



Assessing the Physicochemical Characteristics: A Comparative Analysis of Various Drying Methods in Osmotic Treated Fruit Slices

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ABSTRACT

Background: Due to their high perishability, we cannot store fruits in their fresh form for long. The different drying techniques have affected the physical and nutritional qualities of the dried fruit pieces. Adoption of osmotic dehydration will help to protect and improve the quality characteristics of the final products.

Methods: Selected fruit slices, viz., apple, pineapple, guava, mango and banana, were subjected to sugar osmosis (60°Bx for up to 48 hours), followed by drying in different drying methods, viz., open sun (ODT), solar tunnel (SDT) and hot air drying (CDT) and the physical and chemical characteristics of the end products were analysed.

Result: The osmosis process improved the total soluble solids content, while CDT and SDT improved both the rehydration of the dried fruit slices and the percentage of weight loss. The desirable physical attributes of the dried products significantly varied among the different drying methods and within the fruit slices. The CDT-dried samples had better nutritional properties in terms of total phenol content and antioxidant activity than did the other drying methods and fresh samples, except for vitamin C content, which was greater in fresh fruit slices. The results recommended using CDT techniques in osmosis-treated fruit slices, which could improve fruit's physical and nutritional properties and be useful as good functional foods for a long time.

Key words: Fruit, Hot air drying, Osmosis, Physicochemical, Traditional drying, Vitamin C.

INTRODUCTION

Fruit and vegetable production has steadily increased due to rising global demand for fresh and healthy foods. The production of fruits and vegetables plays a crucial role in global food security by providing essential nutrients and vitamins to the diet. These components include antioxidants, natural colourants, vitamins and minerals and have added advantages in promoting various health benefits to humans (Lutz *et al.*, 2015). Fruits and vegetables are grown world wide, ranging from staples such as tomatoes, potatoes and onions to tropical fruits such as bananas, mangoes and pineapples. In 2021, the total fresh fruits and vegetables were 909.6 million metric tons and 1154.6 million metric tons, respectively (Statista, 2023a, 2023b). China and India are among the world's largest producers of fruits and vegetables. In 2021-22, India produced 107.24 million metric tons of fruits and 204.84 million metric tons of vegetables (NHB, 2023).

Due to improper postharvest handling, approximately 30-40% of the total production losses occurred. Additionally, in developing countries such as India, these losses constitute approximately 50% of the total production of fruits and vegetables (Ramya and Jain, 2017). Fruit and vegetable production during peak seasons is stopped before fruits reach consumers due to the need for additional preservation and storage facilities in the market. Many processing techniques are employed to preserve fruits and vegetables, which leads to enhanced shelf life while ensuring the safety and quality of the end products (Chavan and Amarowicz, 2012; Mehta *et al.*, 2017).

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Drying and/or dehydration are among the most essential and ancient techniques for preserving fruits and vegetables, focusing on considerable savings in packaging, storing, reducing shipping weight, etc. (Suresh Kumar and Sagar, 2016). In traditional drying methods, hot air is applied or circulated in food media, which causes the exchange of heat and mass in the media. Moreover, newer methods, such as microwave-assisted drying, freezing, spraying and vacuum drying, have been developed; additionally, these methods involve highly sophisticated methods and do not require hot air. Moreover, these novel techniques have enhanced product quality through high energy use and high cost (Calín-Sánchez *et al.*, 2010; Adeyeye *et al.*, 2022). Curing or osmosis is a technique for preserving foods by the addition of salt, sugar and spices and dehydration is the earliest form of curing (Nummer and Brian, 2002). Osmotic dehydration is the preferred preservation technology for most fruits and vegetables. This drying process is widely applied in the

preservation of food materials since it lowers the water activity of fruits and vegetables by removing water from a lower concentration of solute to a higher concentration through a semipermeable membrane and subsequent dehydration (moisture reduction process) (Tiwari, 2005). However, osmotically dehydrated end product qualities are affected by various factors such as preliminary treatments, the concentration of the osmotic solution, the quality of the raw material and its maturity, the shape and size of the slices, the duration of the osmosis process, agitation, temperature, additives, drying technique types and dehydration parameters (temperature, relative humidity, heat sources and duration of drying). Several studies have reported the effect of osmosis on specific dehydration reactions in selected fruits and vegetables (Defraeye, 2017; Lutz *et al.*, 2015; Mohammed and Siraj, 2020; Suresh Kumar and Sagar, 2016). However, no studies have reported the combined effect of osmotically treated fruits and various traditional drying techniques.

In this context, the present study aimed to assess the impact of various traditional drying techniques, including open sun drying, solar tunnel drying and hot air drying methods on the physicochemical characteristics of the selected osmotically treated fruit slices.

MATERIALS AND METHODS

Materials

Fully ripened fresh fruits, namely, apple, pineapple, mango, guava and banana fruits and food-grade sucrose were purchased from M/s. Kumaran Stores, Kinathukadavu, Coimbatore, Tamil Nadu. All the fruits were washed thoroughly in running drinkable water for 5 min. The pineapple and banana fruits were peeled with a peeler. The peeled fruits and other fruits, viz., apple, mango (seed removed) and guava, were sliced into uniform cube-shaped

pieces. All the chemicals (analytical grade) used in this study were procured from HiMedia Laboratory, Mumbai.

Osmotic dehydration treatments

A 60°Bx osmotic solution was prepared by mixing sucrose and distilled water. The individual fruit and liquid media were set to 1:1 for 48 hours. The concentration of the osmotic solution was measured at 6 hours intervals. After 48 hours of osmosis treatment, the fruit slices were dried separately in the open sun, solar, or hot air. In the ODT, the osmosis-treated fruit slices were individually arranged into stainless steel trays and kept in open sunlight from 8.00 AM to 5.00 PM every day. The temperature and relative humidity ranged from $22\pm 2^\circ\text{C}$ to $35\pm 2^\circ\text{C}$ and $45\pm 5\%$ to $55\pm 5\%$, respectively and high temperature and low relative humidity were observed mostly at 2.00 to 2.30 PM. Digital thermometers (M/s. Thermco) and digital humidity probes (M/s. ThermoPro) frequently measure temperature and relative humidity, respectively. At the end of every day, the dried fruit slices were kept in a closed container containing silica granules. In the SDT, osmosis-treated fruit slices were arranged in stainless steel trays and kept in a greenhouse-type solar dryer. The temperature ranged from $30\pm 2^\circ\text{C}$ to $55\pm 2^\circ\text{C}$ and the relative humidity ranged from $23\pm 2\%$ to $35\pm 2\%$. The CDT experiments were performed with a stainless steel tray dryer model (M/s. Zigma Machinery, India) set at 60°C with an air velocity of 1.5 m/s. The pictures of the dried fruit slices obtained using different drying techniques are presented in Fig 1. All the drying processes were continuously carried out to reach a moisture content of less than $20\pm 2\%$ of the end product.

Method of analysis

Thickness, length and breadth

A digital Vernier caliper (M/s. 2 for the road, Punjab) was used to measure the thickness, length and breadth of the

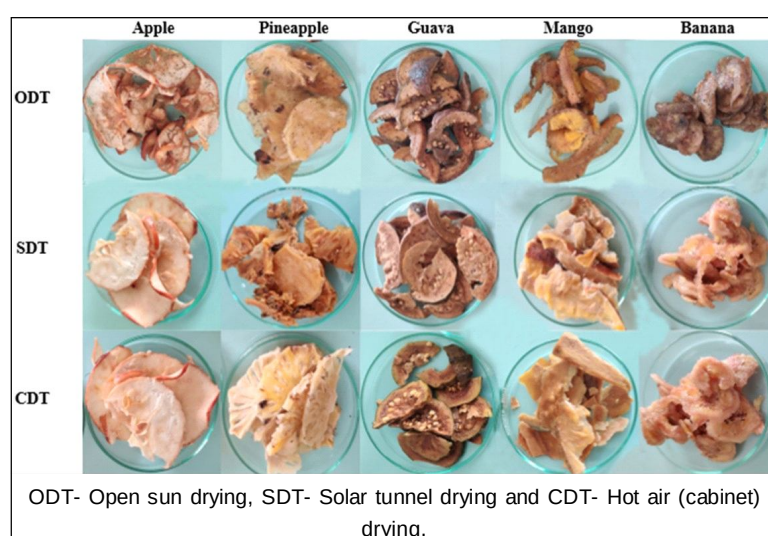


Fig 1: Appearance of the different dehydrated osmosis-treated fruit slices.

fresh and different dried fruit slices. The value was calculated from the mean value of ten sample measurements.

Rehydration ratio

The rehydration capacity of the dried samples was measured by adding 2 g of dry sample to 50°C water in a beaker and incubating for 50 min in a water bath. The samples were removed from the water bath and filtered through filter paper. The rehydration ratio of the sample was calculated from equation (1), as (Salehi, 2023) suggested.

$$\text{Rehydration ratio} = \frac{\text{Rehydrated sample (g)}}{\text{Dried sample (g)}} \times 100 \quad \dots(1)$$

Weight reduction

The percentage weight reduction of the samples was calculated from Equation 2, as suggested by (Eren and Kaymak-Ertekin, 2007).

$$\text{Weight reduction} = \frac{F_0 - F_t}{F_0} \times 100 \quad \dots(2)$$

Where:

F_0 and F_t are the weight of an osmosis-treated fruit slice (g) and the weight of a dried fruit slice (g), respectively.

Chemical characteristics

The moisture content of the samples was estimated by the dry basis method as per the protocol of AOAC, (2012). The total soluble solids (Dryzga *et al.*, 2007) concentration was measured by a portable digital refractometer (M/s. Hanna Instruments, India). The vitamin C content was estimated by the 2,6-dichlorophenol-indophenol titration method (Ranganna, 2005). The total phenolic content (TPC) and antioxidant activity (AOAC, 2012) were estimated by the Folin-Ciocalteu reagent and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay methods and these values are expressed as gallic acid equivalent (GAE) mg/100 g (Singleton *et al.*, 1999) and percentage of % of radical scavenging activity (% RSA) (Lim *et al.*, 2007), respectively, from the methanolic extracts of the fresh and dried samples.

Statistical analysis

All measurements were taken in triplicate and the results are presented as the mean values $\pm$ standard deviations (SD) of triplicate samples. Statistical analysis was performed using one-way analysis of variance (ANOVA) and the means

of the results for each experiment were compared using the Duncan multiple comparison test ($p < 0.05$). SPSS 21.0 (IBM SPSS, Inc., Chicago, IL) statistical software was used for the statistical analyses.

RESULTS AND DISCUSSION

Physicochemical characteristics of fresh fruit slices

The physicochemical characteristics of the selected fresh fruit slices are presented in Table 1 (on a dry weight basis). The physical characteristics, namely, length, width and thickness, ranged from 23.2 to 62.1 mm, 19.9 to 43.4 mm and 1.4 to 4.9 mm, respectively, in the selected fruit slices. The thickness ranged from 3 to 10 mm in rectangular, ring, or cube-shaped slices suitable for osmotic dehydration (Chavan and Amarowicz, 2012). The moisture content of the fruit slices ranged between 68.4 and 85.4% and the moisture content significantly differed among the fruit slices. The composition of the dry material in the fruit slices is the reason for the variation in moisture content. The total soluble solids of the fresh slices from apple, pineapple, guava, mango and banana were contained 10.8, 17.6, 11.4, 21.2 and 24.2°Bx, respectively. The total phenolic content significantly differed among the selected fruit slices and the phenolic content ranged between 32.07 mg GAE/100 g in banana and 135.68 mg GAE/100 g in guava. The antioxidant activity and vitamin C content significantly differed among the fruit slices studied. Compared with all the other fruit slices analyzed, the fresh guava slices exhibited the highest TPC, antioxidant activity and vitamin C content at 135.68 mg GAE/100 g, 48.25% RSA and 114.33 mg/100 g, respectively. The chemical composition of the fruit slices may be attributed to various factors, including agroclimatic factors, maturity, variety, storage and postharvest practices (Rajapaksha *et al.*, 2021). Additionally, the percentage of RSA in terms of antioxidant content was significantly correlated with the TPC and vitamin C content. Similar results were reported for various fruits cultivated in India (Singh *et al.*, 2016).

Changes in total soluble solids during the osmosis process

The changes in the total soluble solids concentration in the osmosis solution and in the selected fruit slices are presented in Fig 2 and Fig 3, respectively. The initial solution

Table 1: Physicochemical characteristics of fresh fruit slices.

Fruit slices	Length (mm)	Breadth (mm)	Thickness (mm)	Moisture content(%)	Total phenol (mg GAE/100g sample)	Anti-oxidant activity (% of RSA)	Vitamin C (mg/100g)
Apple	62.1 $\pm$ 1.54 ^a	43.4 $\pm$ 0.74 ^a	2.5 $\pm$ 0.06 ^c	85.4 $\pm$ 1.11 ^a	109.52 $\pm$ 0.75 ^b	41.25 $\pm$ 1.58 ^b	63.33 $\pm$ 0.71 ^b
Pineapple	58.9 $\pm$ 0.44 ^b	19.9 $\pm$ 0.45 ^e	1.9 $\pm$ 0.05 ^d	80.3 $\pm$ 0.60 ^b	53.57 $\pm$ 1.62 ^d	39.84 $\pm$ 0.11 ^b	38.65 $\pm$ 0.39 ^d
Guava	56.9 $\pm$ 0.54 ^c	29.9 $\pm$ 0.33 ^c	4.9 $\pm$ 0.12 ^a	82.6 $\pm$ 2.36 ^b	135.68 $\pm$ 0.25 ^a	48.25 $\pm$ 2.22 ^a	114.33 $\pm$ 3.03 ^a
Mango	47.9 $\pm$ 1.50 ^d	35.3 $\pm$ 1.15 ^b	1.4 $\pm$ 0.03 ^e	75.2 $\pm$ 2.20 ^c	104.21 $\pm$ 4.41 ^c	28.03 $\pm$ 0.42 ^c	46.30 $\pm$ 0.47 ^c
Banana	23.2 $\pm$ 0.63 ^e	22.6 $\pm$ 0.23 ^d	2.8 $\pm$ 0.07 ^b	68.4 $\pm$ 0.47 ^d	32.07 $\pm$ 1.01 ^e	30.62 $\pm$ 2.16 ^d	16.60 $\pm$ 0.34 ^e

Each value is the Mean $\pm$ SD of three replicate analysis (n=3); GAE - Gallic acid equivalent; RSA- Radical scavenging activity; The values mentioned in superscripts are significantly different at $p < 0.05$ in the same column.

concentration of 60°Bx immediately decreased after 6 hours in the range from 46.2 to 38.1°Bx, after which the concentration gradually decreased in all the samples except for the apple slices. The TSS values ranged from 42.0 to 36.4°Bx, 39.9 to 32.8°Bx, 42.3 to 32.7°Bx, 42.3 to 32.2°Bx, 42.3 to 31.8°Bx, 40.6 to 31°Bx and 29.8 to 39°Bx in the osmosis solution after 12, 18, 24, 30, 36, 42 and 48 hours, respectively. A high decrease in the TSS concentration was observed in the mango slices dipped in osmosis solution, in which the TSS concentration ranged from 60 to 29.8°Bx. In contrast, the lowest decrease in TSS concentration was observed in an osmotic solution containing banana slices at 39°Bx. The banana sample obtained the same results (Fernandes and Rodrigues, 2007). The TSS values of the apple slices containing osmotic solution at 6 hours significantly differed at 12 and 18 hours but were not significantly different at 24, 30, 36, 42, or 38 hours. After the completion of the osmosis treatment, the fruit slices took up soluble solids from the osmosis solution and the soluble solids increased in concentrations ranging from 38.3±0.99 to 51.00±1.18°Bx. The fruit slices were dipped in the solution for a longer time and more soluble solids were transferred

to the product from the solution through the osmosis process (Fernandes and Rodrigues, 2007). Different parameters, such as treatment temperature and duration, the ratio of the solution to sample, microbial contamination and sanitation of the solution, maturity of the fruit, solid gain, the chemical composition of the solution and immersed products and the size and shape of the sample, influence the reduction in TSS in the osmotic solution (Campos *et al.*, 2012; Yadav and Singh, 2014).

Effect of dehydration on physical characteristics

The physical characteristics of the fresh and dried fruit slices were analyzed based on the attributes, namely, the length, breadth and thickness of the fruit slices (Table 2). The desirable physical characteristics of the dried products significantly varied among the different drying methods. The physical changes were significantly different among the slices and dehydration techniques. The results showed that the physical characteristics of the raw fruit slices were significantly highest in the CBT group, followed by the SDT and ODT groups. High decreases in physical characteristics were noted in the CDT-dried guava slices, with 42.53%,

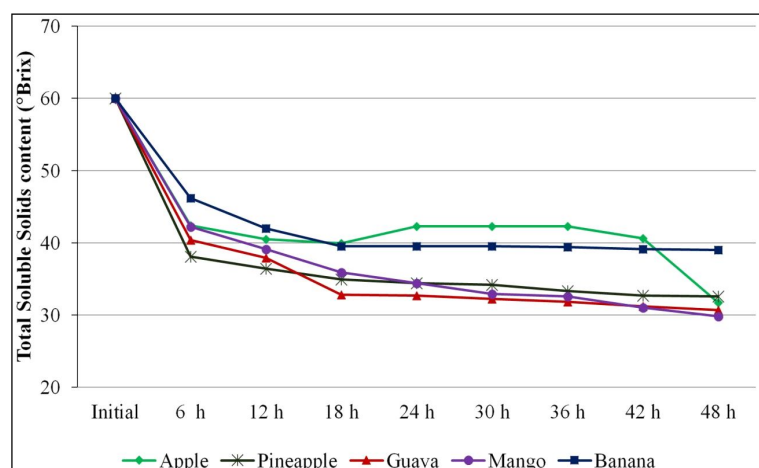


Fig 2: Changes in total soluble solids content during the osmotic process in the osmosis solution.

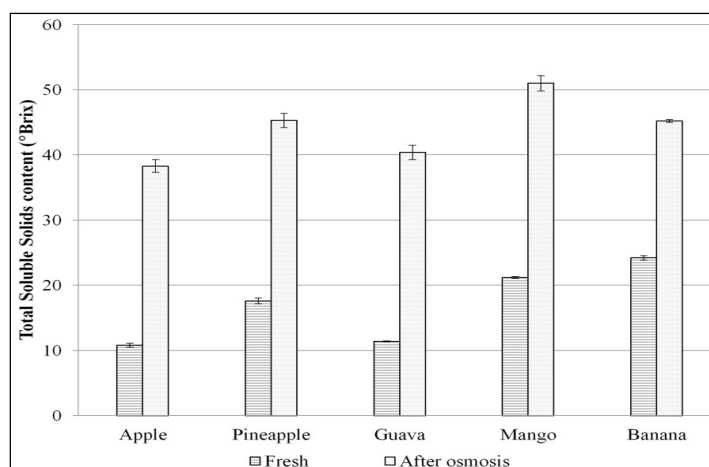


Fig 3: Total soluble solids (°Bx) content of the fresh and osmosis-treated fruit slices.

49.16% and 67.35% decreases in length, breadth and thickness, respectively. The physical characteristics of the osmotic-treated guava slices kept under CDT were greater than those of the other fruit slices dried under the SDT and ODT methods. Mohammed *et al.*, 2020 reported that the physical changes in mango and pineapple fruit slices improved under the drying conditions of conventional solar drying and improved solar drying techniques. The same result was observed for the selected fruit slices in this study, which were dried under solar tunnel drying. However, the physical quality of the selected fruit slices was much improved in the cabinet dryer. The size and shape of the

fruit slices strongly influence the quality of the dried product (Defraeye, 2017). According to glass transition theory, applying the above glass transition temperature to a material leads to the collapse of the pore structure (Caballero *et al.*, 2018).

Effect of dehydration on rehydration (%) and weight loss

Recovering water from dehydrated products is known as rehydration (Tepe and Tepe, 2020). The effects of different dehydration treatments and selected osmotic treatment fruit slices on the rehydration percentage are shown in Fig 4. Among the selected fruit slices, the rehydration percentage was the highest in the CDT treatment, followed by the SDT

Table 2: Physical characteristics of fresh and different dried osmotic fruit slices.

Fruit slices	Particulars	Length (mm)	Breadth (mm)	Thickness (mm)
Apple	Fresh	62.1±1.17 ^a	43.4±0.33 ^a	2.5±0.02 ^a
	ODT	52.4±1.46 ^b	37.2±0.35 ^b	1.7±0.01 ^b
	SDT	48.0±0.16 ^c	35.0±0.90 ^c	1.7±0.01 ^b
	CDT	40.1±0.79 ^d	32.3±0.35 ^d	1.2±0.05 ^c
Pineapple	Fresh	58.9±1.46 ^a	19.9±0.20 ^a	1.9±0.02 ^a
	ODT	54.1±0.59 ^b	16.0±0.39 ^b	1.5±0.01 ^b
	SDT	47.4±0.26 ^c	13.4±0.34 ^c	1.5±0.04 ^b
	CDT	37.6±0.56 ^d	11.5±0.05 ^d	1.3±0.01 ^c
Guava	Fresh	56.91.24 ^a	29.9±0.09 ^a	4.9±0.15 ^a
	ODT	42.2±0.40 ^b	26.5±0.11 ^b	3.6±0.03 ^b
	SDT	34.9±0.78 ^c	20.4±0.22 ^c	3.4±0.05 ^c
	CDT	32.7±0.38 ^d	15.2±0.24 ^d	1.6±0.00 ^d
Mango	Fresh	47.90.96 ^a	35.3±0.55 ^a	1.4±0.04 ^a
	ODT	45.3±0.40 ^b	23.6±0.79 ^b	1.2±0.01 ^b
	SDT	44.5±0.36 ^c	21.3±0.17 ^c	1.1±0.02 ^c
	CDT	43.4±0.09 ^d	17.7±0.31 ^d	0.9±0.02 ^d
Banana	Fresh	23.2±0.11 ^a	22.6±0.07 ^a	2.8±0.08 ^a
	ODT	21.3±0.32 ^b	19.4±0.65 ^b	2.3±0.02 ^b
	SDT	21.2±0.42 ^b	19.6±0.53 ^b	1.6±0.05 ^c
	CDT	20.1±0.37 ^c	17.8±0.47 ^c	1.2±0.04 ^d

Each value is the Mean±SD of three replicate analysis (n=3); The values mentioned in superscripts are significantly different at $p < 0.05$ in the same column within the fruit slices; ODT- Open sun drying, SDT- Solar tunnel drying and CDT- Hot air (cabinet) drying.

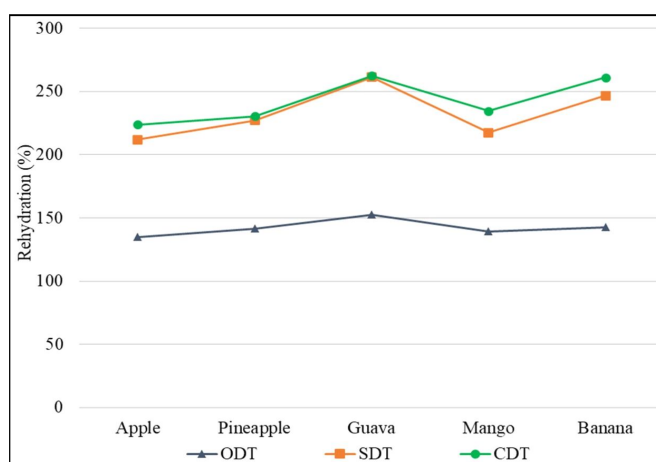


Fig 4: Impacts of dehydration techniques on the rehydration (%) of different osmosis-treated fruit slices.

and ODT treatments. Compared with those of other fruit slices, the guava slices were highly rehydrated by all the dehydration techniques (153% in ODT, 261% in SDT and 262% in CDT), while the lowest rehydration was found in the mango slices, which were dried in the ODT. The solid content of the osmosis-treated mango slices was greater than that of the other fruit slices, resulting in a lower rehydration rate. This can be explained by the contraction of the samples produced by temperature in the fruit slices by various drying times and soluble solids. According to subsequent studies, rehydration characteristics are affected by the physical properties of the dried product, drying conditions and soluble solids (Ramallo and Mascheroni, 2012; Tepe and Tepe, 2020).

The weight reduction of the samples is presented in Fig 5. For the ODT, SDT and CDT groups, the weight loss ranged from 1.4 ± 0.53 to 26.5 ± 1.41 , 15.4 ± 0.83 to 40.5 ± 0.98 and 17.4 ± 1.12 to 41.5 ± 1.56 , respectively. The most significant decrease in weight reduction occurs in the samples subjected to CDT due to the constant temperature application, leading to a higher evaporation rate in the food material (Beigi, 2016). Similarly, the CDT-dried apple slices lost 41.5% of their weight. Similar results were observed from the studies of Hosseini *et al.* (2019); Russo *et al.* (2019); Suresh *et al.* (2016).

Effect of dehydration on chemical characteristics

The moisture content, TPC, AOA and vitamin C content of fresh and different dehydrated fruit slices are shown in Table 3

(on a dry weight basis). The moisture content and vitamin C content were significantly reduced. Moreover, the TPC and AOA improved in the fresh and dehydrated samples depending on the type of fruit slices and dehydration technique. Compared to those of the selected dehydration techniques, CDT (5.2 ± 0.03 to 5.8 ± 0.07) and SDT (6.2 ± 0.11 to 8.2 ± 0.07) had the lowest moisture content with ODT (15.8 ± 0.24 to 24.4 ± 0.30) in the samples. Air temperature had a significant influence on moisture content during dehydration. Due to the shorter drying time, the CDT samples had superior quality to the other dehydration and fresh slice samples in terms of the TPC and AOA content. The temperature during the drying process causes changes in the physical, chemical and biological composition of fresh and dehydrated fruit slices (Mohammed *et al.*, 2020). A large improvement in TPC and AOA was noted in the pineapple (53.57 ± 1.34 to 215.61 ± 1.17 mg GAE/100 g in TPC and 39.84 ± 2.12 to 81.64 ± 2.28 % RSA in AOA) and banana slices (32.07 ± 0.22 to 188.87 ± 0.12 mg GAE/100 g in TPC and 30.62 ± 0.62 to 59.45 ± 1.33 % RSA in AOA) compared with other fruit slices, which were dehydrated in the CDT. These changes could be related to the release of bound phenolics and the hydrolysis of complex phenolics, which result in the production of low-molecular-weight molecules (Raja *et al.*, 2019). Similar results were reported by Lutz *et al.*, 2015; Chaudhary *et al.* (2019); Mohammed *et al.* (2020).

According to the DPPH analysis for AOA, all the dehydrated samples had greater AOAs than did the fresh

Table 3: Chemical characteristics of fresh and different dried osmotic fruit slices.

Fruit slices	Particulars	Moisture content (%)	Total phenol (mg GAE/100 g)	Antioxidant activity (% of RSA)	Vitamin C (mg/100 g)
Apple	Fresh	85.4 ± 2.42^a	109.52 ± 0.56^d	41.25 ± 0.72^d	63.33 ± 1.08^a
	ODT	20.6 ± 0.39^b	131.52 ± 0.62^c	55.23 ± 0.15^c	32.38 ± 0.55^b
	SDT	6.6 ± 0.17^c	169.87 ± 1.94^b	65.58 ± 0.82^b	32.00 ± 0.78^b
	CDT	5.6 ± 0.05^c	253.53 ± 0.17^a	77.56 ± 1.27^a	20.67 ± 0.38^c
Pineapple	Fresh	80.3 ± 0.93^a	53.57 ± 1.34^d	39.84 ± 2.12^d	38.65 ± 0.55^a
	ODT	24.4 ± 0.30^b	96.96 ± 0.91^c	57.65 ± 0.69^c	21.45 ± 0.60^b
	SDT	8.2 ± 0.07^c	128.63 ± 0.56^b	69.92 ± 0.92^b	18.32 ± 0.07^c
	CDT	5.2 ± 0.03^d	215.61 ± 1.17^a	81.64 ± 2.28^a	16.67 ± 0.08^d
Guava	Fresh	82.6 ± 1.52^a	135.68 ± 5.18^c	48.25 ± 1.86^d	114.33 ± 2.02^a
	ODT	15.8 ± 0.24^b	133.32 ± 0.70^c	56.60 ± 0.73^c	88.62 ± 0.90^b
	SDT	6.2 ± 0.11^c	166.77 ± 2.96^b	65.78 ± 1.25^b	86.32 ± 0.76^c
	CDT	5.8 ± 0.07^c	264.59 ± 1.28^a	80.46 ± 2.63^a	61.32 ± 0.08^d
Mango	Fresh	75.2 ± 1.74^a	104.21 ± 4.72^d	28.03 ± 1.16^d	56.30 ± 0.19^a
	ODT	17.2 ± 0.46^b	134.42 ± 3.34^c	37.96 ± 0.32^c	53.60 ± 1.50^b
	SDT	6.9 ± 0.10^c	179.72 ± 2.53^b	49.21 ± 0.48^b	48.32 ± 0.39^c
	CDT	5.7 ± 0.07^d	262.04 ± 1.53^a	59.92 ± 1.55^a	26.67 ± 0.42^d
Banana	Fresh	68.4 ± 0.51^a	32.07 ± 0.22^d	30.62 ± 0.62^d	16.60 ± 0.05^a
	ODT	21.8 ± 0.18^b	66.52 ± 0.70^c	33.14 ± 0.77^c	10.33 ± 0.27^b
	SDT	7.8 ± 0.21^c	104.02 ± 1.44^b	42.57 ± 1.07^b	8.00 ± 0.10^c
	CDT	5.8 ± 0.04^d	188.87 ± 0.12^a	59.45 ± 1.33^a	5.12 ± 0.15^d

Each value is the Mean $\pm$ SD of three replicate analysis (n=3); The values mentioned in superscripts are significantly different at $p < 0.05$ in the same column within the fruit slices; GAE- Gallic acid equivalent; RSA- Radical Scavenging Activity; ODT- Open sun drying, SDT - Solar tunnel drying and CDT- Hot air (cabinet) drying.

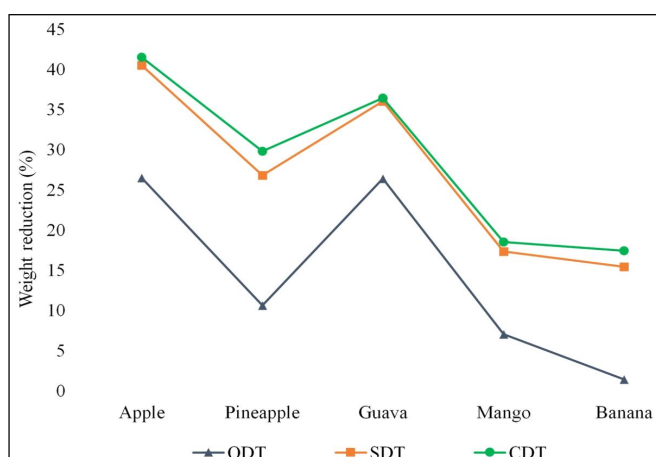


Fig 5: Impacts of dehydration techniques on the weight reduction (%) of different osmosis-treated fruit slices.

samples. The dry fruit slices exhibited greater AOAs in CDT, followed by those in SDT, ODT and fresh fruit slices. This could be due to various factors, such as changes in antioxidant components, the formation of new substances from the Maillard reaction and the inactivation of oxidative and hydrolytic enzymes (Lutz *et al.*, 2015).

Higher ascorbic acid concentrations were obtained in the fresh fruit slices and decreased during the drying process in the order CDT<SDT<ODT. This is because the loss of vitamin C is accelerated by air and heat. Vitamin C degradation depends on the temperature and duration of exposure to drying (Rokib *et al.*, 2021). Vitamin C is heat sensitive and loss of vitamin C occurs during prolonged exposure to temperatures greater than 55°C (Raja *et al.*, 2019).

CONCLUSION

This study investigated how different traditional drying processes affect the physicochemical properties of sugar osmosis-treated fruit slices. Drying techniques, *viz.*, ODT, SDT and CDT, were studied. During the osmosis treatment, the fruit slices take soluble solids from the osmosis solution and increase the TSS concentration. The physical characteristics such as length, breadth and thickness, significantly differed within the selected osmosis-treated fruit slices and drying techniques compared with those of the fresh samples. The results also indicated that drying in a CDT could improve the rehydration and weight reduction percentage of the dried fruit slices. The results showed that the moisture content was strongly reduced in the CDT and SDT groups, which was reflected in the physical characteristics of the dried fruit slices. However, compared with those in other drying and raw fruit slices, the vitamin C content was strongly reduced in CDT and SDT, while the TPC and AOA were increased in CDT. The hot air traditional drying process is a simple technique for obtaining better sources of natural antioxidants and phenolic compounds from osmosis-treated dehydrated products. Hence, among the traditional drying methods, hot air drying techniques are suitable for producing osmosis-treated fruit slices with

improved physical and nutritional properties and are free from any environmental contamination.

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Conflict of interest

The authors declare that they have no conflict of interest.

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