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Effect of Banana Types on Oven Drying Process for Crispy Banana Production

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Abstract-*This study aims to determine the effect of moisture and drying rate on Kepok and milk banana species,* on *the production process of crispy banana. An electric oven was used to examine the drying process at variable temperatures of 70°C, 80°C and 100°C with slices of 1 mm, 2 mm, 3 mm and 4 mm thickness. The results showed that the lowest moisture content and maximum drying rate obtained in Kepok was at a temperature of 100°C, namely 69.167% and 0.045 grams/minute respectively. Meanwhile, for milk banana, the lowest moisture and the maximum drying rate was obtained at a temperature of 100°C, namely 68.167% and 0.042 grams/minute respectively. Furthermore, the organoleptic test results showed that kepok and milk banana experienced browning at 100°C, but did not at 70°C and 80°C with a thickness of 1mm, 2mm and 3mm. In addition, the pore structure of both bananas expanded, while the structure of the bananas appeared bigger after drying.*

Keywords **-** *kepok banana, milk banana, moisture content, drying rate*

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1. Introduction

Drying is the removal of moisture contained in a material using heat energy from natural sources such as sunlight or artificial such as drying equipment. The purpose of drying is to limit the development of microorganisms and enzyme activities that causes spoilage of foodstuffs therefore, increasing the life span of the material [1].

A type of dryer in the form of an isolated thermal chamber used for heating, roasting or drying of a material at certain temperature is an oven. It has a square shape with shelves inside, on which the ingredients to be dried are placed. Apart from ovens, there are other types of dryers, such as drum, tray, spray dryers and many more [2]. The selection of the type of dryer is based on the material to be dried, amount of the material, quality of final product desired and cost of production or economical considerations.

Dryers are used on many products such as crispy bananas to aid the production process. Bananas are one of the fruits originating from Southeast Asia and are widely grown in Indonesia. Furthermore, it requires low maintenance costs and is easily cultivated. Apart from low maintenance costs, bananas also contain high moisture content and nutritional, which makes it very susceptible to diseases caused by the activity of microbes, causing losses to farmers [3]. Therefore, drying is carried out to reduce the moisture content in bananas and inhibit the activity of microbes.

An electric oven is an alternative dryer used with several advantages such as, faster drying rates, makes fruit light, easily operated and less expensive compared to other tools. One of the problems faced in drying with an oven is that it takes an optimum drying time to produce crispy banana products. Therefore, one of the objectives of this study is to produce crispy banana products that have the best quality at optimum time with a relatively fast drying rate.

2. Methodology

2.1 Materials

The materials used in this study were 500gr each of peeled kepok and milk bananas with a variable thickness of 1mm, 2mm, 3mm and 4mm. The main tool used was the Memmert oven type UN 110 (Memmert GmbH + Co. KG, Deutschland) with a capacity of 108liters at temperatures of 70°C, 80°C and 100°C. Other tools include desiccators,

knives, porcelain plates, digital scales, glass covers, glass slide and microscope.

2.2 Moisture Content Determination

The analysis of moisture content was obtained by weighing the initial and final mass of the sample at required time. It was calculated using the equation below [4]:

$$MC(wb) = \frac{m_i - m_f}{m_i} \times 100\% \quad (1)$$

where, m_i is the initial mass (gr), m_f is final mass (gr) and MC(wb) is the moisture content at web basis (%).

2.3 Analysis of Breakeven Point

According to Asmara and Warji [5] the drying rate was calculated by applying the following equation:

$$W = \frac{\frac{(m_{b1} - m_{b2}) \cdot 100}{(100 - m_{b1})(100 - m_{b2})} \times W_d}{\theta} \quad (2)$$

where, W is the rate of water transfer (gr H_2O/minute), W_d is initial solids weight (gr), m_{b1} is the initial moisture content (%), m_{b2} is the final moisture content (%) and θ is the drying time (minutes).

2.4 Analysis of Pores

The pore analysis was carried out with a step by step process which involved taking 1 dried banana slice (milk and kepok) and placing it on a glass preparation. Afterwards, 1-2 drops of distilled water was added and the preparation was covered with a glass. Furthermore, the lighting and diaphragm were adjusted on the microscope at 100x magnification while focusing the image to make it obvious. The condenser and macrometer were adjusted until the image in the preparation was visible. The results were obtained by observing the pores in the image being displayed and a picture was taken to analyze the result observed. The above steps were repeated for other variables.

3. Results and Discussion

3.1 Kepok Banana Moisture Content

Figure 1 shows the observations results of moisture content from drying Kepok bananas using an electric oven at temperatures of 70°C, 80°C and 100°C with slices thickness of 1 mm, 2 mm, 3 mm and 4 mm, respectively. Of the three temperature variables used, the thickness of the slices affected the length of drying time and the resulting moisture content. The drying time used with a slice thickness of 1 mm was shorter than that of 2mm, 3mm and 4mm. This was in accordance with the theory which states that the length of the drying process depends on the cross-sectional area and the heating method used [6]. The results of this study showed that the average moisture content at temperatures of 70°C, 80°C and 100°C were 64.404%, 63.937% and 69.167% respectively. Furthermore, from the differences in temperature variables and slice thickness of

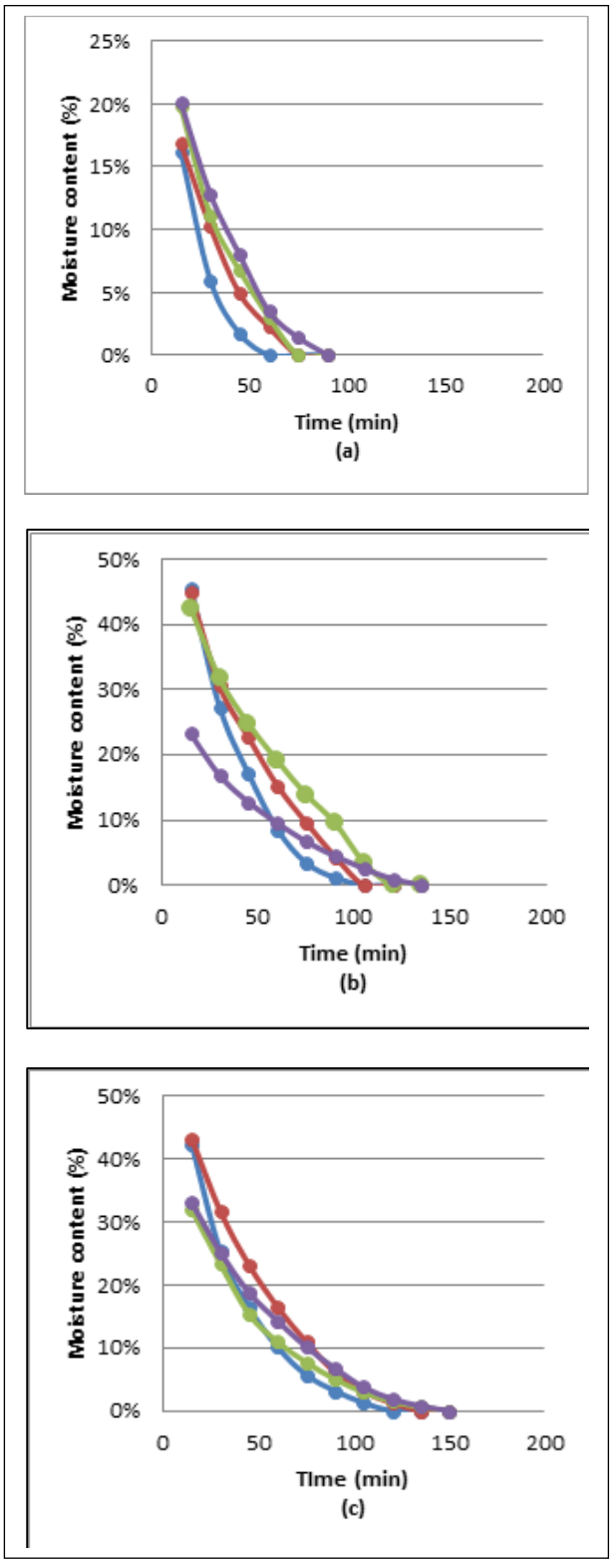

Fig. 1. Moisture content in drying kepok banana. Temperature: 70°C (a), 80°C (b) and 100°C (c); Thicknes: 1 mm ( ), 2mm ( ), 3mm ( ) and 4mm ( ).

each material, there was no significant difference in moisture content. The longest drying time was 180 minutes

at 70°C, while the fastest drying time was 120 minutes at 100°C.

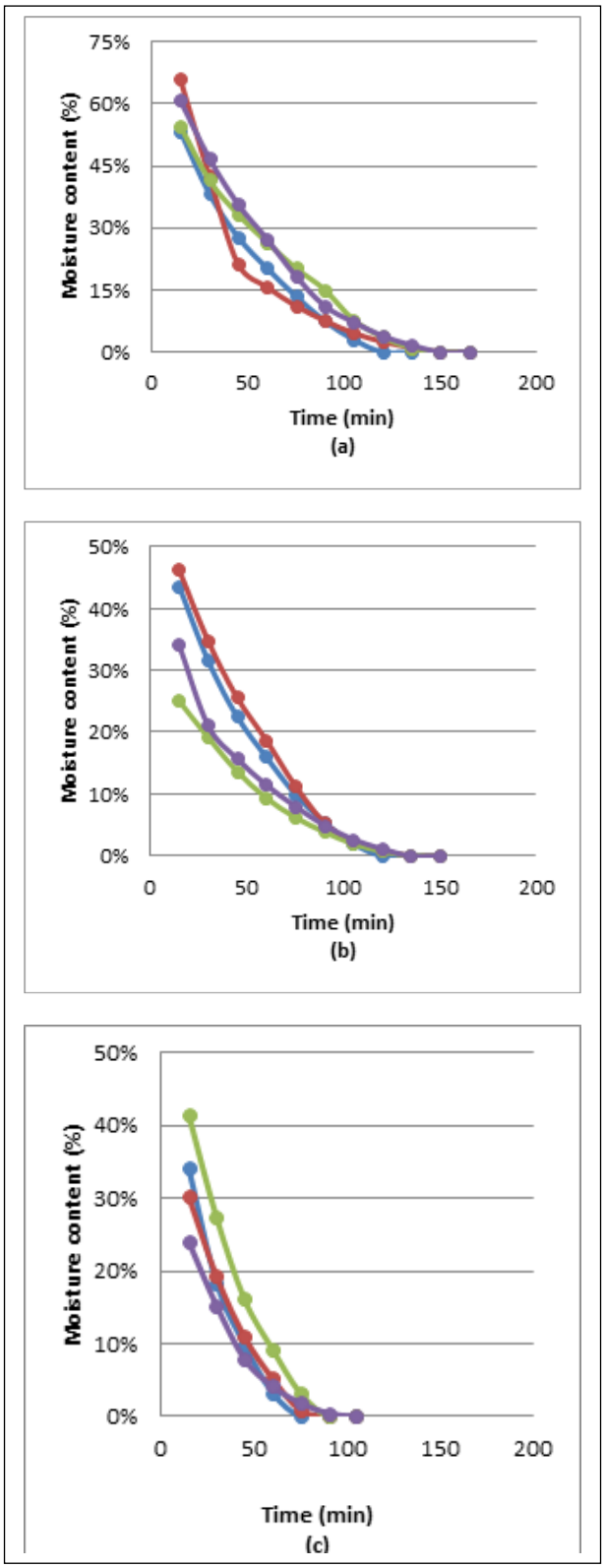

Fig. 2. Moisture content in drying milk banana. Temperature: 70 oC (a), 80 oC (b) and 100 oC (c); Thicknes: 1 mm ( ), 2mm ( ), 3mm ( ) and 4mm ( ).

Monteiro *et al.* dried banana material with a variable thickness of 5 mm slices at 70°C for 45 minutes, using a dryer in form of a vacuum microwave and the result of the study was 47.6% moisture content [7]. The disparity in the moisture content was due to differences in the type of equipment used therefore, the resulting efficiency was different.

Figure 2 shows the observations results of moisture content in drying milk bananas using an electric oven at temperatures of 70°C, 80°C, and 100°C with slices thickness of 1 mm, 2 mm, 3 mm, and 4 mm, respectively. Of the three temperature variables used, the thickness of the slices affected the length of drying time and the resulting moisture content. The drying time used with a slice thickness of 1 mm was shorter than that of 2mm, 3mm and 4mm. This was in accordance with the theory which states that the length of the drying process depends on the cross-sectional area and the heating method used [6].

The results of this study showed that the average total moisture content at temperatures of 70°C, 80°C and 100°C were 63.322%, 62.647% and 68.167% respectively. From the differences in temperature variables and slice thickness of each material, there was no significant difference in moisture content. The longest drying time was 195 minutes at 70°C, while the fastest drying time was 135 minutes at 100°C. This result was supported by Monteiro *et al.* [7].

3.2 Kepok Banana Drying Rate

Figure 3 shows the graph of drying rate against drying time of kepok banana, using electric oven at temperatures of 70°C, 80°C and 100°C with slices thickness of 1 mm, 2 mm, 3 mm and 4 mm, respectively. The maximum drying rate at 100°C, 80°C and 70°C was 0.045gram/minute, 0.040 gram/minute and 0.039 gram/minute respectively. From the graph, at temperature of 100°C (a) it is observed that the drying rate was very fast, at 80ºC (b) the drying rate was quite fast and at 70°C (c) the drying rate was very slow therefore, the time required to carry out the drying process was prolonged.

Sari *et al.* dried 5kg of kapok banana chips using a rack type hybrid dryer with an initial moisture content of 61.25% - 63.09% to 9.61% - 10.47%. The drying time using solar and electrical energy was 9 and 11 hours respectively, while using solar energy and electricity was 8 hours [8].

Figure 4 shows the graph of drying rate against drying time of kepok banana, using electric oven at temperatures of 70°C, 80°C and 100°C with slice thicknesses of 1 mm, 2 mm, 3 mm and 4 mm, respectively. The maximum drying rate at 100°C, 80°C and 70°C was 0.042gram/minute, 0.041grams/minute and 0.034gram/minute respectively. From the graph, at temperature of 100°C (a) it is observed that the drying rate was very fast, at 80°C (b) the drying rate was quite fast and at 70°C (c) the drying rate was very slow therefore, the time required to carry out the drying process was prolonged.

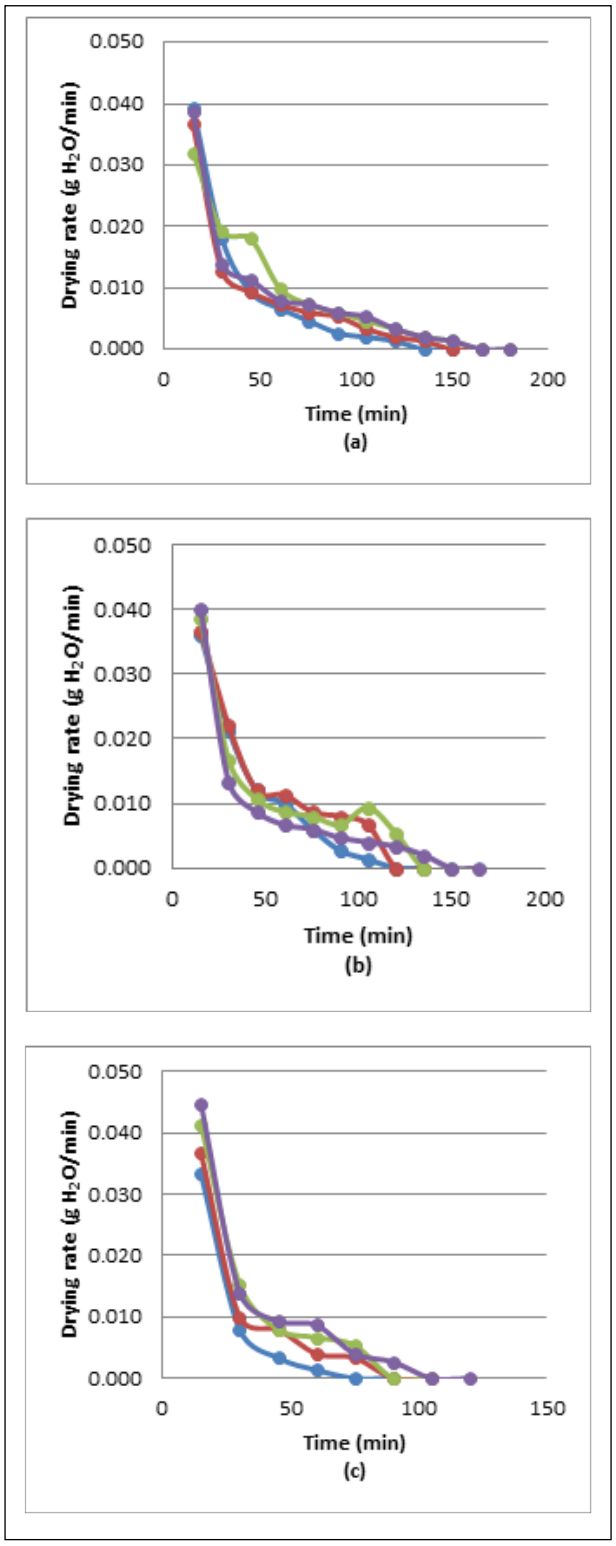

Fig. 3. Drying rate in drying kepok banana. Temperature: 70 oC (a), 80 oC (b) and 100 oC (c); Thicknes: 1 mm ( ), 2mm ( ), 3mm ( ) and 4mm ( ).

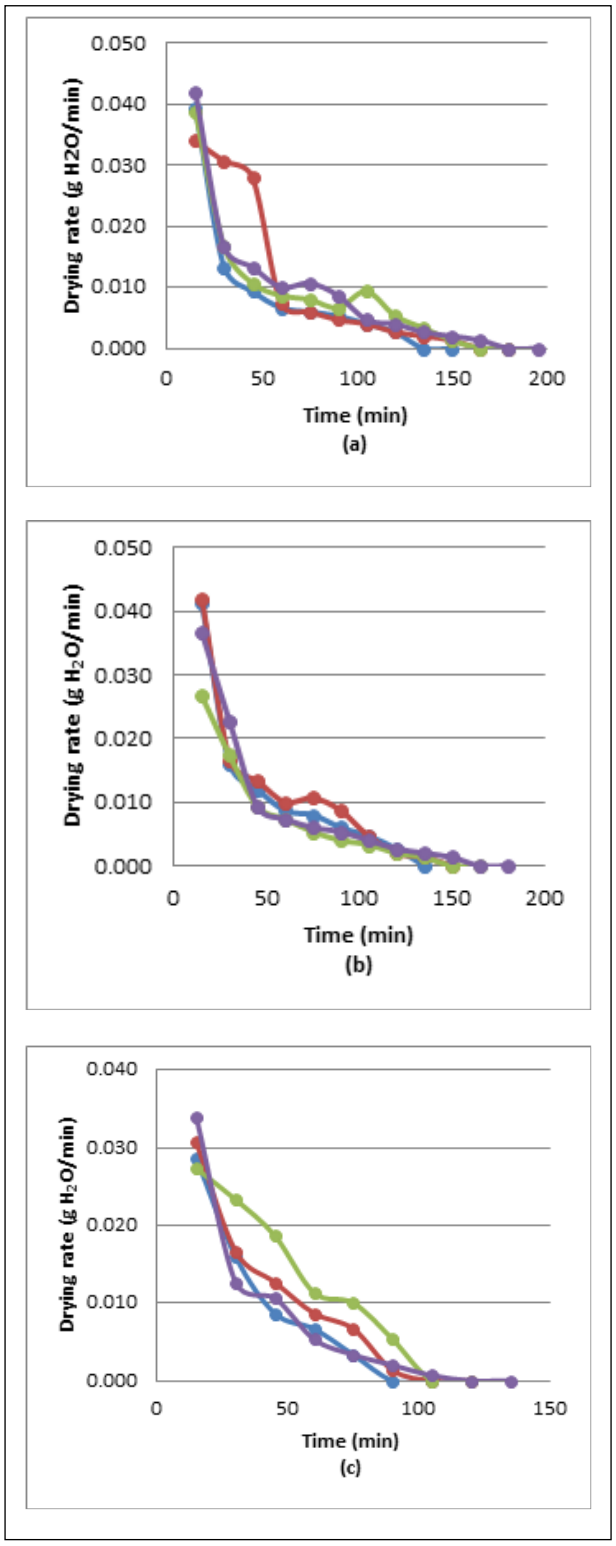

Fig. 4. Drying rate in drying kepok banana. Temperature: 70 oC (a), 80 oC (b) and 100 oC (c); Thicknes: 1 mm ( ), 2mm ( ), 3mm ( ) and 4mm ( ).

3.3 Structure Analysis

3.3.1 Organoleptic Test

From table 1, the organoleptic tests results on Kepok banana at temperatures of 70°C, 80°C and 100°C with 1mm, 2mm, 3mm and 4mm slice thickness was obtained. The banana produced at 70°C and 80°C possessed yellow colour, while 100°C had a slightly brown colour. This was because the temperature used was higher, therefore evaporation occured faster yielding a slightly brown colour. Furthermore, the resulting structure at a thickness of 1mm was not wrinkled, 2 mm and 3 mm were slightly wrinkled, while 4mm slice produced a much wrinkled shape. This was because, the moisture content evaporated during the drying process, which caused the structure of the banana solids to shrink.

The milk banana produced at temperature of 70°C and 80°C possessed yellow colour, while 100°C had a slightly brown colour. This was because the temperature used was higher, therefore evaporation occured faster yielding a slightly brown colour.

Table 1. Organoleptic test of dried banana

Temperature (°C)	Thickness (mm)			
	1	2	3	4
Kepok Banana				
70	3c	2c	2c	1c
80	3c	2c	2c	1c
100	3a	2a	2b	1b
Milk Banana				
70	3c	2c	2c	1c
80	3c	2c	2b	1b
100	3a	2b	2b	1b

Note: Structure:
1 = very wrinkled; 2 = slightly wrinkled; 3 = no wrinkled
Colour: a = dark brown b = slightly brown c = yellow

The resulting structure at a thickness of 1mm was not wrinkled, 2mm and 3 mm were slightly wrinkled while, 4 mm slices produced a much wrinkled shape. This was because the moisture content evaporated during the drying process, which caused the structure of the banana to shrink.

3.3.2 Banana Pores

From the results obtained, the pores produced after drying had a tighter structure compared to those that have not been dried. Furthermore, the structure of the kepok and milk bananas after drying appeared bigger compared to those yet to ge dried. This was because the moisture contained in the material has decreased, leading to an increased capillary pressure in the pore structure, therefore it shrinks and results to a larger pore structure. Meanwhile, the study carried out by Ricardo and Bruno produced the same pore structure, which was bigger [7].

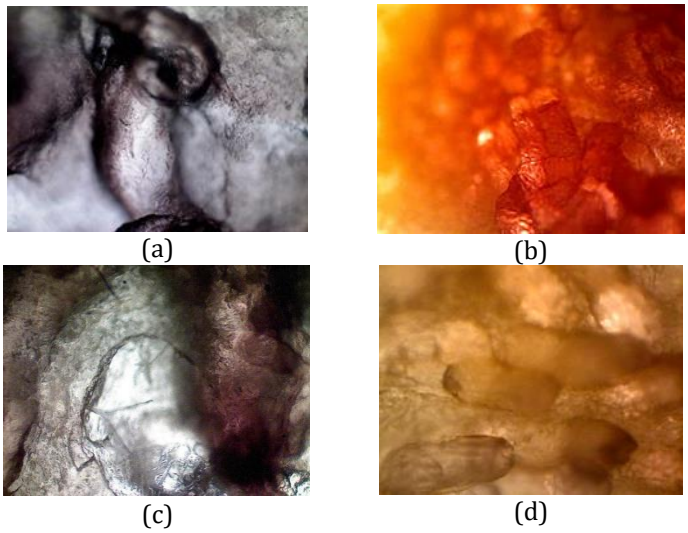

Fig. 3. Kepok (a, b) and milk (c, d) banana pores with 100x enlargement, (a, c) before drying and (b, d) after drying under oven temperature conditions of 100°C and a thickness of 1 mm.

4. Conclusion

From the results, it was concluded that the lowest moisture content and maximum drying rate obtained for Kepok bananas was at 100°C, i.e. 69.167% and 0.042gr/minute respectively, in 120 minutes, while for milk banana was at 100°C, i.e. 68.167% 0.042 gr/minute respectively, in 135 minutes. Furthermore, there was no difference in the drying rate of both bananas however, the kepok banana required 15 minutes drying time faster than the milk one. The pore structure observation of the two variables produced showed that it expanded after drying. This was because the moisture contained in the material decreased, leading to an increased capillary pressure in the pore structure therefore, it shrinks resulting to larger pore structure.

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