JIEETech
Journal of Industrial, Energy and Environment Technology

e-ISSN : 3031-5700
Vol. 3, Issue 1 (2025) : 89-95

Performance Test of Rotary Dryer in the Process of Drying Areca Nut Seeds

Siti Ikhlasul Amalia Sari[*1], Zeani Yurindah[2], Riskiyaa Yorti[3], Ida Febriana[4], Agus Manggala[5]
[1 2 3 4 5] Chemical Engineering Department, Politeknik Negeri Sriwijaya, Jl Srijaya Negara, Bukit Besar Palembang, 30139

*Corresponding Author's e-mail : [*]sitiikhlasulamaliasari17@gmail.com

Article's Information

Received
29/01/2025

Revised
18/03/2025

Accepted
20/03/2025

ABSTRACT

Areca seeds must be dried because if the water content is still high, it is feared that mold will gros so that it will reduce the quality of areca nuts. This study aims to analyze the effect of independent variables to determine the optimum drying conditions. The drying equipment used is a rotary dryer.The heat source comes from the combustion heat source. The use of LPG gas fuel was chosen because it is more efficient in the drying process. Based on the results of testing the variation of these variables for drying for 210 minutes greatly affects the decrease in moisture content, drying rate and thermal efficiency. By design at a temperature of 80℃, the water content is 14,2%, while actually at a temperature of 80℃, the water content is 14% and for the optimum condition of air flow velocity of 6,5 m/s and cylinder rotational speed of 1 Rpm with a thermal efficiency 0f 31,21%, the water content is 14,5% and the drying rate is 0,808 kg/h m^2. The highest efficiency value obtained under the condition of 3 Rpm in 210 minutes is 64,65%.

Keywords: *Areca Nut, Rotary Dryer, Moisture Content, Drying Rate, Thermal Efficiency*

1. INTRODUCTION

One of the industrial plants that provide many benefits to humans is areca nut (Areca catechu L). One of the benefits of areca seeds is as an excellent source of tannins in industry and pharmaceuticals. In addition, areca seeds are also a potential export commodity [1]. Areca seeds have a bitter, spicy, hot taste and contain 0.3-0.6% alkaloids, 15% red tannins, 14% fat, starch and resin [2].

South Sumatera is one of the provinces producing areca nuts, precisely in the Banyuasin and Prabumulih areas [3]. In the pharmaceutical industry, areca nut seeds must be completely dry because if there is still a high water content in the seeds, it is feared that mold and mold will grow which will reduce the quality of areca nut simplisia [4]. Therefore, a drying process is required for areca nut seeds to reduce the moisture content in the material so that the seeds remain qualified to be used as medicines. According [5], the quality requirements for areca seeds based on SNI 01-3450: 1997 are that areca seeds for medicine have a moisture content of 14% while non-medicinal areca seeds have a moisture content of 14,34 – 17,15%. In this case, the relative longevity of areca nut seeds with an average moisture content value of 6.,49% has reached a safe moisture content for storage in a relatively long period of time [6].

Drying areca nut is useful to extend the shelf life, facilitate packaging and further processing. The moisture content of the three types of areca nut are old areca nut 64,86%, young areca nut 63,53%, and dried areca nut 34,18% [7]. High moisture content will stimulate rapid respiration of the seeds, resulting in a decrease in the quality and quantity of areca nuts [8].

Rotary dryer is a type of mechanical dryer that is often used in the drying industry to reduce the moisture content of various materials [9]. It dries a typically granular product in a rotating horizontal cylinder where hot air is introduced to evaporate the water in the product. The purpose of using a rotating horizontal cylinder is to allow the airflow to flow evenly through the surface of the product to be dried [10]. The parameters generated in the rotary dryer are caused by the use of heat sources derived from traditional fuels. One of them is LPG (Liquid Petroleum Gas) fuel. LPG has several advantages because the drying process is more efficient [11].

Previous research [12] shows that the maximum air temperature generated during the 7-hour working test process is 108°C with an airflow velocity of 3,8 m/s. The reduction of the moisture content of the dried areca nut is directly proportional to the mass reduction. Where during the 7-hour drying process the moisture content of the areca nut was reduced by 55% with a drying rate of 7,85% [12].

The reduction in water content is also influenced by the rotational speed of the cylinder, where the percentage of water loss is directly proportional to

the rotational speed of the cylinder. The higher the rotational speed of the cylinder, the higher the evaporated water content [13]. The process of transferring or switching from fuel to dry material can affect the drying of the material [14].

Based on reference to the results of previous studies, where previous studies have not examined the rotational speed of the cylinder and air flow velocity using a rotary dryer in drying areca nuts. So in this study, researchers will examine variations in air flow speed and cylinder rotational speed using a rotary dryer so that it is expected to get the best quality dried areca nuts and in accordance with SNI 01-3450: 1997.

2. MATERIAL AND METHODS

This research was conducted at the Energy Engineering Laboratory of Politeknik Negeri Sriwijaya which consisted of several steps. The first step is the process of preparing raw materials for areca nuts that have been peeled and cleaned from the outer shell (coir) of areca nuts. The second step is the process of testing the tool (test running) to determine the operating conditions of the rotary dryer. The third step is data collection based on variables. Furthermore, the research results were analyzed consisting of moisture content, drying rate, and thermal efficiency of the rotary dryer based on SNI 01-3450-1994.

2.1 Material

The raw material used for this experiment was 55 kg of areca nut. Each run used 10 kg of areca nut. The equipment used for the research is a rotary dryer with a capacity of 50 kg.

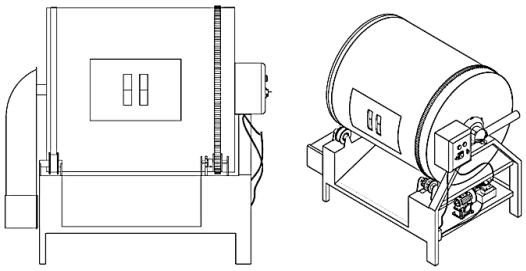


Figure 1. Rotary Dryer

2.2 Methods

As the object of this research, areca nut was used as raw material. The temperature treatment consists of 70°C, 80°C, 90°C, 100°C, and 110°C. The cylinder rotating speed treatment consists of 1 Rpm, 2 Rpm, 3 Rpm. And the treatment of air flow velocity consists of 0,9 m/s, 2,1 m/s, 4,9 m/s, 5,6 m/s and 6,5 m/s. Each treatment uses 10 kg of areca nut and drying time for 210 minutes. The process variables that will be measured and observed are the mass of material before and after drying, the temperature of the material, the temperature of the wet ball and dry ball, the amount of water evaporated and the mass of LPG gas used. Raw data from the measurements and observations are then compiled in tabular form and analyzed to determine the interaction relationship between variables.

2.3 Flow Diagram of Research Process

This research process can be observed in the following diagram.

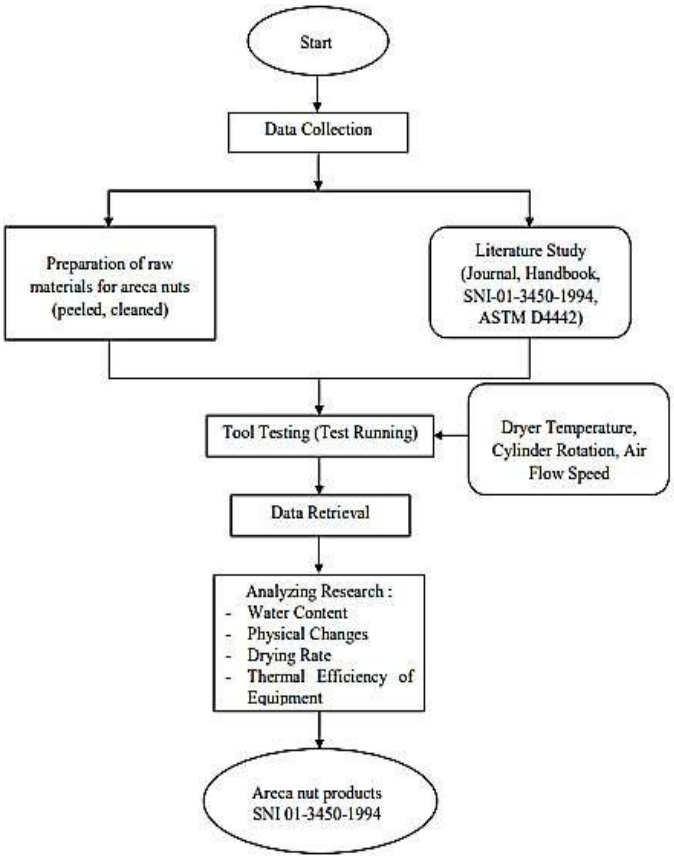


Figure 2. Flow Diagram of Research

3. RESULTS AND DISCUSSIONS

The research was conducted experimentally to determine the moisture content of areca nuts in accordance with SNI 01-3450-1994 with the drying process using a rotary dryer and using fuel in the form of LPG gas.

3.1 Effect of Temperature and Air Flow Velocity on Design and Actual Water Content Reduction

In this rotary dryer, the design air flow velocity is 6,5 m/s. While the actual air flow velocity is 4,9 m/s. The graph of the difference in the decrease in moisture content of areca nuts by design and actual can be seen in Figure 3.

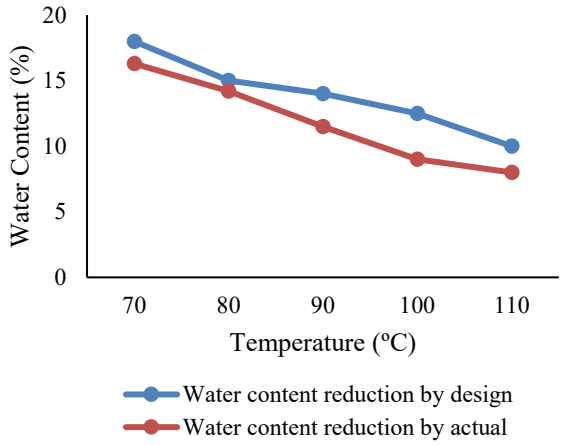


Figure 3. Results of Different Temperatures and Airflow Velocities on Design and Actual Water Content Reduction

From figure 3, the decrease in water content is the greatest at 80ºC. By design, at a temperature of 80ºC with a flow velocity of 6,5 m/s the decrease in water content is 14,2% and in actual terms, the optimal decrease in water content at a temperature of 80ºC with an air flow velocity of 4,9 m/s is 14% which includes SNI 01-3450: 1997 [15].

The difference in water content reduction between design and actual is not that big, this difference is influenced by temperature and hot air flow. The speed of hot air flow is directly proportional to the decrease in water content, namely where the greater the speed of hot air flow supplied, the rate of decrease in water content will be better. This is because the temperature change in the pegering machine occurs so quickly due to the large air flow velocity, so that the saturated air that already contains water vapour will come out to replace the dry air supplied from the blower. From the graphs and data shown that the air flow rate is very influential in reducing the water content of areca nuts because it is directly proportional to the air flow rate and the decrease in water content, besides that temperature also has a big effect on the rate of decrease in water content [16].

3.2 Effect of Cylinder Rotation and Airflow Velocity on Water Content Reduction

Increasing the drying airflow velocity will increase the diffusion of heat from the air into the feed, thereby increasing the amount of water evaporated [17]. This is evidenced in the drying air velocity of 6,5 m/s which has the lowest water content at all the same temperature variables. The following is a graph of the effect or air flow velocity and cylinder rotation on the water content of areca nut seeds.

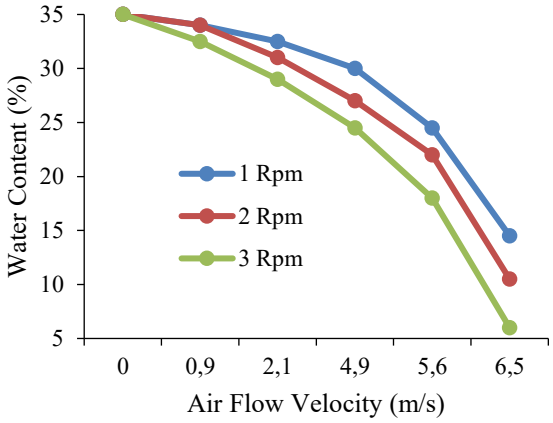


Figure 4. Effect of Cylinder Rotation and Airflow Velocity on the Reduction of Areca Nut Moisture Content

In Figure 4, it can be analyzed that the moisture content of areca nuts is directly proportional to the rotational speed of the cylinder. The higher the rotational speed of the cylinder, the higher the evaporated water content [18]. At each rotating speed the cylinder has reached a moisture content that is in accordance with the SNI 01-3450: 1997 standard, namely 14,5% moisture content as non-medicinal areca nut, 10,5% for medicinal areca nut and 6% moisture content for areca nut stored for a long period of time.

The rotation speed affects the residence time of the product in the drying chamber. The faster the rotation of the cylinder, the shorter the residence time of the dried material. Therefore, the higher the rotational speed of the cylinder, the shorter the contact time between the product and the fuel, so that the drying process is faster and the decrease in moisture content is smaller [19]. This is due to the amount of air that comes into contact with the betel nut which is bound, free water is found on the surface of the betel nut, while bound water is found on the inside of the betel nut, while bound water is found on the inside of the betel nut. Free water first evaporates when the water on the surface runs out during heating, then the bound water content is lost due to the difference in vapour pressure between the inside and outside of the material [16].

The mass transfer process in the drying process is influenced by momentum, namely the drying air flow. Changing the flow rate of the dryer is a momentum transfer process that affects the rate of diffusion of air heat into the material molecules, thereby increasing the temperature of the molecules in the material. The increase in temperature inside the water molecules causes the water vapour pressure inside the molecules to increase, so that the

water in a material is easier to escape from the material molecules [20].

From Figure 5, it can be analysed that the amount of hot air flow is directly proportional to the decrease in water content, i.e. the higher the speed of hot air flow given, the better/larger the rate of decrease in water content.This is because the temperature change in the dryer occurs so quickly due to the high airflow speed that saturated air containing water vapour comes out and is replaced by dry air from the fan. Based on the graphs and data presented, the flow rate has a large effect on the water loss of corn kernels because it is directly proportional to the flow rate and water loss, and temperature and time have a large effect on the rate of water loss [16].

In the drying process, water evaporates from wet materials due to environmental influences such as gas or air with the help of heat. The heat carried by the air heats the surface of the wet material so that the temperature rises and the water evaporates. Therefore, the higher the drying airflow, the faster the drying process takes place. Therefore, the higher the air flow velocity, the faster the drying process [16].

3.3 Effect of Cylinder Rotation and Airflow Velocity on Drying Rate

Cylinder rotation speed and air flow velocity have a significant effect on drying rate. The drying rate increases as the airflow velocity increases and higher cylinder rotations tend to give a more steady increase in the drying rate. Based on Figure 5, it shows that the increase in drying rate is directly proportional to the increase in airflow velocity.

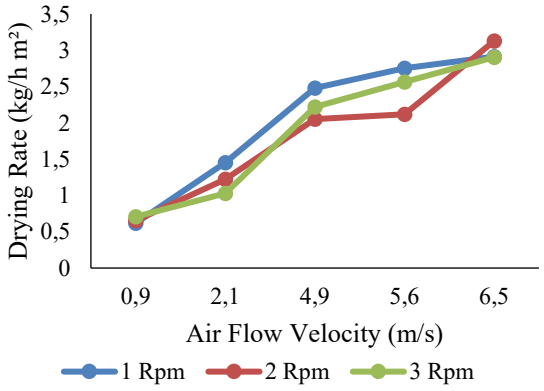


Figure 5. Effect of Cylinder Rotation and Airflow Velocity on Drying Rate

This shows that the drying rate increases with increasing airflow velocity. At a cylinder rotational speed of 1 Rpm, the drying rate increased consistently with increasing airflow velocity and reached the highest value at an airflow velocity of 6,5 m/s. At a cylinder rotating speed of 2 Rpm, a similar pattern was seen with a steady increase in the drying rate as the airflow velocity increased. At a cylinder rotating speed of 3 Rpm, the graph also shows an increase in drying rate with an increase in airflow velocity, but there are smaller fluctuations compared to the lower rotating speeds.

From Figure 5 it can be seen that the rotational density of the cylinder affects the drying rate, where higher rotation (3 Rpm) tends to give a more consistent and possibly higher drying rate compared to lower rotation. This is in line with research conducted by [21], that the highest drying rate is at the largest rotation variation, namely at a cylinder rotation of 10 Rpm. This is because the lower the cylinder rotation, the heat energy in the air in the tube causes a lot of liquid mass to evaporate from the surface of the material. Engine rotation stabilises the air in the cylinder and keeps the material stable at one hot spot in the cylinder.

3.4 Effect of Temperature and Airflow Velocity on Drying Rate

The effect of temperature and air flow velocity on drying rate can be seen in figure 6.

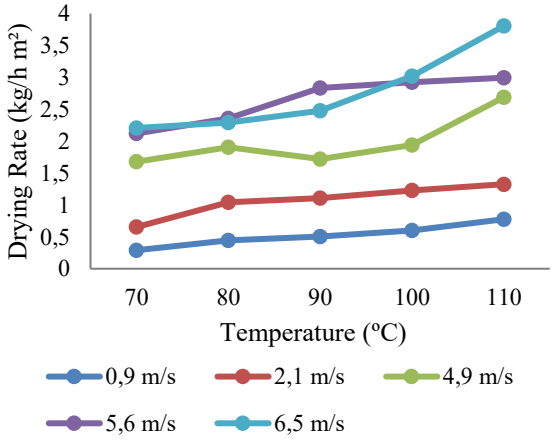


Figure 6. Effect of Temperature and Airflow Velocity on Constant Drying Rate

Figure 6 shows that the temperature and airflow velocity of the dryer are directly proportional to the drying rate. The results obtained with the highest constant drying rate value on the effect of temperature and air flow velocity is at a temperature of 110 ºC and air flow velocity of 6,5 m/s amounting to 3,8049 kg/hour m^2 while for the lowest constant drying rate value obtained at a temperature of 70 ºC with a flow velocity of 0,9 m/s is 0,2901 kg/hour m^2. The higher the drying temperature and air flow, the faster the drying rate. This is because higher air temperatures carry more heat energy, so more liquid mass is evaporated from the surface of the material.

This increase in temperature will also increase the temperature of the material, causing the water vapour pressure inside the material to be higher than in the air, so the water vapour moves from the material to the air [22].

3.5 Effect of Cylinder Rotation and Airflow Velocity on Thermal Efficiency

Proper airflow velocity is critical to improving rotary dryer efficiency. It affects heat and mass transfer rates, temperature distribution, drying time, ultimate moisture control, overheating prevention, and overall energy efficiency. Finding the right balance between airflow velocity and other parameters such as cylinder rotation speed and operating temperature is key to achieving an optimal rotary dryer [23].

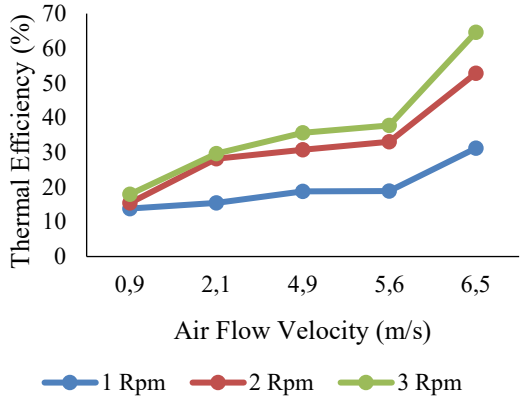


Figure 7. Effect of Cylinder Rotation and Airflow Velocity on Thermal Efficiency

From graph 7, it can be analysed that the efficiency of the tool in the drying process is directly proportional to the rotational speed of the cylinder in the rotary dryer. The faster the rotary dryer rotation, the greater the efficiency of the rotary dryer in drying the material [24]. A good efficiency range in a rotary dryer is 55 - 75% [16]. From the calculation of the efficiency of the device, it can be seen that the highest efficiency is at a cylinder rotation speed of 3 rpm. In general, the optimum cylinder rotation speed in a rotary dryer is very important to improve drying efficiency. It ensures better heat transfer, efficient mixing of materials, uniform distribution of materials, and better temperature control. However the rotation speed should be adjusted according to the nature of the material and the purpose of drying to achieve maximum efficiency without damaging the material [25].

Optimised airflow velocity can improve the energy efficiency of rotary dryers. Efficient airflow reduces the energy required to achieve the desired drying temperature, as fast-moving air transfers heat to the material more efficiently [26]. In Figure 7 it can be seen that the hot air flow velocity is directly proportional to the thermal efficiency, i.e. the higher the hot air flow velocity, the higher the efficiency of the dryer. This is because the higher the airflow velocity used, the better the process, especially in the drying chamber, because the air movement in the drying chamber determines whether or not the drying rate is good.

In general, rotary dryer efficiency values can range from 50% to 70%. The results of research conducted by [16] stated that the highest efficiency in testing with variable cylinder speed is with a drying cylinder speed of 24 rpm resulting in a thermal efficiency of 74,14%. While the efficiency with variable air flow velocity at 15 m/s air flow speed produced an efficiency of 6%. When referring to the results of previous studies, it means that the efficiency value obtained in this rotary dryer is quite good and the operating conditions are quite optimal.

3.6 Effect of Temperature and Airflow Velocity on Thermal Efficiency of the Appliance

The effect of temperature and air flow velocity on thermal efficiency can be seen in figure 8.The drying efficiency of the machine is calculated as the ratio between the heating load energy and the energy generated from fuel combustion [27]. From Figure 8 above, we can compare the drying efficiency between various temperature variations and airflow velocities of the same device and vice versa. The highest drying efficiency was recorded at a temperature of 110°C and an air flow rate of 6,5 m/s, which was 74,60%. The smallest drying efficiency occurred at a temperature of 70°C and air flow rate of 15,21%.

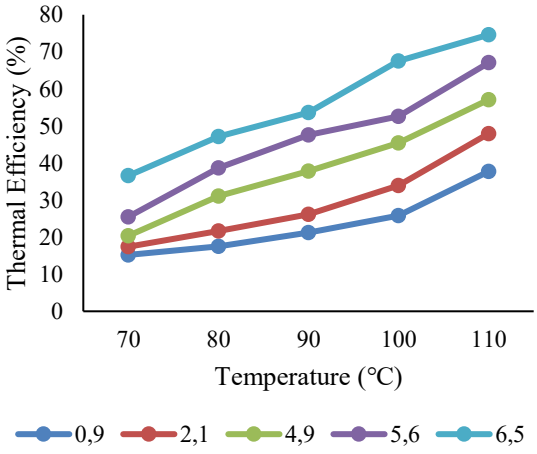


Figure 8. Rotary Dryer Efficiency Results

Increasing temperature generally increases drying efficiency because higher energy helps accelerate water evaporation. High energy

consumption can increase the operating temperature which requires more energy. If the increase in temperature is not matched by a significant drying rate, then the energy consumption per unit of material in the form of dried areca nuts will increase which can reduce the overall energy efficiency.

4. CONCLUSIONS

Based on the results of research that has been done on the drying of areca nuts using a rotary dryer, it is concluded that the decrease in water content, the value of the drying rate and the thermal efficiency of the rotary dryer is directly proportional to the increase in cylinder rotation and air flow velocity The highest thermal efficiency for 64,65% at 3 Rpm cylinder rotation and 6,5 m/s air flow velocity. The best condition for drying areca nuts at variations of cylinder rotation speed and airflow speed is at a speed of 1 Rpm and at an airflow speed of 6,5 m/s which produces areca nut products with a moisture content of 14,5% with the condition of the material that is still intact, not broken, and light brown in colour. Based on temperature and airflow velocity, the decrease in water content by design and actual results obtained for the design at a temperature of 80 ° C with a flow velocity of 6,5 m / s, the decrease in water content is 14,2% while the actual at a temperature of 80 ° C with a flow velocity of 4.9 m / s the decrease in water content is 14% which includes SNI 01-3450: 1997.

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