Vol. 12, No. 1 (2023) : 28 - 38

DOI : http://dx.doi.org/10.23960/jtep-l.v12i1.28-28

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)

Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Drying Characteristics of Jelly Ear Mushroom (*Auricularia auricula*) Using Microwave Oven

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Article History :

Received : 19 June 2022
Received in revised form : 25 July 2022
Accepted : 26 July 2022

Keywords :

Mushroom,
Microwave,
Drying rate,
Fehydration ratio ,
Color change

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ABSTRACT

Jelly ear mushroom (Auricularia auricula) is easily damaged due to high water content of around 85-95%. Therefore, it is necessary to dry it to extend the its shelf life. The purpose of this study was to determine the drying characteristics and physical properties of jelly ear fungus from microwave drying. The treatment combined of blanching consisted of three levels (non-blanching, blanching 2 min, and blanching 5 min) and microwave power (422 W, 579 W, and 782 W). The research was designed randomly with 3 replications. The results showed that blanching treatments and microwave power could reduce the water content from the range of 86,23-88,39% (wet basis) to 6,65-7,89 % without blanching, 6,91-7,92 % with 2-min blanching, and 6,63 -8,54 % with 5-min blanching treatment. The drying rate increased with microwave power. Treatment of non-blanching with wicrowave power of 782 W resulted in the largest color change (ΔE), mamely 74.156, while 2-minute blanching with power of 422 W caused the lowest color change of 43,214. The highest rehydration ratio occurred in the 2-minute blanching treatment, but the rehydration ratio for non-blanching and 2-min blanching treatments tended to decrease as the microwave power increased.

1. INTRODUCTION

Ear fungus (*Auricularia auricula*) is a type of food that is quite popular with the public. As the name implies, this mushroom has a shape like an ear or auricle. Ear mushrooms have high nutritional and economic value. According to Asegab (2011) ear mushrooms are believed to be able to increase immunity, neutralize toxins, lower cholesterol, and improve blood circulation. Ear mushrooms have quite a lot of water content, around 85-95% (Kumar *et al*., 2013). This causes the mushroom to spoil quickly so that its shelf life becomes short. According to Syaiful & Hargono (2009), drying is one method that can be used to make food to a safe level for storage or for use in other processes. Drying can be done by natural drying and mechanical drying, such as using convection ovens, rack-type dryers, cylinder-type dryers (Lestari *et al*., 2020), microwave ovens, and others. Differences in the type of dryer and drying temperature can affect the quality of the food that is dried (Waluyo *et al*., 2021). The advantage of drying using a microwave is that drying can take place more quickly and the quality contained in the material is maintained (Fatimah, 2006).

The working principle of the microwave is by passing microwave radiation on water, fat, and sugar molecules found in food ingredients which will later be absorbed. This energy absorption process is called dielectric heating. The existence of an electric field that varies and is induced through the microwaves causes each side to rotate to align itself with one another. The movement of these molecules causes friction between molecules which creates heat (Saputra & Ningrum, 2010). The use of a microwave oven can speed up the drying process, minimize discoloration due to the heating process (Decareau, 1985), and maintain nutritional value so that it is expected to produce good quality dried ear mushroom products. On heating with microwaves, the heat obtained is generated in the interior of the material when polar molecules experience oscillations due to microwave emission. The heat spreads evenly throughout the material. With such a mechanism, the surface of the material does not experience intensive heating, so that heating can occur evenly throughout all parts of the food (Muchtadi & Sugiyono, 2013).

The drying process using a microwave oven is affected by the microwave power variable and the difference in blanching treatment. To the best of the author's knowledge, there is currently no research on the effect of blanching variations and microwave power on the quality of dried ear mushrooms. In order to obtain quality dried ear mushrooms, it is necessary to conduct research on drying characteristics and physical quality of ear mushrooms with variations in microwave power and blanching.

This study aims to study the drying process of ear mushrooms using a microwave oven, especially the characteristics of changes in water content, color, and rehydration ratio of dried ear mushrooms on differences in blanching treatment and microwave drying power. This research was limited to observing the physical quality of the ear mushrooms with differences in microwave oven power and blanching time in the form of water content, drying rate, color, and rehydration ratio of the dried ear mushrooms using a microwave oven.

2. MATERIALS AND METHODS

2.1. Tools and Materials

Research activities were carried out from December 2021 to February 2022 at the Agricultural Product Engineering Laboratory, Department of Agricultural Engineering, Faculty of Agricultural Technology, University of Jember.

The tools used in this research activity are: Sharp brand microwave oven; Daeyang brand convection oven; digital scales brand Ohaus Pioneer with an accuracy of 0.001 g and 0.01 g; Memmert brand waterbath; aluminum cups; glass cups; marker labels; clamp; desiccator; knife; spatula; measuring cup; white HVS paper; colorimeter CS-10; and stopwatch. The material used was ear mushrooms obtained from supplier in Rambipuji area, Jember, East Java.

2.2. Experimental Design

The study was conducted using a 3x3 factorial completely randomized design (CRD). The first factor was the pre-treatment of blanching (B), consisting of non blanching (B1), 2 minutes (B2), and 5 minutes of blanching (B3). The second factor was the microwave power (D) consisting of 422 W (D1), 579 W (D2), and 782 W (D3). The number of repetitions for each treatment combination was three times. Experimental data from each treatment were processed using the Microsoft Excel 2013 application to evaluate the correct modeling between experimental variables (pre-treatment blanching and microwave power) and to calculate the physical quality parameters of dried ear mushrooms (color and rehydration ratio).

2.3. Research Stages

The mushroom material is washed and then drained, after which it is reduced in size with a width of 1-1.5 cm. A number of samples of ± 200 g were blanched according to design (non blanching, 2 minutes, and 5 minutes). The prepared mushroom samples were then dried using a microwave at different power rates (422 W, 579 W, and 782 W). Drying uses two-minute time intervals, where every two minutes the material is lifted and turned back and forth so that the heat is evenly distributed. After that it is weighed to determine the reduced water content in the material. This step is repeated until the weight of the material is constant. The dried ear mushrooms were then measured for physical quality such as color and the value of the rehydration ratio.

2.4. Analysis Method

Parameters to be observed included water content, drying rate and physical quality of the mushroom including color (L, a, and b), and rehydration ratio.

2.4.1. Water Content (AOAC, 2005)

Initial water content was measured using the gravimetric method using an oven at 105 ° C. The value of the moisture content of the wet material was calculated using Equation (1) for wet basis (W_b) and Equation (2) for dry basis (W_d).

$$Wb = \frac{(m_b - m_c)}{(m_b - m_a)} \times 100\% \tag{1}$$

$$Wd = \frac{(m_b - m_c)}{(m_c - m_a)} \times 100\% \tag{2}$$

where m_a is weight of empty cup, m_b is weight of cup + material before drying, and m_c is weight of cup + material after drying.

2.4.2. Drying Rate

Drying rate can be defined as the amount of moisture evaporated per unit time. According to Brooker *et al.* (1992) drying rate can be calculated using Equation (3).

$$\frac{dW}{dt} = \frac{W_i - W_{i+\Delta t}}{\Delta t} \tag{3}$$

where dW/dt is drying rate (% db per minute), W_i is moisture content on the dry basis of the material at time i, $W_{i+\Delta t}$ is moisture content of the dry base material at time $i+\Delta t$, and Δt is difference in time (min), i = 1, 2, 3,… etc.

2.4.3. Color

Color measurement aims to determine the color properties of the ear fungus which is carried out using the Colorimeter CS-10. The color measurement step is to calibrate the colorimeter first, then shoot it on white paper and then shoot it at the sample at five different points and know the values of ΔL, Δa, and Δb. Calculations to find out the value of L, a, and b are done by using Equations (4) - (6).

$$L = \Delta L + Lt \quad (4)$$

$$a = \Delta a + at \quad (5)$$

$$b = \Delta b + bt \quad (6)$$

where L is color parameter between white on white paper, a is color parameter between red on white paper, and b is color parameter between yellow on white paper.

After the values of L, a, and b are calculated and known, then the total color change value (ΔE) is calculated using Equation (7). The value of L is between white (+100) and black (-100), a is between red (+80) to green (-80), and b is between yellow (+70) and blue (-70) (Sinaga, 2019).

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

2.4.4. Rehydration Ratio

The rehydration ratio was tested to determine the ability of the material to absorb water. The procedure carried out was to weigh ± 2 grams of dried ear fungus samples and put them in a test tube, then add distilled water (mL) until the sample material was submerged. Then the sample was put into a water bath at 90˚C for 15 minutes. After that, the sample was drained for 5 minutes and then weighed and expressed as a percentage of the increase in the weight of the dry matter (Argyropoulos *et al*., 2008). Rehydration ratio (*Rr*) was calculated from initial sample weight (m_i) and weight of sample after absorbing water (m_t) through Equation (8):

$$Rr = \frac{m_i}{m_t} \quad (8)$$

Table 1. Moisture content and drying duration of ear mushrooms

Treatment		Duration	Energy	Moisture content (% wb)	
Power (W)	Blanching	(min)	(J)	Initial	Final
422	*Non* Blanching	30	759.600	86.97	7.89
579		26	658.320	86.23	6.65
782		20	506.400	86.90	6.77
422	Blanching 2 min	30	759.600	87.69	7.92
579		24	607.680	87.69	6.91
782		18	455.760	86.70	7.51
422	Blanching 5 min	30	759.600	87.39	8.34
579		24	607.680	88.39	8.54
782		18	455.760	87.82	6.63

3. RESULTS AND DISCUSSION

3.1. Mushroom Drying

The drying process is carried out until the material reaches a moisture content of ≤10% wb. The results of drying the ear mushrooms in each treatment method can be seen in Table 1. It shows that the final water content was 6.65-7.89% wb in the non blanching treatment, 6.91-7.92 wt% in the 2 min blanching treatment, and 6.63-8.54 wt% in the 5 min blanching treatment.

Based on Table 1, it can be seen that the results of measuring the moisture content of the ear fungus during the drying process using a microwave oven can be seen that the greater the power used, the higher the energy required for drying. The higher the drying power, the more microwave output in the oven room so that it is easier to remove water from the ingredients more quickly (Widyasanti *et al*., 2019). In Table 1 it can also be seen that the blanching treatment resulted in a faster material drying time than without the blanching treatment.

3.1.1. Changes in moisture content during drying

The drying results showed that in all blanching treatments, increasing power resulted in the increase of drying rate. This can be seen on the graph by paying attention to the treatment combinations where line for the 782 W power treatment combination has a shorter line which stops at 18 and 20 minutes. The fastest decrease in water content occurred at a power of 782 W and the longest occurred at a power of 422 W. For example, by using power of 782 W and 5-min blanching treatment, an initial water content of 87.82% (wb) decreased to final of 2.95% (wb) within a duration of 26 min. On the contrary, 40 min was required to decrease the initial water content of 86.974% wb to final of 2.482%ww by using 422 W of power and the non-blanching treatment.

In the microwave oven drying process, the power factor greatly influences the drying process because the higher the power, the movement of the molecules causes greater friction between molecules, which will cause an increase in temperature (Hardiansyah, 2021). Increasing microwave power will produce greater heat and cause the water evaporation process to also increase, so that the water evaporation process will take place more quickly (Murthy *et al*., 2014). The decrease in water content during drying of the ear mushrooms is shown in Figure 1.

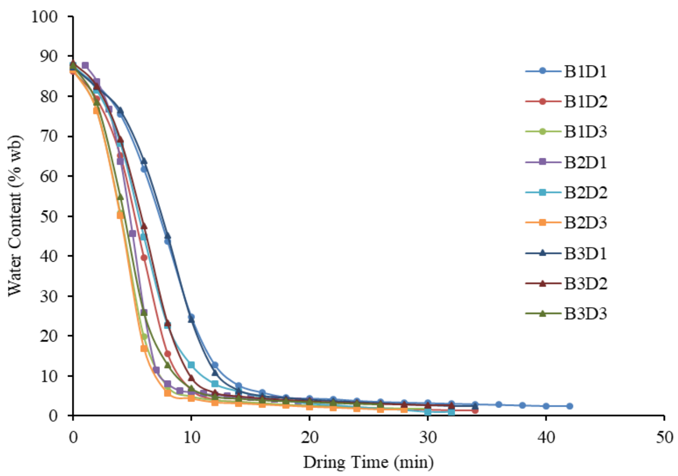

Figure 1. The decrease in water content of wood ear mushrooms at various capacities and blanching treatments

Based on Figure 1, it can be seen the changes in the water content of the ear mushrooms during the drying process were influenced by blanching treatments as well as the microwave power treatment. The longer the drying time, the water content in the material decreases and the speed of reduction of water in the material decreases. A decrease in water content will occur frequently with increasing drying time, with decreasing moisture content of the material, drying efficiency will also decrease (Amanto *et al*., 2015). The higher the microwave power , the shorter the drying time.

In the microwave oven drying process, the power factor is very influential on the drying process. Increasing microwave power will produce greater heat and cause the water evaporation process to also increase, so that the water evaporation process will take place more quickly (Murthy *et al*., 2014). The blanching treatment also affects the drying process because with the blanching process the evaporation process will be faster. This is in accordance with the statement of Widyasanti *et al*. (2019) that blanching provides an increase in cell permeability in the material, namely the pores of the material will open wider, so that evaporation of water from within the material can take place more quickly.

3.1.2. Drying rate

Drying rate can be defined as the amount of moisture evaporated per unit time. The drying rate will decrease as the water content decreases during drying because the amount of bound water decreases the longer it takes. The drying rate value can be calculated using Equation 3 by calculating the difference in dry basis moisture content (% db) divided by the drying time interval. A graph of the drying rate of the ear mushrooms with time in various blanching treatments can be seen in Figures 2 - 4.

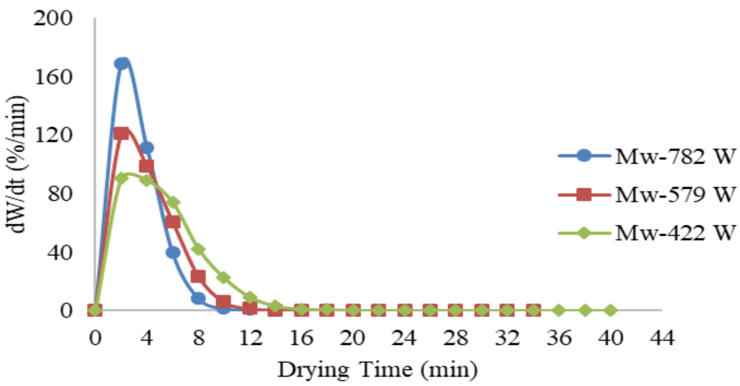

Figure 2. The relationship between the drying rate of the mushroom and the drying time in the non-blanching treatment and various microwave power

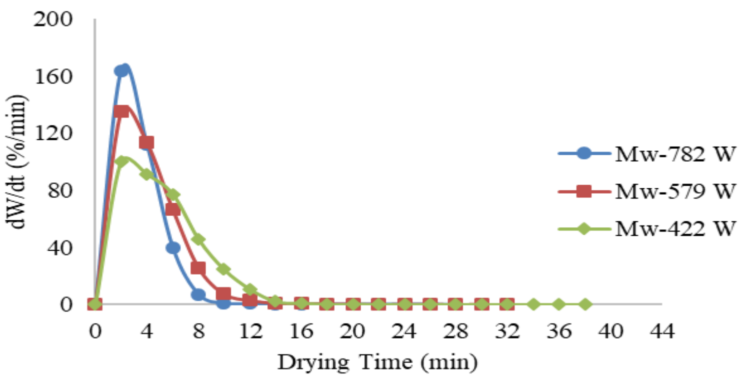

Figure 3. The relationship between the drying rate of the mushroom and the drying time in the 2-min blanching treatment and various microwave power

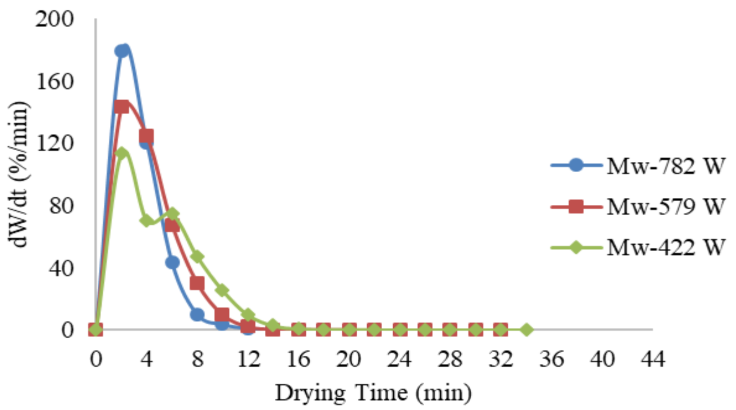

Figure 4. The relationship between the drying rate of the mushroom and the drying time in the 5-min blanching treatment and various microwave power

The graph shows that for all blanching treatments, the highest drying rate occurred at a power of 782 W and the lowest drying rate occurred at a power of 422 W. Of all the power treatments, the highest drying rate occurred in the 5-minute blanching treatment and the lowest drying rate occurred in the non-blanching treatment. This shows that the blanching treatment affects the drying process. According to Widyasanti *et al.* (2019) blanching provides an increase in cell permeability in the material, namely the pores of the material will open wider, so that the evaporation of water from the material can take place more quickly. Materials with blanching treatment have a higher drying rate than without blanching treatment.

The maximum drying rate occurs at the beginning of the drying process because when the water content is still high, the electromagnetic energy emitted and energy absorbed by the material causes the transfer of positive and negative charges on the molecules to take place quickly resulting in high enough heat and the ability to evaporate water quickly (Su'aidah *et al.*, 2014). The longer the drying process, the smaller the drying rate due to the reduction in water content. According to Amanto *et al.* (2015) a decrease in water content will occur frequently with increasing drying time, with decreasing moisture content of the material, drying efficiency will also decrease.

3.2. Physical characteristics of ear fungus

The drying process causes a change in the characteristics of the ear fungus, physical changes that can occur including color and rehydration ratio. Color is a parameter that can be seen directly and is quite important in the selection of food products. While the rehydration ratio relates to the ability of the material to absorb water again after the material is dried.

3.2.1. Color

The color change in the ear fungus was observed using a colorimeter that was fired at the material and yielded values of L, a, and b. Therefore, in this study observed the color change before and after the drying process. Color measurements were carried out to determine the effect of variations in the blanching treatment and microwave power on the drying process of the ear mushrooms. Parameter values L, a, and b can be used to calculate the color change value (ΔE). Figure 5 is a graph of the total color change value ΔE in each treatment.

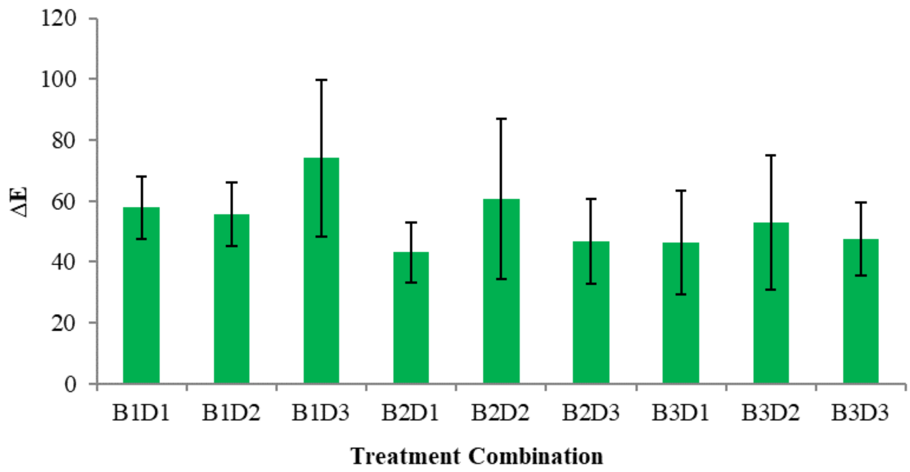

Figure 5. Comparison of ΔE color values before and after drying

Based on Figure 5, it can be seen that the value of ΔE is used to determine the level of color change of the mushroom from before drying to after drying. The value of ΔE in each treatment shows a different value. The resulting ΔE values ranged from 74.156 - 43.214 where the highest value occurred in the non blanching treatment and 782 W power (B1D3) with a value of 74.16 and the lowest value occurred in the 2 minute blanching treatment and 422 W power (B2D1) with a value of 43.21. This shows that the ear mushrooms that go through the blanching process have a smaller color change value than those that are not blanched. The greater the ΔE value, the color of the dried ear mushroom product is increasingly different from the initial conditions of the fresh material (Asgar *et al*., 2013).

The size of the value of the color change can be affected by the browning reaction because the color of the ear fungus becomes darker after drying. Browning reactions are divided into two, namely enzymatic and non-enzymatic reactions. The enzymatic browning process is caused by the activity of enzymes in fresh foodstuffs, such as fresh milk, fruits and vegetables. This reaction can occur when plant tissue is cut, peeled and due to mechanical damage which can cause damage to the integrity of plant tissue. This causes the enzyme to come into contact with the substrate which is usually the amino acid tyrosine (Blackweel, 2012). Meanwhile, non-enzymatic reactions are caused by browning reactions without the influence of enzymes, usually occurring during processing. In general, there are two types of non-enzymatic browning reactions, namely caramelization and Maillard reactions. The Maillard reaction is a reaction that occurs between carbohydrates, especially reducing sugars, and primary amine groups. The results of this reaction produce a brown material. Factors that can affect the Maillard reaction are temperature, sugar concentration, amino concentration, pH, and type of sugar (Arsa, 2016).

3.2.2. Rehydration Ratio

The rehydration ratio is the ability of a material to reabsorb water after it has dried. Rehydration ratio can be used to determine the quality of dry agricultural products. Cell wall elasticity and absorbency are important in heat-induced rehydration. The greater the value of the rehydration coefficient, the greater the ability of the dry product to absorb water and the better the level of elasticity of the cell wall, and vice versa (Asgar and Musaddad, 2006). The rehydration ratio measurement results of the ear mushroom products are shown in Table 2 and and graphically in Figure 6.

Table 2. Effect of treatment on the value of the rehydration ratio of dried ear mushrooms

Treatment		Time (min)	Rehydration Ratio
Daya	Blansing		
422 W		40	6.113±0.462
579 W	Non Blanching	34	6.051±0.302
782 W		30	5.588±0.319
422 W		38	6.626±1.373
579 W	2-min Blanching	32	6.399±1.033
782 W		28	6.193±1.073
422 W		34	5.816±0.378
579 W	5-min Blanching	32	6.542±0.512
782 W		26	5.527±0.168

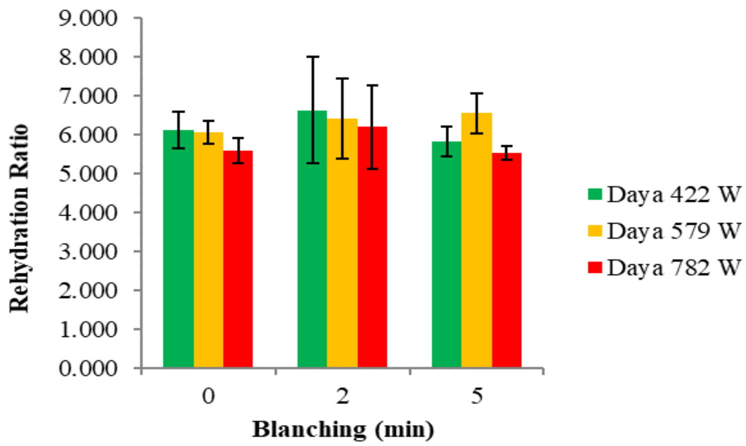

Figure 6. Rehydration ratio of ear mushroom in various treatments

Based on Figure 6, it can be seen that the value of the rehydration ratio is different in each treatment. The average value of the rehydration ratio in the blanching treatment was higher than without the blanching treatment, the highest rehydration ratio value occurred in the 2-min blanching treatment. Overall the highest rehydration ratio value occurred in the 2-min blanching treatment with 422 W power of 6.63 and the lowest value occurred in the 5-min blanching treatment and 782 W power of 5.53. This can be caused by the blanching treatment of the cell wall of the material which is already open and if exposed to excess heat it can cause the cell wall to be damaged. According to Asgar and Musaddad (2008) in general, excessive heat treatment will damage the osmotic properties of the cell wall and cell turgor which in turn will reduce the elasticity of the cell wall. Any treatment that affects the elasticity of the cell wall will affect the rehydration volume of the tissue. So it can be concluded that in the non-blanching and 2-min blanching treatments, the higher the power used, the smaller the rehydration ratio. However, in the 5-min blanching treatment there was a deviation at the power of 579 W where the value of the rehydration ratio was greater than the power of 422 W. This could be caused by the blanching treatment which caused differences in the permeability or elasticity of the mushroom cell walls which affected the water absorption process. The better the level of cell wall elasticity, the better the water absorption and the better the rehydration ratio (Nour *et al.*, 2011).

4. CONCLUSION

Based on the research that has been done, several conclusions can be drawn, namely:

1) The process of drying ear mushrooms using a microwave can reduce the water content from the range of 86.23-88.39 % (wb) to 6.65-7.89 % (wb) in the non blanching treatment, 6.91-7.92 % (wb) in 2-min blanching treatment and 6.63-8.54 % (wb) in 5-min blanching treatment. The fastest drying rate occurred at a power of 782 W for each blanching treatment.

2) The largest total color difference (ΔE) of the mushroom occurred in the treatment without blanching and the power was 782 W. The highest average rehydration ratio value occurred in the 2-min blanching treatment of 6.19-6.63. In research on the characteristics of drying ear mushrooms using a microwave oven, it is necessary to carry out further studies using different drying units and parameters so that it is expected to produce good quality dried ear mushroom products.

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