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Performance Analysis of a Multi Seed Smart Dryer Machine for Drying Peanuts (*Arachis hypogaea L.*)

Siswoyo Soekarno[1,✉], Fina Firdiyanti[1], Soni Sisbudi Harsono[1], Bambang Marhaenanto[1]

[1] Progam Studi Teknik Pertanian, Fakultas Teknologi Pertanian, Universitas Jember. Jalan Kalimantan 37 Kampus Bumi Tegal Boto Jember, 68121, East Java, INDONESIA.

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Corresponding Author:
✉ siswoyo.s@unej.ac.id
(Siswoyo Soekarno)

ABSTRACT

Peanuts are the second largest legume crop in Indonesia, both cultivated on farms and wild. In 2019-2023, Indonesia experienced a decline in peanut production due to the declining in harvesting area. In addition, this is also due to the poor quality of seeds in the cultivation process. This study aims to observe the performance of the Multi Seed Smart Dryer (MSSD) machine for peanut seeding. This research was conducted by observing changes in moisture content, drying rate, drying temperature, and peanut germination test results using the Multi Seed Smart Dryer machine. The results showed that the left side of all shelves experienced an increase in temperature because it was close to the heat source and the level of temperature uniformity was still said to be uniform because it did not exceed the uniformity limit. The peak drying rate occurred at the 12th hour and decreased further. Based on the results of the germination test, the dried beans have a germination rate of 83%. This is in accordance with the passing standard of seed quality according to the Ministry of Agriculture of the Republic of Indonesia and International Seed Testing Association.

1. INTRODUCTION

In Indonesia, peanuts are the second largest type of nut crop, both cultivated on agricultural land and living wild. Peanuts have an important role in meeting nutritional needs. The protein content in peanuts is very supportive in meeting the needs of the Indonesian people. In general, peanuts are used as food and industrial materials so that peanuts have quite high economic value. In Indonesia, peanuts are widely grown, produced, and even sold as food, either ready for consumption or as raw materials (Sebayang *et al*., 2022).

During last five years, national peanut production had declined by 16.7% from 429,099 ton in 2019 to 350,017 ton in 2023 (Direktorat Jenderal Tanaman Pangan, 2024). In 2003, East Java Province was the largest peanut producing area in Indonesia and supplied 24% of the peanuts used for national consumption (Hariyadi & Purnama, 2018). Based on accumulated data from 2010-2015, peanut production shows a decline from 779,228 tonnes to 605,449 tonnes at the end of 2015 (BPS, 2017). According to the Directorate General of Food Crops (2023), peanut production in 2023 will reach 350.06 thousand tonnes, a decrease of 29.91 thousand tonnes or 7.87% compared to peanut production in 2022 of 379.93 thousand tonnes. This significant decline in production occurred due to several factors, such as unhealthy seeds used in the peanut cultivation process. The water content of peanuts after harvest is quite high. This can cause damage to peanut seeds by aflatoxin-producing fungi (Kono, 2021). One of the post-harvest handling of peanuts that is often carried out is the drying process. The peanut drying process is used to reduce the water content which can minimize microbial activity. Drying can extend the shelf life of products without the addition of chemical preservatives (Laily, 2023).

The aim of using an artificial drying machine is to avoid the shortcomings of the natural drying process using solar heat. In general, artificial drying machines work by providing fairly constant heat to the grain, so that the drying process can take place quickly and achieve maximum results. The drying machine is expected to be able to reduce the initial water content by around 30%-40% to 12%-17%. In these conditions, peanut seeds are ready for further processing or are safe enough to store. Convection drying machines will be influenced by humidity, temperature, air flow and circulation speed (Irham, 2022). Smart dryer is a drying machine technology that has the advantage of being able to detect and monitor various material quality parameters that change over time during the drying process, so that controlling drying conditions will produce high quality products (Su *et al*., 2015).

This Multi Seed Smart Dryer drying machine is equipped with several components consisting of a material rack, DHT22 sensor, smart and manual mode monitor, data logger, thermostat sensor, incandescent lamp, blower and cooling fan. The incandescent lamp on the Multi Seed Smart Dryer machine is used as a heat source and the resulting heat temperature is distributed throughout the inside of the machine with the help of a blower. The working system of this machine occurs due to the evaporation of water, this process is useful for reducing the relative humidity of the air by channeling hot air to the peanut seeds. This will cause the water vapor pressure in the air to be lower than the water vapor pressure in peanut seeds (Amar, 2022). The aim of this research is to determine the performance of the machine to produce quality peanut seeds that comply with standards by observing changes in water content and drying rate that occur during drying.

2. MATERIALS AND METHODS

2.1. Materials and Tools

The material used in this research was 20 kg of peanut seeds which had a harvest age of 98 days after planting. The peanut variety used was the local Garuda variety (*Arachis hypogaea L.*) obtained from the Budi Luhur Farmers Group, Curah Malang, Bangsalsari District, Jember Regency, East Java Province. The equipment used in this research was a Multi Seed Smart Dryer, digital scales, moisture meter, stationery, calculator, tray, memory card, and card reader.

2.3. Description of Drying Equipment

The Multi Seed Smart Dryer (MSSD) machine is a mechanical drying device that is square or rectangular in shape. Overall, this tool consists of several main components, namely the rack/tray, incandescent lamp, and blower. The drying process using an MSSD machine is classified as direct drying, where the drying medium (hot air) is in direct contact with the material to be dried. The drying machine used in this research uses a heat source from an incandescent light bulb. This dryer is also equipped with a hot air fan and a cooling fan to expel steam outside the dryer. This dryer operates based on the principle of convection heat transfer (Soekarno *et al*., 2023). The design of this drying machine has overall dimensions of 130 cm long, 50 cm wide, 100 cm high, and has 10 shelves with a distance between shelves of 5 cm.

Figure 1. Multi seed smart dryer

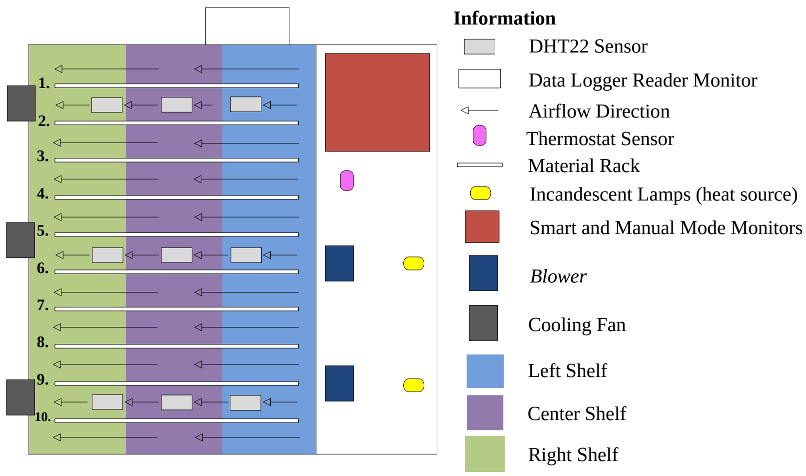

Figure 2. Dryer machine components

2.4. Research Stages

The drying time for peanut seeds in this study was 22 hours. The water content of peanuts used in this research is 28% and the desired final water content is ≤ 11%. The water content is in accordance with the Republic of Indonesia Minister of Agriculture Regulation No. 991/HK.150/C/05/2018 concerning standards seed quality approval and ISTA (International Seed Testing Association) for type class peanut seeds with a maximum water content of 11%. The first stage of research was carried out by separating the skin from the peanut seeds. Next, measure the initial water content in peanuts using the Grain Moisture Meter Analyzer LDS-1G. This tool is used by taking several samples of peanuts according to the measurements and then inserting them into a measuring tool that has been set with the PH code 11. Next, the tool will display the results of the water content of the peanuts. The Multi Seed Smart Dryer machine uses 10 shelves, so that each shelf contains 2 kg of peanuts. This is because the drying process does not cause accumulation between the seeds. Weighing using an Arashi AKS 03 digital scale.

Peanut seeds that have been weighed are then arranged and placed on a shelf. Before loading the materials on the rack into the machine, it is necessary to make settings on the machine. Machine settings start from turning on the machine, inserting an SD card memory to save data logger recordings, and setting the thermostat to 35-38°C. The thermostat is located in the incandescent lamp area. This will also affect the temperature distribution results in the drying room, which has a lower temperature than the thermostat setting temperature. During the drying process, it is necessary to check the water content of the peanut material every 8 hours of drying. This aims to determine the decrease in water content in peanut ingredients, in order to obtain peanut seeds according to the specified seed drying standards. When the drying process is complete, it will produce dry peanut seeds that meet the quality requirements for germination testing. Before carrying out a germination test, it is necessary to select seeds with good quality. The need for a germination test is 4 samples, each sample requires 100 seeds. The germination test was carried out by sending samples to the Seed Technology Laboratory, Jember State Polytechnic. The observation data obtained will then be analyzed quantitatively descriptively. The results of the analysis will be displayed in the form of tables and graphs using the parameters of average value, minimum and maximum value.

2.5. Analysis Method

Drying Rate Analysis

The drying rate profile during the drying process can be determined using the following equation (Nurba, *et al*., 2019).

$$\frac{dM}{dt} = \left(\frac{M_{t1} - M_{t2}}{\Delta t}\right) \quad (1)$$

where *Dm/dt* is drying rate (%db/min), M_{t1} is water content of peanut seeds at time *t1* (%), M_{t2} is water content of peanut seeds at time *t2* (%), and Δt is time difference between *t1* and *t2* (min).

Uniformity Test Analysis

According to Pratama (2020), the data uniformity test can be carried out using the following equation.

$$BKA = \bar{x} + k\sigma \quad (2)$$

$$BKB = \bar{x} - k\sigma \quad (3)$$

$$\sigma = \sqrt{\frac{\sum(x-x)^{-2}}{N-1}} \quad (4)$$

where *BKA* is upper control limit, BKB is lower control limit, $\bar{x}$ is average data value, σ is standard deviation, *N* is number of data, and *k* is level of confidence.

3. RESULTS AND DISCUSSION

3.1. Distribution of Air Temperature and Relative Air Humidity

3.1.1. Drying Room Temperature

Figure 3 shows the temperature distribution divided into 3 parts, namely the left, middle and right. This section is based on the location of the DHT 22 sensors which are spread across the machine, located on the left, middle and right. Based on the observations, on the left side there was a significant increase in temperature compared to the middle and right parts. The temperature increase occurred at 700 minutes. The initial temperature on the left was 31°C and increased to 34°C, in the middle the initial temperature was 30°C then rose to 33°C, and on the right the initial temperature was 29°C then rose to 32°C. This happens because the left side of the shelf is adjacent to the heat source room. In the convection drying method, the closer to the heat source, the more heat received, and vice versa (Rahmanto & Majanasastra, 2019). The higher the temperature, the more heat energy is released and the greater the amount of water is evaporated from the surface of the material during the drying process (Akbar *et al*., 2021).

3.1.2. Relative Humidity

Figure 4 shows that from minute 0 to minute 440 with humidity values between 66%-77%. During this time the humidity value did not change drastically. However, there is a difference in humidity values, namely an average 67% on the left side, average 71% on the middle side, and average of 77% on the right side. The factor that influence the

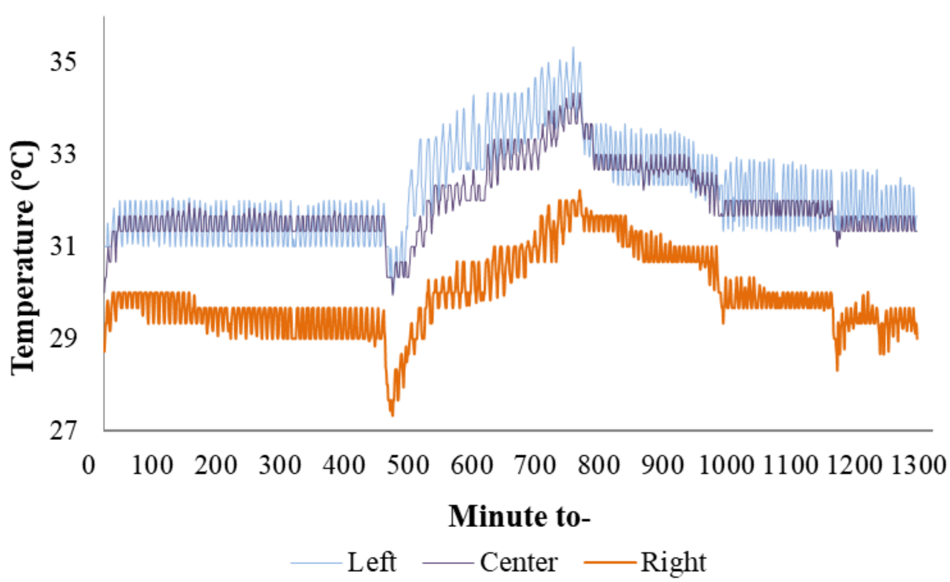

Figure 3. Room temperature distribution

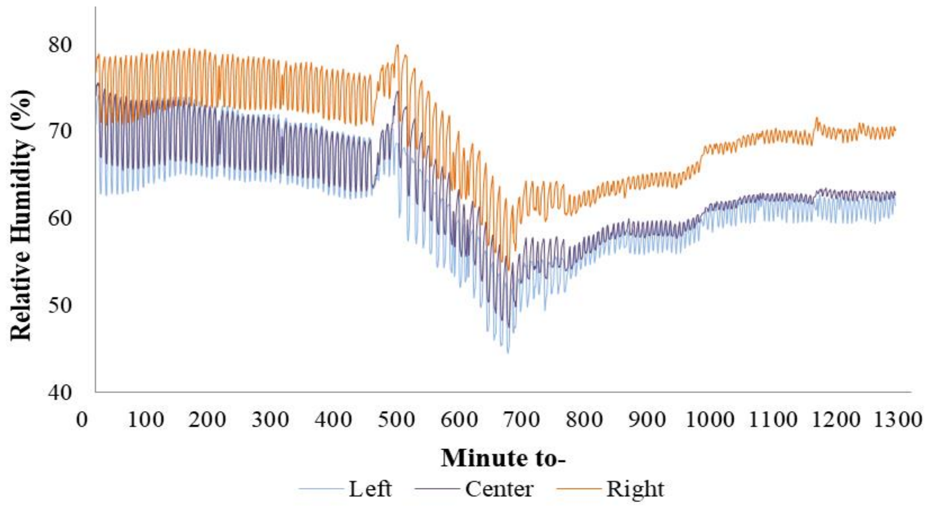

Figure 4. Relative humidity distribution

difference in humidity values is the temperature received on each shelf. Based on the research results of Aprilandani & Tanggasari (2022), it is stated that the lower the humidity value, the higher the temperature value. From the 473rd to the 645th minute, there was a significant decrease in air humidity with an average decrease of 22%. This is influenced by an increase in temperature which occurs with an average of 8°C. According to research by Rahayuningtyas & Kuala (2016), one of the factors that influences the drying process is humidity. The smaller the percentage of humidity in the air in the drying room, the faster the drying process will take place.

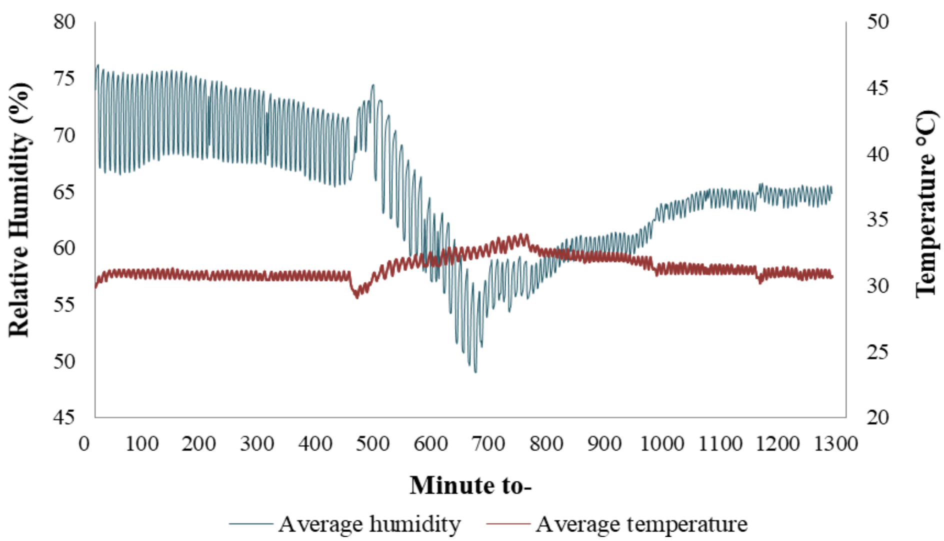

Figure 5. Relationship between temperature and relative humidity

3.1.3. Relationship between temperature and relative air humidity

Based on Figure 5, it shows that when the drying process lasted 8 hours and was at an average temperature of 31°C, the humidity in the machine did not change. However, the water content of peanuts during the first 8 hours of the drying process decreased by around 8.6%. Humidity does not change because the water content of the material moves to the surrounding material. Based on the research results of Hendrawan (2018), it is stated that there are two processes during drying, namely the transfer of water vapor from the inside of the material to the surface of the material by diffusion and the transfer of water vapor from the surface of the material to the free air.

The figure shows that at 600 minutes the average temperature increased by 1.5°C and the average air humidity decreased by 9.7%. This is in accordance with research by Hardiyanti & Andraini (2022), that temperature will affect the humidity level in a room, the higher the temperature, the lower the humidity in the storage room. Apart from temperature, the presence of water around the drying room will affect air humidity during the drying process. Every time the moisture value increases, this is followed by a decrease in the water content value of the material.

3.2. Temperature Uniformity

Based on Figure 6, it shows that the drying temperature produced by incandescent lamps as engine heaters has relatively good temperature uniformity values. Based on the temperature uniformity results above, the difference in drying temperature between the lowest and highest is 2°C. This means that the temperature difference is very small and the dryer temperature uniformity is quite high. This temperature uniformity is very important to achieve uniform drying results. Temperature uniformity can also be seen from the temperature results which are still within the lower control limit and upper control limit. Based on research results, Mulkan & Zulfadli (2021) stated that the faster the air spreads, the better the heat transfer. This is in accordance with the function of the blower on the machine which is used to speed up heat distribution by convection during the drying process.

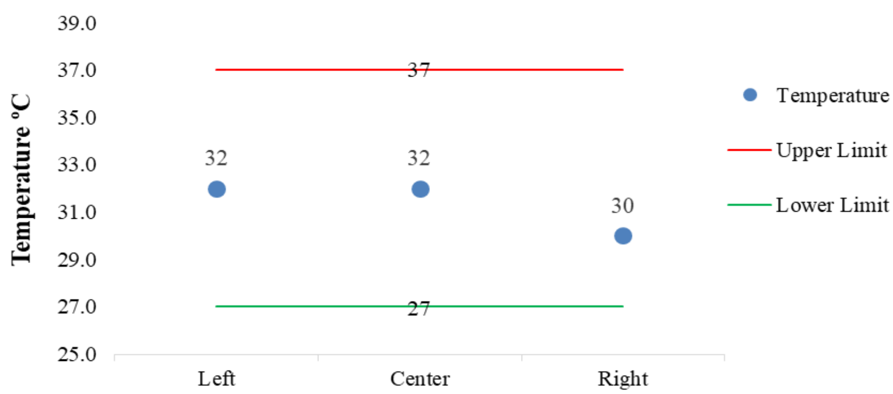

Figure 6. Uniformity of peanuts seed drying

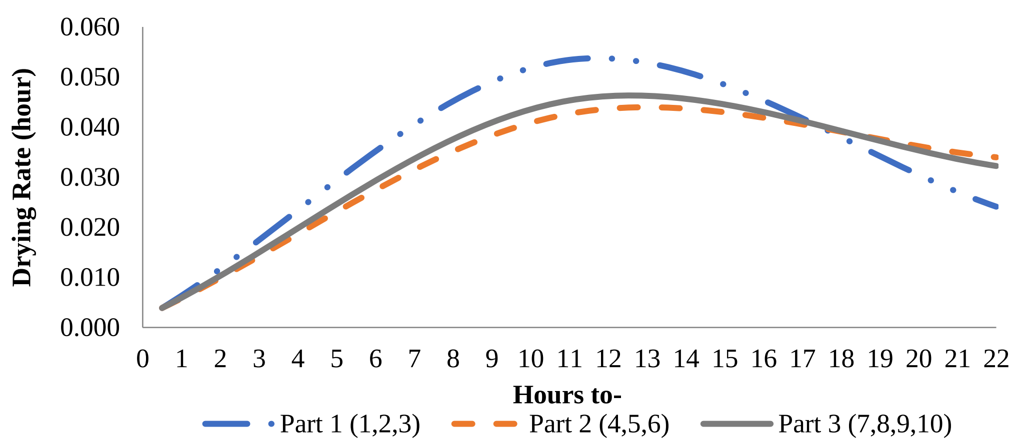

Figure 7. Drying rate of peanut seeds

3.3. Drying Rate

In Figure 7, it is found that the drying rate of peanut seeds is divided into 3 parts, in part 1 (1,2,3), in part 2 (4,5,6) and in part 3 (7,8,9,10). The division of the shelf into 3 parts corresponds to the distribution of the direction of hot air flow from each blower and makes it easier to interpret the graph. The process of drying peanut seeds experienced a significant decrease in water content over a period of 22 hours. In the graph, it can be seen that the drying rate of peanut seeds in each section of the shelf has a similar character, namely that there is a decrease in the drying rate after the 12th hour. This is due to the evaporation of the water content in the peanut seeds during the drying process. The more evaporation occurs, the lower the water content in the material so that the drying rate will decrease (Arsyad, 2018).

However, the second check in part 1 experienced a significant decrease in the drying rate and was different from parts 2 and 3. This explains that the water content in peanut seeds did not evaporate during the final drying period. In accordance with research by Hasibuan & Ridhatullah (2019), it is stated that there are two factors that influence the drying rate. One is internal factors such as the surface area of the material, and the other is external factors such as temperature, humidity, wind speed, and air flow.

3.4. Uniformity of Water Content of Peanut Seeds

Figure 8 shows that the final water content value in section 1 (shelf 1,2,3) is 12.1%, section 2 (shelf 4,5,6) is 12.5%, and section 3 (shelf 7, 8,9,10) of 11.7%. The final water content value obtained for each section of the shelf is different, but is still said to be uniform because it does not exceed the uniformity limit. This can happen because the heat distribution is not comprehensive on each shelf. Thus, there is a change in rotation of each shelf which is carried out every 8 hours to measure the water content of the material to obtain maximum drying results. This is in accordance with the opinion of Jamilah *et al*., (2024), temperature has a significant influence on water content, the higher the temperature value, the lower the water content. The water content reaches an equilibrium value because it is influenced by the high temperature during the drying process (Widiaswanti *et al*., 2023).

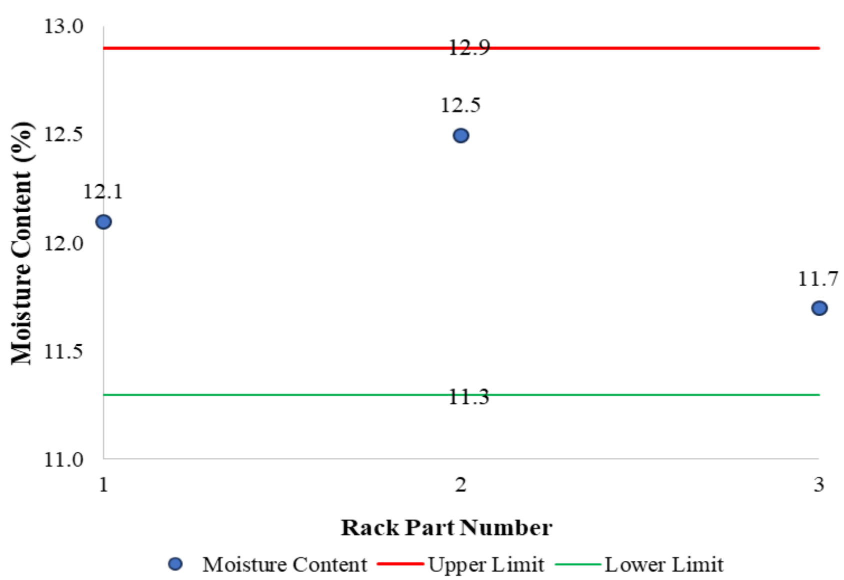

Figure 8. Final moisture content

3.5. Peanut Seed Germination

Based on Table 1, the results of testing the quality of peanut seeds include normal sprouts at 83%, abnormal sprouts at 7%, dead seeds at 10%, fresh seeds that do not grow at 0%, and hard seeds at 0%. According to the Republic of Indonesia Ministry of Agriculture Decree no. 991/HK.150/C/05/2018 concerning standards for passing seed quality and ISTA (International Seed Testing Association) for type class peanut seeds, namely a maximum water content of 11% and a minimum growth capacity of 80%. Based on these regulations, it can be said that the results of testing the quality of bean seeds are in accordance with these regulations.

Table 1. Observation results of peanut seeds

Water content (%)	Germination power				
	Normal Sprouts (%)	Abnormal Sprouts (%)	Seed Dead (%)	Healthy Seeds Don't Grow (%)	Hard Seed (%)
7,1	83	7	10	0	0

The criteria for abnormal sprouts are sprouts that do not have primary or secondary roots that grow ideally, the hypocotyl is broken or injured, the cotyledons are damaged, deformed, wrinkled, swollen or shortened. Dead seeds are seeds that do not germinate at the end of the test, but are not hard or fresh seeds. These seeds are characterized by slow wilting, fading color, and lots of mold. Fresh seeds that do not grow are seeds that do not develop until the end of the testing process, but still have the potential to develop into normal sprouts. This type of seed can actually receive water during the testing process, but experiences disturbances in the subsequent development process (Gea *et al*., 2022). Meanwhile, hard seeds are seeds that are still hard at the end of the germination test due to the impermeability of the seed coat to water or low permeability (Prabhandaru & Saputro, 2017).

Based on research by Muniarti (2013), temperature has an influence on germination in increasing metabolic activity. Seed quality will always be related to physiological factors. Seeds can be said to be quality if they have a large percentage of germination capacity. Physical factors relate to size, structure and resistance to disease, while genetic factors carry superior traits from their parents.

The storage period for peanut seeds according to the results of research by Parinduri (2023) states that the germination capacity of peanut seeds for 8 weeks still has good quality and normal germination. However, if the seeds are more than 8 weeks old, the quality is less than the standard 80%. The estimated shelf life of peanut seeds can last up to 60 days if the seed water content is low and stable until the end of the storage period. Seed storage is carried out by placing them in thick glass plastic in a closed room at a temperature of 30°C so that the growth capacity and seed vigor index remain good (Antoro & Setiono, 2022).

4. CONCLUSION

Based on the results and discussion of this research, it can be concluded that the use of the Multi Seed Smart Dryer machine for drying peanut seeds can be said to be effective for seeding. The peanut drying process produces a good level of temperature uniformity, optimal drying results, and seed quality results that meet the standards of the Republic of Indonesia Minister of Agriculture Decree No.991/HK.150/C/05/2018 and ISTA. The process of drying 20 kg of peanuts using a Multi Seed Smart Dryer machine takes 22 hours. The moisture content of peanuts decreased from 28.6% to 12%. The results of testing the quality of peanut seeds meet the standards with a germination capacity of 83%.

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