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Drying Characteristics of Papaya (*Carica Papaya* L.) Fruit Leather Using Microwave Oven

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ABSTRACT

Fruit leather is a thin sheet of oven-dried fruit flesh. While papaya fruit is a perishable fruit with various types of fruit leather is one of the processed food products that can be preserved and has added value. This study aimed to determine papaya fruit leather's drying characteristics using a microwave oven, namely changes in water content, drying rate, color, and water activity. The methods used were experimental methods with treatment variables of different microwave power (329 W, 428 W, and 701 W) and material thickness (1 mm, 3 mm, and 5 mm). The research design was selected in complete randomization with 3 replications. The results showed that the moisture content value decreased from 87.10-87.67%bb to 10.21-16.51%bb. The highest drying rate occurred at 701 W power and 1 mm material thickness with a value of 282.79%bb. The highest total color (ΔE) value occurred in the treatment of 701 W power and 1 mm material thickness which was 28.78. The highest water activity (aw) value occurred at 329 W power treatment and 5 mm material thickness which was 0.463.

1. INTRODUCTION

California papaya (*Carica papaya* L.) is a tropical fruit that grows widely in tropical and subtropical areas and has good selling value due to its high nutritional content. Papaya fruit is included in the group of climacteric fruits whose ripening is influenced by high respiration rates and ethylene production. The higher the level of ethylene production, the lower the shelf life of the fruit. Papaya fruit has a high level of ethylene production (ranging from 10 - 100 ul ethylene/kg/hour) so when it is ripe, papaya fruit can only last at room temperature for 3 - 4 days (Taris *et al*., 2015). Therefore, alternative preservation techniques are needed to extend the shelf life of papaya fruit. An alternative to extending papaya's fruit shelf life is making fruit leather products (Astuti *et al*., 2015).

Fruit leather is a processed fruit product, which generally has consistency in thin dry sheets with a thickness of 2-3 mm (Herlina *et al*., 2020). Fruit leather has 10 - 20% water content, less than 0.7 water activity (*aw*), plastic texture, and a skin-like appearance (Fauziah *et al*., 2015). Drying fruit leather using an oven by heating it at 60 - 70°C.

A microwave oven is an artificial heating device that uses microwave energy. This oven has many advantages, namely faster drying time; low drying temperature; low energy consumption; and food quality is maintained starting from color, texture, and nutrition (Sommano *et al*., 2011 in Hirun *et al*., 2012). Microwave ovens have been used extensively in food processing applications. The specific principle of microwave heating is heat production in food through 2 mechanisms. First, there is friction between molecules due to rapid movement between molecules with permanent dipoles in response to changing microwave waves. Second, with the action of microwave waves which result in collisions between ions, the kinetic energy becomes irregular and heat begins to appear (Wray & Ramaswamy, 2015). The greater the microwaved power, the greater the drying rate, the greater the color change in the product (Lestari *et al*., 2023). The goal of a microwave oven is expected to speed up the drying process and maintain nutritional value to produce good quality papaya fruit leather products. This research was conducted to determine the characteristics of drying papaya fruit leather using a microwave-based on differences in microwave power and material thickness.

2. METHODS

2.1. Tools

The tools used in this study were a Memmert convection oven; Sharp microwave oven; digital scales with an accuracy of 0.01 g and 0.001 g; Phillips blender; Swift-aw Lab; digital camera; stopwatch; knife; tray/cup/glass container; spatula; desiccator; CS-10 colorimeter, thermometer. The main ingredient used in this study was young California (local) papaya.

2.2. Research Design

This research used three repetitions for each combination of experimental treatments between microwave oven power (329W, 428W, and 701W) and material thickness (1mm, 3mm, and 5mm). Experimental data from each treatment was processed using the Microsoft Excel 2010 application to analyze changes in water content, drying rate, color, and water activity of fruit leather.

2.3. Research Steps

This research used three repetitions for each experimental treatment combination of microwave oven power (329W, 428W, and 701W) and material thickness (1mm, 3mm, and 5mm). Experimental data from each treatment was processed using the Microsoft Excel 2010 application to analyze changes in water content, drying rate, color, and water activity of the fruit leather products produced.

2.4. Methods Analysis

The methods used for parameter analysis include water content, drying rate, and quality of papaya fruit leather including color and water activity.

2.4.1. Moisture Content (AOAC, 2005)

The initial water content measurement was carried out using the gravimetric method. The moisture content based on wet and dry material was calculated respectively using Equation (1) and (2).

$$m(\%bb) = \frac{(b-c)}{(b-a)} \tag{1}$$

$$M(\%bk) = \frac{(b-c)}{(c-a)} \tag{2}$$

with a is empty cup weight, b and c is weight of cup + material before and after drying, respectively.

2.4.2. Drying Rate

The drying rate can be defined as the amount of water content evaporated per unit of time. According to Brooker *et al*. (1992), the drying rate can be calculated using the following equation.

$$\frac{dM}{dt} = \frac{Mt_1 - Mt_2}{\Delta t} \tag{3}$$

where dM/dt is drying rate (%db/min), Mt_1 is moisture content at t_1, Mt_2 is moisture content at t_2, and Δt is time interval between t_1 and t_2 (min)

2.4.3. Color

Color measurements aim to determine color properties of papaya leather was carried out using a CS-10 colorimeter. The color measurement steps are calibrating the Colorimeter, then shooting at the white paper, and the sample at five different points, so the values ΔL, Δa, Δb were known. Calculations to determine the values of L, a, and b were done using Equation:

$$L = \Delta L + Lt \tag{4}$$

$$a = \Delta a + at \tag{5}$$

$$b = \Delta b + bt \tag{6}$$

where Lt, at, and bt are the target color values (white paper). After the L, a, and b were known, then the total color change value (ΔE) was calculated using the equation

$$\Delta E = \sqrt{[(L - Lt)^2 + (a - at)^2 + (b - bt)^2]} \tag{7}$$

where L is color parameter range white (+100) to black (-100), a is color parameter range red (+80) to green (-80), and b is color parameter yellow (+70) to blue (-70) (Sinaga, 2019).

2.4.4. Water Activity

After determining the color properties, the product is size reduction to calculate the water activity. Water activity measurement using the Swift-aw Lab tool. Water activity steps are warmed up for ± 5 minutes, then the product is formed in a container provided with a predetermined limit. When the warm-up is complete, the container is inserted into the tool, and measurements are taken until the tool beeps or the water activity value is constant.

3. RESULTS

3.1. Water Content of Papaya Fruit Leather

Water content is a physical property that indicates the amount of water in the material and decreases with the drying time (Nurmuliana *et al*., 2022). The results showed that the initial water content of papaya fruit was quite high between 87.10 - 87.67%bb. The decrease in water content of the material during the drying process of papaya fruit leather can be seen in Figure 1. Based on Figure 1, the water content of papaya fruit leather during the drying process in various treatments. At 329 W power, the initial water content is 87.67%, then the water content decreases at material thicknesses of 1 mm, 3 mm, and 5 mm by 18.21%; 15.45%, and 15.84%. At 428 W power, the initial water content is 87.17%, then it decreases at material thicknesses of 1 mm, 3 mm, and 5 mm by 16.51%; 11.38%, and 14.32%.

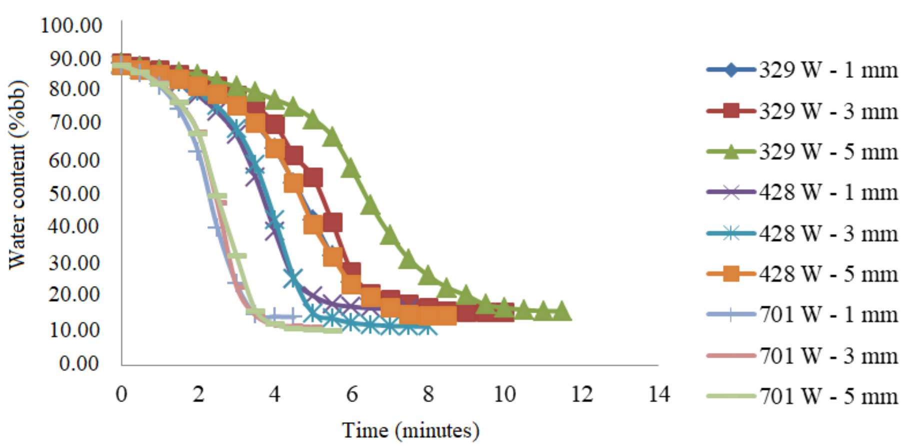

Figure 1. Papaya fruit leather's water content in various treatments.

At 701 W power, the initial water content is 87.10%, then the water content decreases at material thicknesses of 1 mm, 3 mm, and 5 mm by 14.09%; 11.22%, and 10.21%. The decrease in water content (%wb) is influenced by the amount of power used and the thickness of the material.

The power used affects the microwaves produced. The water contained in the papaya fruit leather is an electric dipole that have negative and positive charges. According to Kurniasari (2008) in Effendy *et al*. (2020), with the presence of a changing electric field induced through microwaves on each side will rotate to align themselves with each other. The movement of these molecules will create heat along with the molecule friction. The heat energy is function as a heating agent in the microwave.

The product will be shrinkage during the drying process. According to Nurhawa *et al*. (2016), drying causes shrinkage in the dried material. According to Mukmin *et al*. (2021), the thickness of the material also affects the water content reduction, the longer water content reduction, and the thinner the material, the faster the rate of water content reduction. The surface area of the material greatly affects drying, one of which is by increasing the surface area. This concurs with Rahmawan (2001) in Leviana & Paramita (2017), that the drying process is influenced by the thickness of the material being dried and the thinner the material, the faster the drying time.

3.2. Drying Rate

The drying rate curve for papaya fruit leather is obtained from drying time (minutes) and water content (%bk). The drying rate curve can be used to determine the level of change in drying rate during the drying process. The drying rate curve of papaya fruit leather in various treatments with variations in microwave power and material thickness can be seen in Figure 2 to Figure 4.

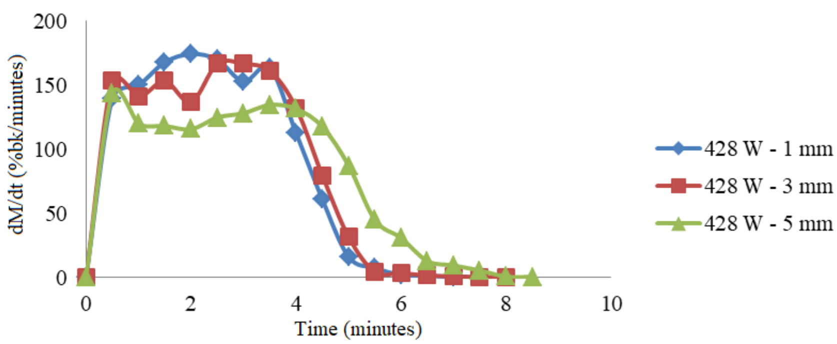

Figure 2. The drying rate of papaya fruit leather and drying time at 428 W power and various thicknesses.

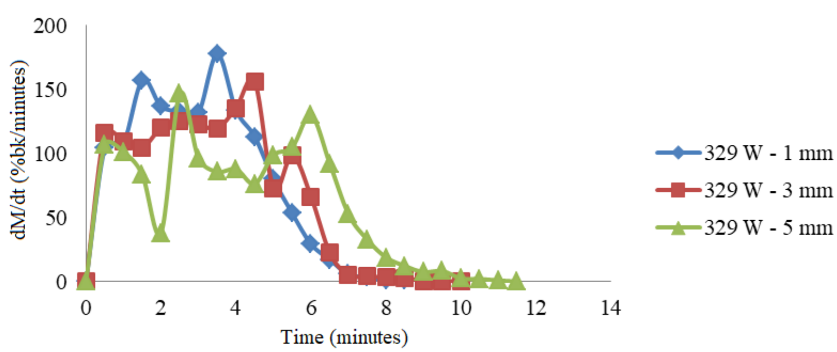

Figure 3. The drying rate of papaya fruit leather and drying time at 329 W power and various thicknesses.

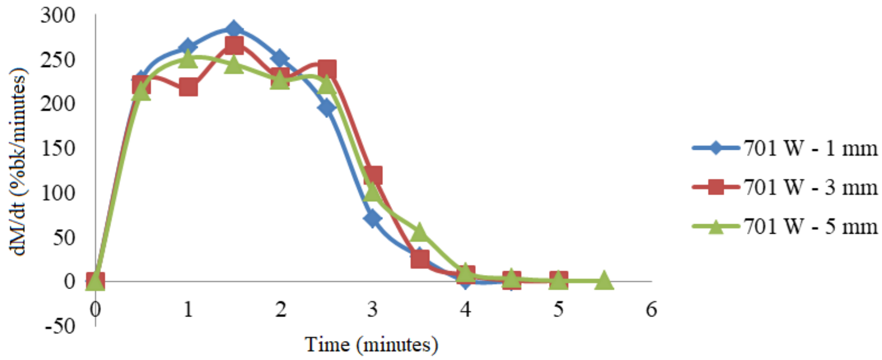

Figure 4. The drying rate of papaya fruit leather and drying time at 701 W power and various thicknesses.

Figures 2, 3, and 4 showed that the drying rate will fluctuate, but decrease as the water content in the material decreases. According to Hartulistiyoso & Sudarmaji (2005), stable heating in a microwave oven is influenced by the amount of microwave energy absorbed and the ability to release it (dissipate) into heat. The effect of changes in material temperature in changing the ability to absorb and dissipate heat causes fluctuations in the material's temperature. This fluctuation in material temperature will then affect the drying rate value. Thus, the drying rate against water content fluctuates in a microwave oven due to changes in temperature on the material surface.

3.3. Color

The process affects color changes. Color observations are divided into 3 parameters, L, a, and b. In this research, the observations of color changes before and after drying. The L, a, and b value parameters to calculate the color change value (ΔE). Figure 5 shows the total color value (ΔE) in each treatment. Based on Figure 5, the different color change values can be seen. The resulting values range from 28.78 to 35.27 where the highest value occurs in the 701 W power treatment and 1 mm material thickness, the lowest value happens in the 428 W power treatment and 3 mm material thickness. This value is used to determine the level of color change of fruit leather before and after drying. The color change is the loss of water content in papaya fruit leather. According to Bahanawan & Sugiyanto (2020), the color included in the composition of extractive substances will degrade due to the loss of water content. The reduction in water content in the material is influenced by the heat given to the material. Temperature will affect color change, the higher the temperature, the greater the color change.

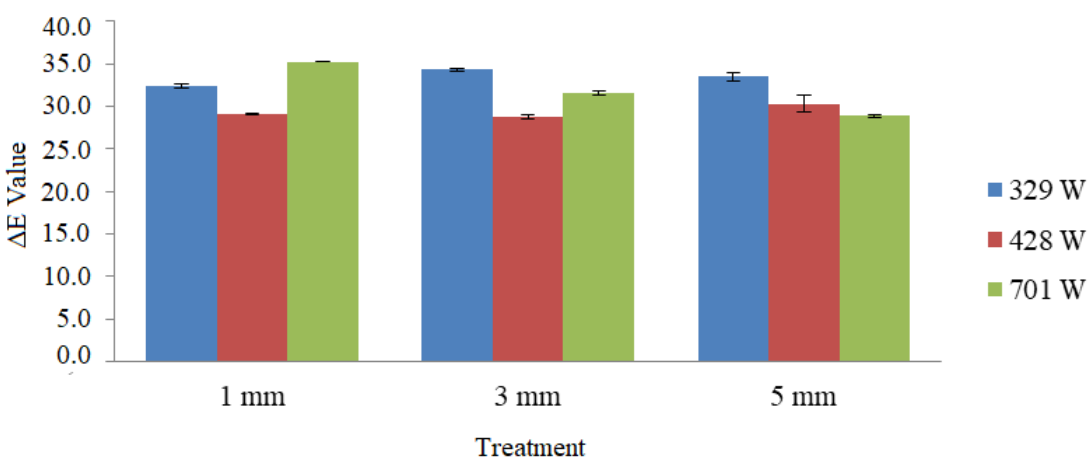

Figure 5. Total color value (ΔE) for each treatment.

3.4. Water Activity (*aw*)

Water activity is one of the critical factors in determining the shelf life of a product. Some dry food products have a water activity range of 0.3 for very dry products and 0.99 for fresh wet products (Chowdhury *et al*., 2012). The water activity value of fruit leather ranges from 0.44 to 0.49 (Rahmawati & Fachriah, 2022). Figure 6 shows the water activity value of papaya fruit leather. At 329 W power, the amount of water activity at material thicknesses of 1 mm, 3 mm, and 5 mm is 0.451; 0.459; and 0.463; while at 428 W power, it is 0.427; 0.431; and 0.44. At 701 W power, the amount of water activity at material thicknesses of 1 mm, 3 mm, and 5 mm is 0.425; 0.429; and 0.442. The value of water activity ranges of 0.425-0.463 belongs to the criteria. The water content is affected by the power and thickness of papaya fruit leather.

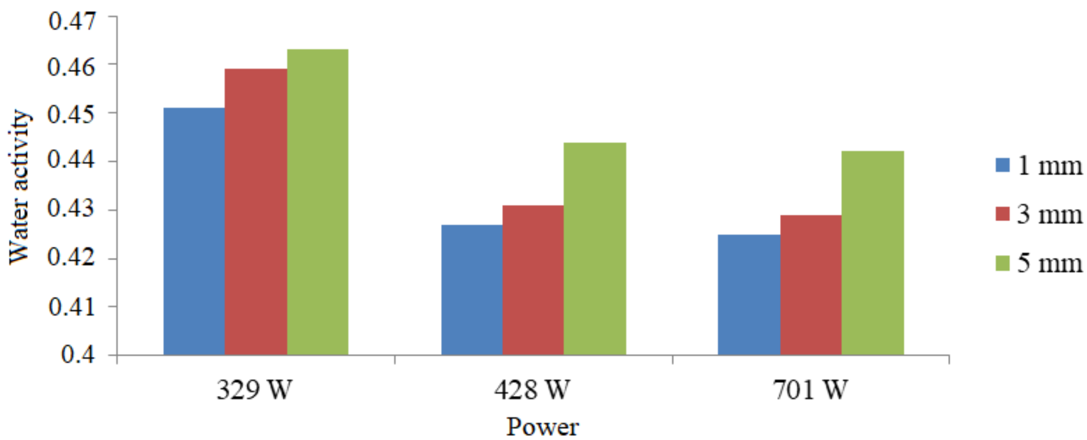

Figure 6. Comparison of water activity values of papaya fruit leather after the drying process.

Praseptiangga *et al*. (2016), said the increasing water activity in fruit leather is influenced by the water content in the fruit leather, where the higher the water content indicates the higher the free water content contained. In testing by thermogravimetry, the water content is determined based on the amount of water evaporated until the sample has a constant weight. The higher the water content indicates the more water evaporated in the drying process. Water that can be evaporated is included in the group of free water that is not strongly bound. This causes less free water to remain in the fruit leather. Thus, changes in water activity are directly proportional to changes in water content in fruit leather.

4. CONCLUSION

The drying process of papaya fruit leather using a microwave oven has the highest drying rate value at 701 W power and 1 mm material thickness. The water content of the fruit leather is around 10-20%. The color difference occurs during the manufacture of papaya fruit leather, which fluctuates. The highest value occurs at 701 W power and 1 mm material thickness, which is 28.78, while the lowest value occurs at 428 W power and 3 mm material thickness, which is 35.27. In addition, the highest water activity value occurs at 329 W power and 5 mm material thickness, which is 0.46; while the lowest value occurs at 701 W power and 1 mm material thickness, which is 0.43.

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