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Monitoring of Rice Dryer Machine Using Tray Dryer Method

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Abstrak

Indonesia merupakan negara agraris dengan 40% mata pencaharian penduduknya adalah petani. Padi yang dipanen biasanya memiliki kadar air 20-27% pada basis basah. Jenis pengering buatan yang sering digunakan adalah jenis bak atau putar. Penelitian ini bertujuan untuk mengembangkan alat pengering beras dengan metode kombinasi oven dan tipe putar. Berdasarkan hasil dapat disimpulkan bahwa semakin tinggi kecepatan pengering maka waktu pengeringan semakin singkat. Hasil bersih dari pengujian ini adalah bahwa hubungan antara waktu dan putaran mesin berbanding terbalik. Semakin tinggi kecepatan, semakin pendek waktu pengeringan. Hasil bersih dari pengujian ini adalah bahwa hubungan antara waktu dan putaran mesin berbanding terbalik. Hasil penjemuran beras dapat dikatakan kering, namun tidak termasuk standar beras siap saji. Semakin tinggi kecepatan, semakin pendek waktu pengeringan.

Keywords:
artificial dryer;
rice dryer;
combined tray;

Abstract

Indonesia is an agricultural country with 40% of the population's livelihood provided by farmers. Harvested rice typically has a moisture content of 20-27% on a wet basis. The type of artificial dryer that is often used is the tub or rotary type. This research aims to develop a rice dryer using a combined tray and rotary-type method. Based on the result, the higher the speed dryer, the shorter the drying time. The net result of this test is that the relationship between time and engine speed is inversely proportional. The higher the speed, the shorter the drying time. The net result of this test is that the relationship between time and engine speed is inversely proportional. Rice drying results can be described as dry, but not including ready-to-eat rice standards. The higher the speed, the shorter the drying time.

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1. Introduction

Indonesia is an agricultural country with 40% of the population's livelihood provided by farmers. Rice is one of the most common crops in Indonesia. People choose to grow rice because most of the staple food of Indonesians is rice [1]. Before becoming ready-to-eat rice, the rice must go through several processes, namely drying or drying, milling, and after that, it becomes rice which is then cooked into the rice.

The Central Bureau of Statistics (BPS) said rice production will reach 31.36 million tons in 2021. The production figures come from the 2021 rice harvested area reaching 1,696,712.36 hectares and the rice production is estimated at 55.16 million tonnes of dry ground grain (GKG).[2]. Rice production produced by farmers in Central Java reaches approximately 9,618,656.81 tons per year. Harvested rice generally has a moisture content of about 20-23% wet in the dry season and 24-27% in the rainy season[3]. Based on the Indonesian National Standard (SNI), the quality of premium rice, both class 1 and class 2, has a maximum moisture content of 14% on a wet basis, so to reduce the water content, drying is carried out.

Drying is one of the post-harvest handling carried out on grain[4]. To find out the criteria for dry rice in the drying process, it is marked by a clicking sound when dried. The grain drying process can be done mechanically to improve the quality of the grain using an artificial rice dryer. The type of artificial dryer that is often used is the tub or rotary type[5]. This type of machine has never been used in previous research. This type of combined dryer will reduce the grain's moisture content until the moisture content is below 14%. However, the appropriate technology for smallholder-scale grain dryers is still mechanical. Research on grain monitoring systems that utilize new microcontroller-based technology in drying will continue to be developed to obtain ideal rice drying results.

Research on the grain monitoring system was carried out by[5],[6], and,[7] under the title "Arduino-Based Rice Grain Moisture Monitoring which aims to create an Arduino-based rice grain moisture monitoring system using DHT 11 sensors and Soil Moisture". Based on the test results, it was found that the system can measure the moisture and moisture content of the rice grain, to minimize damage to rice when milling.

Rice is a rice-producing food crop commodity that plays an important role in Indonesia's economic life[8]. Based on the National Standardization Agency for dry rice that is ready to be milled, it has a maximum water content of 14%.[9]. Drying aims to remove some of the water from the material by evaporating the water using heat energy[10]. The threshed rice will be subjected to a drying process.

The proposed system that we used in this research is using a tray method that is rarely used in a rice dryer machine. Previous research was on tub and rotary types, which lack power efficiency and high cost to be implemented. To solve the problem, this research aims to develop a rice dryer using a combined tray and rotary-type method.

2. Methods

The research method used is described in the following flowchart:

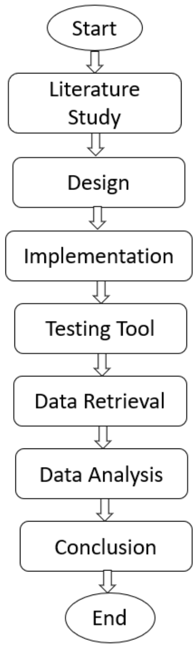

Figure 1. Research Flowchart

Figure 1 shows the research flow chart starting from the literature study, rice dryer design, tool testing, data analysis, and the conclusion of the research. Literature sources can be in the form of final assignments, theses, and journals. The data obtained can be in the form of readings from measuring instruments or data from literacy sources which are then processed to conclude the research.

The drying technique is divided into two ways, natural drying, and artificial drying. Rice drying speed can be calculated by the following equation (1) below:

$$LP = \frac{Mw.o - Mw.i}{\Delta t} \quad (1)$$

Information :

LP : drying rate (% wk/hour)
Mw.o : initial water content of the material (% bk)
Mw.i : final water content (% bk)
T : drying time (hours)

The drying rate in a process has an important element, where the drying rate is about how the drying process takes place[8]. A limited amount is an amount of water that is evaporated per unit of time or a decrease in the water content of a material every time[9].

Several terms are used to describe the level of rice dryness, including:

1) Dry harvest (moisture content ± 25%)
2) Dry village (water content ± 19%)
3) Dry barn/store (water content ± 16%)
4) Dry milled (moisture content = 14%)

Besides the level of rice dryness, there are 3 quantitative requirements for grain quality according to SNI 01-6128 – 2008 that affect the quality of rice. Grain quality is determined by 7 factors, those are:

1) Water content factors such as the amount of water content in grain grains expressed in units of percent of wet weight (Wet Basis).

2) Hollow grain; grains that are not fully developed or due to attack by pests, diseases, or other causes so that they do not contain rice even though the two husks are closed or open. Half-empty grain grains are classified as empty grains.
3) Dirt; all other foreign objects that are not classified as a grain, for example, dust, soil particles, sand, stones, gravel, pieces of wood, rice stalks, other seeds, dead insects, and so on. Included in the dirt category are unhulled grains (broken rice) and broken unhulled grains.
4) Broken Items; the damaged grain is brown rice (after the grain is peeled) that is damaged. This category includes grain grains whose contents are white/translucent, calcified white, and red in color with spots of other colors.
5) Yellow Grain Cracked rice (after the grain is peeled) is yellow, brown, or yellowish and the yellow is damaged due to the discoloration that occurs during treatment.
6) Calcification Grain; Rice broken skin (after the grain is peeled) is white like chalk (chalky) and has a soft texture caused by physiological factors. White grains like chalk that are intact and hard are included as healthy grains (not chalk grains).
7) Red Grain; brown rice grains (after the grain is peeled) are red due to the variety of rice they come from.

Based on the 7 factors above, the rice criteria have a specification that has been ruled by SNI 01-6128 – 2008. Its criteria are being tested in the laboratory and have some numerical results for their factors. These criteria usually recognize the rice quality standard in a livestock market or rice producer. Table 1 shows the different criteria for grain quality:

Table 1. Rice Quality Standards

No	Component	Quality (%)		
		I	II	III
1	Moisture Content (maximum)	14.0	14.0	14.0
2	Empty Grain (maximum)	1.0	2.0	3.0
3	Broken Grain and Yellow Grain (maximum)	2.0	5.0	7.0
4	Whitewashing Grain and Young grain (maximum)	1.0	5.0	10.0
5	Red Items (maximum)	1.0	2.0	4.0
6	Object Foreign (maximum)	-	2.0	4.0
7	Other Rice Varieties	2.0	5.0	10.0

One of the components of grain quality for the quantitative requirements of SNI is content water. In Table 1 it can be seen that the moisture content of the grain produced is 14% water content, this already meets the quality requirements of SNI[10]. This is due to treatment the drying is done with a thickness of 3-5 cm and reversed once every 2 hours, so that the grain has reached a moisture content of about 14% on the third day. Water is a major factor that is applied in rice dryers. The decrease of water proportionally to the time of rice dryer. Equation 2 below shows the formulation of a decrease in water content during the drying process can be known by the following equation (2):

$$\text{Ka} = \frac{Mt - Mk}{Mt} \text{ x}100\% \quad (2)$$

Information:
Ka = decrease water content (%)
Mt = total initial wet rice mass (kg)
Mk = final total dry rice mass (kg)

2.1 Block Diagram

The system design stage is carried out as an initial step before the tool is ready to be realized to ensure that the system can run according to its function and analyze the need to make the tool. The Block Diagram is one part of making this tool because, from this block diagram, it can be seen how the whole circuit works to clarify the tool made, and simplify the process of making the tool so that a monitoring system will be formed with the previous design.[11]. Figure 2 is a block diagram applied in a rice dryer.

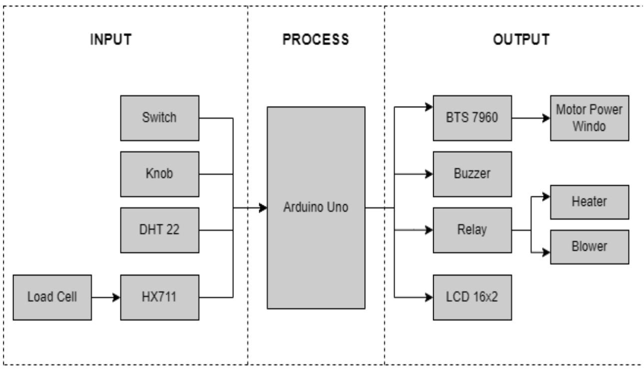

Figure 2. Block Diagram

The components in the block diagram are described in the following descriptions:

a) The switch acts as a liaison and breaker for the heater, blower, and motor working methods.
b) There are three buttons for setting or setting the level for temperature, humidity, and motor rotational speed. Button 1 is a set point to determine the specified limit, button 2 is used as a set down to determine the limit value to be set, then button 3 is a set up to increase the value from the previous limit.
c) The DHT 22 sensor is an indication of the temperature released by the heater in the room, the temperature sensor will send a signal which is then displayed by the LCD.
d) Load cell gives an indication of the weight of the rice, the load cell will send a signal to the HX711 which is used as a driver to read the value of the weight of the load.
e) Arduino Uno is used as control of the entire block diagram work system, where the input will be processed in the Arduino which will then be displayed on the LCD.
f) Heater as a heat source in the rice drying process. Blower as a driver of hot air in the rice drying process.

g) BTS 7960 is used as a driver for the power window motor. The relay can control the heater and blower.

The working process of the rice dryer is described in the following figure 3:

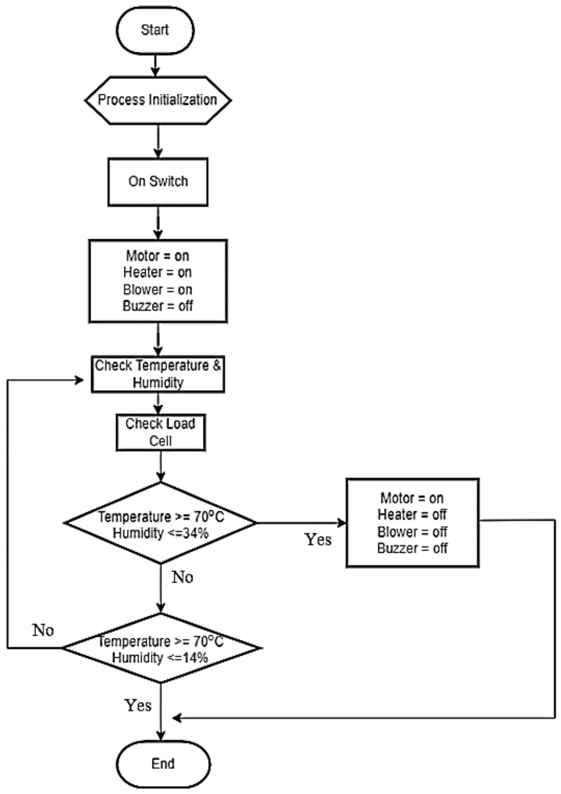

Figure 3. Flowchart

The working principle of this system is that when the switch is pressed, the heater and blower will work and are controlled by the Arduino controller. At the same time, the temperature, humidity, and motor speed have been set within a certain time as the time limit for the tool's working method. The heat generated by the heater will be driven by pressurized air from the blower to dry the rice[12]. Water content readings are done manually for higher data accuracy. After the time has reached the working limit and the moisture content has reached the desired standard, the method will stop working[13]. The dried rice is removed manually.

2.2 Combination Tray System

Combination tray dryer drying is the right choice because apart from its simple technology and pollution-free[14]. The capacity of rice to be dried is only capable of a maximum limit of 1 kg in one drying. Especially for drying superior rice seeds produced by seed breeders. To get maximum results, a combination of tray and rotary is needed in the mechanical manufacture of this dryer, thus perfect results will be obtained[15]. This machine is one of the latest technology applications with several additional electronic components.

3. Results and Discussion

This research resulted in a rice dryer using the tray dryer method that can be used for farmers on a home scale. This tool is capable of drying rice with a stable temperature of 40ºC and a maximum PWM setting of 200.

3.1 Rice Drying Results

This discussion is an analysis of the results of rice drying with the tray dryer method. The test results can be in the form of calculation analysis, physical analysis of rice, or analysis of measuring instrument readings. Analysis of calculations and measurements will be presented in the form of tables and graphs.

3.1.1 The Effect of Motor Speed on the Result of Moisture Content

The following are the results of rice drying with the effect of motor rotation on the test results.

Table 2. Water content measurement between sensor and instrument

Time (min.)	PWM	Water Content Measurement		Dryness Degree (YL-69
		Instrument (%)	Sensor (%)	
0	100	18	26	Moist
30	100	12	15	Dry
60	100	10	5	Dry
0	180	14	23	Dry
15	180	11	16	Dry
30	180	11	0	Dry

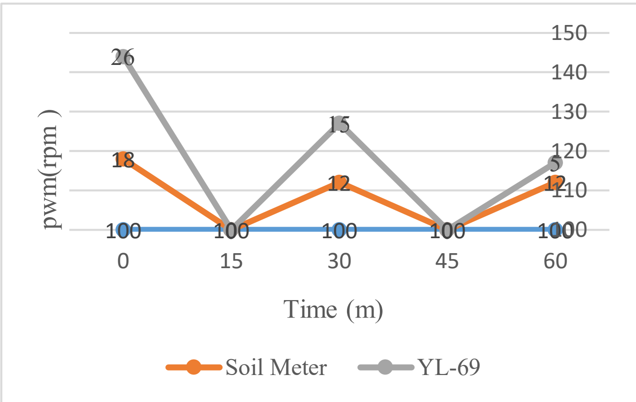

Figure 4. Decrease in Water Content at Pwm 100

Based on the table above shows the results of the comparison between the soil meter and the YL-69 sensor. The value displayed by the sensor shows a greater result than the measuring instrument. In dry rice, the value displayed by the sensor always shows a number below 10% until it shows the number 0. While the measuring instrument still reads the number 10, 12%. In the first minute, the water content of rice is read as 23% on the sensor and 14% on the measuring instrument. At the 15th minute with a motor rotation of 180, the reading of the measuring instrument shows a value of 11% while the sensor shows a value of 16%. In the 30th minute, the result that is read on the sensor is 0% or indicates dry rice. The dry rice category ranges from 10-30, in humid conditions at 30-60, and in wet conditions at 60-100%.

From this measurement, we can see that PWM 100 and time measurement 30 minutes have more water content than

PWM 180 and time measurement with only 15 minutes. Different water content measurements in instruments and sensors have the same dryness degree based on the YL-69 sensor which set the dry category if the percentage of water content is more than 23% from their base, and this is also similar to the result of research [16]. Figure 4 shows a graph of motor rotation affecting water content reduction.

3.1.2 Pwm Test Against Time

The following is a table of the stirrer rotation test results on the drying duration, which can be seen in Table 3.

Table 1. Effect of Motor Rotation vs Time

No	Initial weight (g)	After Drying Process		Difference (%)
		Load cells (g)	Digital Scales (g)	
1	500	359.47	472	24
2	500	404.32	487	16
3	700	441.12	641	31
4	700	445.12	648	31
5	1000	537.30	819	34

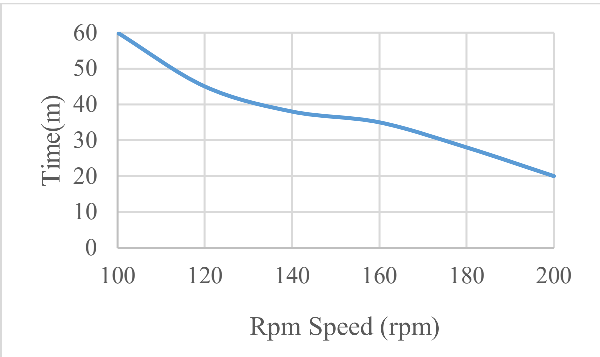

Figure 5. Graph of the Effect of Motor Speed on Time

Based on Table 3, the results of the test with a stable temperature of 40°C the time needed to achieve dryness of ready-to-mill rice is 120 to 130 minutes, while at 35 to 65 minutes the rice is said to be dry but cannot enter the criteria for ready-milled rice. Testing using a temperature of 40°C is still not evenly distributed on the surface of the drying layer in the tray. The water content of rice in this test has an average of 23% which is not too high due to harvesting in the dry season. After the rice undergoes a drying process in the machine, changes occur including the color of the rice becoming brighter yellowish than the color of the rice before drying; the texture of the rice is hard, and it looks like there is no water sticking to it.

The table above shows that the DHT sensor reads room temperature and the average temperature is stable at 40°C with 39% humidity in rice with a mass of 700 grams each time. The experiment was carried out with the lowest speed of the motor, namely 100 rpm with a time of 60 minutes producing dry grain weighing 648 grams, the second experiment with a speed of 120 with a length of time of 43 minutes with a weight of 627 grams, 140 the length of time needed to dry was 38 minutes producing a weight of 641 grams and so on until the fastest rotation of 200 rpm can dry rice in 20 minutes to produce 672 grams. Figure 5 below will show the effect of the stirrer rotation on the drying time.

With the parameter humidity and temperature that we set in a certain number, the correlation between PWM and the drying process is directly proportional. With the constant speed of the motor, the stirring process needs a lot of time for all the rice to distribute the heat to dry. But with this condition, it also affects overall weight after the drying process. The weight for fast rpm has less weight than the slow rpm because the stirrer causes the rice to spread across not only the tray dryer but only the bottom part of the rice drying machine.

3.1.3 Rice Mass Comparison Test with Sensors and Digital Scales

The following is the result of reading the mass of rice during the drying process, which can be seen in Table 4.

Table 2. Measurement Using Load Cell with Digital Scale

Test			Weight (grams)		Time (m)
PWM	Temperature (°C)	Humidity (%)	Beginning	End	
100	40.90	39	700	648	60
120	41.30	39	700	627	43
140	40.60	39	700	641	38
160	40. 38	39	700	640	36
180	40.56	39	700	685	30
200	40.42	39	700	672	20

Table 4 shows the measurement results using a load cell with a comparison of digital scales. With an initial weight of 500 grams, after the drying process, the rice shrunk to 359.47 grams, which was read by the load cell and 472 by the digital scale. The difference between the two is 24%. In another experiment, the difference between 10-30% was obtained with the results on digital scales.

Some rice samples with weights of 500, 700, and 1000 grams are tested to investigate the difference in water content percentage after the drying process. Based on this measurement, it shows that almost all categories have a percentage of error, but it also shows that errors happen not higher than 35% which is a standard error for a mass measurement of livestock.

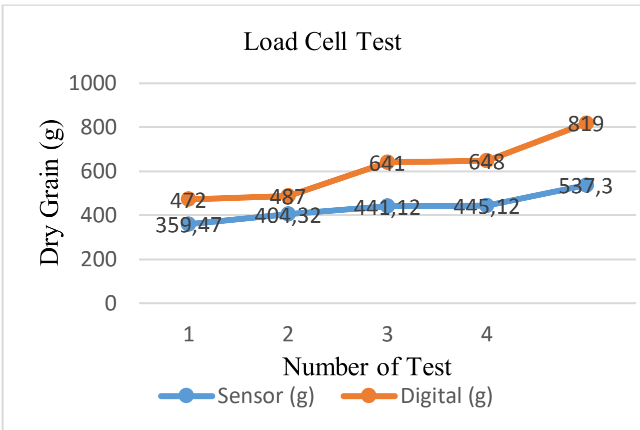

Figure 6 Sensor Testing Graph with Measuring Instruments

3.2 Comparison of Natural Drying with Machine

In Table 5 below, water content from in the early minutes, rice still has a high water content, which is between 14-30%. The time used to compare is 1 hour while testing rice using sunlight takes 3 hours, and using a machine takes a maximum of 1 hour 30 minutes. In Table 4.10 it can be described that in the initial minutes with an initial weight of 700 grams, the rice still has a normal weight and water content as in the initial state. Then at the 15th minute, the natural drying experienced an initial shrinkage of 4%, and the drying using a machine experienced a shrinkage of 23%. Each sampling was carried out for an interval of 15 minutes. At the last minute, which is the 60th minute, with an initial weight of 700 grams, it decreased by 275 grams with a net weight of 425 grams. While on the dryer the weight that is read on the LCD is 404 grams, but the net weight on the digital scale is 648 grams.

Table 5. measurement of water content between natural drying and machine drying

Time (m)	After Drying Process			
	Water content (%)		Loss of Water Content (%)	
	Natural	Machine	Natural	Machine
0	23	23	0	0
15	19	18	4	27
30	16	12	7	36
45	14	7	9	37
60	11	0	11	42
75	9	-	28	-
90	8	-	32	-
105	5	-	35	-
120	0	-	39	-

The loss of water content in natural drying is greater than that of the machine because there is material scattered on the floor, and it uses direct sunlight. In this tray dryer, the initial shrinkage has a high value then in the following minutes, it has a stable temperature and humidity value. So the water loss in the engine is less. The results of the loss of water content can be seen in the calculation below: and use direct sunlight. In this tray dryer, the initial shrinkage has a high value then in the following minutes, it has a stable temperature and humidity value. So the water loss in the engine is less. The results of the loss of water content can be seen in Figure 7 and the use of direct sunlight. In this tray dryer, the initial shrinkage has a high value then in the following minutes, it has a stable temperature and humidity value. So the water loss in the engine is less. The results of the loss of water content can be seen in Equation (3) and Equation (4) below:

$$\text{Ka} = \frac{\text{Mt}-\text{Mk}}{\text{Mt}} \text{ x } 100\% \quad (3)$$

$$\text{Ka} = \frac{835-725}{835} \text{ x } 100\%$$

$$\text{Ka} = 13\ \%$$

$$\textbf{LP} = \frac{Mwo-Mwi}{t} \quad \textbf{(4)}$$

$$\textbf{Lp} = \frac{3\%-13\%}{60}$$

$$\textbf{Lp} = \textbf{0.17\% bk/min}$$

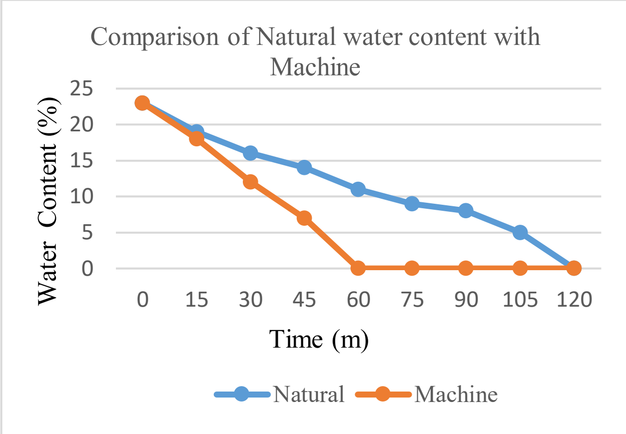

Figure 7. Water content degradation between Natural and Artificial Drying

4. Conclusion

To improve the drying of grains, a rice dryer was built using the combined oven and rotary process. The machine dries the grain with the help of a heater that blows fans around the room to equalize the room temperature. Monitoring is via an LCD which displays sensor readings for temperature, humidity, and grain weight. The drying time for the grains depends on how fast and how many grains you put in the bowl. In the test at 100 rpm, it can be dried for 1 hour. At a speed of 200, grain can be dried in 25 minutes. Both results indicated that the rice was dry but not up to par for ready-to-eat rice. The higher the speed, the shorter the drying time.

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