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Comparison Effect of Different Drying Methods on Physicochemical Properties and Antioxidant Activity of Pineapple Fruits

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Abstract: Thanks to their high fiber, antioxidant activity, vitamin and mineral content, dried fruits are much healthier and more nutritious snacks than other processed snack foods. However, many research shows that certain compounds may degrade in the drying process, notably antioxidants, so drying method is very important to obtain desirable and healthy dried products. In this study, the comparison of quality characteristics of fluidized bed, microwave and vacuum dried pineapples was investigated. Pineapple slices were dried using fluidized bed dryer at 80 °C for 3 h. Vacuum drying treatments were performed using vacuum oven at 21.5 kPa and 60 °C for 12 h. Drying treatments in a microwave oven were performed at 360 W for 24 min. Color, rehydration capacity, shrinking ratio, antioxidant activity, total phenolic content measurements and sensory analysis were conducted in order to compare the physical, chemical and sensory properties of dried pineapples. Microwave dried samples had the highest L* value, total phenolic content and antioxidant activity compared to other samples ($p < 0.05$). On the other hand, vacuum dried samples took the highest flavor and overall impression values by the panelists ($p < 0.05$). When it was compared to other drying methods used in this study, fluidized bed drying caused the highest decrease in physicochemical, antioxidant activity and of pineapple samples. In the result of this study, it was revealed that being quick, cheap, and practical method, microwave drying has a promising potential for high-quality dried products.

Keywords: Drying, Pineapple, Antioxidant activity, Sensory

Introduction

Drying, one of the oldest food preservation methods, is the simple and practical process of dehydrating foods until there is not enough moisture to support microbial activity. Drying removes the water needed by bacteria, yeasts, and molds need to grow. When they adequately dried and properly stored, dehydrated foods are shelf stable and convenient to store. The drying food preservation method is easy to do, very safe, and can be used for most types of foods (meats, fruits, and vegetables). Many different foods can be prepared by dehydration. Moreover, dried foods are good sources of quick energy and wholesome nutrition. Therefore, dried foods are healthy alternatives for busy executives, hungry backpackers and active women and children, all of whom can benefit from the ease of use and nutritional content of dried foods.

Pineapple (*Ananas comosus L.*) is a member of the botanical family Bromeliaceae. It is rich sources of ascorbic acid, minerals, fibers, and antioxidants. (Ramallo & Mascheroni, 2012). Pineapple fruit is a good way to increase the nutritive value of poor people's diets and to reduce dietary deficiencies (Da Silva et al., 2013). Pineapple fruit is consumed fresh and/or processed as juice or canned. Additionally, drying pineapple slices and rings can be used as an alternative processing technology with the ability to enrich this raw material and expand consumption.

There are many food drying methods including solar drying, freeze drying, vacuum drying, microwave drying, drum drying, spray drying. Each has its own advantages and limitations. The final product obtained from these methods may differ in physical, chemical, and nutritional properties (Caparino et al., 2012). Since the physical and chemical properties of dried foods depend on the drying methods and drying conditions, it is critical to determine the appropriate drying method and drying conditions. Vacuum drying is a process in which materials are dried in a reduced pressure environment, which lowers the heat needed for rapid drying (Parikh, 2015).

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Fluidized bed drying allowing uniform drying of food items because heat from the air flow goes directly to the surface. Microwave drying is caused by water vapour pressure differences between interior and surface regions which provide a driving force for moisture transfer (Maskan, 2001). Microwave drying offered an alternative way to improve the quality of dehydrated products.

Only a few studies have been conducted regarding drying of pineapple fruit to extend the shelf life. Therefore, the objective of this study is the comparison of the freeze drying, vacuum drying and microwave drying methods for the processing of pineapple fruit in respect to drying, color, rehydration capacity, shrinking ratio, antioxidant activity, total phenolic content measurements and sensory analysis obtained by the three drying techniques.

Material and Methods

Metarials

In all the experiments in this study, wholly matured and healthy pineapples were used. Fresh fruits (Golden sweet) were purchased from a farmer's market in Bursa, Turkey. The fruits were then stored until analysis at a temperature of 4 ± 0.5°C.

Using a food slicer, the samples were sliced into pieces 3 ± 0.04 mm.

Drying Process

Pineapple slices were dried using fluidized bed dryer at 80 °C for 3 h. Vacuum drying treatments were performed using vacuum oven at 21.5 kPa and 60 °C for 12 h. Drying treatments in a microwave oven were performed at 360 W for 24 min.

Color Analysis

Color values (L*, a* and b*) was measured using a chroma meter (model CR-400, Konica Minolta Inc., Osaka, Japan) equipped with a D65 illuminant and operating with CIE L*a*b* color space. Calibration was performed with the white color calibration tile prior to the color measurements.

Determination of Rehydration Ratio

Rehydration experiments for dried samples at 40°C were carried out in distilled water bath at temperature of 25 and 50°C (±1°C). Approximately 1 g of dried samples was added to 400 mL distilled water, in a 500 mL beaker. The sample was withdrawn from the liquid every 20 min, and excess water was carefully removed by blotting on a tissue paper, before weighing. The rehydration ratio (RR) was calculated by the following equation:

$$RR = Wr/Wd$$

where Wr is the weight of moisture (kg) and Wd is the weight of dry matter (kg).

Determination of Shrinkage Ratio

The shrinkage/volume change of the samples was expressed as a bulk shrinkage ratio of sample volume at any time to initial volume.

Antioxidant Activity Measurements

Antioxidant activity was determined according to method described by Singleton et al. (1999). (DPPH (2,2-diphenyl-1-picrylhydrazyl)-free radical scavenging activity of the pineapple extracts was spectrophotometrically evaluated. To 3.9 mL of a 25 mM methanolic solution of the DPPH radical (Sigma-Aldrich, Germany), 0.1 mL of the appropriately diluted extract was added, and the mixture was vortexed for 15–30 s. The reaction of the mixture was allowed to proceed in the dark at room temperature for 30 min. After this, the absorbance was measured at 515 nm (UV Lambda 35, Perkin-Elmer Corp., Shelton, CT, USA). The results were expressed as µmol Trolox equivalents (TE)/g d.w. Three sets of each sample were analyzed.

Determination of Total Phenolic Content

Total phenolic content was determined using a slight modification of the procedure described by Cemeroğlu (2009). Briefly, 5-g samples were homogenized by beating in a mortar with 50 mL of 80% methanol for 5 min. The homogenate was boiled for 5 min in a beaker. The extract was filtered by Whatman 4 filter. The residue in the beaker was reboiled for 10 min by adding 50 mL of 80% methanol. The 2 extracts were combined in 100-mL volumetric flasks and allowed to cool. After cooling, the flask was completed with distilled water, 5 mL of the extract was taken into a 50-mL volumetric flask, and 5 mL of distilled water was added to it. Then 0.5 mL of Folin–Ciocalteu reagent was added, and the container was shaken vigorously. After waiting for 3 min, 1 mL of 36% sodium carbonate solution was added. The container was then filled with distilled water and shaken strongly. The container was left in a dark environment for 1 h. The absorbance at 725 nm was measured afterwards.

Sensory Analysis

A panel of 24 judges carried out a sensory evaluation using a hedonic scale (Altuğ-Onoğur and Elmacı, 2011). Appearance, texture, flavor, and overall impression were evaluated. Panelists had experience in evaluating different food products.

Statistical Analysis

The experiment was conducted using a completely randomized design with 3 replications. Data were analyzed using the PROC MIXED procedure of SAS (SAS, 1999).

Results and Discussions

Effects of drying process on color values of pineapple slices are given in Table 1. Color is one of the most important quality attributes of foods because it directly influences consumer acceptability. Drying methods affected the color parameters of the dried pineapple fruits. L* and b* values in all the dried samples decreased compared with the fresh fruit. On the other hand, a* value of the fresh sample significantly ($P < 0.05$) lower than that of any other drying method. The decrease in L* value could be explained by Maillard reactions that contribute to the formation of colored compounds, called melanoidins (Bolek & Ozdemir, 2017). Fluidized bed dried pineapple slices presented the lowest L* value. L *and b* value of dried pineapples slices by vacuum and microwave are not different significantly ($p > 0.05$).

Table 1. Color values of pineapple slices

Drying method	**L***	**a***	**b***
Fresh	70.12 ± 0.45^{a}	0.49 ± 0.02^{c}	41.88 ± 0.12^{a}
Vacuum	56.21 ± 1.10^{b}	11.32 ± 0.58^{b}	37.90 ± 1.15^{b}
Microwave	54.42 ± 1.16^{b}	11.85 ± 0.32^{b}	36.21 ± 1.52^{c}
Fluidized bed	47.20 ± 1.25^{c}	12.89 ± 0.22^{a}	29.57 ± 1.60^{c}

a–c: Means having a different subscript within a column differ ($p < 0.05$).

Effects of drying process on rehydration and shrinkage ratios are given in Table 2. Drying methods affected the rehydration and shrinkage ratio of the dried pineapple fruits significantly ($p<0.05$). Rehydration ratio is very important quality characteristic for drying fruits. It depends on processing conditions, sample preparation, sample composition and extent of the structural and chemical disruption induced by drying (Singh et al., 2006). The rate of water removal influences the extent of shrinkage during air drying of tissue foods. Rehydration capacity and shrinkage ratio of vacuum dried and microwave dried pineapple slices are higher than fluidized bed dried pineapple slices.

Table 2. Rehydration and Shrinkage Ratio of dried pineapple slices

Drying method	**Rehydration Capacity**	**Shrinkage Ratio**
Vacuum	4.18 ± 0.02^a	0.82 ± 0.03^a
Microwave	4.10 ± 0.01^a	0.76 ± 0.02^a
Fluidized bed	3.36 ± 0.02^b	0.40 ± 0.03^a

a–b: Means having a different subscript within a column differ ($p < 0.05$).

Effects of drying process on antioxidant activity and total phenolic content of pineapple slices are given in Table 3. Drying method affected antioxidant activity and total phenolic contents of pineapple slices significantly ($p< 0.05$). Fluidized bed drying caused a decrease in antioxidant activity and total phenolic content of pineapple slices more than vacuum drying and microwave drying ($p < 0.05$).

Table 3. Antioxidant activity and total phenolic content of pineapple slices

Drying Method	**Antioxidant Activity µmol Trolox/g**	**Total Phenolic Content mg GAE/100 g**
Fresh	14.55 ± 0.09^a	468.52^a
Vacuum	8.20 ± 0.05^b	410.32^b
Microwave	8.12 ± 0.07^b	400.72^b
Fluidized bed	5.22 ± 0.05^c	320.65^c

a–c: Means having a different subscript within a column differ ($p < 0.05$).

Effects of drying process on sensorial properties of pineapple slices are given in Table 4. Drying method is affected sensory properties of pineapple slices significantly ($p<0.05$). Vacuum dried and microwave dried pineapple slices took higher texture and overall impression scores than fluidized bed roasted pineapple slices. However, appearance and flavor values of fluidized bed dried pineapple slices higher than others. This result could be explained by long drying time of vacuum drying technique.

Table 4. Sensory Properties of pineapple slices

Drying method	**Appearance**	**Texture**	**Flavor**	**Overall impression**
Vacuum	3.90 ± 0.12^c	4.92 ± 0.14^a	4.86 ± 0.18^a	4.95 ± 0.02^a
Microwave	4.96 ± 0.22^a	4.25 ± 0.12^a	3.20 ± 0.15^c	4.90 ± 0.03^a
Fluidized bed	4.22 ± 0.15^b	3.50 ± 0.22^b	4.10 ± 0.32^b	4.10 ± 0.01^b

a–c: Means having a different subscript within a column differ ($p < 0.05$).

Conclusion

This study investigated the effect different drying methods on the color, rehydration capacity, shrinking ratio, antioxidant activity, total phenolic content and sensory properties of pineapple slices. The shortest drying time was achieved using the microwave drying method compared to the vacuum drying and fluidized bed drying. Fluidized bed drying caused a decrease in antioxidant activity and total phenolic content of pineapple slices more than vacuum drying and microwave drying ($p < 0.05$). Rehydration capacity and shrinkage ratio of vacuum dried and microwave dried pineapple slices are higher than fluidized bed dried pineapple slices. On the other hand, vacuum dried and microwave dried pineapple slices took higher texture and overall impression scores than fluidized bed roasted pineapple slices. This study indicated that microwave drying shortens the drying time and can improve the overall quality of the dried pineapple slices.

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