International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 13, Issue 8 [August. 2024] PP: 11-14

Analysis of Corn Moisture Content in Rack Type Dryer Towards Variations in Temperature and Drying Time

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ABSTRACT: *Corn is one of the most important food crops besides wheat and rice. Farmers are often faced with problems in the drying process, namely the high initial water content of corn and unfavorable weather. A rack-type dryer is an alternative technology that can be used for the drying process. The study was conducted to determine the effect of changes in dryer temperature on the drying characteristics of corn kernels using a rack-type dryer including: water content of the material and mass of the test material. The experimental method was used in this study. The heating temperatures used in the drying process were 60ºC, 65ºC, 70 ºC and 75ºC with a drying air speed of 2 m / s repeated 3 times until a water content of 14 - 15% was obtained. The results of this study are that the higher the temperature used to dry corn kernels, the greater the drying rate. The value of the decrease in water content ranges from 3 - 4% every 30 minutes.*

Date of Submission: 01-08-2024 Date of acceptance: 09-08-2024

I. INTRODUCTION

Drying is a very important post-harvest handling stage as an effort to maintain the quality of corn during storage. So far, the corn drying process has been carried out in two ways, namely: the first with direct sunlight and the second with artificial heating. Drying with direct sunlight can be done if the intensity of sunlight is sufficient and it is not rainy. The drying process with direct sunlight is faced with non-uniform water content depending on the relative humidity of the surrounding air during the drying process. Drying with artificial heating is constrained by low efficiency which is still below 60% [1]. Corn has a high selling price if the water content in the corn kernels meets the desired standards on the market, the Indonesian national standard determines the water content in corn, namely 13-14% [2].

Drying is the process of transferring heat and water vapor simultaneously which requires heat to evaporate water from the surface of the material without changing the chemical properties of the material [3]. A drying system with artificial heating is needed as an alternative for post-harvest handling. A rack-type dryer is one type of dryer that is often used in the drying process. Drying using a rack dryer is one of the effective drying methods, the drying process can be carried out at any time or not depending on the weather and space. In addition, drying with a rack type does not require a lot of labor. Drying of grain with a rack type affects the drying rate and changes in water content in corn kernels or causes water content to decrease. The faster the drying rate and the decrease in water content are smaller or slower if the temperature of the drying room is higher and the drying process is longer [1].

AIT type drying using solar collectors shows that the upper rack will dry faster than the lower rack. The maximum capacity of this AIT model dryer for drying crackers is 7.8 kg. The efficiency value of the collector is 21.5% - 53.27% and the efficiency of the drying room is 3.89% - 23.15%. This efficiency is highly dependent on weather conditions that affect the intensity of solar radiation [4].

The rice drying process produces an average drying room temperature of 40.42°C with sunlight, while the average relative humidity is 41.45% and the drying time is 7 hours. The results showed that the average final water content was 14.88% bb, the average drying rate was 0.64% bk/hour, and the drying energy was 32595.32 kJ [5].

The greenhouse effect shallot dryer (ERK) is a dryer that utilizes solar energy as the only heat source to increase the temperature of the material in the drying process. The results of the study showed that the average temperature of the dryer for 4 days, namely the lowest temperature was 37.75°C, the highest temperature was 51.75°C; while the lowest and highest ambient temperatures were 25.8°C and 37.0°C, respectively, with an average drying efficiency of 39.9% [6].

Research on the corn drying process using a vertical cylinder dryer showed that the time used to dry corn to reach a water content of 12-14% in each test was different. While the drying rate for each performance test almost had the same value of around 5 kg H_2O/Hour [7].

Fast drying was obtained at high air temperatures, conversely long drying times were obtained at low air temperatures. In this study, variations in air temperature of 55°C, 60°C and 65°C were used, obtaining the results that at an air temperature of 65°C it produced the fastest drying time compared to drying at temperatures of 55°C and 60°C. Meanwhile, the longest drying time was obtained at an air temperature of 55°C [8].

Drying is one of the most important factors in determining the quality of corn seeds, in addition to the harvesting process. The quality of corn seeds is determined by its water content. Drying aims to reduce the water content in corn seeds to a condition where the water content in corn seeds cannot reduce the quality of corn seeds and corn seeds are not overgrown with mold. Based on its energy source, drying of corn can be divided into natural drying and artificial drying [9].

Drying corn in a fluidized bed tool found that the higher the air speed, the faster the corn drying time, in the study, using a drying air speed of 7 m/s produced the fastest drying time while an air speed of 5 m/s obtained the longest drying time [8]. The performance of a corn dryer with a biomass combustion energy source showed that the drying rate could be faster if the air speed was increased. Drying corn to reduce the water content from 19% to 12% took 47 minutes with an air speed of 3 m/s [10].

II. RESEARCH METHODS

This study is an experimental study using two types of variables, namely dependent variables and independent variables. The dependent variable is a variable that is influenced by other variables such as the power used, by analyzing the dependent variable, it is expected to find answers or explanations regarding the problems being tested. The dependent variable in this study is to obtain the drying rate. The independent variable is a variable that can be adjusted and determined according to testing needs. The independent variables used in this study are variations in the speed of the heating drying chamber temperature of 60ºC, 65ºC, 70 ºC and 75ºC with an air speed of 2 m / s.

The initial mass of corn, mt (kg) and the dry mass of corn, mk (kg) are used to calculate the water content, Ka (%) [11, 12]. To obtain the dry mass of corn, a heating process is carried out at a temperature of 80ºC ± 1ºC until there is no weight loss.

$$K_a = \frac{m_t - m_k}{m_t} \text{ x } 100\% \qquad \ldots\ldots\ldots\ldots \qquad (1)$$

The mass of evaporated water, mw is calculated based on the mass of corn after drying, mp (kg) with the initial mass of corn, mt (kg).

$$m_w = m_t - m_p \qquad \ldots\ldots\ldots\ldots \qquad (2)$$

The research procedure carried out is as follows,

The stage of determining the initial water content of the material, to determine the water content the method used is the drying method.

1. The material is placed on an oven tray with a known weight as a sample and then weighed carefully on a digital scale with a weight of 1 kg.
2. The material and the oven tray are put into an electric oven set at a temperature of 80oC ± 1oC for 30 minutes.
3. The material is then weighed to determine the mass of the material.
4. Put it back in the oven for 30 minutes and repeat steps 2 and 3, until the weight is obtained does not decrease or change.

Drying stage

1. Turn on the dryer's power.
2. Set the air temperature entering the dryer using the specified temperature.
3. Set the air flow rate by the fan according to the testing needs, which is 2 m/s.
4. Put the corn kernels into the dryer weighing 2 kg with each rack 0.5 kg.
5. Weigh the material every 30 minutes and record the mass of corn and air speed until the maximum corn water content is 14%.
6. Repeat steps 2 to 5 with temperature variations in point 2 with variations in air temperature entering 60ºC, 65ºC, 70 ºC and 75ºC. and air speed 2 m/s.

III. RESULTS AND DISCUSSION

In the implementation of the research, data collection was taken every half hour after the corn was put into the dryer for 3.5 hours. Based on Figure 1, the graph of the relationship between mass and time obtained, the mass of dried corn is directly proportional to the time used to dry the corn itself. The longer the time used for the drying process of corn kernels, the less water mass in the corn can be dried. The water content contained in corn kernels is getting less and as a result, the water in the corn kernels is getting harder to evaporate, this happens as a result of the longer time needed for the drying process.

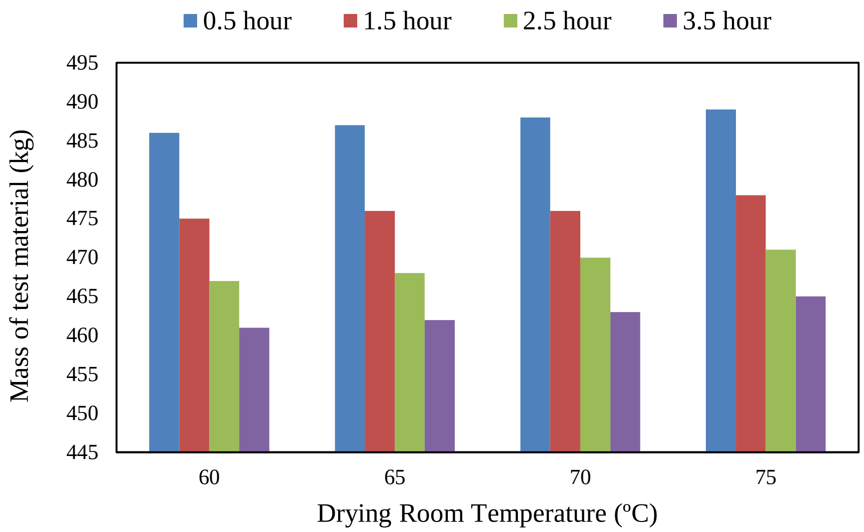

Fig 1. Relationship between the mass of the test material and the temperature of the drying chamber.

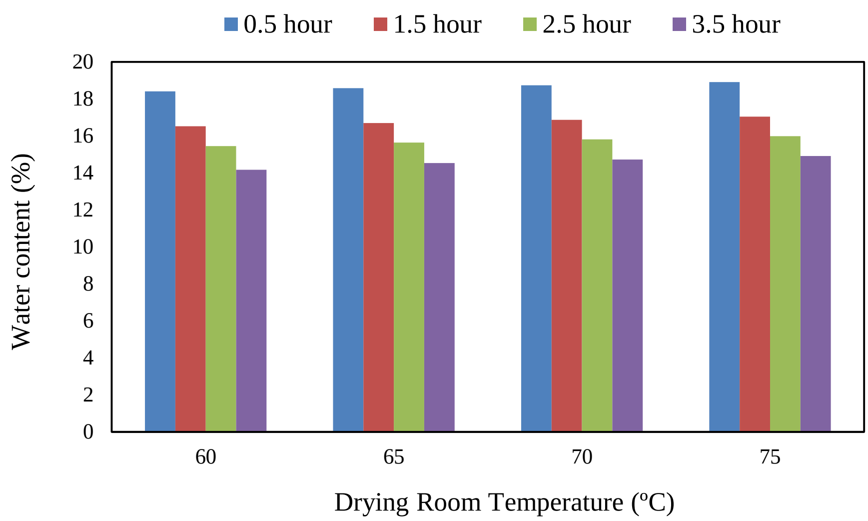

Fig 2. Relationship between water content and drying room temperature

Figure 2 shows the initial water content of corn of 20.7% requires a drying time of 210 minutes (3.5 hours). In the first 30 minutes, the water content of corn decreased by an average of 10.2 - 11% at each variation of the incoming air temperature. At the beginning of drying corn seeds, there was a relatively rapid decrease in water content, then gradually decreased slowly until the specified water content was obtained ranging from 14 - 15%. Furthermore, the range of water content reduction values ranges from 3-4% every 30 minutes until 3.5 hours, so that the average final water content for variation 1 (inlet air temperature 60oC) is 18.42%, the average final water content for variation 2 (inlet air temperature 65oC) is 16.88%, variation 3 (inlet air temperature 70oC) is 15.64%, variation 4 (inlet air temperature 75oC) is 14.55%. The research that has been done shows that the initial water content is 20.7%. This water content is used for initial data on the reduction in water content of corn seeds obtained by the method of weighing corn seeds after the drying process takes place. During the drying process of corn seeds, the water content continues to decrease, which is between 3-4% every 30 minutes.

As a result of the drying process where corn kernels absorb heat energy from the drying air, there will be a decrease in water content. So that the water content which was originally 20.7% evaporates slowly from the corn kernels to the drying air. This means that when the evaporation process occurs, the corn kernels slowly lose their mass or better known as mass transfer. Corn kernels have three types of water content, namely free water, water bound to the material and water that is chemically bound in the material. Initially, the water that evaporates is free water followed by bound water and then chemically bound water (figure 2).

Distribution of average temperature of drying chamber for inlet air temperature of 60oC, 65oC, 70oC and 75oC. The higher the inlet air temperature, the higher the average temperature of the drying chamber. The average temperature of the drying chamber for inlet air temperature of 75oC is slightly higher compared to inlet air temperature of 70oC, 65oC and 60oC. This is because the higher the inlet air temperature, the better the heat transfer in the drying chamber [8,13], while the air velocity entering the drying chamber remains at 2 m/s. This condition has the effect that the higher the air temperature of the drying chamber, the higher the heat energy carried by the air so that the greater the amount of liquid mass evaporated from the surface of the material. An increase in temperature will increase the temperature of the material and cause the water vapor pressure in the material to be higher than the water vapor pressure in the air, so that water vapor transfer occurs from the material to the air. At the beginning of the drying process, the temperature of the drying chamber tends to be low, but as the drying process time increases. This is because the water content of the evaporated material is getting smaller.

IV. CONCLUSION

Based on the analysis of drying process data with air speed of 2 m/s and temperature of 60ºC, 65ºC, 70ºC and 75ºC, it can be concluded that the capability obtained by the designed dryer. The higher the air temperature of the drying room, the higher the heat energy carried by the air so that the greater the amount of liquid mass evaporated from the surface of the material, so that the drying rate is better. The value of the decrease in water content ranges from 3-4% every 30 minutes.

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