# Performance Test of Chili Dryer with Greenhouse Effect System based On Solar Panel

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**Abstract.** This study aims to explain the results of performance test from chili dryers with greenhouse effect system based on solar panel. The performance test methods carried out by an experiment. The experimental process was carried out by comparing two samples (with initial mass was 200g) dried in a dryer (experiment) and conventionally (control). The data collected were the mass of each sample every 30 minutes, temperature and humidity. This study was conducted from 10.00 a.m. to 03.00 p.m., along two days. Data was analyzed with graphs method. Results showed that the chili dryer with greenhouse effect system based on solar panel, able to increasing the temperature and reducing air humidity. This condition can make the drying process become more effective. The average mass of chili in experiment group was 33g and control group was 58g. The average temperature inside the dryer was 43.84°C, while the average temperature outside the dryer was 41.48°C. The average humidity inside the dryer was 16.03%, while the average humidity outside the dryer was 49.87%.

**Keywords:** chili, dryer, greenhouse effect, solar panels.

## 1 Introduction

The chili drying process can be classified into two namely, natural and mechanical [1]. The natural drying process was carried out by laying the material under the sun. The advantages of this method were energy savings, the ability to produce high heat, and practical. The disadvantages of this method include being easily contaminated, difficult to control, requiring a large space, and requiring a long time [2]. The mechanical drying method was done by flowing hot air into the material. The advantage of this method was that the capacity of the dryer could be adjusted to meet the needs, it did not require a large space, and the condition of the dryer could be controlled. The disadvantage of this method was that it was wasteful of energy and not environmentally friendly [3]. Wasteful of energy because modern dryers use heat sources from PLN electricity. It will burden farmers economically because the equipment was turned on for a long time. Not environmentally friendly because mechanical dryers, in addition to using heat sources from PLN electricity, also use firewood, oil, fuel, and other fuels, which of course produce carbon dioxide ($CO_2$). In addition, the flow of hot air produced from the process of burning carbon materials is certainly not completely clean and can contaminate the chili itself chemically.


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Based on this, it was considered necessary to develop a chili dryer that was able to combine the advantages of natural and mechanical methods and minimize the disadvantages of each of these methods. Chili dryer with greenhouse effect system based on solar panel was a drying system made with a transparent wall so that the sun's heat can enter the drying room and be confined in it [4]. This tool was also equipped with a heat collector (made of black aluminum and stone). The heat that was collected in the collector was flowed into the drying chamber using an input fan. In addition to the input fan, this tool is also equipped with an output fan. The output fan has functions to drive water vapor formed during the drying process from inside to outside the drying chamber. This fan was turned on using electricity from solar panels. By using this tool, the heat from sunlight was not only used as a heat source in the drying process but also as a source of electricity to turn on the fan. Optimized heat rays with a greenhouse effect system and the presence of air flow in the tool are believed to be able to increase the temperature and reduce humidity in the drying room. If the temperature increases and the humidity decreases, the drying process can take place more optimally [5]. The purpose of this study is to test the performance of chili dryers with greenhouse effect systems based on solar panel. The test was carried out using an experimental method, which compares the final mass of chili dried using a dryer and conventionally.

## 2 Method

Performance test of the chili dryer with greenhouse effect system based on solar panel developed in this study, carried out by an experimental method. Because it uses an experimental method, this research has dependent and independent variables [6]. The dependent variable was the mass of chili after the drying process. Independent variables were the drying method, namely the experimental group (chili dried using a dryer) and the control group (chili dried conventionally). The initial mass of the sample for each group was 200g. The study was conducted for two days (July 29–30, 2023). Data collection was carried out every 30 minutes, from 10 a.m. to 3 p.m. So, in one day there are 10 data were collected. Data collection techniques presented in table I.

**Tabel 1.** Data Collection Techniques

| No | Illustration | Information |
|---|---|---|
| 1 |  | Measure the initial mass of the sample. The initial mass of the sample was measured using a digital balance. Two groups of samples were made, namely the control group and the experiment group. The initial mass of the sample for every group was 200g. |
| 2 |  | The control group was conventionally dried. It was done by drying the sample in an open area under the sun from 10 a.m. to 3 p.m. |

| No | Illustration | Information |
|---|---|---|
| 3 |  | The experiment group was dried using a dryer. It was done by entering the sample into the chili dryer with a greenhouse effect system based on solar panel from 10 a.m. to 3 p.m. |
| 4 |  | Measure the mass of each sample every thirty minutes. Besides that, researchers also record the values of temperature and humidity. This activity was done both in the control and experiment groups. The data collection process will be carried out for two days, from July 29 to 30, 2023. |

The data analysis technique in this study was to use the graph method [7]. Researchers made a profile graph of changes in temperature, humidity, and mass based on a table of research results for two days. There are six graphs, namely (a) temperature profile graph inside and outside the dryer on day I, (b) temperature profile graph inside and outside the dryer on day II, (c) humidity profile graph inside and outside the dryer on day I, (d) humidity profile graphs inside and outside the dryer on day II, (e) mass reduction profile between experiment and control on day I, and (f) mass reduction profile between experiment and control on day II. Descriptive and quantitative analysis was done based on the graphs that have been made.

## 3 Results and Discussion

Chili dryer with greenhouse effect system based on solar panel, that tested for its performance in this study, was presented in figure 1.

**Fig. 1.** Chili dryer with greenhouse effect system based on solar panel.

This dryer has a transparent wall so that the sun's heat can enter and be confined to it. Besides that, this tool was also equipped with a heat collector made from aluminum and black stone. The surface of this heat collector was covered by glass so that solar heat could enter it. The aluminum inside this heat collector was folded like the letter W so that the surface area increased. With a larger surface area, more heat can be collected [8]. Black stones are scattered between the folds. Aluminum and black stone were good conductors. The air inside the heat collector has a high temperature value (hot air). The input fan (passing hot air from the heat collector to the drying chamber) and the output fan (moving moisture from inside the drying chamber to the outside) were turned on using electricity sourced from solar panels.

Based on figure 1, the specifications of the dryer were presented in table 2.

**Tabel 2.** Specification of Dryer.

| No | Specification | Information |
|---|---|---|
| 1 | Dimention | Drying room: p = 30 cm, l = 30 cm, t = 60 cm.<br>Heat collector: p = 50 cm, l = 30 cm, t = 15 cm. |
| 2 | Solar panel | Power = 4 x 10 Wp,<br>Voc = 17,5 V<br>Isc = 5,56 A. |
| 3 | SCC | This dryer uses Solar Charge Controller with:<br>V = 12 V<br>I = 30 A. |
| 4 | Battery | This dryer uses battery with specification:<br>12 V 20 Ah.<br>P = 240 W. |
| 5 | Inverter | This dryer uses inverter with specification:<br>P = 4000 W.<br>Vin = 12V.<br>Vout = 220 V.<br>f = 50Hz. |
| 6 | Fan | This dryer uses two fans with specification:<br>V = 220 VAC,<br>P = 20 W. |
| 7 | Thermometer | This dryer uses a sticky thermometer that is able to measure temperature and humidity simultaneously. |
| 8 | Heat collector | This dryer has a heat collector with dimensions: p = 50 cm, l = 30 cm, and t = 15 cm. Conductor inside the heat collector was made from the folded aluminum in W-shaped and black stone. |

### 3.1 Result

The data collection process was carried out for 10 hours. In one day, the data collection process was carried out for 5 hours (10.00 a.m. to 03.00 p.m.). The research was done in this time interval because in Indonesia, the optimum sun shine occurs from 08.30 a.m. to 03.30 p.m. [9]. The study was conducted from July 29–30, 2023. The study was done in the Mechanical Engineering Department, State Polytechnic of Sambas, West Borneo, Indonesia. The data collected in this research were mass, temperature, and air humidity. The measurement process was done every 30 minutes. Researchers are collecting data on chili mass using a digital balance. Researchers are collecting data on temperature and air humidity inside and outside the chili dryer using thermohydrometers. The research data are presented in tables III and IV.

**Table 3.** Research Results Day I (July 29, 2023)

| No | Time | Experiment | | | Control | | |
|---|---|---|---|---|---|---|---|
| | | m (g) | T (°C) | H (%) | m (g) | T (°C) | H (%) |
| 1 | 11.00 a.m. | 200 | 34,9 | 55 | 200 | 34,9 | 55 |
| 2 | 11.30 a.m. | 186 | 49,7 | 24 | 196 | 36,2 | 42 |
| 3 | 12.00 a.m. | 171 | 49,4 | 24 | 192 | 38,5 | 39 |
| 4 | 12.30 p.m. | 162 | 50,2 | 23 | 190 | 38,7 | 38 |
| 5 | 01.00 p.m. | 148 | 48,4 | 24 | 187 | 37,4 | 38 |
| 6 | 01.30 p.m. | 141 | 48,0 | 24 | 183 | 39,0 | 36 |
| 7 | 02.00 p.m. | 132 | 46,5 | 26 | 179 | 39,3 | 38 |
| 8 | 02.30 p.m. | 124 | 46,6 | 26 | 175 | 40,2 | 35 |
| 9 | 03.00 p.m. | 119 | 41,6 | 32 | 173 | 35,5 | 40 |
| 10 | 03.30 p.m. | 114 | 39,9 | 40 | 171 | 34,6 | 48 |

**Tabel 4.** Research Results Day Ii (July 30, 2023)

| No | Time | Experiment | | | Control | | |
|---|---|---|---|---|---|---|---|
| | | m (g) | T (°C) | H (%) | m (g) | T (°C) | H (%) |
| 1 | 10.00 a.m. | 114 | 33,7 | 64 | 171 | 33,7 | 64 |
| 2 | 10.30 a.m. | 70 | 49,3 | 26 | 142 | 40,0 | 40 |
| 3 | 11.00 a.m. | 65 | 49,9 | 24 | 138 | 39,6 | 38 |
| 4 | 11.30 a.m. | 61 | 47,8 | 26 | 135 | 38,0 | 39 |
| 5 | 12.00 a.m. | 56 | 47,2 | 27 | 133 | 37,8 | 40 |
| 6 | 12.30 p.m. | 54 | 47,7 | 27 | 130 | 39,2 | 41 |
| 7 | 01.00 p.m. | 52 | 44,9 | 33 | 128 | 36,6 | 44 |
| 8 | 01.30 p.m. | 50 | 52,0 | 20 | 122 | 40,2 | 36 |
| 9 | 02.00 p.m. | 48 | 51,4 | 23 | 121 | 41,4 | 37 |
| 10 | 02.30 p.m. | 46 | 54,8 | 20 | 117 | 39,6 | 35 |
| 11 | 03.00 p.m. | 45 | 53,3 | 20 | 113 | 42,9 | 33 |

Based on the temperature value measured every 30 minutes in Table III, the difference in temperature profiles inside and outside the dryer chamber on the first day was presented in Figure 2.

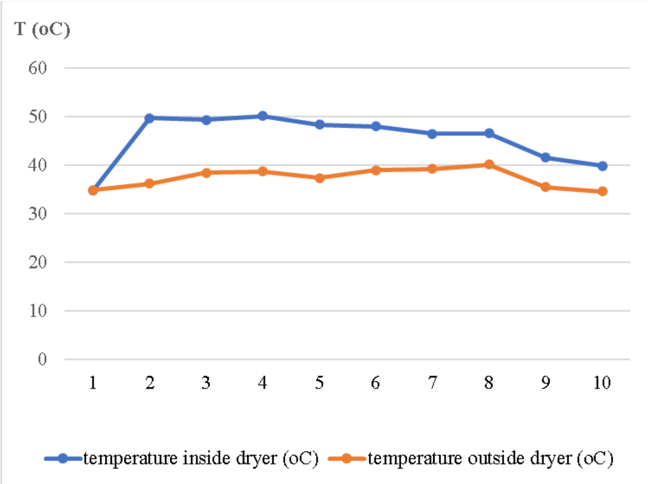


**Fig. 2.** Profile of temperature changes inside and outside the dryer (day I).

Figure 2 shows that on the first day of testing, it was visually seen that the temperature inside the dryer was relatively higher than outside the dryer. The average temperature outside the dryer (the temperature used to dry samples conventionally) was 37.4°C. The average temperature inside the dryer (the temperature used to dry samples experimentally) was 45.5°C. So, there was an average temperature difference up to 8.1°C.

Based on the temperature value measured every 30 minutes in Table IV, the difference in temperature profiles inside and outside the dryer chamber on the second day was presented in Figure 3.

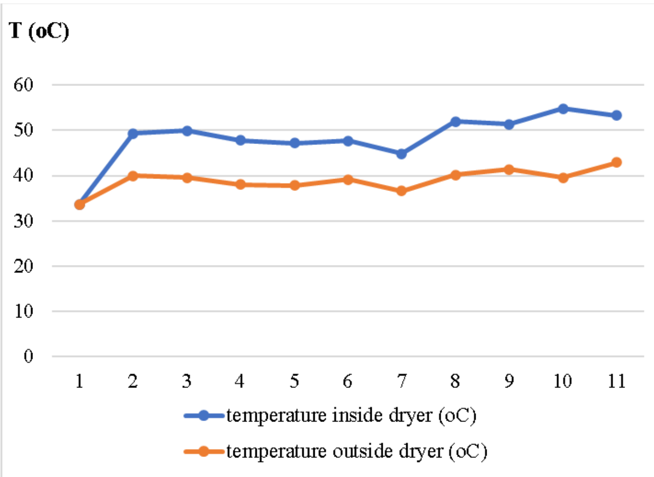


**Fig. 3.** Profile of temperature changes inside and outside the dryer (day II).

Figure 3 shows that on the second day of testing, it was visually seen that the temperature inside the dryer was relatively higher than outside the dryer. The average temperature outside the dryer (the temperature used to dry samples conventionally) was 39°C. The average temperature inside the dryer (the temperature used to dry samples experimentally) was 48.3°C. So, there was an average temperature difference up to 9.3°C.

Based on the humidity value measured every 30 minutes in Table III, the difference in air humidity profiles inside and outside the dryer chamber on the first day was presented in Figure 4.

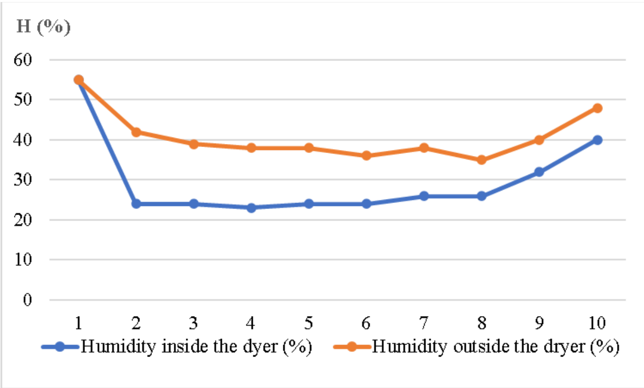


**Fig. 4.** Profile of humidity changes inside and outside the dyer (day I).

Figure 4 shows the change in air humidity value during the drying process of the first day from 11.00 a.m. to 03.30 p.m. It was seen that the average value of humidity inside the dyer (29.8%) was lower than the value of humidity outside the dryer or environment (40.9%). So, there was an average humidity difference up to 11.1%.

Based on the humidity value measured every 30 minutes in Table IV, the difference in humidity profiles inside and outside the dryer chamber on the second day was presented in Figure 5.

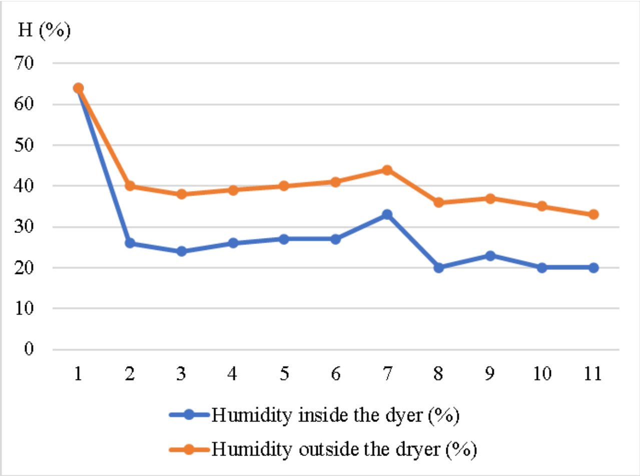


**Fig. 5.** Profile of humidity changes inside and outside the dyer (day II).

Figure 5 shows the change in air humidity value during the drying process of the second day from 10.00 a.m. to 03.00 p.m. It was seen that the average value of humidity inside the dryer (28.2%) was lower than the value of humidity outside the dryer or environment (40.6%). So, there was an average humidity difference up to 12.4%.

Based on the mass values measured every 30 minutes in Table III, the difference in mass reduction profiles between the control and experiment groups on the first day was presented in Figure 6.

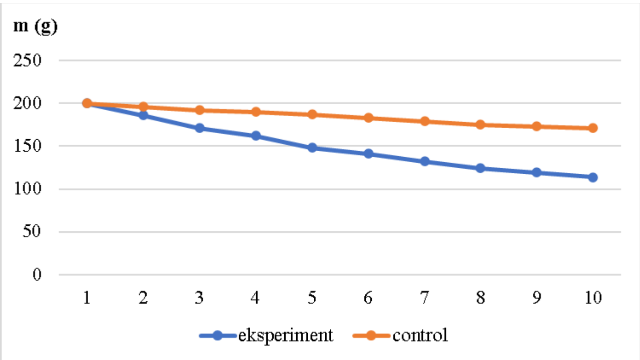


**Fig. 6.** Mass reduction profile between control and experiment group (day I).

Figure 6 shows that the mass reduction of the sample using a chili dryer with greenhouse effect system based on solar panel was faster than the conventional method. The final mass of the sample in the experiment group on the first day was 114g, while in the control group it was 171g. There was a 54g of difference. The dryer was able to reduce the mass of chili up to 43%, while the conventional method only achieved 14.5%.

The chili dryer with greenhouse effect system based on solar panel was more optimal than the conventional method in the drying process on the first day.

Based on the mass value measured every 30 minutes in Table IV, the difference in mass reduction profiles between control and experiment group on the second day was presented in Figure 7.

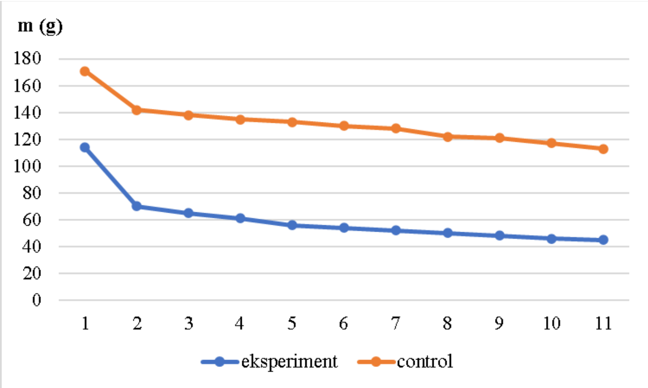


**Fig. 7.** Mass reduction profile between control and experiment group (day II).

Figure 7 shows that the mass reduction of the sample using a chili dryer with greenhouse effect system based on solar panel was faster than the conventional method. The final mass of the sample in the experiment group on the second day was 45 g, while in the control group it was 113 g. There was 68g of difference. The dryer was able to reduce the mass of chili up to 60.52%, while the conventional method was only 38.60%. The chili dryer with greenhouse effect system based on solar panel was more optimal than the conventional method in the drying process on the second day.

In addition, qualitatively comparing the shape of chili after drying using experiment and conventional method, presented in figure 8.

A B

**Fig. 8.** The shape of chili after drying using experimental (A) and conventional method (B).

Based on figure 8, with the same drying time duration (10 hours), the sample that was dried using chili dryer with greenhouse effect system based on solar panel has a more wrinkled, dry, slightly dark, and hard shape. The sample that was dried using the conventional method looks larger, moist, bright, and mushy. This difference in physical characteristics indicates a difference in the water content contained in chili. The results of laboratory tests showed the sample dried using chili dryer with greenhouse effect system based on solar panel had 17% moisture content, while the sample dried using the conventional method had 59% moisture content. This fact shows that the dryer was able to carry out the drying process more optimally than conventional methods.

### 3.2 Discussion

Based on the results of the testing process of chili dryer with greenhouse effect based on solar panel, which have been carried out for two days (July 29 and 30, 2023), three facts can be formulated as follows: The final mass of dried chili using a dryer for two days is 45g, while the final mass of conventionally dried chili is 113g. Second, the average temperature inside the dryer during the two days of the data collection process was 46.93°C, while the average temperature outside the dryer from the two experiments was 38.2°C. Third, the average humidity of the air inside the dryer is 28.99%, while the average humidity of the air outside the dryer is 40.77%. The drying process will be optimal if the temperature increases and the humidity decreases.

Environmental factors affecting the drying process are temperature and humidity [10]. This dryer was able to increase the average temperature up to 8.73°C. This is due to the impact of the greenhouse effect phenomenon that occurs inside the dryer. The dryer was covered with clear mica and glass, making sunlight easier to enter. After passing through the medium (mica and glass), the wavelength of sunlight changes. This physical phenomenon causes heat from sunlight to be trapped in the drying chamber [11]. Dryers with greenhouse effect types are proven to be able to produce relatively higher air temperatures [12]. In addition, there is an additional heat source in the dryer, such as blowing hot air from a heat collector equipped with aluminum and stones at the top. This heat collector is able to make the temperature inside the dryer more stable in the afternoon, whether cloudy or rainy [13].

Besides temperature, humidity also affects the drying process. Humidity was affected by temperature and air flow speed. If the volume of air flow increases, the ability to carry water from the surface of the material increases too, so that the drying process is more effective [14]. In order to increase the speed of air flow, a fan was installed in the dryer. The addition of a fan to the dryer can increase the speed of airflow and uniformize the temperature distribution inside the dryer [15].

The chili dryer with greenhouse effect based on solar panel has been able to work by increasing the temperature (by optimizing solar heat with a greenhouse effect system and blowing hot air from the heat collector) and reducing air density (with the addition of two fans, namely the input and output fans). This can make the drying process more effective so as to produce a lower final mass of chili compared to conventional methods.

## 4 Conclusion And Suggestions

Based on the results of the performance test, three facts can be formulated as follows: (a) The final mass of the sample dried using a chili dryer with greenhouse effect system based on solar panel was 45g, while the conventional was 113g. Laboratory tests showed that the experiment group has 17% moisture content, while the control group has 59% moisture content. (b) The average temperature inside the dryer was 46.93°C, while the average temperature outside the dryer was 38.2°C. (c) The average air humidity inside the dryer was 28.99%, while the average air humidity outside the dryer was 40.77%. (d) Higher temperatures and lower humidity can make the drying process more optimal.

Suggestions that can be given from this study are as follows: (a) The size of the heat collector needs to be enlarged so that the heat generated becomes more optimal. (b) It is necessary to conduct further research using only one input fan. It is suspected that this treatment may increase the temperature inside the drying chamber. (c) Further research needs to be done by utilizing the surface temperature of solar panels as an additional source of heat flow into the drying room. It is suspected that if the heat on the surface of the solar panel decreases, the voltage will increase.

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