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by Rusdi Nur

The Forced Convection Biomass and Solar Collector Dryer to Drying Seaweed Using Exhaust Fan

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Abstract. The natural process of drying seaweed takes a long time depending on sunlight. In addition, the effects of weather, seasons, and the turn of day and night make this process more limited and unable to fully control. Post harvest seaweed has a moisture content of about 92.5% and takes a long time in the drying process. The design of dryer consists of a solar collector equipped with an exhaust fan which serves to accelerate the occurrence of forced heat convection from the collector and the drying chamber and the air heating system using a solar collector by using rock media as a rock bed heat storage material. This paper investigated the drying process by using solar collectors, biomass, and hybrid to dry seaweed. The research method is done in the testing activity using prototype solar collector that using rock bed system arranged on solar collector. The results obtained by testing the solar collector heat source at an average solar radiation intensity of 957.48 W/m² average collector temperature of 79.53ºC shows that the solar collector is functioning maximally by generating a drying room temperature. An average of 52.89ºC indicates a spreading of heat from the solar collector to every drying tray already fulfilled for the process of drying the seaweed. The average of drying rate has 0.0123 gram/sec for 2 days, 0.0569 grams/sec for 400 minutes, and 0.0893 grams/sec for 300 minutes for testing with solar collector, biomass and hybrid respectively. The efficiency rate of drying is 4.48%, 10.31%, and 13.36% for the solar collector, biomass, and hybrid respectively.

INTRODUCTION

The drying is one of the critical post-harvest handling stages in determining the quality of seaweed. The natural drying process usually takes a long time because the temperature and energy depend on sunlight. In addition, the effects of weather, seasons, and the turn of day and night make this process more limited and unable to fully control. If weather conditions do not support the water content is increasingly high so it can be a medium for mold and mold growth. Moreover, if the drying is done in the open. This will trigger the presence of contaminants that reduce the quality of seaweed products, such as dust, dirt and unwanted foreign objects (1).

Bala et al was conducted a solar dryer research using a transparent collector cover and heating the absorber. The ambient air is forced through the collector tunnel. Heat is transferred from the air absorber in the collector and hot air from the collector as it passes through the product and absorbs the moisture from the product. The solar radiation also passes through the dry transparent cover and heats the product in dry. This increases the drying rate and the temperature in the dry rise in the range from 37.0°C to 66.5°C. Due to very low resistance when the air is forced to pass over the product to be dried using a fan with a power of 20-30 Watt. The test results show collector efficiency, drying efficiency and overall efficiency for loading 160 kg of mushroom material. The overall efficiency is in the range of 30.43% - 38.47% while the overall efficiency for natural convection of solar dryers is in the range of 12% - 18% (2].

Patil and Sukla developed a convection type of convection box that can dry a variety of food products. Drying is done on red-gram, soydal (split soybean) and soyflakes. The results obtained were from the initial water content of 48.83, 62.80 and 30%, respectively, indicating that the drying time was 18, 15 and 6 hours with a thermal efficiency of 17.32, 26.43 and 11.85% (3).

The results of research conducted by Oviantari and Parwata were observed the influence and optimization of drying technique and water content of seaweed material of Eucheuma cottonii to the quantity (rendemen) and quality (viscosity) of semi-refined carrageenan produced. The results of this study concluded that to improve the quantity and quality of seaweed produced products can be dried by direct drying techniques that produce semi-refined carrageenan (SRC) with high rendemen level and low viscosity. Using indirect drying techniques, it will produce semi-refined carrageenan with high rendemen level and has a smaller viscosity (4).

The research was performed by (5), they studied modeling adapted to predictable prototype dimensions of the required drying time. The model was distributed for air parameters (temperature, humidity, and velocity) and moisture content of maize and then experiments to obtain ISD performance. The results showed that the simulation performed based on the thermal equilibrium model showed an uneven distribution of water content when drying was done without stirring. Factors that influence the artificial drying process are the regulation of flow direction and the speed of hot air and the thickness of the pile of the dried material. Henderson and Perry (6) and Broker et al. (7) stated that the drying process can be divided into two periods, ie the period of drying rate is fixed and the drying rate decreases. The drying mechanism at the descending drying rate comprises two processes: the movement of water from within the material to the surface of the material and the discharge of water from the surface of the water into the surrounding air. The descending rate of drying occurs after a constant drying rate in which the moisture content of the material is less than the critical moisture content.

Thus another better way to dry seaweed is to use artificial driers or drying machines that have high heat-absorbing qualities on collectors and biomass energy sources that have the ability to circulate the flow of hot air that spread evenly to maintain the quality of seaweed materials. Based on these problems it is necessary to have an effort to develop efficient, effective and appropriate technology in drying seaweed. This effort is expected to improve the drying process faster and has a uniform temperature distribution, not dependent on sunlight, weather and local climate. Therefore it is necessary to have a combination of energy in the process of drying of seaweed with heat collector system of heat and heat of biomass with uniform heat so that it will get the result of dry seaweed that has high value added.

EXPERIMENTAL METHOD

Materials and Equipment

The test materials used are eucheumacottonii base as type seaweed. The equipment used is a dryer unit consisting of a solar collector and a dryer tray, a heating chamber from biomass furnace, production workshop equipment, instrumentation (thermocouple, pyranometer, anemometer, tachometer, digital scales and data recorder).

Method

This study carried out following standard methods starting from the design process of identifying problems, formulating and solving problems, functional design, and structure, image engineering, fabrication and testing of the performance. Based on the design criteria for the functional design of a solar collector which consists of the wall of the collector, glass heat trapping and arrangement of stones as a storage medium heat, draft drying tray includes capacity per tray dryer, space heater furnace biomass, installation of turbines cyclone ventilators and exhaust fans at the Solar collector. The structural design of the dryer is made based on an engineering analysis designed through the selection and characteristics of the material. The design and manufacture of this dryer can be seen in Fig. 1 below.

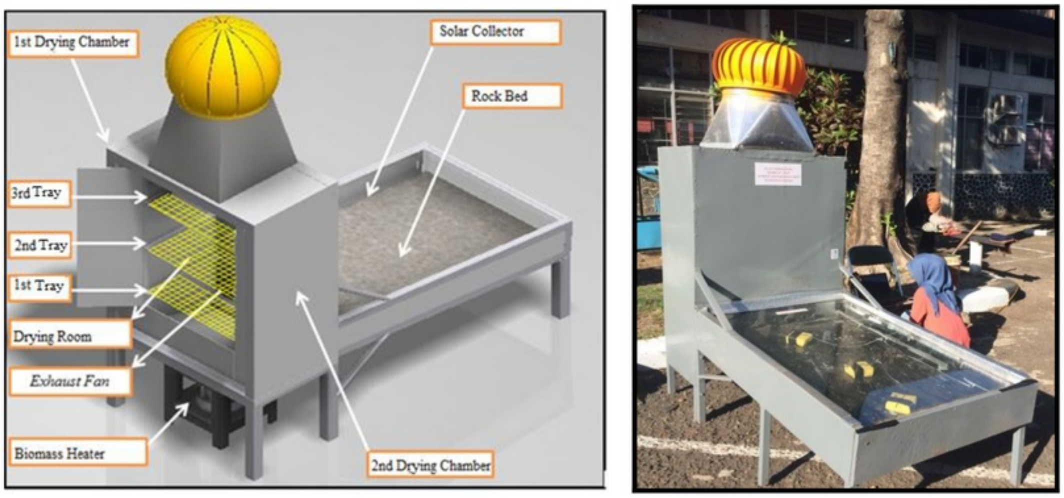

FIGURE 1. Solar collector dryer

Testing the performance of the dryer was conducted to determine the distribution of temperature variation ventilator hole diameter on a drying tray to determine the effect of wind speed exhaust fan. The parameters measured include the temperature of each tray, the exhaust fan spin, and the wind speed. Testing the temperature of the solar collector and the drying tray by using solar collectors and heat biomass. The testing is done by placing a stone structure in the solar collectors and take measurements of temperature changes on the solar collector and the drying tray to changes in the solar radiation intensity.

RESULTS AND DISCUSSION

The experiment of this dryer has given the following results:

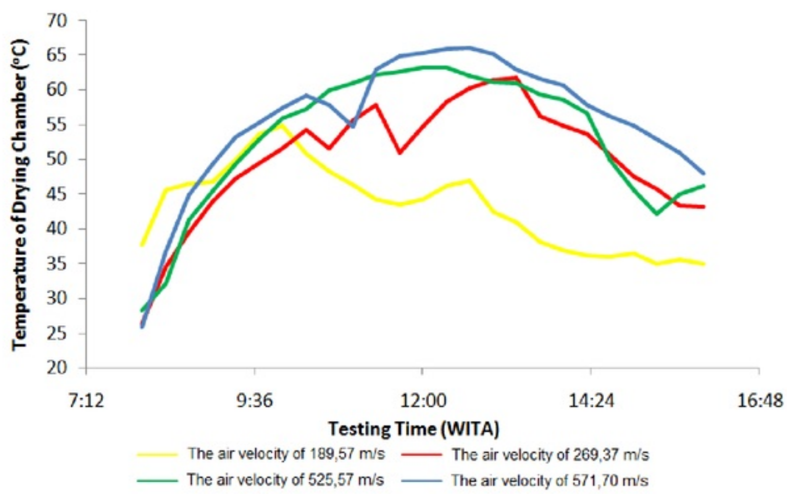

FIGURE 2. The variation of the air velocity versus the average temperature distribution of the drying chamber

Fig. 2 shows the test of air velocity from the solar collector to the drying chamber by using an exhaust fan which serves to increase the transfer of hot air in the solar collector to the drying chamber. The flow velocity was performed by 189.57 m/s, 269.37 m/s, 525.57 m/s and 571.70 m/s. The maximum airflow velocity of 571.70 m/s was obtained to maximally provide the highest drying room temperature increase. It was indicated that the exhaust fan rotation rate influences the transfer of hot air flow to the drying chamber so as to increase the maximum drying room temperature with an average value of 55.62°C and the maximum temperature of 66.03°C. The speed of the dryer air flow affects the faster drying process in evaporating the mass of water transferred into the atmosphere.

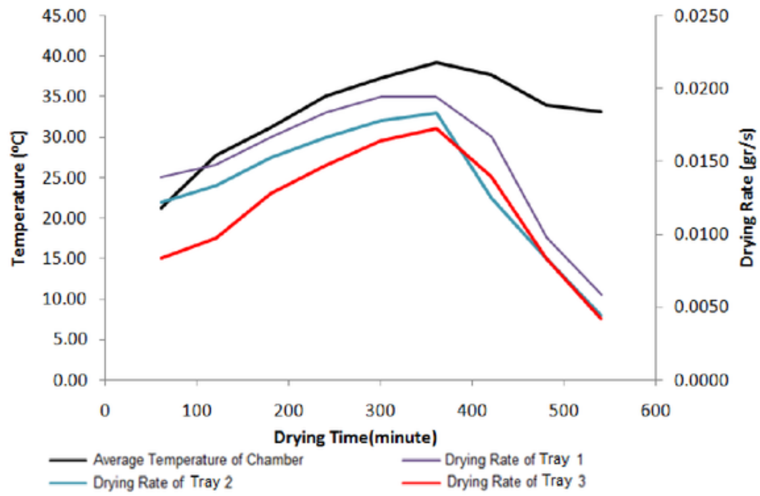

FIGURE 3. Graph of the drying time versus the drying rate and the average temperature of the drying chamber

Fig. 3 shows the long-drying relationship of seaweed drying to the drying chamber to the change of material drying rate and temperature change in the drying chamber. The average temperature of the drying chamber was 33.37°C, with a test time span of 540 mins by utilizing heat energy in the solar collector. The drying rate on the 1st tray of 0.0150 gr/s was showed at the beginning of the faster drying rate testing compared with the drying rate of the material on 2^{nd} tray averaging 0.0132 gr/s and the average 3^{rd} tray 0.0117 g/s, the drying drying rate is due to the drying position on 1^{st} tray which is closer to the heat source, then tray of 2 and 3. This following figure shows the higher the temperature in the dryer room the faster the drying process takes place.

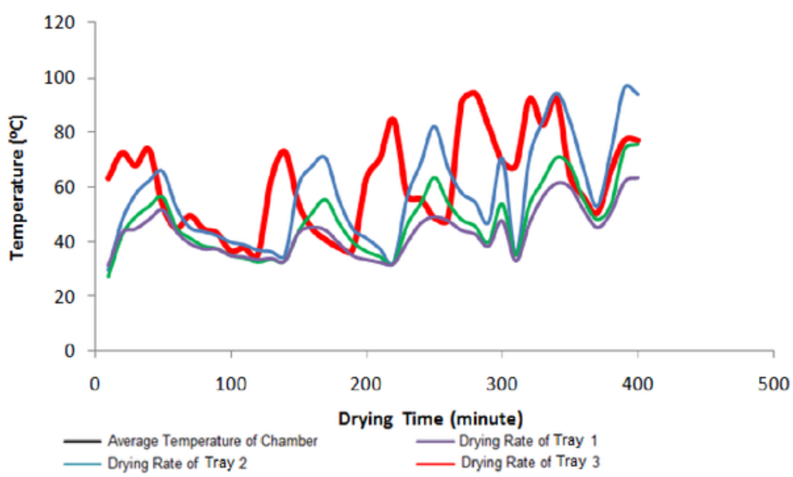

FIGURE 4. Graph of drying time versus the temperature of heater room and dryer tray

Fig. 4 shows the long drying relationship taking place with the biomass heat source to the drying temperature change in the tray positions of 1, 2 and 3. The heat transfer process of the heating chamber I 52.44ºC and the heating chamber II 70.07ºC with an average temperature of 61.48ºC to the drying chamber on the 1st tray with an average temperature of 61.75ºC, 2nd tray of 51.12ºC and 3rd tray of 46.54ºC hence on the condition of the heating room temperature is possible the process of drying well without damaging structure and quality of seaweed materials. The results of this test have also been carried out by 98] supplying stable hot air temperatures at 60 ± 3°C for more than 24 hours during the overall drying duration.

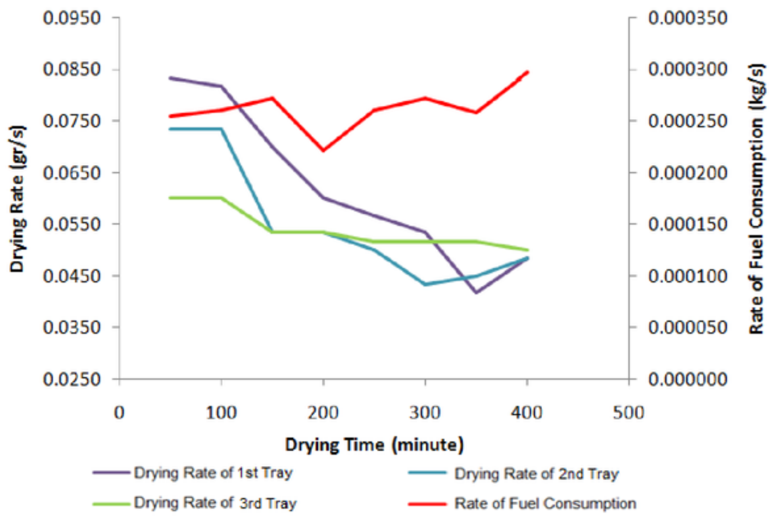

FIGURE 5. Graph of drying time versus the fuel consumption rate and dryer rate

Fig. 5 shows the average drying rate of materials on the tray of 1, 2 and 3 was 0.057 g/s, using biomass fuel at an average fuel consumption rate of 0.00026 kg/s and 400 minutes of drying time. The longer the drainage is consumed, the more biomass fuel consumption, the greater the drying rate at the beginning because the surface of the test material is still wet to form a layer of water which will subsequently dry from the surface so that faster evaporation on the top surface of the material. Furthermore, it will decrease because of the movement of moisture content from within the material to the surface of the material by diffusion and the transfer of water content from the surface of the material into the free air.

Research hybrid solar dryers have been carried out by Amer et. al. which developed the process of drying ripe banana slices by using direct solar energy and a heat exchanger (9).Vlachos and Karapantsios develop a low-cost drying design equipped with solar collectors, heat storage cabinets, and solar chimneys. The design is based on energy balance and in the mean hourly data radiation reduction procedure for sloping surfaces. Total solar radiation measurements in the horizontal plane, ambient temperature, and humidity, air velocity, relative humidity and humidity in the dryer as well as solid weight density data were used as a tool for studying dryer performance (10). In the drying process, an investigation has been conducted to obtain minimum energy consumption (11). The same study conducted by Nur et. al. investigates the energy consumption in the turning process (12).

CONCLUSION

It can be concluded as follows:

- The test of variation of air flow velocity from the solar collector to the drying chamber using the exhaust fan at the airflow velocity of 571.70 m/s is maximally capable of providing the highest drying room temperature increase, indicating that the speed of the exhaust fan spin has an effect on transfer of hot air flow to the dryer room with an average temperature of 55.62ºC and a maximum of 66.03ºC.

- Average drying rate of material on each dryer tray using 0.0133 gr/s solar collector heat source while on drying with 0.0569 g/s of biomass heat source. The highest drying rate occurs in drying by using a biomass heat source.
- The use of fuel consumption in the biomass dryer affects the changes and increase of temperature in the heating chamber and will further accelerate the process of deterioration. To increase the temperature of the heating chamber with an average rate of 61.26ºC, it takes an average fuel mass of 0.76 every 50 m0inutes of combustion with a fuel consumption rate of 0.000262 kg/s.
- The average efficiency of solar drying system of 4.48% solar collector and 10.31% biomass shows that there is greater evaporation due to the release of molecular bonds on the material.

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