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# Analysis of Demudification Drying of Peanut Seeds (*Arachis hypogaea* L.) and Identification of Seed Quality

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**ABSTRACT**

*One strategy to increase peanut production is to use good-quality seeds. The content of the seed determines the quality of the seed. Drying with low relative humidity can lower the drying temperature so that drying is done quickly and seed quality is maintained. This research was conducted to analyze the process and differences in peanut seed drying using dehumidifier drying and oven drying methods. Drying was carried out using a dehumidifier and oven drying machine at 30 °C, 40 °C, and 50 °C until the moisture content reached 9%, with observations every 30 minutes. Then the dried seeds were analyzed for their physical and physiological qualities. The results showed that the time needed for dehumidifier drying was faster than oven drying, with the details of dehumidifier machine drying at 30 °C, 40 °C, and 50 °C being 18.5 hours, 15 hours, and 10.5 hours. While drying in the oven at the same temperature, it takes 21 h, 17 h, and 12 h. From the results of the analysis of the physical quality of the seeds, the germination test, and the vigor test, it can be seen that dehumidifier drying gave the highest seed percentage results of 98%, 98%, and 88%.*

## 1. INTRODUCTION

Peanuts are a highly valuable food crop, both economically and nutritionally, particularly in terms of their protein and fat content. However, domestic peanut production in Indonesia has been unable to keep up with the demand. The productivity of peanuts in Indonesia is approximately 638,896 tons per year, while the demand for peanuts reaches around 816 thousand tons annually (Safira *et al*., 2017). Domestic peanut production is caused by several factors, such as seed quality (Dewi *et al*., 2018), soil conditions (Siregar *et al*., 2017), fulfillment of nutrient requirements (Samosir *et al*., 2019), and others.

One of the key factors influencing peanut productivity is the quality of the seed. To increase peanut production, the seeds used must be superior and of high quality. Seed quality comprises four essential components: physical quality, physiological quality, genetic quality, and seed health quality (Ningsih *et al*., 2018). The high physical quality of the seeds can be observed from their physical appearance, which should be clean, bright, plump, and uniform in size. Additionally, the physiological quality of a good seed can be determined by its viability, such as a high germination rate (>80%) and desirable vigor values, including rapid growth, uniform development, and extended shelf life (Kolo & Tefa, 2016). Seed quality and shelf life are influenced by the moisture content of the seeds. At the time of harvest, the moisture content of peanuts typically ranges from 35% to 50%. Under these high moisture conditions, the Aspergillus fungus can thrive and produce aflatoxins. In contrast, peanuts intended for use as seeds should have a moisture content around 9-12% (Dewi *et al*., 2018). The lower the moisture content of the seeds, the longer their shelf life will be. To reduce the moisture content of the peanut seeds, drying is typically done by exposing them to direct sunlight. This method is simpler and more cost-effective, but it requires 4-5 days to achieve a moisture content below 10% in the peanut seeds (Wahyuni *et al*., 2021).

Therefore, it is necessary to have an alternative drying method that does not depend on the season. One approach is to circulate hot air over the material to be dried, such as drying in an oven. The use of an oven can replace sunlight as a drying medium and is not affected by the weather. To optimize drying, various drying innovations are needed. One of them is a dehumidifier-based dryer, which was created to overcome the limitations of ovens that can only be temperature controlled. Besides being able to control the air temperature, a dehumidifier dryer is also designed to control the humidity in the room. A dehumidifier dryer is mechanical drying using a modified mechanical dryer, namely drying temperature and low RH (relative humidity) with the addition of a dehumidifier, a component that can reduce the moisture content in the air so that the humidity level becomes low through the dehumidification process. The mechanism of action involves a condensation process to remove moisture from the air. The way a dehumidifier works depends on the vapor compression refrigeration process because it uses an evaporator and condenser. The incoming air is flowed through the evaporator first to produce cold air with a high water vapor content, then the air is flowed back to the condenser. The condenser has the function of absorbing the moisture content of the air that has previously passed through the evaporator so that the resulting air tends to be warm and dry (Kurniawan *et al*., 2017). Dehumidifier dryers can dry products at low RH and temperatures (Susilo *et al*., 2012). In this research, to maintain the quality of peanut seeds, drying was carried out at three different temperatures, namely 30 °C, 40 °C, and 50 °C in a drying room. Drying rate and quality of peanut seeds (physical quality and physiological quality). Then this research aims to test the performance of a drying machine with a dehumidification process to dry peanut seeds.

## 2. MATERIALS AND METHODS

### 2.1. Tools and Materials

The tools and materials used in this research were a dehumidifier drying machine, a forced air oven (Memmert type UF30), digital scales, drying trays, paper straw, plastic, and peanuts (*Arachis hypogaea* L.).

### 2.2. Sample Preparation

Peanut (*Arachis hypogaea* L.) used for research material is cultivated by farmers in Batu City, Malang, East Java, with the Giraffe variety. The peanuts are purchased from the local market no later than two days after being harvested. The samples used for drying were 20 intact seeds. The purpose of using 20 seeds is to select seeds that are almost the same size. The initial moisture content of peanuts was determined wet at 53% which was measured using the oven method, drying at a temperature of 105 °C for 12 hours (Daud *et al*., 2019).

### 2.3. Drying Experiment

The research was conducted at the Mechatronics Laboratory, Department of Agricultural Engineering, Faculty of Agricultural Technology, Brawijaya University. The drying process was carried out using both an oven and a dehumidifier dryer. The peanut seed drying temperatures tested were 30°C, 40°C, and 50°C. The optimal temperature range for drying the peanut seeds was found to be 45-50°C (Corbin, 2019). The drying process was continued until the peanut seeds reached a moisture content of 9%, with measurements taken every 30 minutes. For each drying temperature and method (dehumidifier drying and oven drying), 20 whole peanuts were dried. The temperature and relative humidity were monitored using a DHT22 sensor placed at six different locations within the dehumidifier dryer system: the ambient air, the dehumidifier unit, the air outlet after the dehumidifier unit, the air outlet after the heat recovery unit, the drying chamber, and the air outlet after the drying chamber, as depicted in Figure 1.

- **Box Control**

The control box is used as a place for electronic components for the control system. This part is made of black acrylic with dimensions of 27 cm × 24 cm × 24 cm and 2 mm thick. In the control box there are components for Arduino Mega, Arduino Uno, RTC DS3231, SD card module, 1 channel relay, cables, 16×2 LCD, and I2C LCD. The temperature and humidity value data from the DHT22 sensor readings is displayed on the 16×2 LCD

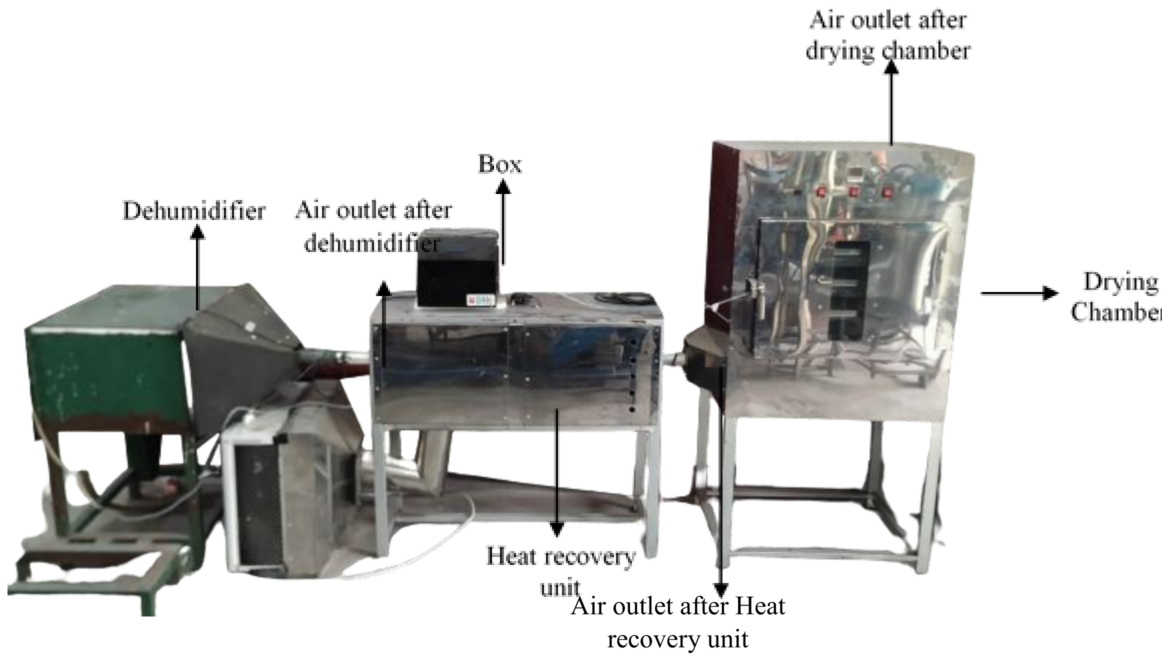



Figure 1. Dehumidifier drying machine used during experiment.

- **Dehumidifier Unit**

The components used in the dehumidifier room include the air inlet, evaporator, condenser and fan. The inlet air channel functions to channel air from the environment and drain condensation water. This channel is located at the back and bottom of the funnel-shaped condensation chamber. The evaporator is used to reduce the temperature and increase the RH (relative humidity) of air from the environment. The fan is used to circulate air with low RH and temperature as a result of the condensation process. The condenser is used to change the refrigerant liquid from vapor to liquid phase and remove heat.

- **Heat Recovery Unit**

This section aims to increase the temperature of the condensed air so that minimum heat is wasted into the environment. This temperature increase uses a heat exchanger so that the condensation air is not mixed with outside air whose RH is still high.

- **Drying Chamber**

The previous air flow enters the drying room with a low RH to facilitate the drying process and maintain good seed quality. The drying room is also equipped with a blower to remove excess hot air and there are three shelves to accommodate samples. Air flows from the bottom rack to the top rack. The size of each rack is 90 cm x 42 cm.

### 2.4. Drying Rate

The drying rate is observed to determine the drying process of the material being dried. The drying time series is calculated by dividing the difference between the initial weight and the final weight of the material by the difference between the initial and final drying times as in the following formula:

$$\acute{m}_d = \frac{Wo - Wf}{t} \tag{1}$$

where *Wo* is sample weight before drying (g), *Wf* is sample weight after drying (g), and *t* is drying time (min).

### 2.5. Seed Quality Test

Physical and physiological quality of seed was observed. The physical quality test is carried out by separating intact seeds from damaged seeds and then calculating the percentage. While the physiological quality test was carried out by the germination test and vigor test. Germination test using the rolled paper test method established in plastic (UKDdp), where the seeds are placed on sheets of paper (3–4 sheets) moistened on transparent plastic. Observations were made based on the percentage of total normal sprouts on the 7th day after planting. Testing the vigor of seeds was carried out using the Accelerated Aging Test (AAT) method and observed on the 7$^{th}$ day after planting (Ernawati, 2012). This method is carried out by oven at 40°C and 100% relative humidity for 72 hours (Barrozo *et al*., 2005). The seeds are placed in gauze which is inserted into the top of a plastic box containing 40 ml of water. The AAT method tests seeds with two environmental variables, namely temperature and high relative humidity which causes seed damage more quickly. Seeds with high vigor will withstand extreme conditions, seed damage will occur slowly, and germination will be higher than seeds with low vigor. After the oven, the germination of the seeds is tested for germination using the rolled paper set up in plastic (UKDdp) test method and the percentage of normal sprouts is calculated.

## 3. RESULTS AND DISCUSSION

### 3.1. Temperature and Relative Humidity

Table 1 presents the distribution of temperature and relative humidity data collected from the data acquisition system during the drying process. The data was recorded at six observation points: 1) ambient; 2) dehumidifier units; 3) air outlet after dehumidifier chamber; 4) air outlet after heat recovery unit; 5) drying room; and 6) air outlet after drying chamber. The observations were continued until the peanuts reached a moisture content of 9%. The average drying temperature at 30°C was 31.09±1.19°C; at 40°C was 44.24±3.95°C; and at 50°C was 52.11±1.85°C. The relative humidity in the drying chamber at 30°C, 40°C, and 50°C was 34.40±3.02%, 37.76±3.61%, and 28.00±2.18%, respectively. This humidity level was lower than the ambient humidity. In the drying chamber, the temperature that occurs is different from the setting temperature. This is because during the drying process, the air temperature entering the chamber is not constant, in accordance with the literature, which says that changes in temperature and humidity in the environment often occur during drying, which causes the temperature and RH in the chamber to change dryer is not constant (Muliyani *et al*., 2021). Then the position of the sun and the weather also affect the increase and decrease in room temperature (Sarinda *et al*, 2017).

Table 1. The distribution temperature and relative humidity

| Position | Temperature Setting 30 °C | | Temperature Setting 40 °C | | Temperature Setting 50 °C | |
|---|---|---|---|---|---|---|
| | Temp (°C) | RH (%) | Temp (°C) | RH (%) | Temp (°C) | RH (%) |
| Ambient | 28.43±1.90 | 69.67±1.07 | 29.50±1.62 | 65.21±3.72 | 29.49±1.54 | 68.68±4.00 |
| Dehumidifier unit | 13.88±0.52 | 89.67±1.84 | 15.81±0.92 | 89.25±2.14 | 15.97±1.78 | 93.69±1.87 |
| Air outlet after dehumidifier unit | 12.03±0.75 | 89.48±0.87 | 15.97±1.76 | 91.95±2.29 | 15.24±2.39 | 91.58±0.84 |
| Air outlet after heat recovery unit | 21.73±1.37 | 56.78±3.26 | 22.63±1.87 | 64.28±3.75 | 22.85±2.90 | 64.42±4.21 |
| Drying chamber | 31.09±1.19 | 34.40±2.74 | 44.24±2.95 | 37.76±3.61 | 52.11±1.82 | 28.00±2.18 |
| Air outlet after drying chamber | 48.42±4.06 | 27.19±1.37 | 50.73±3.68 | 26.31±3.09 | 59.71±2.86 | 18.50±1.13 |

Note: Temp = temperature; RH = relative humidity

### 3.2. Moisture Content and Mass Reduction

From Table 2 below, it can be seen that the final water content of the ingredients at temperatures of 30 °C, 40 °C, and 50 °C was 9.30%, 9.22%, and 9.16%, respectively, with an initial moisture content of 53.26%, 53.4%, and 53.01%. The time required to reach the final moisture content at 30 °C, 40 °C, and 50 °C is 18.5 hours, 15 hours, and 10.5 hours, respectively. From these results, it can be seen that the temperature affects the drying time. Of the three temperatures, the highest temperature of 50 °C requires the fastest time when compared to the other three temperatures. This indicates that when the temperature is increased in the dryer or other drying processes, the time required to remove moisture from a material or product will decrease. An increase in temperature causes the water molecules in the material to become more active and have a higher kinetic energy, making it easier for them to evaporate more quickly (Rahayuningtyas & Kuala, 2016).

Table 2. Average final mass, final water content as well as the time required for dehumidifier drying

| Temperature (°C) | Initial mass (grams) | Final Mass (grams) | Initial Water Content (%) | Final Water Content (%) | Drying time (hours) |
|---|---|---|---|---|---|
| 30 | 12.39 | 6.39 | 53.26 | 9.30 | 18.5 |
| 40 | 11.54 | 5.97 | 53.04 | 9.22 | 15 |
| 50 | 11.69 | 6.05 | 53.01 | 9.16 | 10.5 |

Table 3. Average final mass, final water content as well as the time required for oven drying

| Temperature (°C) | Initial mass (grams) | Final Mass (grams) | Initial Water Content (%) | Final Water Content (%) | Drying time (hours) |
|---|---|---|---|---|---|
| 30 | 12.26 | 6.35 | 53.01 | 9.36 | 21 |
| 40 | 11.05 | 5.73 | 52.99 | 9.33 | 17 |
| 50 | 11.43 | 5.95 | 52.78 | 9.32 | 12 |

Furthermore, from Table 3, in oven drying, the final moisture content of the material at temperatures of 30°C, 40°C, and 50°C was 9.36%, 9.33%, and 9.32%, respectively, with an initial moisture content of 53.01%, 52.99%, and 52.78%. The time needed to reach the final water level at 30 °C, 40 °C, and 50 °C was 21 hours, 17 hours, and 12 hours, respectively. The results showed that temperature affects drying time. Of the three temperatures, the highest temperature of 50 °C requires the fastest time when compared to the other three temperatures. However, when compared to drying a dehumidifier, the time needed to dry in an oven is longer, while drying with a dehumidifier takes less time. It can be seen that the drying temperature as well as drying method also affects the time required for drying.

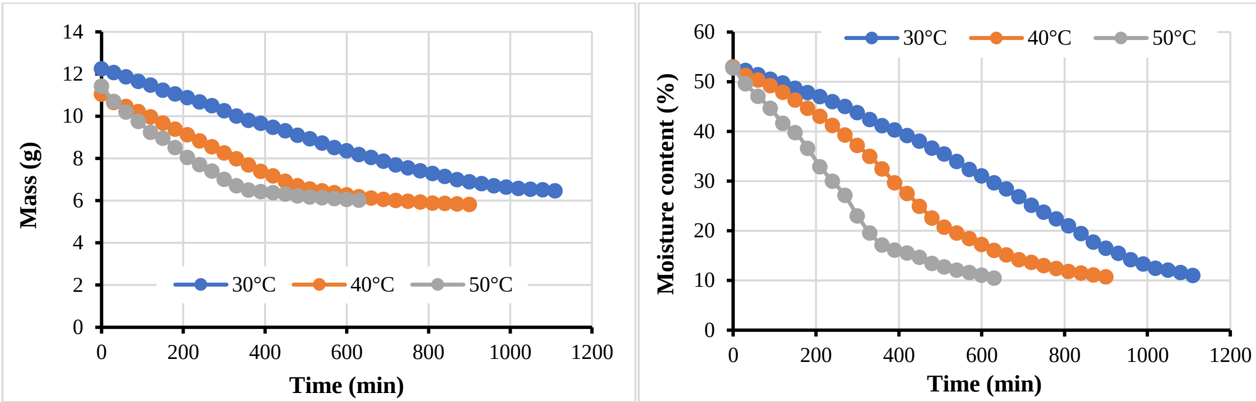
In Figures 2 and 3 below, you can see the graphs of the decrease in mass and moisture content in the drying dehumidifier and oven. From the figure, it can be seen that at the beginning of drying, the curve decreases rapidly, then becomes progressively more sloping. This indicates a rapid decrease in mass, and as time increases, the mass decrease becomes slower. This is caused by the mass of water present on the surface of the material, which causes a rapid decrease in water content. But when the decrease in water content approaches equilibrium, the decrease in water content is slower because the mass of water on the surface is getting thinner, so a diffusion process occurs (Mukmin *et al*., 2021).

### 3.3. Drying Rate

In drying with an oven, an analysis of the drying speed was also carried out, which can be seen in Figure 4. From this figure, it can be seen that the average drying rate at all drying temperatures, both dehumidifiers and ovens, fluctuated. From the following figure, it can also be seen that the temperature with the highest drying rate is 50 %db/min. This is in accordance with the literature, which says that the drying rate during the process is determined by the evaporation rate of the material. Water in the dried material, the evaporation of water mass from the surface of the material will increase rapidly with an increase in temperature in the drying process (Rozana *et al.*, 2016). Furthermore, the decrease in drying rate is caused by a decrease in water content. In addition to free water, the material also contains bound water, where bound water is water that is difficult to move to the surface of the material during drying so that the rate of evaporation of water decreases (Hasibuan *et al*., 2019). The rate of evaporation of water in the dried material is affected by the RH temperature and the speed of the drying air; the higher the drying temperature used, the higher the drying air rate (Agustina, 2016).

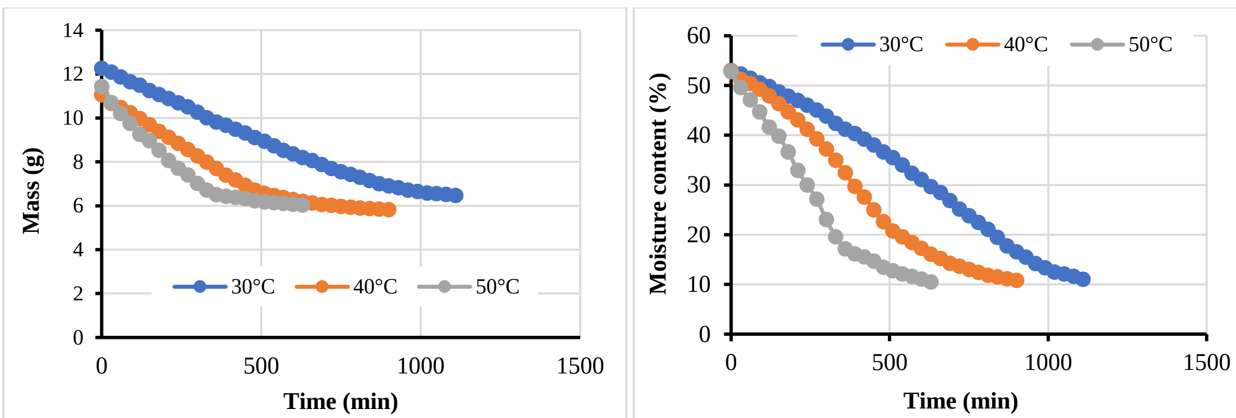
### 3.4. Seed Quality Testing

The result of the normal seed percentage on the analysis of physical quality on the chart can be seen that at a temperature of 30 °C on the drying using the dehumidifier dryer machine and the oven has a percentage of 96.4% and



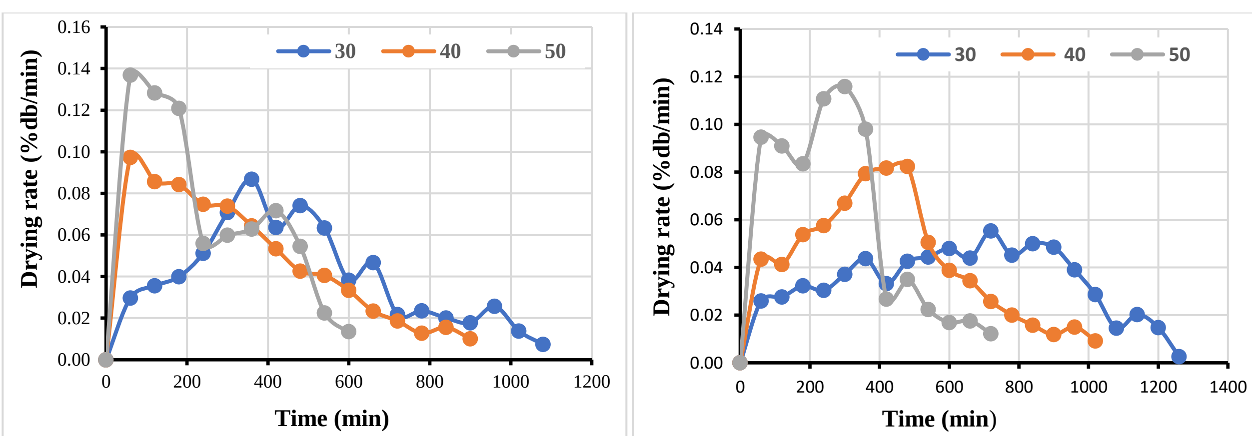

(a) (b)

Figure 2. Reduction in mass (a) and moisture content (b) of peanut seeds during drying in dehumidifier machine




(a) (b)

Figure 3. Reduction in mass (a) and moisture content (b) of peanut seeds in an oven drying machine




(a) (b)

Figure 4. Drying rate: (a) dehumidifier dryer, and (b) oven

95.5%. Then the 40 °C drying temperature with the dehumidifier dryer and the oven had a normal seed percentage of 97.8% and 96.7%. At 50 °C, drying the dehumidifier produces 95.3% of normal seeds and the oven produces almost the same normal seed, which is 95.07%. From such a graph at Figure 5 can be seen that the highest percentage on the dehumidifier drying with a temperature of 40 °C. This can be because the dehumidifier dryer needs a faster time than the oven. It's in line with the literature that says that a process of drying too long or performed at too high temperatures can cause structural worms on seeds, seed cells to become fragile and break, thus interfering with vital functions and seed metabolism (Putraningsih *et al*, 2018).

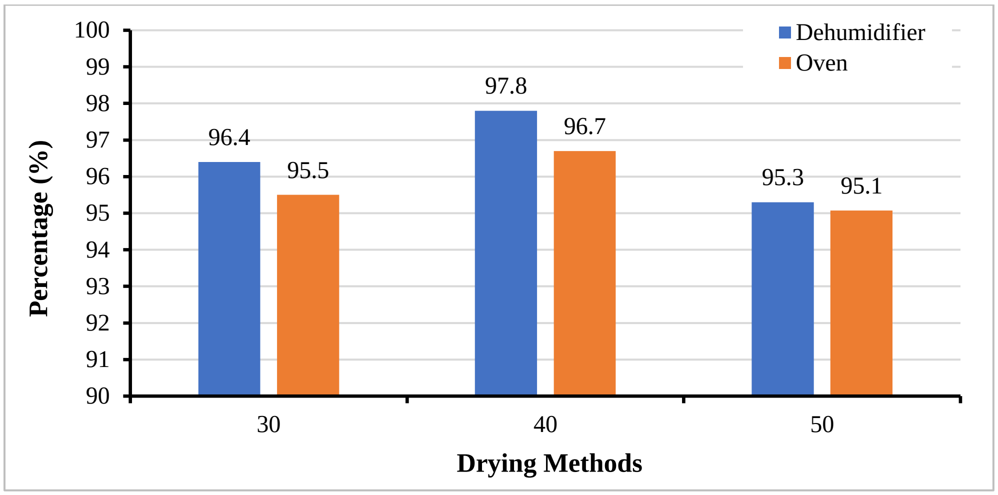
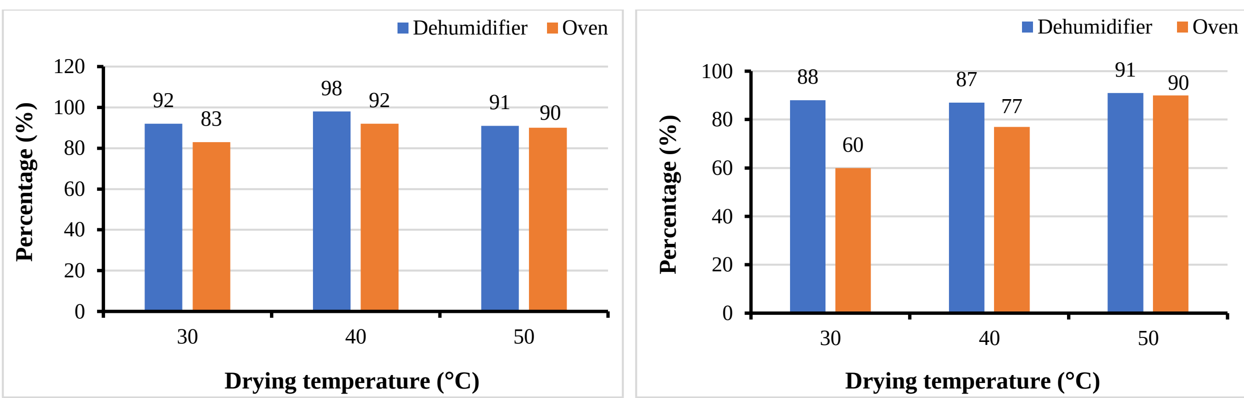



Figure 5. Effect of drying method on the normal seed percentage




(a) (b)

Figure 6. (a) Percentage of seed germination, and (b) Percentage of seed germination at vigor condition.

Then the percentage of seed germination at a temperature of 30 °C when drying using a dehumidifier and oven drying machine has a percentage of 92% and 83% (Figure 6a). Then the drying temperature of 40 °C with a dehumidifier and oven dryer had an increased germination percentage of 98% and 92% (Figure 6b). At a temperature of 50 °C, dehumidifier drying produces germination power of 91% and the oven produces almost the same germination power of 90%. Meanwhile, the results of presenting vigor at a temperature of 30 °C when drying using a dehumidifier and oven drying machine had a percentage of 88% and 60%. Then the drying temperature of 40 °C with a dehumidifier and oven dryer had a vigor percentage of 87% and 77%. At a temperature of 50 °C, dehumidifier drying produces 91% vigor and the oven produces 90% germination at vigor. The percentage of germination and vigor can be seen in Figure 6. This is because temperatures that are too high can cause excessive evaporation of water in the seeds and result in damage to cells and important physiological components in the seeds. This can also cause a decrease in germination and seed viability (Copeland *et al*., 2014). Seed vigor is influenced by various factors, from the seeds still on the mother plant to harvesting. In addition, seed vigor is also influenced by the process and method of drying, cleaning, sorting, packaging, and seed storage conditions (Ilyas, 2012).

## 4. CONCLUSION

The distribution of temperature and humidity within the dehumidifier dryer showed stable results at the six observation points across the three tested temperatures. The average drying temperature was 31.09±1.19°C at 30°C, 44.24±3.95°C at 40°C, and 52.11±1.85°C at 50°C. The relative humidity in the drying chamber was 34.40±3.02% at 30°C, 37.76±3.61% at 40°C, and 28.00±1.18% at 50°C. This humidity level was lower than the ambient humidity. The dehumidifier drying time required to reach the target 9% moisture content was 18.5 hours at 30°C, 15 hours at 40°C, and 10.5 hours at 50°C. While in the oven, drying at 30 °C, 40 °C and 50 °C takes 21 h, 17 h, and 12 h. The results of the physical quality analysis, i.e. the dehumidifier's drying temperature of 40 °C, give the greatest percentage of whole seeds compared to other temperatures of 98%. In the germination test in the dehumidifier, drying at 40 °C also gives the grain the largest percentage compared to other temperatures of 98%. Whereas in the vigor test on its dried at 30 °C, dehumidifier gives the largest percentage of shoots (88%).

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