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Application of Foam Mat Drying Method for the Production of Instant Red Ginger Powder using Microwave

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ABSTRACT

Drying red ginger juice into instant powder is done to extend the shelf life of ginger which easily undergoes physical and chemical changes. This research aims to determine the characteristics of red ginger juice powder resulting from the foam mat drying method using a microwave. This research used a Completely Randomized Design method with two factors. Factor I is the microwave oven power (341 W, 364 W, and 466 W). Factor II is the concentration of maltodextrin (10%, 15%, and 20%). Data analysis used a two-way ANOVA test and continued with the DMRT test and scoring test. The results of the powder characteristics produce FM values (5.01 – 5.55); D (0.14 – 0.21 mm); yield (6.70 – 7.11%); powder moisture content (3.26 – 6.37%); brightness level (71.10 – 84.97); redness level (4.14 – 9.13); yellowness level (16.35 – 25.67); water absorption capacity (32.76 – 53.11) and solubility (99.93 – 99.99). Differences in microwave power affect the parameters of degree of fineness (FM), grain size (D), water content, brightness level (L), redness level (a), yellowness level (b), water absorption capacity, and solubility power. Differences in maltodextrin concentration affect the parameters of redness level and solubility. The best combination treatment is 343 W microwave power treatment with a maltodextrin concentration of 20%.

1. INTRODUCTION

Red ginger is one of the most popular varieties of ginger in Indonesia due to its high nutritional value (Aryanta, 2019). Based on data from BPS (2022), the production of red ginger in Indonesia in 2020 was 183.52 thousand tons and increased to 307.24 thousand tons in 2021. Ginger output increases year after year, providing an opportunity for ginger rhizome management to boost its selling value. The distribution process of ginger in fresh form has a higher damage rate because fresh ginger rhizomes have a moisture content of ±90% (Widyanti *et al*., 2021).

The drying of red ginger juice into instant powder is an example of proper post-harvest processing. Instant red ginger juice powder is one type of processed ginger obtained by drying ginger juice. One of the drying methods is microwave-based foam mat drying. Microwaves work by utilizing wave radiation, which is quickly absorbed by water molecules, resulting in faster water evaporation (Simanjuntak & Widyawati, 2022).

Mechanical drying has the advantage of being faster, which reduces energy use and saves money. Maltodextrin is a component used in the foam method. According to Srihari *et al*. (2010) maltodextrin has the advantages of being easily soluble in cold water, having a high solubility, and the ability to form films. Based on this explanation, research is required on the features of instant red ginger juice powder produced by the foam mat drying method with varying microwave power and maltodextrin concentration to determine the product quality.

2. MATERIALS AND METHOD

The main component was red ginger sourced from Tanjung Market in Jember Kidul, Jember Regency. The fillers used were maltodextrin and Tween 80 foaming agent. The chemicals used for analysis included distilled water. To make instant red ginger juice powder, a digital scale (Ohaus Pioneer), blender (Philips HR-2815/B), Cosmos CM-1279 mixer, spoon, basin, plastic container, filter cloth, glass cup, microwave (Panasonic NN-ST557M), food miller (Fomac FCT-Z300), Tyler standard sieve (Retsch AS 200 Basic sieve shaker), and plastic clips were used. Analytical tools utilized for analysis included an analytical balance, beaker glass, erlenmeyer, measuring cup, burette, spatula, petri dish, desiccator, filter paper, oven, aluminum cup, white HVS paper, CR-10 colorimeter, test tube, and centrifuge (DRE Centrifuge 781808N).

2.1. Research Procedure

The production of red ginger extract refers to the method (Heriyadi *et al*., 2024). The production of red ginger extract refers to the method (Purbasari & Putri, 2021) conducted by varying microwave power (343 W, 413 W, and 660 W) and maltodextrin concentrations (10%, 15%, and 20%). Red ginger juice was combined with maltodextrin and Tween 80 in a mixer for 10 minutes. The 400 g red ginger juice was poured onto a glass dish and placed in a microwave oven and dried at the specified power variations.

2.2. Analysis Method

2.2.1. Water Content Analysis

Moisture content was determined according to (AOAC, 1995) by heating an empty cup at 110°C for 15 min and cooling in a desiccator for 15 min (a). Powder sample was weighed ±5 g (b). The cup with the material was heated at 110°C for 6 h, then put in a desiccator for 15 min and weighed (c). Water content was calculated as follows:

$$\text{Water Content (\%wb)} = \frac{(b-a)-(b-c)}{(b-a)} \times 100 \quad (1)$$

2.2.2. Size Distribution Analysis

Particle size distribution was determined using a conventional Tyler sieve composed of 8 sieves ranging in size from 10, 12, 16, 20, 50, 60, 80, and 100 mesh and a pan. A 50 gram sample was introduced to the sieve and vibrated for 10 min. The fineness modulus (*FM*) and sieve grain diameter *D* (mm) were calculated as follows (Witdarko *et al*., 2019):

$$FM = \frac{\text{Total amount \% cumulative of retained material}}{100} \quad (2)$$

$$D = 0{,}0041(2)^{FM} \quad (3)$$

2.2.3. Yield Analysis

Yield is the final result derived using input over output processed. The yield was calculated as follows (Sari *et al*., 2019):

$$\text{Yield (\%)} = \frac{Final\ material\ weight(g)}{Initial\ material\ weight\ (g)} \times 100 \quad (5)$$

2.2.4. Color Analysis

Color measurement used the Hunter method. A white HVS paper was used as standard. The measurement was to obtain *L*, *a*, and *b* values. Δ*L*, Δ*a*, and Δ*b* values were calculated using the following formula (Bahanawan & Krisdianto, 2020).

$$\Delta L^* = L^* + L^*_s \quad (6)$$

$$\Delta a^* = a^* + a^*_s \quad (7)$$

$$\Delta b^* = b^* + b^*_s \quad (8)$$

where L^*, a^*, and b^* is respectively the value of brightness, redness, and yellowness, and subscript *s* stand for sample.

2.2.5. Analysis of Water Absorbency

The water absorption was measured by weighing a test tube (W_1) and adding 1 g of sample and 10 ml of distilled water (W_2). The sample was mixed for 1 minute and then set aside at room temperature for 30 min. The sample was centrifuged at 3,500 rpm for 30 min before discarding any leftover water that was not absorbed by the powder. Next, the test tube + material + water (W_3) was weighed and the water absorption value was calculated as the following (Rieuwpassa *et al*., 2013):

$$\text{Water Absorption (\%)} = \frac{(W_3 - W_1)}{W_2} \text{x}100 \quad (9)$$

2.2.6. Solubility Analysis

A 0.5 g sample was weighed and diluted in 50 mL of distilled water (W_1). The mixture was stirred to reduce the size of the sample so that it dissolved easily and filtered with filter paper of known weight. The unfiltered sample was placed for 1 hour at 105˚C, cooled in a desiccator for 15 minutes, and weighed (W_2). Solubility can be calculated by the following formula (Anam *et al*., 2020):

$$\text{Solubility (\%)} = \frac{W_1 - W_2}{W_1} \text{ x } 100 \quad (10)$$

2.3. Data Analysis

The findings from the combined treatment of microwave power and maltodextrin concentration are the average of three repetitions. The research data was tested using two-way ANOVA to determine the effect of the treatment combination. The analysis was carried out using Microsoft Excel 2021, followed by the DMRT test and scoring test.

3. RESULTS AND DISCUSSION

3.1. Water Content

The dried red ginger juice powder was measured for moisture content according to SNI standard. A low moisture content in a component can prevent bacteria and fungi from damaging the product (Purnomo *et al*., 2014). According to Figure 1, the measurement results show that the highest moisture content value is obtained from a combination of

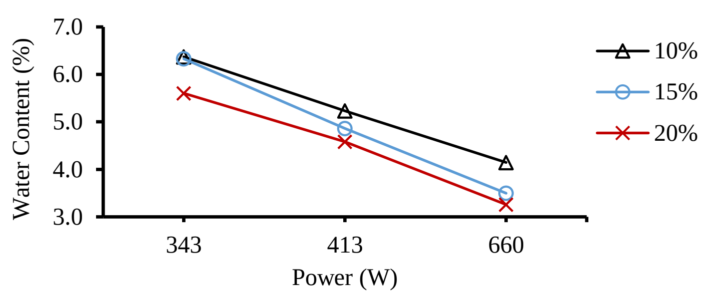

Figure 1. Correlation between moisture content and treatment combination

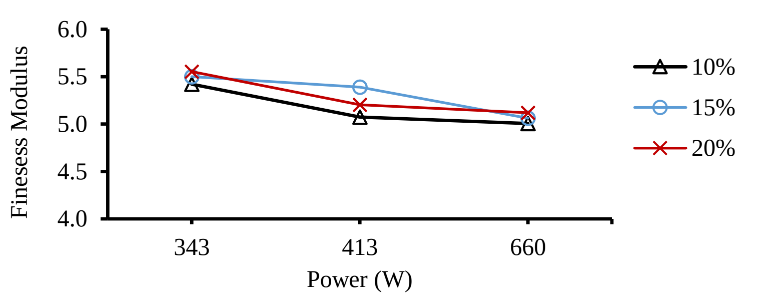

Figure 2. Correlation between fineness modulus (FM) and treatment combination

343 W power with 10% maltodextrin concentration at 6.37%, while the lowest moisture content value is obtained from a combination of 660 W power with 20% maltodextrin concentration at 3.26%. The amount of drying power utilized influences the water content, with higher power resulting in lower water content. This was in a line with study conducted by Wiyono (2017) who found that increasing the drying power will also reduce the moisture content of temulawak pollen.

3.2. Particle Size Distribution

Particle size distribution includes fineness modulus (FM) and grain diameter (D). The fineness of the material can be determined using sieves of various mesh sizes (Simatupang *et al*., 2021). According to Figure 2, the highest fineness modulus was achieved from the 343 W power treatment with 20% maltodextrin concentration of 5.55, while the lowest value was obtained from the 660 W power treatment with 10% maltodextrin concentration of 5.01. The drying power influences the fineness modulus, with higher drying power producing lower fineness values. The lower the FM value, the finer the grain size produced (Afrilia *et al*., 2023). The finer the material, the better the quality produced because materials with high fineness will be easy to handle in further production (Marta *et al*., 2017). The value of grain diameter (*D*) is related to the fineness modulus (*FM*).

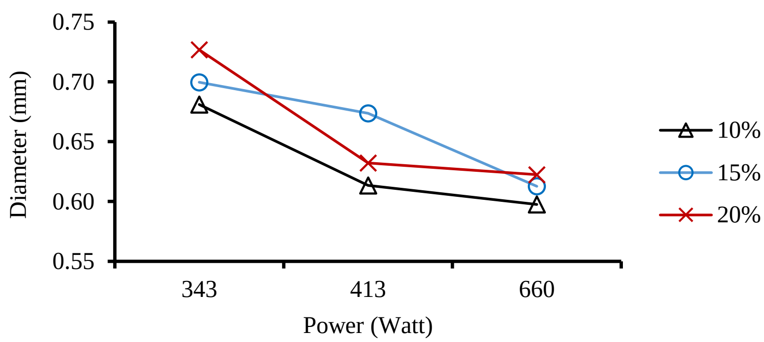

Figure 3. Correlation between grain diameter D (mm) and treatment combination

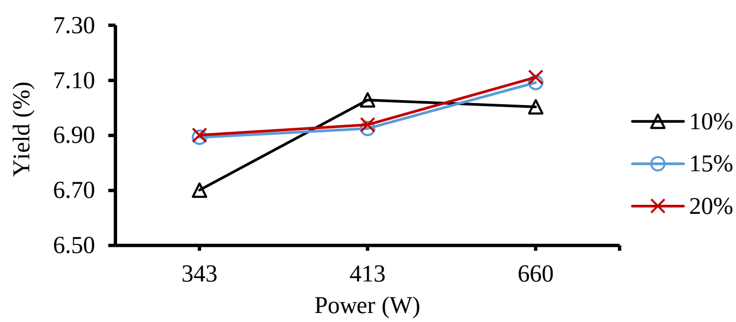

Figure 4. Correlation between yield and treatment combination

According to Figure 3, the largest grain diameter (D) value of 0.21 mm was obtained from the 343 W power treatment with 20% maltodextrin concentration, while the lowest grain diameter (D) value of 0.14 mm was obtained from the 660 W power treatment with 10% maltodextrin concentration. The drying power influences the granule diameter. The higher the drying power, the smaller the granule diameter. The grain diameter (D) and fineness modulus (FM) values are directly related (Purbasari & Putri, 2021).

3.3. Yield

The yield of red ginger extract powder obtained from the process over the amount of materials before drying. According to Figure 4, the highest yield value of red ginger extract powder was obtained from the treatment of 20% maltodextrin concentration with 660 W drying power of 7.11%, and the lowest yield value was obtained from the treatment of 10%

maltodextrin concentration with 343 W power of 6.70%. According to Furayda & Khairi (2023) yield is the powder resulting from the crystallisation stage of the ingredient solution, water, sugar, and maltodextrin.

3.4. Color

The color measurement parameters are divided into three: brightness level (*L**), reddish level (*a**), and yellowness level (*b**). According to Figure 5, the highest *L** value of 84.97 was obtained by combining 343 W power with 20% maltodextrin concentration, while the lowest *L** value of 71.10 was produced by combining 660 W power with 20% maltodextrin concentration. The higher microwave oven power caused a decrease in the color brightness of red ginger juice powder. This was in a line with study conducted by Purbasari *et al*. (2023) who found that the drying process using higher microwave power, the color of the resulting material in turmeric powder is darker. The value of *a** indicates the degree of redness of the red ginger juice powder.

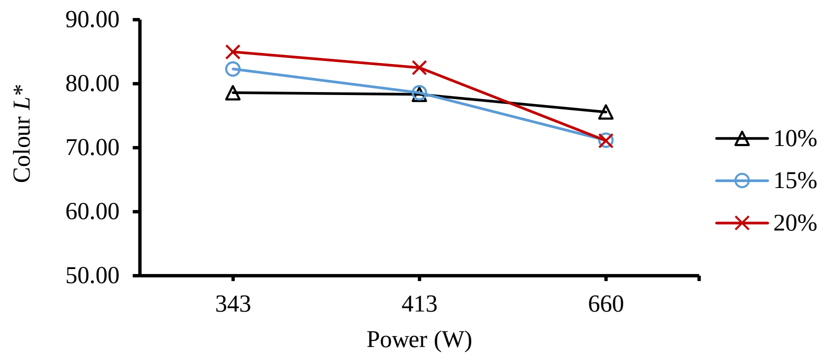

Figure 5. Correlation between colour (*L**) and treatment combination

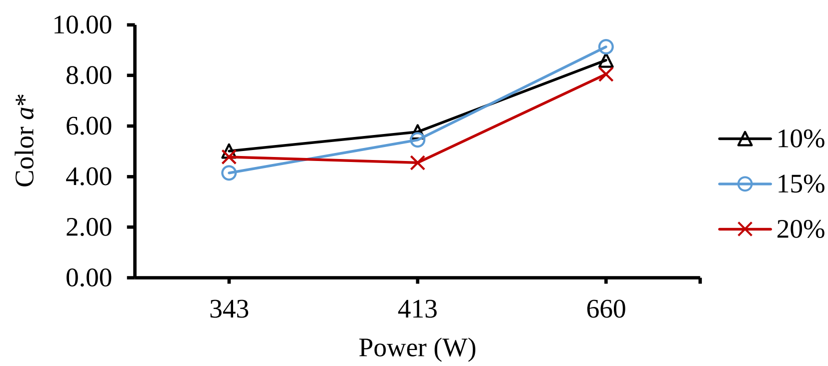

Figure 6. Correlation between color (*a**) and treatment combination

The maximum *a** value of 9.13 was obtained by combining 660 W microwave power with 15% maltodextrin concentration, while the lowest *a** value of 4.14 was produced by combining 343 W microwave power with 15% maltodextrin concentration (Figure 6). The higher microwave power in the drying process of red ginger juice produced powder with a high redness level. This was in a line with study conducted by Purbasari (2019) who found that the higher the drying temperature, the greater the value of a, indicating that the color of the product was close to red. A high concentration of maltodextrin could help to protect powder color during the drying process (Widyanti *et al*., 2021). The b value indicated the yellowness level of the material.

The highest yellowness value of 25.67 was obtained from the treatment of a combination of 413 W microwave power and 15% maltodextrin concentration, while the lowest value of 16.35 was produced from a combination of 343 W microwave power and 20% maltodextrin (Figure 7). The higher the microwave power in the drying process will result in a yellowness level of red ginger extract powder. This was in a line with study conducted by Purbasari & Putri (2021) who found that yellowness value will increase with higher microwave power.

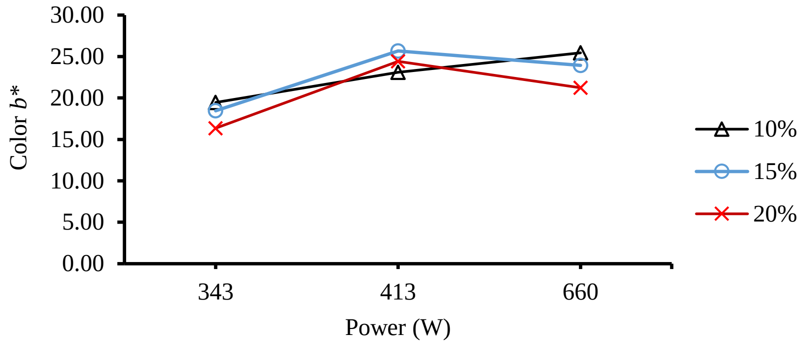

Figure 7. Correlation between color (*b**) and treatment combination

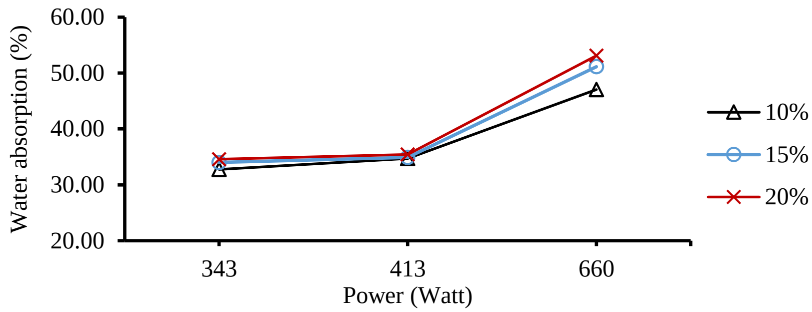

Figure 8. Correlation between water absorption and treatment combination

3.5. Water Absorption

Water absorption is the ability of red ginger juice powder to absorb water. According to Ulyarti *et al*. (2022) that water absorption is the ability of granules to absorb and bind water. According to Figure 8, the highest absorption value of 53.11 was obtained from the combined treatment of 660 W power with 20% maltodextrin concentration, while the lowest value was 32.76 from the combined treatment of 343 W power with 10% maltodextrin concentration. The value of water absorption increases along with the high microwave power used. This was in a line with study conducted by Purbasari (2019) who found that the drying temperature has a considerable impact on the water absorption of soy milk powder. The higher the water absorption of the material, the higher its quality since it can absorb water effectively (Purwanto *et al*., 2013).

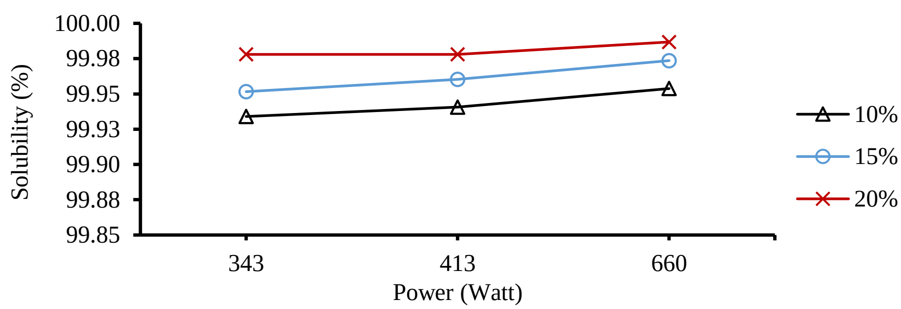

Figure 9. Correlation between solubility and treatment combination

3.6. Solubility

Solubility is one of the physical parameters carried out by putting the powder into water, then filtered using filter paper (Yuliawaty & Susanto, 2015). According to Figure 9, the highest solubility value was 99.99 from the combined treatment of 660 W microwave power with 20% maltodextrin concentration, and the lowest solubility value was 99.93 from the combined treatment of 343 W microwave power with 10% maltodextrin concentration. The solubility value increased with increasing drying power and maltodextrin concentration. This was in a line with study conducted by Yuliawaty & Susanto (2015) who found that increasing the content of maltodextrin has a substantial impact on the solubility of noni leaf instant drinks. The more fillers, the higher the solubility. Study by Pangesti *et al*. (2014) stated that water absorption and solubility have the same tendency to be directly proportional.

3.7. Statistical Analysis

The physical characteristics of instant red ginger extract powder are presented in Table 1 and Table 2. According to Table 1, microwave power treatment causes substantial differences in the following observation variables: fineness level, grain diameter, moisture content, brightness level (L*), redness level (a*), yellowness level (b*), water absorption (DSA), and solubility (DK). Table 2 shows that the observation variables of redness and solubility fluctuate significantly depending on the content of maltodextrin. This is showed by the value of the observation variable with various letter notations. Based on the scoring test for choosing the optimum treatment, the P1M3 (microwave power 343 W, maltodextrin concentration 20%) was selected as the best. The P1M3 and P2M3 treatments had the same total score of 15, but P1M3 was the superior treatment since it required less energy to use microwave power while using the same maltodextrin concentration. The total score results are shown in Table 3.

Table 1. Duncan test results of microwave power effect

Microwave Power	FM	D	KA	L	a	b	DSA	DK
343	5.49±0.36a	0.19±0.06a	6.10±0.57b	81.95±0.33b	4.64±0.63b	18.09±0.82a	6869±0.23a	99.96±0.03b
413	5.11±0.37a	0.16±0.03a	4.89±0.82a	79.80±0.03b	5.26±0.92a	24.39±0.83b	63.57±0.48a	99.96±0.03a
660	5.22±0.38b	0.15±0.05b	3.63± 0.61	72,61±0.68a	7.07±0.27b	23.54±0.04b	49.52±0.44b	99.93±0.03a

Note: Different lowercases imply significant different according to DMRT at 95% confidence level.

Table 2. Duncan test results of the effect of maltodextrin concentration

Maltodextrin Concentration (%)	Redness Level (a*)	Solubility
10	6.46±0.09a	99.93±0.03b
15	4.71±0.84b	99.94±0.04a
20	5.79±0.78a	99.96±0.02a

Note: Different lowercases imply significant different according to DMRT at 95% confidence level.

Table 3. Total scoring results based on observation variables

Treatment Combination	Average Score		Score		Total Score
	Redness Level (a*)	Solubility	Redness Level (a*)	Solubility	
P1M1	5.01	99.93	6	1	7
P1M2	4.14	99.95	9	4	13
P1M3	4.77	99.98	7	8	15
P2M1	5.77	99.94	4	2	6
P2M2	5.45	99.96	5	5	10
P2M3	4.55	99.98	8	7	15
P3M1	8.6	99.95	2	3	5
P3M2	9.13	99.97	1	6	7
P3M3	8.05	99.99	3	9	12

4. CONCLUSION

The combination of microwave power variation and maltodextrin concentration on the characteristics of instant red ginger juice powder was influenced by drying power on the parameters of fineness modulus (*FM*), grain diameter (*D*), moisture content, color (L*, a*, b*), water absorption, and solubility. Meanwhile, maltodextrin concentration affected the parameters of color (a*) and solubility. The physical characteristics of instant red ginger extract powder resulted in

FM (5.01-5.55); D (0.14-0.21 mm); yield (6.70-7.11%); powder moisture content (3.26-6.37%); brightness level (71.10-84.97); redness level (4.14-9.13); yellowness level (16.35-25.67); water absorption (32.76-53.11%) and solubility (99.93-99.99%). The best treatment based on the observation variables is the combination of 343 W microwave power treatment with 20% maltodextrin concentration.

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