed to the hydrolysis of sucrose during the drying process.

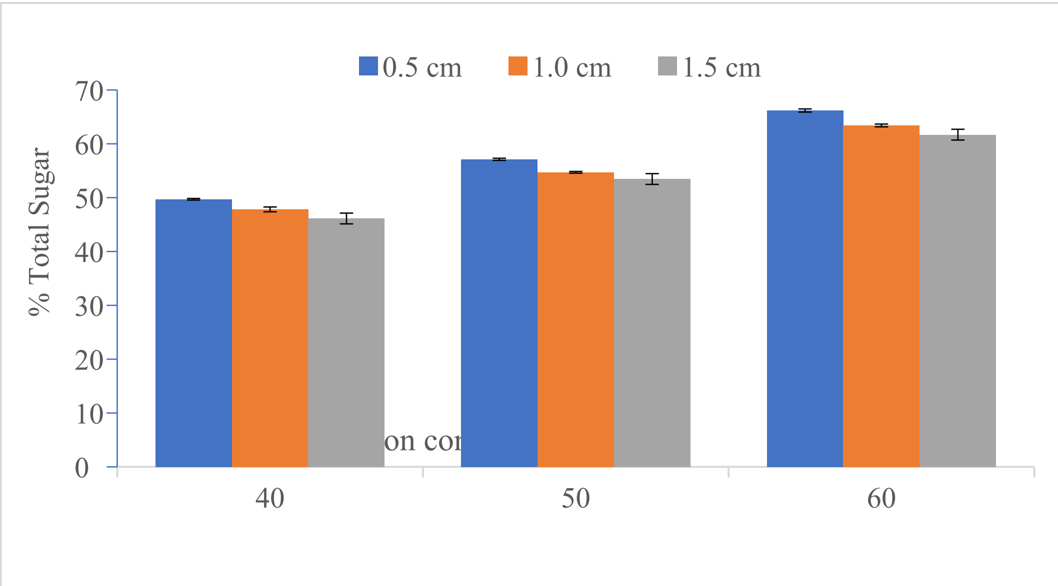

Figure 6. Total sugar content (%) of ODMWD pineapple slices.

Rehydration Ratio

Rehydration is one of the dried food product quality indicators. The degree of rehydration a product provides is a good indicator of how fresh it is. The capacity of water uptake during rehydration can be measured using the rehydration ratio. It indicates the substance's capacity to return to its original properties (Nishadh & Mathai, 2014). It also provides information about internal damage in the product that occurred during drying (Tripathy & Kumar, 2009). The rehydration capacity of the dried fruits is not affected by the drying conditions of the microwave programs (Botha et al., 2012). The results of the rehydration ratio of ODMWD pineapple slices are depicted in Figure 7. The thickness of the sample slice showed an effect on the rehydration ratio. The 0.5 cm slices possessed a higher rehydration ratio than other samples in all three different concentrations of osmotic solution. The osmotic solutions concentration showed the same effect on the water rehydration of ODMWD samples. More concentrated fruit components are associated with a greater rehydration ratio. A larger rehydration ratio could have resulted from the absorption of more water due to the presence of more tissues (Ramallo & Mascheroni, 2012). A high rehydration ratio indicates that the dried material is of high quality because pores allow water to penetrate the cells (Okpala & Ekechi, 2014).

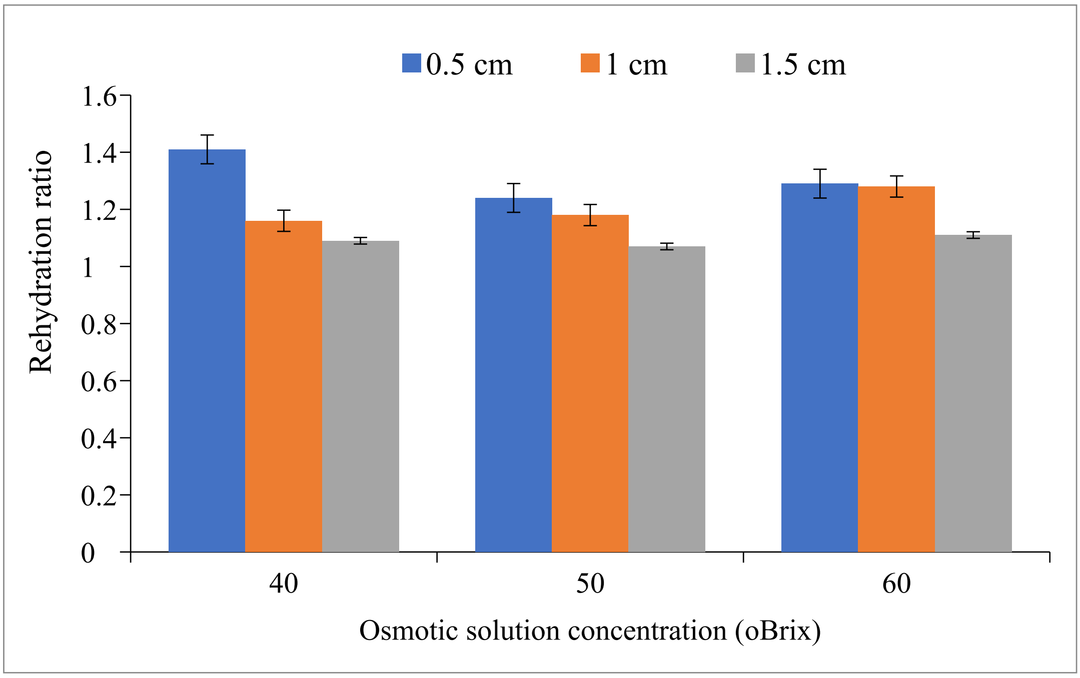

Figure 7: Rehydration ratio of ODMWD pineapple slices.

Total Phenolic Content of ODMWD pineapple slices

The total phenolic content (TPC) of all ODMWD samples is shown in Figure 8. The slice thickness and concentration of the osmotic solution demonstrated an effect on the TPC of the final dried product. The sample treated with 60 °Brix exhibited a gradual increase with an increase in slice thickness, whereas the 40 °Brix treated sample possesses a gradual decrease with an increase in slice thickness. The highest value of TPC of 78.5 mg GAE/100g was recorded for the sample of 1.5 cm thickness and treated with 50 °Brix solution. In this study, the retention of antioxidant activity is greater at higher concentration levels of osmotic solution. The retention of more TPC in slices may be due to the high concentration of osmotic solution promoting a protective impact on the fruit's surface by limiting the outflow of antioxidant substances (Almeida et al., 2015). These results agreed with those of Rahman et al. (2018).

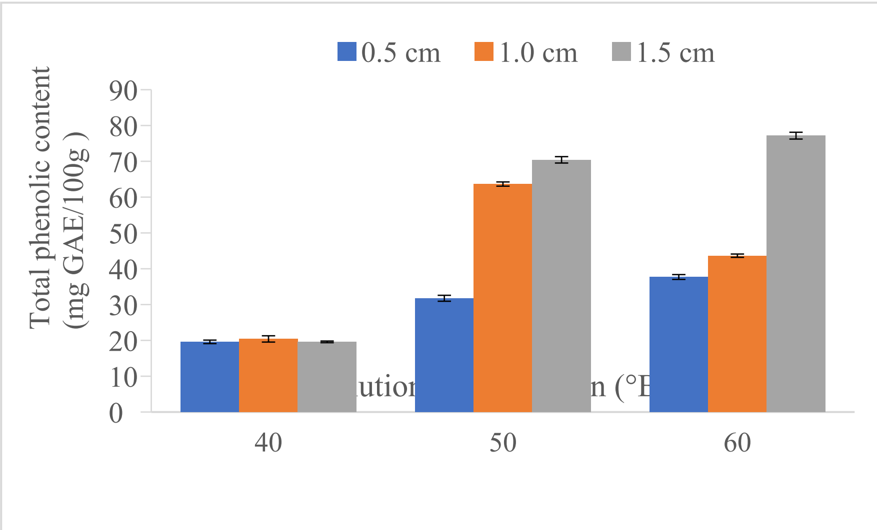

Figure 8. Total Phenolic Content of ODMWD pineapple slices

Conclusion

In the research study, microwave drying and rehydration were performed after OD of pineapple slices. Variation in slice thickness and the concentration of the solution was found to have an effect on the mass transfer kinetics and physiochemical properties and the phenolic content of both OD and ODMWD pineapple samples. Osmosis, used as a pre-treatment before microwave drying, successfully reduced drying time. Therefore, it can be concluded that the proposed research not only facilities faster moisture removal from pineapple fruits but also yields quality dehydrated slices. The outcomes of this study indicated that osmotic dehydration followed by microwave drying of pineapple fruit could be used for value-added processing products.

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