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Evaluate The Effect of Pretreatments and Drying Techniques on the Sweet Potato Slices

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ABSTRACT

As the quality of dried products may vary greatly with different production procedures, the optimal procedures must be applied to produce dried products that meet consumer desires. Thus, the purpose of this study was to evaluate how different drying methods (ventilation oven, microwave, and combined microwave + ventilation oven) and pretreatments (blanching and 1% citric acid) affected the proximate composition, color, and sensory properties of sweet potato slices. Non-treated samples were used as control samples. The treatment contents of moisture, ash, total sugars, and ascorbic acid were measured both before and after drying. In comparison to blanched and control samples, sweet potato samples treated with a citric acid solution and microwave dried have the lowest decrease value across all drying methods. The obtained results suggested that ventilation oven adversely influenced the phenolic and flavonoid compounds of dried sweet potatoes. Among the methods used, the combined method and microwave had the greatest effect on phenolic compounds. The carotenoids and *Β*-carotene values in dried treatments by the microwave drying method were higher than combined and ventilation oven methods, respectively. The data indicated that all treatments dried by the microwave method recorded a low change in the color change index (ΔE) value, particularly all samples treated with citric acid 1%. In fact, all of the samples treated with 1% citric acid demonstrated an acceptance index of up to 77.92%. Therefore, it was confirmed that the treatments using citric acid 1% and microwave drying were most suitable for sweet potato slices.

1.Introduction

Sweet potatoes (*Ipomoea batatas* L.), from the *Convolvulaceae* family, have a wide range of genetic variety and offer many different sensory aspects, including a broad range of colors , taste, and texture to meet consumers demands. Root vegetables are significant nutritional and energy sources. The fibre, vitamins, and minerals included in them are also good sources. Modern techniques for food preservation are provided by food advances. Food processing is a viable option for ensuring a more consistent supply (Bach, et al., 2021). Sweet potatoes are frequently ranked as the second most significant crop for staple foods in both developed and developing countries due to their significant contribution to the human diet. A variety of nutrients are present in the naturally occurring white, yellow, purple, and orange flesh colors of sweet potatoes. The orange-fleshed sweet potato has gained popularity among many food technologists and nutritionists due to its high level of carotenoids and pleasing sensory qualities with color (Bhuyan et al., 2022). Plantations of sweet potato tubers are expanding all over the world as a result of increased economic production. It is the world's most important root tuber crop after wheat, rice, maize, potato, barley, and cassava in temperate, subtropical, and tropical regions of the world.

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Egypt cultivates about 30.351 feddans annually of sweet potatoes, and produces about 467.537 tons annually, according to the department of agricultural Economic Ministry of Agriculture and Land Reclamation (2021). The biofortification of an important food crop is thought to have been most successful with orange-fleshed sweet potatoes (OFSP). In Africa vitamin A deficiency remains a serious nutritional concern, and OFSP consumption provides beta-carotene to the population, thereby alleviating this problem (Laurie et al., 2017). South African consumers favor sweet potatoes that are starchy or floury because they have higher dry matter content. Maltose content and sweetness both seem desirable to South African consumers. It has a high nutritional value, especially vitamin A, carotenoids, bioactive B-carotene and phenolic compounds (Lee and Lee, 2017). Sweet potato is seen as an important functional and staple food for human consumption due to its high antioxidant, phytochemical, immunomodulatory, and anticancer properties, which are beneficial to human health (Ayeleso et al., 2017). Prior to drying, pretreatments could significantly boost water diffusion and speed up drying. Additionally, it has been said that they can help lessen some undesirable alterations. The main purpose of pretreatments often includes deactivating enzymes like polyphenoloxidase, peroxidase, and phenolase and inhibiting certain unfavorable chemical reactions that result in a variety of detrimental alterations to a product citric and ascorbic acids are some of the most common and commercially used pretreatments (Ozdemir et al., 2016). Drying by convection has been used for a very long time because it is simple and affordable, but because the process is delayed and the temperature is high, there is a large energy usage. Due to its rapid drying rate and superior food quality, the microwave-drying method is currently being researched as a convective drying alternative. Electromagnetic waves are used in microwave drying to heat materials voluminously, which removes moisture from food by raising the temperature during microwave drying by applying an electromagnetic field. Due to the homogenous energy distribution, low energy consumption, produce good quality products and development of acceptable dry product qualities that are supplied by microwave radiation application during drying (Huang et al., 2021 and İlter et al., 2018). Therefore, the objective of the present study was to evaluate the effects of different drying techniques, including hot air drying, microwave drying, and combined drying (microwave and hot air drying), and the influence of prior drying pretreatments (bleaching and 1% citric acid) on the quality attributes of the sweet potato slices product.

2. Materials and Methods

The experimental works of this study were carried out in Food Technology Research Institute (FTRI), Agriculture Research Center (ARC), Giza, Egypt laboratories.

Materials

Orange flesh sweet potato tubers were obtained from Horticulture Research Institute, Agriculture Research Center, Al-Giza, Egypt. All chemical reagents were purchased from El-Gomhoria co., Cairo. Egypt. All the solvents were obtained from commercial sources (Sigma and Merck). The carotenoid and phenolic standards were obtained from Sigma-Aldrich (St Louis, MO, USA).

Technological Methods

Sample preparation

The sweet potato tubers were washed in running water, drained, and peeled; the flesh was cut into slices (3-mm thickness), and the slices were divided into three portions control, immersion in boiling water, and Immersion in citric acid.

Drying methods

Oven drying

One hundred grams of orange-fleshed sweet potato slices were prepared and dried in a ventilation oven (Fisher Scientific model 230, U.S.A.) at 60ºC. The mass was measured until it reached weight stability. Each experiment was replicated three times.

Microwave drying

One hundred grams of orange-fleshed sweet potato slices were dried using a digital microwave oven

(400 watts, NGM-25D2, JAC, Egypt). The mass was measured until it reached weight stability. Each run was replicated three times.

Combined drying (Microwave and ventilation oven):

One hundred grams of orange-fleshed sweet potato slices were dried using a digital microwave oven (NGM-25D2, JAC, Egypt). Microwave power (400 watts) was used for 7 minutes of partial drying, followed by continuous drying in a ventilation oven (Fisher Scientific model 230, USA) at 60 ºC. The mass was measured until it reached weight stability. Each run was replicated three times.

The pretreatments and above mentioned drying techniques re illustrated in Table (1).

Table 1. Pretreatments and drying techniques

Drying techniques	Treatments		
	Control	**Boiling water w:v (1:5) (98ºC) for 5 min**	**Immersion in 1% citric acid w:v (1:5) for 5 min**
ventilation oven	60ºC/3.5 hrs. until weight stability (T1)	60ºC/2.5 hrs. until weight stability (T2)	60ºC/2.5 hrs. until weight stability (T3)
microwave oven	400watt/28 min. until weight stability (T4)	400 watt/22 min. until weight stability (T5)	400 watt/22 min. until weight stability (T6)
combined drying	400watt/7min + 60ºC/2.5 hrs. until weight stability (T7)	400watt/7min + 60ºC/1.5 hrs. until weight stability (T8)	400watt/7min + 60ºC/1.5 hrs. until weight stability (T9)

The dried sweet potato slices were cooled down to room temperature and packed into PET/Al/LDPE (polyester/aluminum foil/low density polyethylene).

Analytical Methods:

Proximate analysis:

The moisture, total solids, ash, total sugars, ascorbic acid and total carbohydrates were determined using standard methods of the Association of Official Analytical Chemists (AOAC, 2016). The Folin-Ciocalteu reagent, as described by Singleton and Rossi (1965), was used to determine the total phenolic content. $AlCl_3$ colorimetric assay was used to measure the total flavonoid content in accordance with the technique described by Tacouri et al. (2013).

Total Carotenoids, β- carotene contents determination:

To determine the total amount of carotenoids, β-carotene content, approximately 15 g of the samples, plus 3 g of celite 454 (Tedia, Ohio, USA) were weighed in a digital balance. For the carotenoid extraction, successive additions of 25 mL of acetone, which was transferred into a sintered funnel (5 μ_m) attached to a 250 mL Buchner flask and filtered under vacuum. The sample was subjected to this process several times until it lost its color. The obtained extract was then put into a separatory funnel with a capacity of 500 mL and 40 mL petroleum ether, and the acetone was drained out. The process was carried out four times until no more solvent was left behind. The extract was then poured into a 50 mL volumetric flask containing 15 g of anhydrous sodium sulphate through a funnel. According to Rodriguez and Kimura (2004), the volume was made up of petroleum ether, and the samples were read at 450 nm using a Jenway T^{M} 6705 Spectrophotometer.

Color profile measurements

Color of dried sweet potato slices was tested using Chroma meter (Minolta CR 400, Minolta Camera, Co., Osaka, Japan) equipped with an 8 mm measuring head and a D65 illuminant.

The CIE-Lab scale was used for evaluation of $L*$ for brightness, $a*$ for (+) redness - (-)greenness and $b*$ for (+) yellowness - (-) blueness, accordingly. The total color difference (ΔE), which was used to describe the change in the sample surface color, was calculated using the following equation (Carini et al., 2010).

$$\Delta \mathbf{E} = \sqrt{(\Delta \mathbf{L})^2 + (\Delta \mathbf{a})^2 + (\Delta \mathbf{b})^2}$$

Measurements were performed in 3 replications for each sample. Where $\Delta L^* = L^*$sample – L^*standard; $\Delta a^* = a^*$sample – a^*standard; $\Delta b^* = b^*$sample` - b*standard.

Sensory Evaluation

The dried sweet potato slices were evaluated organolopeticlly according to (Rosas-Nexticapa, et al., 2005). Ten panelists (staff members from Food Technology Research Institute, Agric. Res. Center, were evaluated, The panelists scored the dried sweet potato slices for color taste texture appearance, overall acceptability, and index of acceptance (I.A) using a 9-point Hedonic scale. The IA was calculated using the following equation. IA= (M/9) x100. Where: M: indicates the average of the evaluation carried out by sensory panel.

Statistical analysis

The statistical analysis was carried out using one -way ANOVA using SPSS, ver. 22 (IBM Corp. Released 2013). Data were treated as a complete randomization design according to (Steel et al., 1997). Multiple comparisons were carried out applying Duncun test the significance level was set at < 0.05

3. Results and Discussions

Chemical composition of sweet potatoes flesh

Data in Table (2) showed that, the sweet potato (*Impomea batata* L.) has a high nutritional value, mainly total carbohydrates, vitamin C, *B*-carotene, carotenoids, phenolic and flavonoid compounds, as well as antioxidant activity. The moisture content of fresh sweet potatoes was 71.52%, as shown in Table 2.

Meanwhile, total carbohydrates and total sugars represent the main components of fresh sweet potatoes, which were 64.37 and 23.14 % respectively. Data in the same table showed that the ash, ascorbic acid, total phenolic, total flavonoid, total carotenoids, β-carotene contents of fresh sweet potatoes were 2.97%, 70.06, 30.63, 15.73, 26.84 and 23.52 mg/100 g, respectively. This result was in agreement with (Feina et al., 2019) and Lee and Lee (2017) they mentioned that sweet potatoes are rich in nutritional contents such as vitamin C, phenolic compounds and high levels of B-carotene, carotenoids. Consequently, these orange-fleshed cultivars can be considered a valuable source of vitamin A. (Julieta et al., 2022).

Table 2. Proximate chemical composition (mean±SD) of sweet potato flesh (on dry weight basis*)

Parameter	Value
Moisture %	71.52+ 0.170
T.S %	28.48+0.170
*Total sugars %	23.14+0.482
*Total carbohydrates mg/100g	64.37+0.354
*Ash %	2.97+0.220
*Ascorbic acid mg/100g	70.06+0.496
*Total phenolic content mg/100g (as chlorogenic)	30.63+ 0.155
*Total flavonoid content mg/100g (as catechin)	23.73+0.250
*Total carotenoids (as B- carotene) mg/100g	32.84+0.178
*β carotene mg/100g	23.52+0.336

Effect of drying by different methods and pretreatments on the chemical composition of sweet potatoes

For moisture content, (Table 3) the slices of orange sweet potato that were dried by using microwaves (T4, T5, T6) recorded (7.09, 9.72and 8.31 %) respectively. The microwave heating effect causes the moisture to evaporate more rapidly. (Farris and Piergiovanni, 2009).

Due to volumetric heating, vapors are generated inside the slices of sweet potato and an internal pressure gradient is developed that forces the water outside of the sweet potato slices. This pressure gradient is the driving force to transporting moisture in vapor form to sweet potato surface. There are a few differences in the ash content of dried sweet potato slices between the treatments, except, T5 which recorded the very lowest decrease (0.35%) comparing with the other treatments. Furthermore, studies have shown that pretreatments such as soaking and blanching have an effect on the amount of ash in sweet potato products.

The differences in total sugars and ascorbic acid between fresh orange sweet potato slices and processed slices were recorded in Table 3. The results showed that the ventilated oven gave the highest decrease in both total sugars and ascorbic acid of the different treatments.

Table 3. Effect of pretreatments and drying methods on the chemical composition (mean ±SD) of sweet potatoes slices.

Treatment	Drying Methods								
	Ventilation oven			Microwave			Microwave + Oven		
	T1 control	T2 blanched	T3 1% citric acid	T4 control	T5 blanched	T6 1% citric acid	T7 control	T8 Blanched	T9 1% citric acid
Moisture (%)									
Before Drying	71.52 ±0.170	72.65 ±0.101	71.82 ±0.104	71.52 ±0.170	72.65 ±0.101	71.82 ±0.104	71.52 ±0.170	72.65 ±0.101	71.82 ±0.104
After Drying	5.77 ±0.350	8.43 ±0.180	6.37 ±0.150	7.09 ±0.230	9.72 ±0.300	8.31 ±0.330	5.42 ±0.180	7.36 ±0.160	6.43 ±0.310
%Variation	-91.93	88.40-	91.13-	-90.09	-86.62	-88.43	-92.42	-89.87	-91.05
Ash (%)									
Before Drying	2.97 ±0.220	2.89 ±0.236	2.92 ±0.353	2.97 ±0.220	2.89 ±0.236	2.92 ±0.353	2.97 ±0.220	2.89 ±0.236	2.92 ±0.353
After Drying	2.94 ±0.378	2.86 ±0.425	2.89 ±0.259	2.95 ±0.268	2.88 ±0.252	2.90 ±0.384	2.94 ±0.409	2.87 ±0.493	2.89 ±0.462
%Variation	-1.01	-1.04	-1.03	-0.67	-0.35	-0.68	-1.01	-0.69	-1.03
Total sugars (%)									
Before Drying	23.14 ±0.482	21.27 ±0.585	22.63 ±0.472	23.14 ±0.482	21.27 ±0.585	22.63 ±0.472	23.14 ±0.482	21.27 ±0.585	22.63 ±0.472
After Drying	22.70 ±0.582	20.91 ±0.373	22.31 ±0.485	22.92 ±0.266	21.08 ±0.365	22.48 ±0.442	22.74 ±0.538	20.98 ±0.363	22.39 ±0.238
%Variation	-1.89	-1.69	-1.40	-0.95	-0.89	-0.66	-1.74	-1.36	-1.08
Ascorbic acid (mg/100g)									
Before Drying	70.06 ±0.496	42.63 ±0.504	62.96 ±0.432	70.06 ±0.496	42.63 ±0.504	62.96 ±0.432	70.06 ±0.496	42.63 ±0.504	62.96 ±0.432
After Drying	15.09 ±0.564	14.41 ±0.425	25.74 ±0.577	35.13 ±0.263	22.77 ±0.503	36.35 ±0.652	29.21 ±0.465	18.98 ±0.727	29.30 ±0.372
%Variation	-78.46	-66.20	-59.12	-49.86	-46.59	-42.26	-58.31	-55.48	-53.46

On the contrary, combined drying by microwave and air oven was recorded as having the lowest decrease in sugar content, especially for the slices that immersed in 1% citric acid before drying. One of the essential nutrients found in sweet potatoes is ascorbic acid. The results obtained in this study showed a decrease in the ascorbic acid content throughout the treatments before drying and after drying. The minimum decrease in the ascorbic acid content was showed in the slices (T4,T5,T6) which drying by microwave only forward by combined drying method (T7,T8,T9) at least air oven drying had the maximum decrease in ascorbic acid content (T1,T2,T3). Ascorbic acid is very reactive and heat sensitive, and it primarily breaks down by thermal or oxidative processes. The samples treated by 1% citric acid had low decrease of ascorbic acid content when compared with other samples.

Long drying times used on samples and blanching are the main causes of ascorbic acid oxidative degradation, which may be the reason for these reductions Abano and Amoah (2015). According to previous studies these data are comparable with Mana et al., (2012) who reported that, the microwave energy and hot air temperature caused the losses of ascorbic acid while the ascorbic acid content was highest in the sample dried by microwave than hot air dried because the long drying time caused a higher loss of ascorbic acid.

Effect of pretreatment processes and drying methods on phenolic compounds in sweet potato slices.

The results of the total phenolic compounds of sweet potato slices dried by ventilation oven, microwave and combined drying methods are shown in Table 4. The results showed that the total phenolic content was affected by drying methods and pretreatments. The total phenolic content of treated sweet potato slices dried by different methods was higher than in control samples. The breakdown of insoluble bound phenol coincided with the disruption of the cell structure, which increased the extractability of the phenolic compounds and resulted in an increase in the phenolic content in dried products (Ozcan-Sinir et al., 2019). Furthermore, the treatments (T3, T6 and T9) that were treated with 1% citric acid and dried using various drying methods had the highest polyphenol levels compared to the blanched treatments. The citric acid contributed to the reduction in the oxidation rate caused by oxidative enzymes (polyphenoloxidase and peoxidase).

Table 4. Effect of pretreatment processes and drying methods on phenolic and flavonoid compounds (mean ±SD) in sweet potato slices.

Treatment	Drying Methods								
	Ventilation oven			Microwave			Microwave + Oven		
	T1 control	T2 Blanched	T3 1% citric acid	T4 control	T5 blanched	T6 1% citric acid	T7 control	T8 blanched	T9 1% citric acid
Total phenolic compounds mg/100gm as chlorogenic acid									
Before Drying	30.63 ±0.155	33.20 ±0.145	38.00 ±0.220	30.63 ±0.155	33.20 ±0.145	38.00 ±0.220	30.63 ±0.155	33.20 ±0.145	38.00 ±0.220
After Drying	18.13 ±0.392	34.12 ±0.215	42.18 ±0.152	25.57 ±0.154	36.15 ±0.367	45.53 ±0.153	22.87 ±0.270	38.18 ±0.468	49.21 ±0.211
%Variation	-40.81	+2.77	+11.00	-16.52	+8.89	+19.82	-25.33	+15.00	+29.50
Total flavonoid contents mg/100gm as catechin									
Before Drying	23.73 ±0.250	22.70 ±0.166	26.15 ±0.204	23.73 ±0.250	22.70 ±0.166	26.15 ±0.204	23.73 ±0.250	22.70 ±0.166	26.15 ±0.204
After Drying	11.65 ±0.394	14.50 ±0.545	16.40 ±0.275	16.85 ±0.495	17.90 ±0.444	20.05 ±0.204	15.62 ±0.357	17.45 ±0.556	19.65 ±0.282
%Variation	-50.91	-37.28	-29.64	-29.01	-21.15	-23.33	-34.18	-23.13	-24.68

Furthermore, the most commonly used pretreatment techniques in the food industry are blanching and acidulating compounds since they are simple to apply, effective at enzyme inhibition and accelerate the drying rate while preserving food color and flavor. The results are similar to those reported by (Guanghe et al., 2017). In comparison to hot air and microwave dried berries, the combined microwave-hot-air-dried berries had significantly increased total phenolic contents.

Conversely, a high decrease in content of total flavonoids was found in sweet potato slices dried in a ventilation oven compared with combined drying and microwave methods, respectively. The results indicate that flavonoids were more sensitive to the dehydration conditions than other phenolic components and the drying conditions, particularly the temperature and duration of use, may have caused the loss of flavonoid components. Meanwhile, the dried sample treatments immersed in 1% citric acid (T9, T6, and T3) higher total flavonoid content compared with other treatments. Citric acid is used in food manufacturing to prevent the browning and improve the texture. The sweet potato samples dried with the microwave method only had a much content of total flavonoids than other drying method.

Effect of different drying methods on the carotenoids compounds in sweet potato treated by different methods.

Sweet potatoes are a good source of antioxidants such as carotenoids, which can have a variety of beneficial health effects.

Table 5. Effect of pretreatment processes and drying methods on total carotenoids and β-carotene (mean ±SD) of sweet potatoes slices.

Treatment	Drying Methods								
	Ventilation oven			Microwave			Microwave + Oven		
	T1 control	T2 Blanched	T3 1% citric acid	T4 Control	T5 blanched	T6 1% citric acid	T7 control	T8 blanched	T9 1% citric acid
Total carotenoids mg/100gm									
Before Drying	32.48 ±0.178	30.32 ±0.389	35.90 ±0.454	32.48 ±0.178	30.32 ±0.389	35.90 ±0.454	32.48 ±0.178	30.32 ±0.389	35.90 ±0.454
After Drying	21.17 ±0.306	22.40 ±0.244	27.98 ±0.114	26.10 ±0.226	25.64 ±0.199	31.96 ±0.299	25.19 ±0.149	23.94 ±0.196	30.54 ±0.168
%Variation	-34.82	-26.12	-22.05	-19.63	-15.43	-10.96	-22.45	-21.06	-14.91
β-carotene mg/100gm									
Before Drying	23.52 ±0.336	27.46 ±0.331	33.78 ±0.526	23.52 ±0.336	27.46 ±0.331	33.78 ±0.526	23.52 ±0.336	27.46 ±0.331	33.78 ±0.526
After Drying	10.37 ±0.118	19.44 ±0.116	24.64 ±0.305	18.29 ±0.273	22.71 ±0.205	28.50 ±0.378	15.43 ±0.232	21.94 ±0.254	27.13 ±0.108
%Variation	-55.91	-29.20	-22.07	-22.24	-17.29	-15.63	-34.40	-20.11	-19.68

The degradation of total carotenoids and β-carotene occurred in the dried sweet potato slices using different drying methods. Many factors, such as available oxygen, high temperatures, and low water activity, cause oxidative damage in carotenoids. (Kidmose et al., 2007). The total loss of carotenoids and β-carotene content illustrated in Table 5. in the dried potato slices treated with 1% citric acid (T6, T9 and T3 respectively) showed the lowest decrease compared to other treatments. Low enzyme activity (peroxidases) at lower pH, which have the ability to breakdown carotene, is likely to be the cause of samples treated with 1% citric acid having increased carotene content.

In addition, the solubility of crystalline carotenoids, which are found in plant material's vacuoles, may have been enhanced by soaking in 1% citric acid prior to drying procedures. The carotenoids and B-carotene values in dried treatments by the microwave drying method were higher than combined and ventilation oven methods, indicating that microwave drying reduced the entire drying process, resulting in a substantial savings in drying time and avoiding excessive loss of bioactive compounds. Contrary It is clear that the control samples (T1, T4 and T7) without any treatments before drying recorded a high degradation rate of the carotenoids and β-carotene compared to other treatments Followed by blanched treatments (T2, T5, T8).

Processing methods include washing, blanching, adding chemicals and drying might be each may have an effect on the structure and composition of carotenoids. Blanching and citric acid acidification are used as preprocessing methods to preserve bioactive compounds and achieve the desired quality of final products. While the blanching process causes starch gelatinization and slows the rate of moisture evaporation from the sweet potato slices during oven air drying. The samples that had been pretreated with citric acid solution had a low rate of breakdown of carotenoids and β-carotene, Citric acid has been shown to speed up drying because pectin loosens in an acidic environment, allowing water to be removed and requiring less energy to dry and increase the permeability of the cell membrane slices, leading to an increase in water diffusivity, and improve color (Rashid et al., 2022). This result could be attributed to oxidative reactions that happen during drying and are accelerated by air temperature (Doymaz, 2020).

Effect of pretreatment processes and drying methods on the color values of sweet potatoes.

Color is one of the main factors that affect a product's quality. It contributes to creating the first impression, which affects how motivated buyers are to buy.

Table 6. Effect of pretreatment processes and drying methods on color parameters (mean ±SD) in sweet potatoes slices.

Drying Methods	Treatments	L*	a*	b*	ΔE
-	Raw	$74.56^{c}\pm1.28$	$19.54^{h}\pm1.89$	$53.72^{a}\pm1.04$	$10.91^{f}\pm0.00$
Ventilation oven	Control (T1)	$55.52^{i}\pm1.10$	$39.28^{a}\pm1.12$	$22.75^{h}\pm0.89$	$37.54^{a}\pm2.33$
	Blanched (T2)	$79.61^{a}\pm1.19$	$31.33^{de}\pm1.02$	$25.36^{g}\pm1.25$	$28.87^{b}\pm3.23$
	1% citric acid (T3)	$77.26^{b}\pm1.04$	$29.25^{f}\pm0.89$	$31.58^{f}\pm1.54$	$22.44^{c}\pm2.62$
Microwave	Control (T4)	$60.47^{h}\pm1.66$	$32.84^{cd}\pm1.09$	$35.62^{e}\pm1.27$	$23.07^{c}\pm0.46$
	Blanched (T5)	$67.25^{ef}\pm1.09$	$26.11^{g}\pm1.17$	$45.65^{c}\pm1.44$	$11.87^{f}\pm1.15$
	1% citric acid (T6)	$65.35f^{g}\pm1.76$	$30.39^{ef}\pm0.82$	$48.67^{b}\pm1.25$	$10.88^{f}\pm1.06$
Microwave +Oven	Control (T7)	$63.52^{g}\pm0.96$	$36.58^{b}\pm1.11$	$32.65^{f}\pm1.47$	$24.63^{c}\pm0.21$
	Blanched (T8)	$71.57^{d}\pm0.98$	$34.35^{c}\pm0.90$	$35.32^{e}\pm1.05$	$19.18^{d}\pm0.26$
	1% citric acid (T9)	$68.38^{e}\pm1.27$	$26.68^{g}\pm1.10$	$39.51^{d}\pm0.63$	$15.99^{e}\pm0.81$

Means within a column a,b,c showing the same letters are not significantly different (P≤ 0.05)

It could be mentioned that all treatments have a clear effect on the color of the final product due to discoloration caused by the processing methods. Carotenoids are a significant class of naturally occurring yellow, orange, and red pigments that are widely dispersed in a variety of fruits, vegetables, and other foods. Vegetables lose carotenoids when they are dried; unless they are protected from air and light, the increased surface area of dried products causes even more losses (through autoxidation). The color values (L, a, b and ΔE) of the fresh sample were recorded at 74.56, 19.54, 53.72 and 10.91, respectively.

As shown in Table 6., the T2 had the highest lightness L* value (79.61). In comparison to all dried samples, the T1 had the lowest (55.52), a* value recorded (39.28), and yellowness b* value (22.75). The decrease in b* value indicates that the yellowness of the samples may be due to carotenoids loss. While increment (a*) values might be related to the Millard reaction. Color change index (ΔE) value of T1 (37.54) was higher than that of other treatments.

The pigment degradation, browning reaction, or both during dehydration can be due to a change in color. The presented data indicated that all treatments dried by the microwave method recorded negligible change in color characteristics due to the lower thermal intensity and shorter drying times. The microwave's low reaction rate may have resulted in fewer brown pigments than the combined methods and oven drying method.

Hence, microwave drying is used to produce high-quality products, accelerate the drying process, increase mass transfer, and ensure uniform heating with low energy consumption.

Effect of drying and pretreatment methods on the sensory characteristics of dried sweet potatoes slices.

Since consumer acceptance typically promotes the marketing of any new product, sensory evaluation is one of the factors of greatest importance. Table 7. displays the statistical analysis of testing sensory evaluation scores. In terms of color, taste, texture, appearance and overall acceptability, all treatments had good sensory acceptability. All of the sensory attributes that were evaluated had mean scores that were higher than 6.

Table 7. Effect of pretreatment processes and drying methods on sensory characteristics of dried sweet potato slices

Drying Methods		Color	Taste	Texture	Appearance	Overall acceptability	I. A
Ventilation oven	Control (T1)	5.8^{Bd}	7.50^{Aab}	7.05^{Bb}	6.00^{Bc}	6.6^{Bcd}	73.19^{Bcd}
	Blanched (T2)	6.7^{Ac}	5.80^{Cd}	7.75^{Aab}	5.6^{Bc}	6.47^{Bd}	71.82^{Bd}
	1% citric acid (T3)	6.9^{Abc}	6.50^{Bcd}	7.00^{Bb}	7.65^{Aa}	7.01^{Abc}	77.92^{Abc}
Microwave	Control (T4)	7.2^{Bbc}	8.05^{Aa}	7.15^{Bb}	7.9^{Aa}	7.59^{Aa}	84.17^{Aa}
	Blanched (T5)	7.7^{Aab}	6.15^{Bd}	8.00^{Aa}	6.2^{Bbc}	7.01^{Bbc}	77.92^{Bbc}
	1% citric acid (T6)	8.1^{Aa}	7.50^{Aab}	7.10^{Bb}	8.15^{Aa}	7.73^{Aa}	85.70^{Aa}
Microwave Oven	Control T(7)	6.5^{Bc}	7.90^{Aab}	6.15^{Bc}	6.9^{Bb}	6.88^{Abcd}	76.25^{Abcd}
	Blanched (T8)	7.1^{Bb}	6.05^{Cd}	7.75^{Aab}	6.4^{Bbc}	6.85^{Abcd}	75.83^{Abcd}
	1% citric acid (T9)	7.8^{Aab}	7.10^{Bbc}	6.15^{Bc}	7.7Aa	7.2^{Ab}	80.00^{Ab}

*Means within a column A,B,C showing the same letters are not significantly different (P≤ 0.05) for the treatments in the same drying method.

**Means within a column a,b,c showing the same letters are not significantly different (P≤ 0.05) for all treatments.

Among the various classes of foods physical properties, color is probably the most crucial visual element in the perception of product quality. The results in Table 7. showed that all samples treated with 1% citric acid had the best results for colors, followed by samples that had been blanched. The Maillard reaction causes the color of sweet potato slices to change while they are drying. The color was improved by pretreatment before drying because it prevented oxidation, and samples dried more quickly than control samples. These results are in agreement with (Ozdemir et al., 2016). Additionally, in comparison to other samples, the values assigned to the control samples color decreased significantly. Therefore, slices of sweet potatoes were pretreated before drying to reduce this undesirable change. Comparing all dried treatments, the taste attribute revealed statistically significant differences ($p \leq 0.05$). While there are no discernible differences in taste between T4 and T6, Furthermore, the texture of the blanched and dried treatments T5, T8, and T2 scored higher than the others. Also, the appearance of dried sweet potato samples T6, T4, T9 and T3 obtained the highest score compared to other treatments.

Sweet potatoes could be blanched to improve food products' overall acceptability, color, flavor, and texture (Damto and Chala, 2019). Additionally, blanching is a crucial step in the preparation of sweet potatoes.

Sweet potatoes are given a soft or firm bite through blanching, which alters their textural characteristics. The analysis of variance (ANOVA) of the data reveled that no significant differences ($p \leq 0.05$) between the samples in overall acceptability except for T1, T2 and T5 as shown in Table 7. The samples T6, T4, and T9 have the best acceptance according to the index of acceptance (IA), scoring 85.70, 84.17, and 80.0%, respectively, higher than the other samples. Except for T2, which received 71.82%, all of the samples demonstrated an acceptance index that exceeded 73.19%.

4. Conclusions

The study established that the sweet potato slices treated with 1% citric acid and dried by microwave were the most suitable techniques to produce dried sweet potato slices, which also gained high nutritional value and acceptable sensory characteristics.

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