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Effect of Air Velocity and Grain Mass on Drying Rate of Inpari 42 Variety Grain Using Fluidized Bed Dryer

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ABSTRACT

Statistical data shows that rice production increases every period along with the increase in demand. Harvested paddy must be dried immediately to avoid damage due to microbial attack that can live in high moisture content. Therefore, the main objective of drying is to reduce the moisture content from the harvest moisture content (23-27%) to a safe moisture content for storage (14%). Currently, there are several dryers made as a solution in post-harvest handling of grains such as green beans, soybeans, grain and so on. One example of this dryer is the Fluidized Bed Dryer. This tool is a mechanical dryer that can be used in drying grain. The advantage of this tool is that the temperature can be controlled and can produce quality and uniform drying results. The purpose of this study was to determine the drying characteristics of Inpari 42 grain using a fluidized bed dryer. This research method uses speed variations of 1.5 m/s, 2.0 m/s, and 2.5 m/s with sample masses of 200 g, 250 g and 300 g, using a temperature of 55 °C. The research parameters include moisture content, drying rate, damaged grain. The drying process shows that the change in sample mass is influenced by the air velocity used. Along with the increase in moisture content, the drying rate will affect the rate of drying obtained in this study the drying rate pattern is decreasing. It can be concluded that air velocity affects the drying rate and air velocity affects the cracked grain.

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1. INTRODUCTION

The most essential staple food in many nations, particularly Indonesia, is rice. Because it is a daily food staple, rice holds great significance for the Indonesian people. As time goes by the amount of rice production increases from time to time so that the accumulation of rice production harvested by farmers. In the current era, the harvested rice is carried out post-harvest processing by drying. Drying aims to minimize transportation costs and reduce or reduce the value of water content from 23-27% to 14% so that grain can produce quality rice in accordance with the provisions of the quality value and can be stored with a long vulnerability.

One of the agricultural products that have not been efficient in post-harvest handling is grain. Grain itself is usually still found drying by drying it directly in the sun. Drying in this way is less effective and has several disadvantages including depending on the weather, the use of a large area, drying takes a long time, the product results are not uniform, and very easily contaminated with foreign objects. Effective drying should get a controllable heat temperature to get the water content that should be so that grain with good quality and quality is obtained.

Now in the era of technology and digitalization, it does not rule out the possibility of someone being able to make more advanced technology. Currently, there are several drying equipment made as a solution in handling post-harvest grains such as green beans, soybeans, grain and so on. One example of this dryer is the Fluidized Bed Dryer, this tool is present as a solution in handling grain drying. The advantage in using this tool is that the temperature can be controlled and can produce quality and uniform product drying results.

Based on the description above, the use of a mechanical dryer with the principle of fluidization is considered necessary because it can facilitate the grain drying process and can produce good grain according to the required quality.

2. MATERIALS AND METHODS

2.1 Study Area

This research was conducted at the processing laboratory of the Department of Agricultural Technology, Department of Agricultural Engineering, Faculty of Agriculture, Hasanuddin University, Makassar. Rice, with the Latin name *Oryza sativa* L, is an agricultural product from grains that we can find in almost all cities in Indonesia [1]. Rice plants can grow in places with high temperatures and long exposure to bright sunlight. The growth of rice is certainly influenced by planting temperature, length of sunlight, soil conditions, soil pH, soil sulfite content, and soil salinity. INPARI stands for Inbred Irrigated Rice Paddy, which is inbred rice grown in paddy fields. Inpari has 69 varieties, one of which is Inpari 42 (BBPADI, 2019). Inpari 42 Agritan GSR (Green Super Rice) is a rice variety designed to produce high yields under optimal and suboptimal conditions (limited water and fertilizer availability). Grain is some amount of rice grains separated from the stem through threshing [2]. Generally, harvested grain has a fairly high moisture content, ranging from 2–26%. Before storage, a post-harvest process is carried out on the grain with a drying method so that it can be stored longer [3]. The tool used in this research is a fluidized bed dryer. Data collection was carried out using measuring instruments such as a hygrometer, anemometer, desiccator, electric balance, stopwatch, aluminum foil, and oven.

2.2 Fluidized Bed Dryer

Drying is the process of using heat energy to remove moisture from food or to separate a relatively small amount of moisture from the original amount [4]. Drying grain itself is a process to reduce the amount of water content in the grain so that it can produce quality rice [5]. A fluidized bed dryer is a drying system that uses air velocity above the terminal velocity of the grain being dried so that the grain floats in the drying process. Fluidized bed dryers have a number of advantages, such as a rather high mass and heat transfer rate due to relatively good contact between the dryer and hot air, temperatures and humidity similar to others, a simple structure, and a high drying capacity [5].

2.3 Research Parameters

2.3.1 Moisture Content

In this research, the measurement of water content includes wet base water content (Kabb) and dry base water content (Kabk). The measurement of water content is carried out to determine the mass of a sample and the mass of water that has evaporated. Calculating water content using the formula:

Wet basis moisture content

$$Ka_{bb} = \frac{Wm-Wd}{wm} \times 100\% \tag{1}$$

Dry basis moisture content

$$Ka_{bk} = \frac{Wm-Wd}{Wd} + 100\% \tag{2}$$

where:

KAbb = Wet basis moisture content (%)
KAbk = Dry basis moisture content (%)
Wm = Initial weight of material (g)
Wd = Weight of solids in the material (g)

2.3.2 Drying Rate

The calculation of the drying rate is carried out to determine the drying rate given by the time interval (minutes) as for the equation that will be used as follows:

$$\text{Drying rate} = \frac{Wm-Wt}{Wd}\ X\ \frac{1}{t2-t1} \tag{3}$$

where:

Wm = Weight of water in the material (g)
Wt = Weight of material at time (g)
Wd = Weight of solid material (g)
t2-t1 = Change in time (hours)

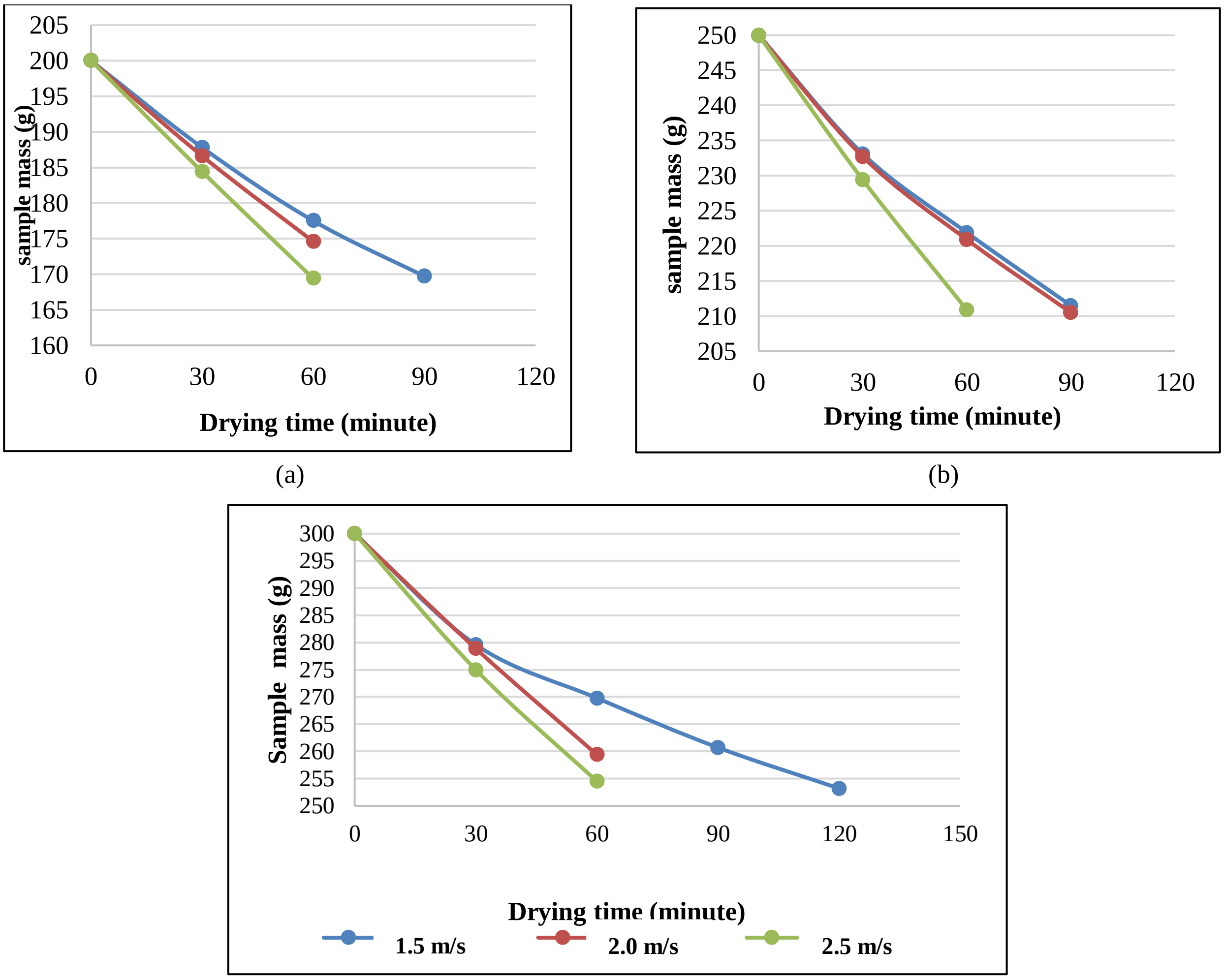
2.3.3 Broken Rice Grains

Head rice is healthy or deformed rice grains that have a size greater than 25% and smaller than 75% of whole rice grains. Observed by calculating the percentage of broken grain mass and sample mass.

$$\text{broken rice grains} = \frac{\text{broken rice grains (g)}}{\text{sample weight (g)}} \times 100\% \quad (4)$$

3. RESULTS AND DISCUSSION (10 PT)

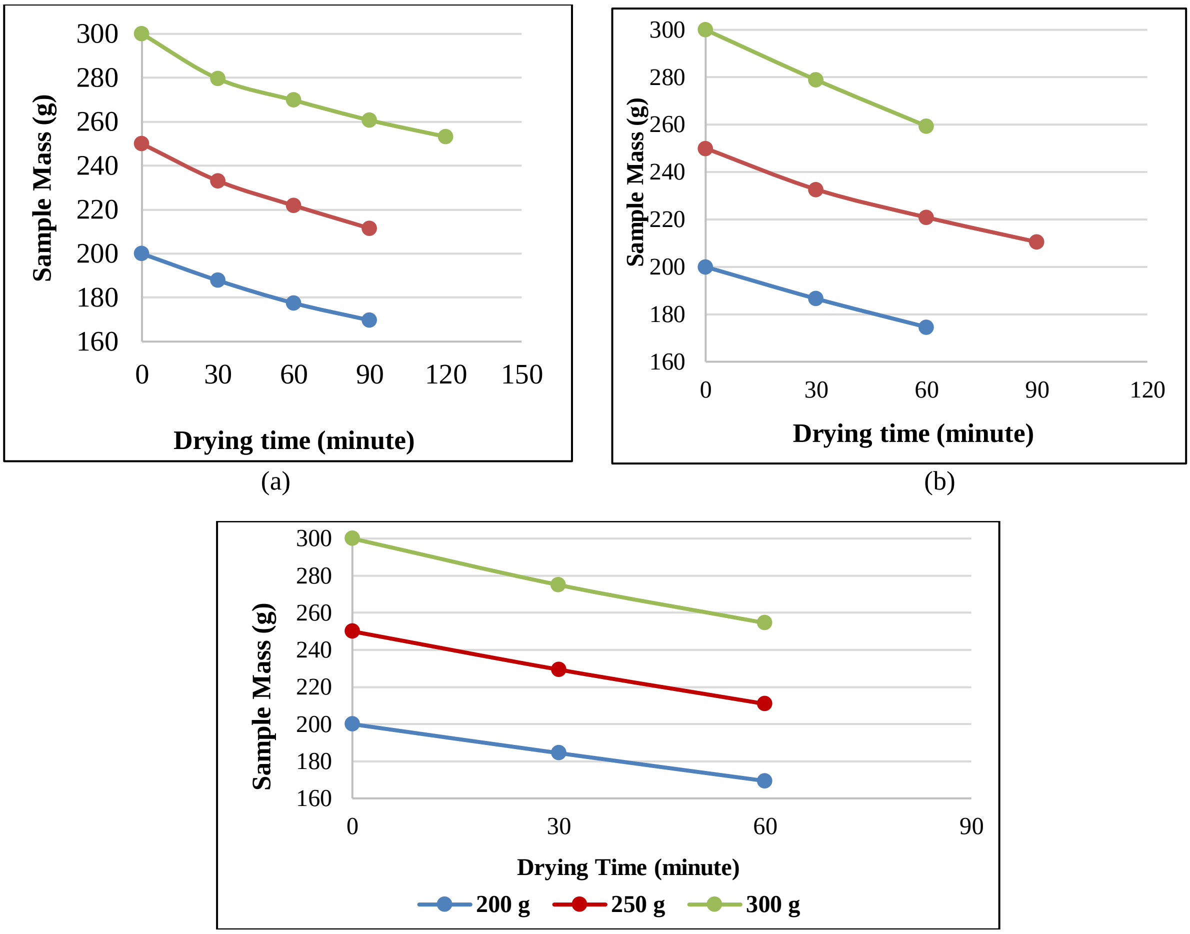
3.1. Mass loss of sample



(a) (b) (c)

Figure 1. Effect of air velocity on the change in sample mass during drying; (a) initial mass 200 g, (b) initial mass 250 g and (c) initial mass 300 g.

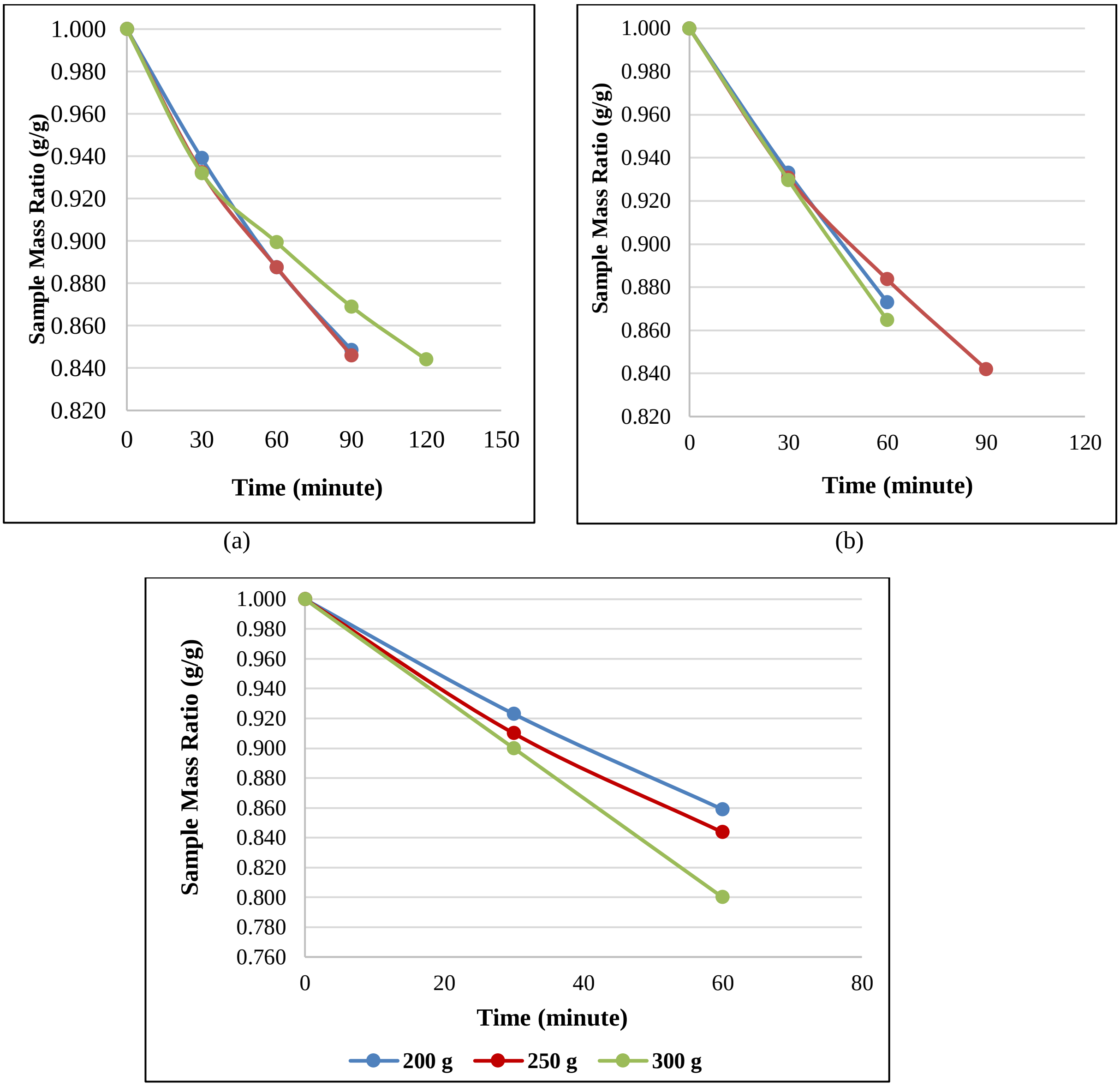
From the observation results can be seen in Figure 1 (a), (b), and (c) it is known that there is a decrease in mass in each sample. Where the 200 g sample decreased at a speed of 1.5 m/s until it reached 169.7 g and at a speed of 2.0 m/s until it reached 174.6 g, while at a speed of 2.5 m/s it decreased until it reached 169.4 g. Furthermore, the 300 g sample with a speed of 1.5 m/s, 2.0 m/s, and 2.5 m/s decreased to 169.4 g. Furthermore, in the 300 g sample with a speed of 1.5 m/s, 2.0 m/s, and 2.5 m/s, the results showed a decrease in the mass of the sample after drying to 253.2 g, 259.4 g and 254.5 g, respectively. The drying process has shown that the change in sample mass can be said to be influenced by the air velocity used. Where the greater the air velocity used, the greater the decrease in sample mass that will be produced. This is in accordance with the statement of [6] which states that the material will experience a decrease in sample mass during the drying process.



(c)

Figure 2. Effect of initial mass of the sample on the change in mass of the sample during drying; (a) 1.5 m/s speed, (b) 2.0 m/s speed, and (c) 2.5 m/s speed.

It can be seen in Figure 2(a) where the air velocity used is 1.5 m/s speed, the time to reduce the mass of the sample to the required time is 120 minutes, the longest is at a mass of 300 g. The other two masses only take 90 minutes. The other two masses only take 90 minutes. Furthermore, Figure 2 (b) with an air velocity of 2.0 m/s obtained the results of the longest sample mass reduction time which takes 90 minutes. This longest time is at a mass of 250 g while the other two sample masses only take 60 minutes until the desired mass is reached. Finally, in Figure 2(c), the time to reduce the mass of the sample to the desired mass takes 60 minutes evenly for all sample masses, namely 200 g, 250 g and 300 g. It can be seen from the three speeds above, it can be seen that the higher the air speed, the faster the decrease in sample mass. This is in accordance with the statement of Figiarto et al., (2012) [6] which states that the material will experience a decrease in sample mass during the drying process. At the beginning of the drying process the amount of water vapor evaporated is more than the next minute. The higher the temperature of the drying air, the greater the heat energy carried by the air so that the more the mass of the surface of the mass is dried. As for why at a speed of 2.0 m/s where the time required for a mass of 200 g for 60 minutes and a mass of 250 g for 90 minutes while the mass of 300 g takes only 60 minutes. In this graph there is something that looks odd, namely why the mass of 300 g is faster than the mass of 250 g while both use the same speed. This may be explained due to the influence of interstitial velocity, where what we know is that interstitial velocity is a measurement of how fast water flows through the media in a certain direction or in this case a shorter explanation is that the more closed the air flow pore, the more constant the airflow.

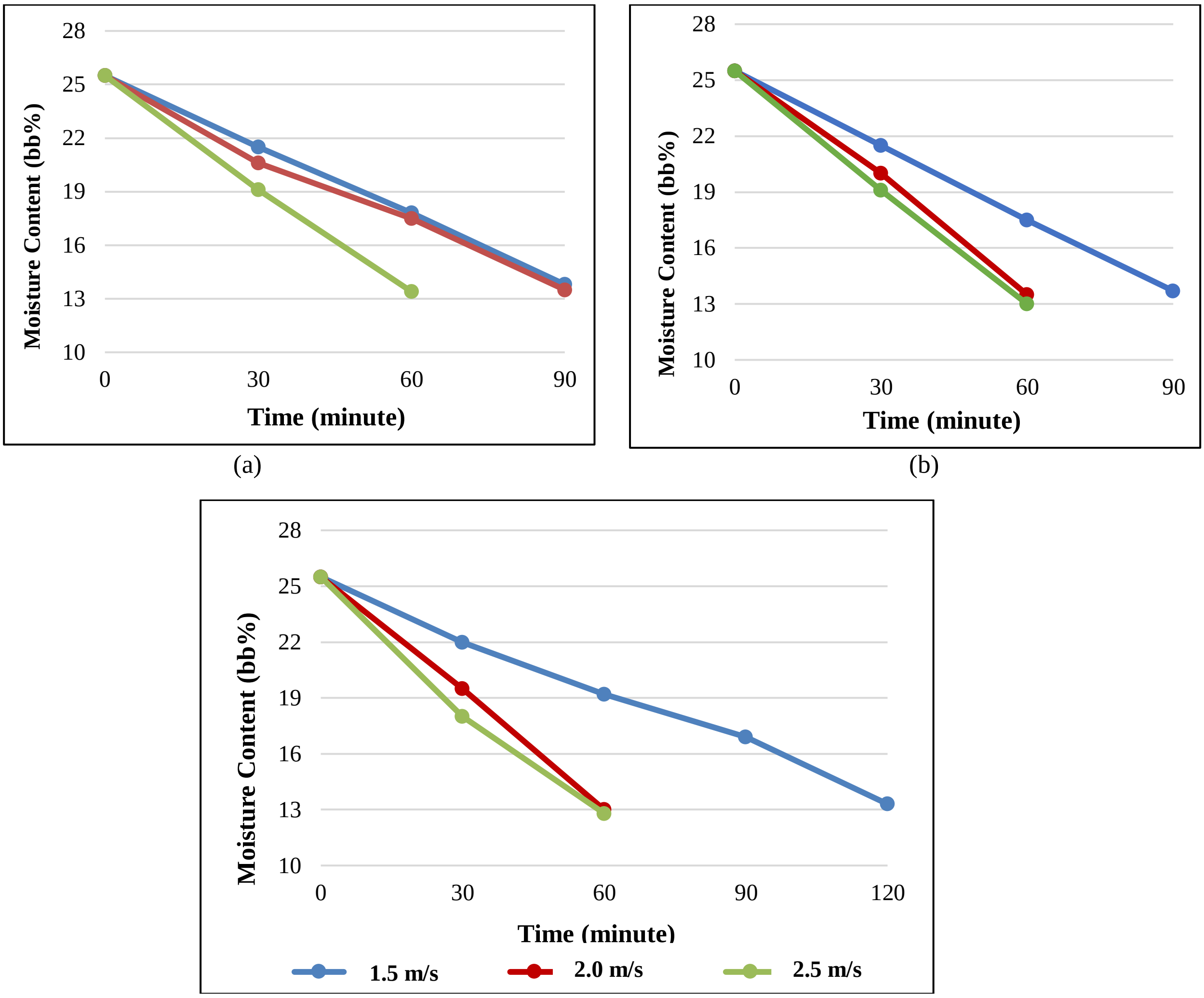


(c)

Figure 3. Effect of mass ratio on speed during drying; (a) speed of 1.5 m/s, (b) speed of 2.0 m/s, and (c) speed of 2.5 m/s.

From the observation results can be seen Figure 3 (a), (b) and (c) where in the picture has a speed of 1.5 m/s on the mass of 200 and 300 g takes 90 minutes while the mass of 300 grams, takes 120 minutes. Then in Figure 3(b) with a speed of 2.0 m/s at a sample mass of 250 g takes 90 minutes and at a mass of 200 and 300 g only takes 60 minutes. Then in Figure 3(c) it can be seen that each mass, namely 200, 250 and 300 g with a speed of 2.5 m/s, all only takes 60 minutes. This is because it is influenced by the air speed used. Although it has the same time in the three sample masses, the difference in the decrease in mass ratio and the resulting water content is different. Where at a mass of 200 g the final ratio of the sample mass is 0.859, then at a mass of 250 g is 0.844 and at a mass of 300 g is 0.800. The drying process requires heat to evaporate the water contained in the material and airflow is needed to transport the drying water vapor around the material to keep the relative humidity of the drying air low.

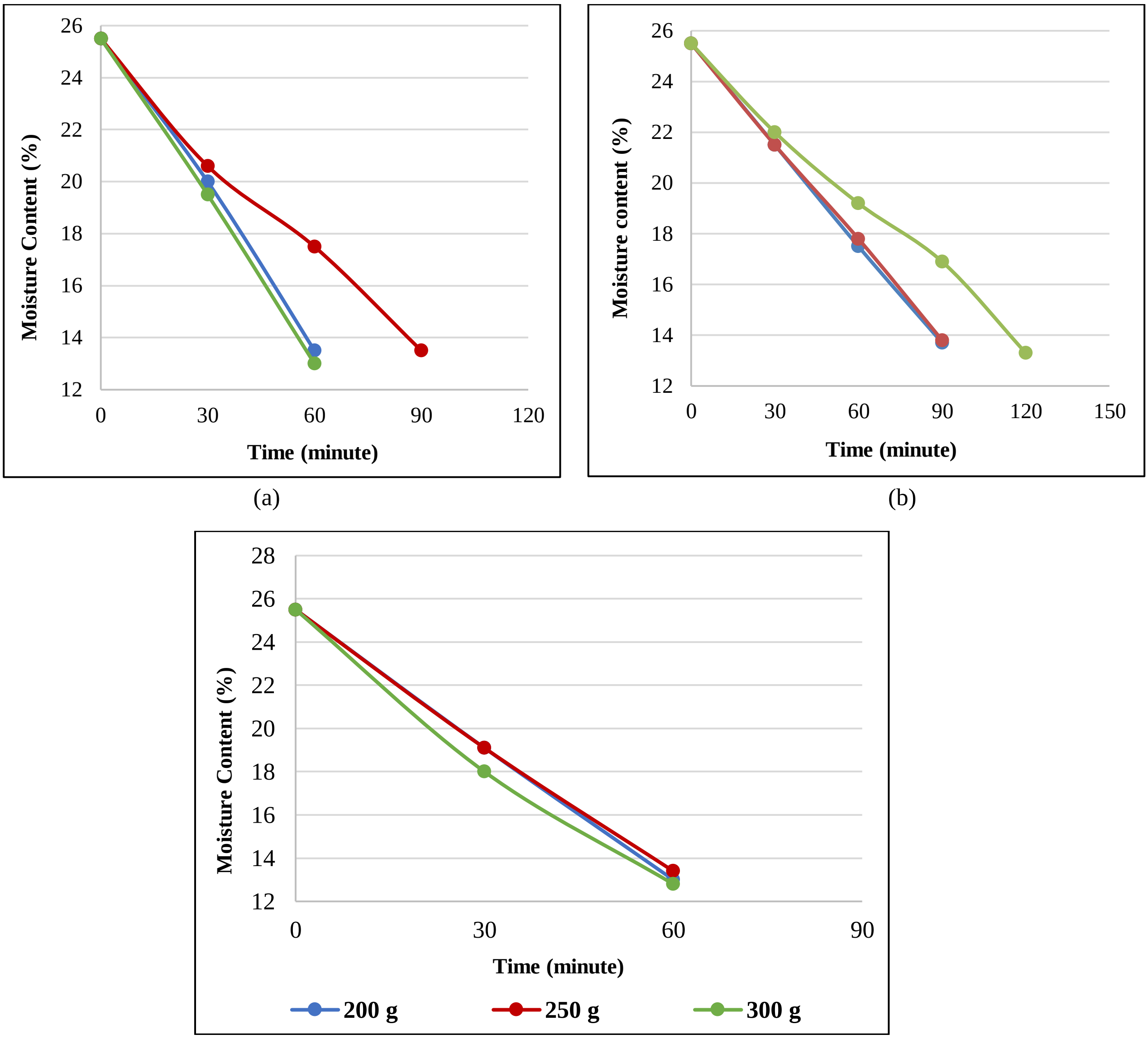
3.2. Moisture Content



(a) (b) (c)

Figure 4. Effect of decreasing moisture content on speed during drying; (a) 200 g mass, (b) 250 g mass and (c) 300 g mass.

From the observation of the 200 g sample mass, it is clear that the moisture content contained in the grain can be expressed as a percentage. Figure 4(a) shows that at an air velocity of 1.5 m/s, the pattern of decreasing moisture content continued for 90 minutes before the moisture content became 13.7%. At 2.0 m/s air velocity, it took 60 minutes to reach 13.5% moisture. Then it took 60 minutes to reach a moisture content of 13% with an air velocity of 2.5 m/s, the fastest drying process was drying at 2.0 m/s and 2.5 m/s. Because the higher the air speed during the drying process, the more water evaporates in the material. The air speed in the dryer affects the amount of water evaporation contained in the material [6]. Then in Figure 4(c) it can be seen that at a sample mass of 300 g with a speed of 1.5 m/s it takes 120 minutes to get the required moisture content while at a speed of 2.0 m/s and a speed of 2.5 m/s it only takes 60 minutes. The decrease in moisture content is caused by air speed and the length of drying time, causing the moisture content in the grain to decrease. The decrease in grain moisture content is influenced by the length of drying time, causing the moisture content in the grain to decrease [6].



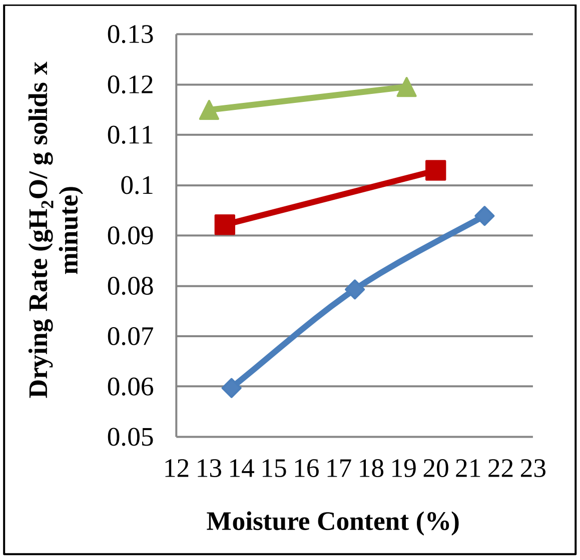
(a) (b)

(c)

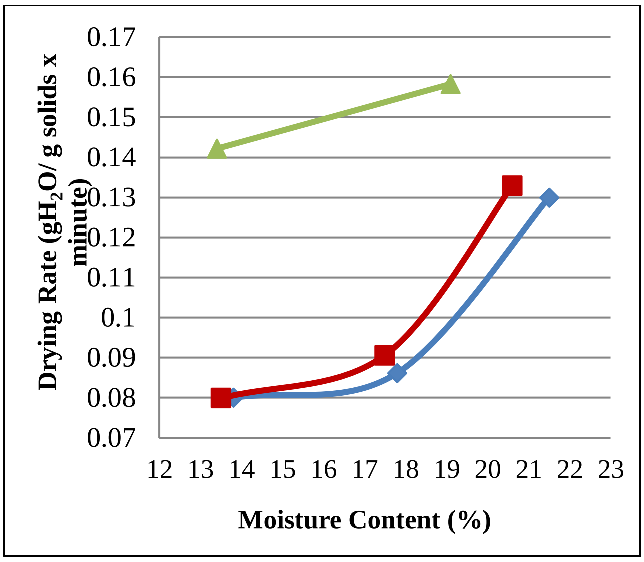
Figure 5. Effect of water content reduction on mass at velocity; (a) 1.5 m, (b) 2.0 m/s and (c) 2.5 m/s.

In Figure 5(a), (b) and (c) it can be seen that the decrease in water content obtained is different at each speed used. As in Figure 5(a) and 5(b) the longest time needed is different where in Figure 5(a) which takes 120 minutes the longest in the sample mass of 300 g and Figure 5(b) takes 90 minutes the longest in reducing the water content with a 250 g sample. Then at a speed of 2.5 m/s all masses, namely 200, 250 and 300 g, require the same time to reduce the water content, namely for 60 minutes. Although the time generated at different speeds and different masses is the same, the resulting water content is different, for example at a speed of 2.5 m/s although all of them take the same time but the decrease in water content obtained is different where the results obtained successively with a sample mass of 200, 250 and 300 g are 13%, 13.4% and 12.8%, it can be seen that although the time of decreasing the water content produced is the same but the difference in water content produced is different at different speeds, this has been explained in the decrease in sample mass.

3.3. Drying Rate



(a)



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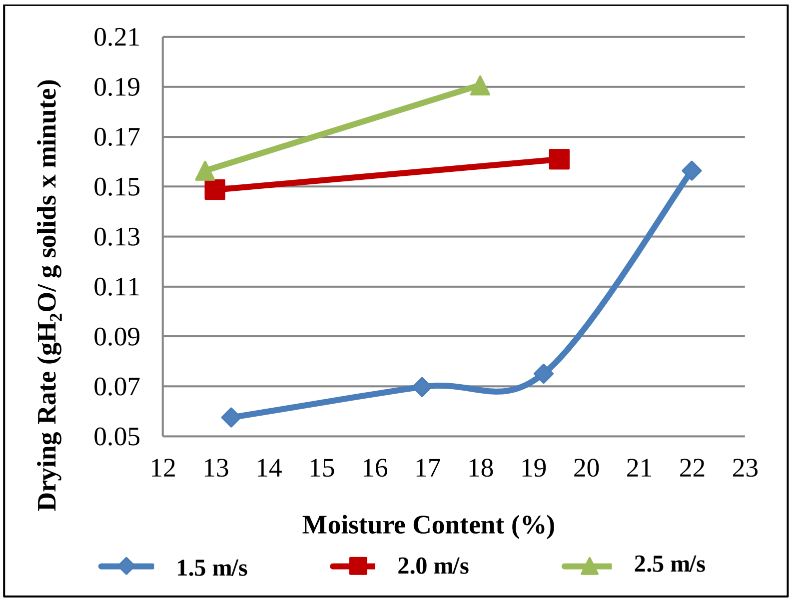

(c)

Figure 6. Graph of drying rate pattern against sample changes during drying; (a) 200 g sample, (b) 250 g sample and (c) 300 g sample.

From the results of the research on the effect of drying rate carried out on the sample mass of 200 g can be seen in Figure 6(a) and the sample mass of 250 g can be seen in Figure 6(b) while the sample mass of 300 g can be seen in Figure 6(c). In all pictures with each speed of 1.5 m/s, 2.0 m/s and 2.5 m/s. It can be seen and known that at the beginning of drying it is still the same, namely at the beginning of drying, the maximum drying speed is obtained compared to the next minute measurement. The higher the air speed, the faster it dries. The drying process there is heat transfer from the drying media to the dried material and mass transfer of water from the dried material to the drying media. The greater the drying air speed, the lower the relative humidity of the air [1].

3.4. Percentage of Cracked Rice

Different percentage results were obtained where at a speed of 1.5 m/s with a sample mass of 200 had a percentage of cracked seeds of 3%. At a sample of 250 g has a percentage of cracked seeds 4% and at a mass of 300 g the percentage of cracked seeds 6% for a speed of 1.5 m/s is still said to be safe because it has a percentage value still below 7%. Then at a speed of 2.0 m/s, the percentage results at a mass of 200 g are 5%, a sample mass of 250 g is 6% and a sample mass of 300 g is 9%. For a speed of 2.0 m/s, only the 300 g sample mass has an unsafe percentage of cracked seeds because it is above 7%. Then finally at a speed of 2.5 m/s, the percentage of cracked seeds obtained with a sample mass of 200, 250, and 300 g is 8%, 9%, and 10%, respectively. As for this speed, it can be said to be unsafe for the percentage of cracked seeds because it can be seen that the percentage of cracked seeds is not below 7%, this is influenced by the moisture content of the grain, if the moisture content is less or more than 13-14% it will increase the broken grains, so it can be seen that the high speed (2.5 m/s) in this drying system does provide a short drying time but it turns out that there is an increase in the number of broken grains and a decrease in the number of whole rice. The largest percentage of cracked grains in this study was obtained at drying rates of 2.0 m/s and 2.5 m/s with a percentage of damaged grains above 7%.

Grain and rice wholeness is very important considering that if it is not in accordance with the standard it will affect the safety of the product itself, especially when entering the storage process stage. The quality of grain in accordance with SNI standards has a maximum percentage value of damaged grains of 7% [7].

The DMRT test of the cracked seed research results in appendix 4 of the sample mass treatment section with the analysis of observation data conducted shows a significant DMRT test because the value produced by DMRT is below ($p>0.05$), therefore the treatment of sample mass on cracked seeds produces normal data because it is significant above 0.05. And then based on the results shown by the table in appendix 4, the air speed treatment section shows the results of the analysis of cracked seeds with the average value of speed showing there is a significant difference between cracked seeds and speed because it produces a significant value ($p<0.05$), followed by further tests with DMRT/DUNCAN obtained significant data.

From the comparison of this study with other studies, it can be said that this study is consistent with previous studies. Therefore, the research is feasible, but this does not use tempering until cracks appear in the research results obtained. The next research should use tempering to avoid cracking.

4. CONCLUSIONS (10 PT)

Based on the results of the study, the following conclusions were obtained:

1. The combination of air velocity and grain mass that provides the fastest drying time (60 minutes) is at an air velocity of 2.5 m/s with grain masses of 200 g, 250 g and 300 g. The combination of air velocity and grain mass that gives the longest drying time (120 minutes) is at an air velocity of 1.5 m/s with a grain mass of 300 g.
2. Air velocity of 2.5 m/s became the air velocity that produced the most cracking or cracked seeds with the percentage of cracked seeds all above 7%.
3. The air speed that is suitable for drying grain varieties of Inpari 42 in this study is the speed of 2.0 m/s with a mass of 200 g grain. Because the drying rate is fairly fast with the time required is only 60 minutes with the number of cracked seeds produced 5%.

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