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## DRYING PORANG (*AMORPHOPHALLUS ONCOPHYLLUS*) USING DRYER TRAY TYPE WITH DOUBLE GLASS COLLECTORS

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### ABSTRACT:

Porang (*Amorphophallus oncophyllus*) have potential and high economic value to be developed. Porang tubers contain *glocumannan* (natural fiber and dissolves in water) in the form of flour which can be used as a food source in the form of flour, besides that it can also be used as a cosmetic ingredient, and jelly. Drying is an important process for handling and processing porang. One of the potential drying technologies to be developed is using a double glass solar collector. The use of solar collectors has developed to provide energy, including in obtaining agricultural products. The method used in this study is an experimental method in the laboratory. The dryer that will be used in this study is a dryer tray type using double glass as a collector of solar energy. Drying experiments were carried out on porang tuber slices. An analysis has been carried out on the supply of heat energy and its utilization, as well as an analysis on the performance of double glass solar energy collectors for the extraction of porang tuber slices. The results of this study indicate that the work of double glass solar collectors is able to provide useful energy for 7 hours effectively, amounting to 2890.30 joules and the largest available at 13.00 Central Indonesian Time (WITA) is 5374.96 joules. The average energy for evaporation is 24.67 j/kg, the average temperature to increase the temperature of the product being dried is 3336 kJ, at an average RH condition of 34.29%. With the thermal efficiency of the collector drying system reaching an average of 82.36%, resulting in an average moisture content of 7.48%. Drying using double glass solar collectors which was carried out in this study, was quite effective and efficient until 16.00 WITA

**Keywords:** Double glass solar collector, Drying, Porang.

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## INTRODUCTION

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Porang (*Amorphophallus Oncophyllus Prain*), also known as iles-iles, is one of the potential root crops. These plants usually grow in tropical and subtropical regions, producing carbohydrates, fats, proteins, minerals, vitamins and dietary fiber. This plant has long been used as food and exported as industrial raw material. The water content in fresh porang tubers is relatively high, which is around 83.3%, causing them to be susceptible to damage. For this reason, handling or processing must be carried out immediately (Saleh, et.al, 2015).

Drying is an important step in processing porang tubers. The main objectives of drying include to preserve foods and increase their shelf life by reducing the water content and water activity; reduce space requirements for storage and transport; diversify the supply of foods with different flavours and textures, thus offering the consumers a great choice when buying foods (Raquel P. F. Guiné, 2018).

Drying technology is one of the efforts to answer challenges in handling and processing agricultural products. Dryer with double glass collector, is one of the technologies that can be developed to utilize solar energy for drying. In this system, a heat-collecting medium in the form of double glass is used. Double glass is a heat collector

(collector) used to absorb heat. The use of double glass as a heat absorbing material is intended to obtain high heat in the collector. This collector is a heat exchanger whose function is to absorb the intensity of solar radiation and convert it into heat (Duffie et al., 2013).

The heat generated is used to increase the air temperature in the solar collector. The heat transferred is determined by the temperature of the absorbing plate, the temperature of the heat-collecting medium, and the heat transfer coefficient from the absorbing plate to the heat-collecting medium (Arunprasad et al.. 2020). This collector has been used in this study, as a heat collector in a tray type dryer to dry porang tubers. The performance of solar collectors can be improved by using forced flow and flat plates. Hot air in the collector room then flows into the drying room (dryer).

## RESEARCH METHODS

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This research was conducted in the Laboratory. The materials used in this study were porang chips obtained from farmers. Porang was peeled and sliced with a thickness of 3 mm, 6 mm and 8 mm. with sliced thickness treatment of 3 mm, 6 mm and 8 mm. The tools used in this study were a tray dryer solar type with a double glass collector, with dimensions is 85 cm long, 75 cm wide, 29 cm high at the front and 56 cm at the

back, thermocouple, data loggers, analytical balance, thermometer, oven.

Entering temperature measurement using the equation;

$$T_i = T_o - \frac{qu}{mC_p} \dots\dots\dots (1)$$

where:  $T_i$  is the inlet temperature ( $^{\circ}\text{C}$ ),  $T_o$  is the outlet temperature ( $^{\circ}\text{C}$ ),  $qu$  is the heat absorbed by the collector ( $\text{W}/\text{m}^2$ ),  $m$  is the mass of the product (kg), and  $C_p$  is the specific heat of the product ( $\text{kJ}/\text{kg}^{\circ}\text{C}$ ).

Exit temperature ( $T_o$ ), is calculated using a mathematical equation (Highgate dan Probert, 1996);

$$T_o = \frac{T_a + (\tau\alpha)I}{U_L + [T_i - T_a - (\tau\alpha)I / U_L] \exp(-F'U_L / GC_a)} \dots\dots (2)$$

where:  $T_o$  is the ambient temperature ( $^{\circ}\text{C}$ ),  $U_L$  is the total heat loss coefficient ( $\text{W}/\text{m}^2$ ),  $T_i$  is the inlet temperature ( $^{\circ}\text{C}$ ),  $I$  is the solar radiation intensity ( $\text{W}/\text{m}^2$ ),  $F'$  is the efficiency factor,  $G$  is solar constant ( $1353 \text{ W}/\text{m}^2$ ),  $C_a$  is the specific heat of humidity ( $\text{J}/\text{kg}^{\circ}\text{C}$ ).

Relative humidity,  $\phi$  (%), is determined using the following equation (Singh and Heldman 1993):

$$\phi = \frac{p_w}{p_s} \dots\dots\dots (3)$$

where:  $p_w$  is the density of water vapor and air ( $\text{Kg}/\text{m}^3$ ),  $p_s$  is the density of water vapor at the temperature of the air mixture ( $\text{Kg}/\text{m}^3$ ).

The useful energy,  $Q_u$  ( $\text{W}/\text{m}^2$ ), is calculated using the equation (ASHRAE Standard, 1978 in Admayanti 2005)

$$Q_u = A_c (S - U_L (T_i - T_a)) \dots\dots (4)$$

where:  $A_c$  is the surface area of the collector ( $\text{m}^2$ ),  $S$  is the solar radiation absorbed by the absorber ( $\text{W}/\text{m}^2$ ),  $U_L$  is the coefficient of Total Heat Loss ( $\text{W}/\text{m}^2$ ),  $T_i$  is the inlet temperature ( $^{\circ}\text{C}$ ), and  $T_a$  is the ambient temperature ( $^{\circ}\text{C}$ ).

Efficiency of collector,  $\eta_c$  (%), is calculated using the equation (Susanto, 2008) as follows:

$$\eta_c = \frac{Q_u}{A_c \cdot I_t} \times 100\% \dots\dots\dots (5)$$

where:  $Q_u$  is the useful energy ( $\text{W}/\text{m}^2$ ),  $A_c$  is the collector area ( $\text{m}^2$ ),  $I_t$  is the radiation intensity ( $\text{W}/\text{m}^2$ ).

The energy to increase the temperature of the material,  $Q_p$  (kJ), is calculated by the equation;

$$Q_p = M_p \times C_p \times (T_p - T_{amb}) \dots\dots\dots (6)$$

where:  $Q_p$  is the useful energy of the product (kJ),  $M_p$  is the mass of the product (kg),  $C_p$  is the density of the product ( $\text{kJ}/\text{kg}$ ),  $T_p$  is the product temperature ( $^{\circ}\text{C}$ ), and  $T_{amb}$  is the ambient temperature ( $^{\circ}\text{C}$ ).

The energy for water evaporation on the dried material,  $Q_{evap}$  (kJ/kg), is calculated using the equation:

$$Q_{evap} = M_{am} \times hfg \dots\dots\dots (7)$$

where:  $M_{am}$  is the mass of porang chip water (kJ/kg),  $hfg$  is the latent heat of evaporation of water (kJ/kg).

Efficiency of system thermal (%), is calculated using the equation:

$$\eta_s = \frac{Q_p + Q_{evaporasi}}{A_c J_t} \times 100\% \dots\dots\dots (8)$$

where:  $Q_p$  is the useful heat product (kJ), is the surface area of the collector (m<sup>2</sup>), It is the radia intensity (W/m<sup>2</sup>).

**RESULTS AND DISCUSSION**

**1. Temperature of Drying.**

Effective enough heat energy is obtained starting at 10.00 Central Indonesian Time (WITA) around 70°C, with a radiation intensity of 548.7 - 731.6 watts, up to 15.00 WITA, which reaches temperatures between 64°C - 84°C, with a radiation intensity of 527.2 -690.3 watts.

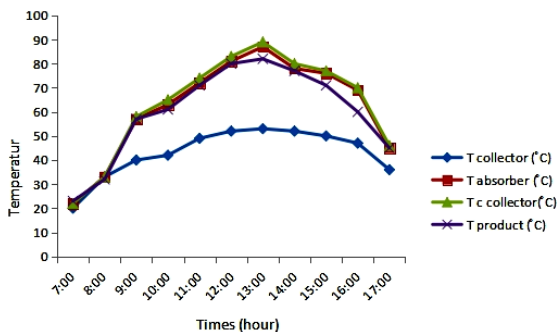


Figure 1. Glass Temperature, Absorber, Collector Room and Product Dried

This condition has an influence on the temperature of the collector room which reaches a peak condition obtained at 13.00 WITA at 83°C – 102°C, with a radiation intensity of 919.4 - 1433.7 watts. Optimal drying effectiveness occurs during the day, especially at 10.00 to 15.00 WITA. At that time, the intensity of the light emitted was quite strong. The higher room temperature of the collector, absorber and product is due to the transmission of long wave solar radiation hitting them, blocking the short waves originating from the absorber (Lasisi et al., 2020). This condition has a heating effect on the double glass solar collector and results in a difference in inlet temperature (collector room temperature), causing heat accumulation in the system (drying chamber).

The temperature value is affected by the level of intensity of solar radiation and the transmissivity (Fawas et al., 2012). This condition reaches its maximum when the solar radiation reaches its maximum point (collector position with the sun 90°), because the temperature transmitted by the glass to the double glass solar collector reaches its peak. This is also influenced by the absorption and accumulation (Alit et al., 2022). The situation mentioned above occurs, according to Sutanto (2008), because glass can trap radiation that has short waves effectively, and this affects the high and low room temperature of the double glass solar collector.

The pattern of increase and decrease in room temperature of the

double glass solar collector and the environment during the drying process is related to the pattern of solar irradiance which increases in the morning and decreases in the afternoon. In the morning, at 07.00 WITA, the temperature of the collector room is almost the same as the ambient temperature.

## 2. Relative Humidity.

The drying process can occur if the combination of temperature and humidity allows the release of water so that a balanced moisture content is achieved (Taib et al., 1988). The relative humidity conditions of the environment and the collector room tend to be different between the relative humidity of the environment and the collector or drying room (Al-Neama et al., 2018). At 07.00 WITA the environmental RH conditions ranged from 84.25% - 91.61%, while the RH in the collector or drying room was 53.76% - 69.65%. Furthermore, at 11.00 WITA, the environmental RH was 52.38% - 67.61% and the drying room RH was 37.99% - 46.6%. At 13.00 WITA, the RH for the environment was 48.78% - 77.08%, and the RH for the drying room was 32.79% - 44.76%. Judging from the RH value of the collector or drying chamber, the relatively low RH value for drying is from 11.00 to 14.00 WITA.

The distance between the glass and the plate affects the amount of heat lost. This is in accordance with the opinion of Handoyo (2001), which states that the size of the heat loss that occurs in double glass solar collectors is influenced by the distance of the glass to the plate (Bakari, R., Minja, R,J,A., and

Njau, K,N., 2014). The greater the distance between the plate and the glass, the higher the heat loss that occurs. Conversely, the smaller the distance between the glass and the plate, the lower the heat loss that occurs. If the heat loss is small, it can be said that the collector produces more useful energy.

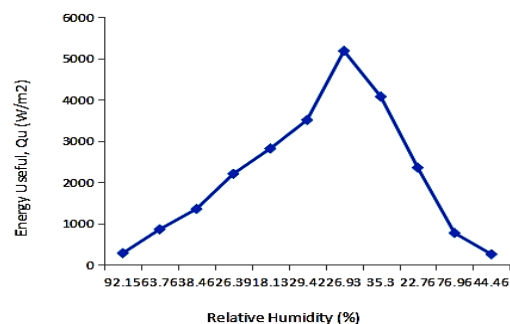


Figure 2. Relative Humidity and Energy Useful

In addition, the heat sink affects the amount of useful heat energy, heat loss due to convection, conduction and radiation. The amount of useful heat energy collected also depends on the optical properties (transmissivity and reflectivity), the properties of the absorbing plate (absorptivity and emissivity) and heat losses (loss of heat) due to convection, conduction, and back radiation (Zu et al., 2021).

## 3. Efficiency Thermal of Solar Energy Collector Dryer ( $\eta_c$ )

The experimental results show that the efficiency of the double glass solar collector reaches between 87.85% - 95.14% at 07.00 in the morning, then at 09.00 WITA it reaches 75.59 (%) - 93.05 (%). At 13.00 WITA, the thermal efficiency of the system ranged from 79.20 (%) - 92.17 (%). At 15.00 WITA the

thermal efficiency of the system was 77.05 (%) - 82.38 (%). At 16.00 WITA it fell to 47.73 (%) - 62.09 (%). There is a fluctuation in the value of the thermal efficiency of the system. This condition is influenced by the drying system which still has weaknesses related to both materials and construction, which causes several leaks and the influence of environmental factors (Seetapong et al., 2017), Judging from the efficiency value, for drying for a drying time of 6-7 hours from 09.00 WITA to 15.00 WITA, this system has a fairly good thermal efficiency.

Fluctuations in the value of collector efficiency in each product drying process are influenced by factors such as the level of intensity of solar radiation reaching the surface of the collector, emissivity and absorptivity, inlet temperature, ambient temperature and heat loss (Sitorus et al., 2018).

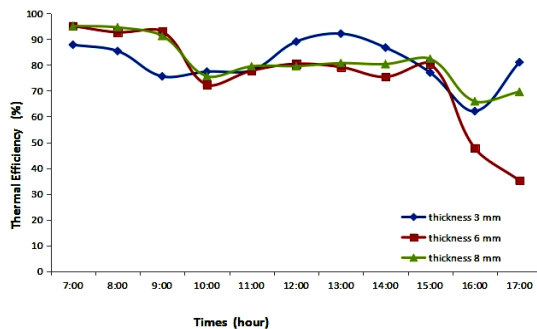


Figure 3. Efficiency Thermal

The intensity of solar radiation is affected by cloudy weather conditions causing a decrease in intensity, which then impacts thermal efficiency (Proszak-Miąsik et al., 2017). The collector efficiency depends on the ambient temperature, the level of solar radiation

that reaches the earth's surface and the inlet temperature. Efficient drying is produced until 15.00 WITA, after 15.00, the efficiency of the drying system has decreased.

#### 4. Moisture Content of Dried Porang

Drying for 10 hours of experimentation from 07.00 WITA to 17.00 WITA, was able to dry the product in the form of porang chips from the initial moisture content of 86.88% to 5.94%.

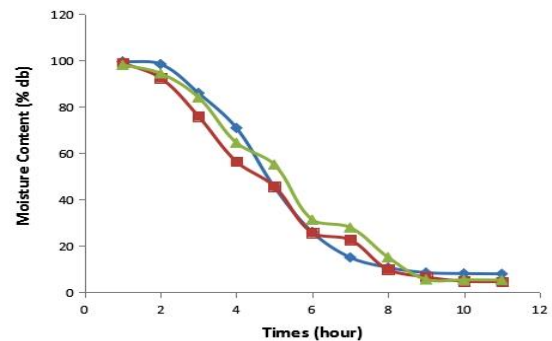


Figure 4. Dring Rate Chip Porang

The rate of reduction moisture content began to occur at 09.00 WITA 13.11% per hour, previously at 08.00 WITA it was 3.79% per hour, then at 10.00 WITA the amount of reduced water increased sharply to reach 18.02% per hours, the peak at 12.00 reached 21.09%. The rate of decreases towards a constant (Farhan et al., 2022). The difference in the time of decreasing the moisture content was affected by the thickness of the slices. The thicker the slices, the greater the amount of water evaporated, and the longer it takes (Limpaiboon, K. 2011). In addition to thickness, the decrease in water content is also influenced by the characteristics of

the dryer, namely temperature, relative humidity, the amount of solar thermal energy absorbed by the collector, the airflow velocity which affects the high and low temperature of the collector space, and the surface heat transfer coefficient, as well as the character of the dried material (Lee,G,H., 2013).

## CONCLUSION

Drying porang using a dryer with a double glass solar collector was quite effective and efficient until 15.00 WITA for eight hours, with a pattern of drying rate decreasing towards constant. The double glass solar collector used to absorb solar energy is capable of providing useful energy of 2890.30 joules and the largest available at 13.00 WITA is 5374.96 joules. The average energy for evaporation is 24.67 j/kg, the average energy for raising the temperature of the dried product is 3336 kJ, at an average RH condition of 34.29%. With the efficiency of the collector thermal drying system reaching an average of 82.36%, resulting in an average moisture content of 7.48%.

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