

MODIFICATION OF ROCKET STOVE FUELED BY WOOD WASTE IN THE FOOD DRYING PROCESS AS A SUBSTITUTE FOR SUNLIGHT

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ABSTRACT

Traditional snacks in Maluku made from sago, in the form of dried food which in the final process is produced by drying in the sun, are often constrained (stopped) when the rainy season arrives. As a campus community that focuses more on vocational fields, we can take a role to bridge the gap between the needs of the traditional home-based snack industry for access to appropriate technology that can be developed. One solution is to provide a means of drying food through research into the manufacture of a modified rocket stove as a container for drying food made from sago. This modified rocket stove product adds a drying container at the top that is knocked down, so that the basic function of the rocket stove can be maintained and can also be expanded with variations in the installation of the drying container. From this research, a rocket stove with dimensions of 40 cm x 10 cm x 60 cm was produced which was modified by adding a table (95 cm x 45 cm x 70 cm) with a hollow/box with the addition of 3.5 mm³ holes at four corners on the top side of the table plate, which functioned to release excess hot air. The modified rocket stove design, in its operation of the sago kasbi drying process with the highest fuel consumption efficiency value is in the Negeri Oma sago kasbi product which is 4.98 gr/minute of combustion, while the highest sago drying productivity efficiency is from Negeri Pia, which is 0.45 gr/gr of dried sago.

Keywords: Rocket stove, Sago kasbi, Appropriate technology.

INTRODUCTION

Traditional sago-based snacks in Maluku are usually produced on a home industry scale with limited capacity. Products that are often found in the market for traditional snacks made from sago include sago plates, sago kasbi (cassava), dried sago, sago tumbu (mashed), bagea, sarut, and many other variants. Generally, all of them are in the form of dried food which in the final process is produced by drying in the sun. The final production stage, which still depends on the intensity of sunlight, is often constrained (stopped) when the rainy season arrives. The characteristics of Maluku, which is a province consisting of a group of islands, where a large number of islands are small islands, also affect the rain pattern which can still fall even in the summer period. This will have a direct impact on the production process of traditional dried snacks in Maluku. Faced with these conditions, it is necessary to find alternative solutions to help small industries in launching the traditional snack production process, especially at the product drying stage by utilizing appropriate technology.

The access of small (home) industries to appropriate technology, especially to help the final stage of the drying process of traditional snacks, is felt to be rather difficult. For

this reason, as a campus community that focuses more on vocational fields, we can take a role to bridge the gap between the needs of the traditional home-based snack industry for access to appropriate technology that can be developed. One solution is to provide a means of drying food through research into the manufacture of a modified rocket stove as a container for drying traditional food made from sago. The benefit of making a modified rocket stove as a food drying process container, is that the production process of traditional sago-based snacks can still be carried out, even though the weather does not allow drying (rainy conditions).

THEORETICAL FRAMEWORK

Heat Transfer

"Heat transfer can be defined as a process where heat transfer occurs due to the effect of temperature changes on an object. At the same temperature level, this heat transfer process cannot work. Where due to the difference in temperature that simultaneously impacts the heat transfer process, as well as the driving of electric current due to the voltage that works" (Luqman Buchori, 2011). Heat transfer from conditions that have high temperatures to conditions with lower temperatures, specifically distinguished by heat transfer in conduction, convection and emission.

According to (Holman, 1987), "it is explained that heat distributed from a place that has a high temperature to a lower temperature is categorized as heat transfer by conduction, where the medium for heat transfer is fixed. In connection with the rate of heat flow, there are several factors that influence including the area of the surface of objects that rub against each other, the existence of heat conductors produced by these objects and there is a difference in initial temperature ". "The definition of convection heat transfer or also known as heat transfer based on flow, is a process related to the surface of the object, where the process of heat distribution occurs due to the motion of the heated substance. So that in general in a state of thermodynamic equilibrium, the temperature on the surface of the object is different from the ambient temperature" (Kern, 1950). The stages of heat transfer by flow or convection can be divided into:

1.Natural Convection. Also termed as free convection, it is a type of heat transfer that is influenced by temperature differences and differences in density, so there is no external force that can push it. For example: a plate in a hot condition is then left in the surrounding air without any source of movement caused.

2.Forced Convection. The definition of forced convection is the ongoing transfer of heat using liquid or gas media due to external energy factors. For example, blowing cold air using a blower system on a plate that is in a hot condition. While heat transfer by way of radiation, is emphasized on the transfer process that does not require media, but is influenced by electromagnetic wave emission. Where the transfer process is based on wavelengths at certain intervals. For example, the sun's rays of light or heat towards the earth (Luqman Buchori, 2011).

METHODS

This research is a research and development, so that the products produced are also a means of research to obtain optimal function in the process of drying food from products with appropriate technology. The type of research data is primary data, namely the heating

temperature of the rocket stove design. The research variables used are independent variables, namely the amount of wood waste fuel and the dependent variable is the temperature/temperature and moisture content of sago kasbi (cassava). The data collection method is divided into the following stages:

1. Pre-research: modification of the rocket stove design, namely by adding a drying table that can be knocked down to the rocket stove. The table made as a modified part of the rocket stove has a connecting funnel with a size of 15 x 15 cm at the bottom center of the table plate as an inlet receiving hot air produced by the rocket stove. The table plate is made hollow/boxy with the addition of 3.5 mm diameter space at four corners on the upper side of the table plate, which functions to release excess hot air trapped in the table cavity while removing the heat accumulated in the table plate cavity and flowing heat evenly on the surface of the upper table plate by utilizing a hot air flowing system due to the pressure difference inside the table cavity with the air outside on the surface of the table top. The heat on top plate is utilized as a dryer for processed sago. The next stage is assembling the tool.
2. Data testing: data collection of heating temperature, work results of the modified rocket stove, data collection of the amount of fuel needed for the drying process of food products made from sago until the optimization of moisture content in dried sago products as available in the market.
3. Data processing: heating time, amount of fuel, temperature, and optimum moisture content of dried sago that must be achieved.
4. Data output: amount of fuel versus dry sago production capacity.

RESULTS AND DISCUSSION

From this research, a rocket stove with dimensions of 40 cm x 10 cm x 60 cm was modified by adding a table (95 cm x 45 cm x 70 cm), which was made as part of the rocket stove and had a connecting funnel (15 x 15 x 15 cm) at the bottom center of the table plate as an inlet for receiving hot air generated by the rocket stove. The table plate is made of stainless steel (food grade), made hollow/box with the addition of 3.5 mm $\square$ holes at four corners on the top side of the table plate, which serves to release excess hot air trapped in the table cavity by utilizing the difference in air density inside the table cavity with the outside air on the table top surface. The heat on the top side of the table plate is utilized as a dryer for processed sago kasbi products. The resulting dryer is as follows (Figure-1):

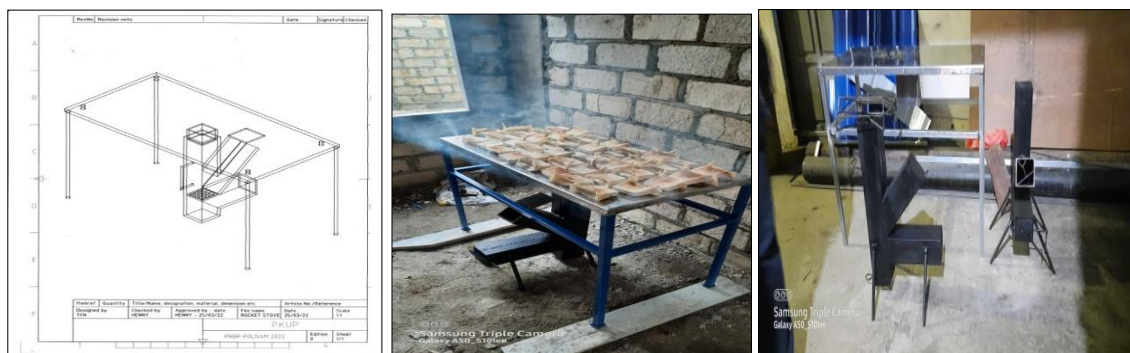


Figure-1.Modified Rocket Stove

Dry sago cassava and fresh sago cassava were selected from Haruku Island, namely from Negeri Oma and Negeri Haruku, and from Negeri Pia on Saparua Island. The moisture content of fresh sago cassava and dried sago cassava was checked at the Standardization and Service Center for Industrial Services Ambon (BSPJI Ambon).

Data from the drying process using a modified rocket stove can be described as follows:

1. For fresh sago kasbi material from Negeri Pia (Saparua Island) once process:

- a. BSPJI laboratory test results for sago kasbi moisture content = 21.39%
- b. Weight of wood fuel = 1,750 gr.
- c. Duration of rocket stove operation = 2 hours, 31 min, 51.30 sec (151.86 min).
- d. Number of sago processed = 61 bh.
- e. Weight of fresh sago kasbi = 3,900 gr.
- f. Weight of dried sago cassava = 3,250 gr.
- g. Total water content reduction =
- h. Max temperature of combustion chamber = 373°C.
- i. Table bottom funnel temperature = 150°C.
- j. Table top max temperature = 195°C.

2. Fresh sago kasbi from Negeri Oma (Haruku Island) once processed:

- a. BSPJI laboratory test result for sago kasbi moisture content = 29.72%
- b. Weight of fuel wood = 1,800 gr.
- c. Duration of rocket stove operation = 6 hours, 01 min, 13.45 sec (361.22 min).
- d. Number of sago processed = 158 bh.
- e. Weight of fresh sago kasbi = 2,699 gr.
- f. Weight of dried sago cassava = 2,012 gr.
- g. Total water content reduction =
- h. Max temperature of combustion chamber = 440.9°C.
- i. Table bottom funnel temperature = 262.5°C.
- j. Table top max temperature = 167°C.

3. Fresh sago kasbi from Negeri Haruku (Haruku Island) once processed:

- a. BSPJI laboratory test result for sago kasbi moisture content = 30.52%
- b. Weight of fuel wood = 1,975 gr.
- c. Duration of rocket stove operation = 4 hours, 10 min, 37.23 s (250.62 min).
- d. Number of sago processed = 236 bh.
- e. Weight of fresh sago kasbi = 4,028 gr.
- f. Weight of dried sago cassava = 3,103 gr.
- g. Total water content reduction =
- h. Max temperature of combustion chamber = 463°C.
- i. Table bottom funnel temperature = 190°C.
- j. Table top max temperature = 179.8°C.

The fuel in the rocket stove is waste wood left over from construction work or the remaining felling of trees/ranting from plant maintenance with a relatively small size (10 x 1.5 x 1.5 cm), which is used in the process of drying processed sago kasbi. Sawdust or leftover wood chips can also be utilized as fuel. In essence, wood of any type and shape can be utilized. It is intended that the production process can utilize

cheap and abundant fuel resources as a substitute for solar radiation in the drying process in summer. The variable studied in this study was the ratio of fuel weight to the operational time of the drying process (Figure-2). The temperatures reached at the kiln and the drying table surface were also measured as part of the research data. The ratio of fuel weight to the weight of sago that can be processed is also part of the variables recorded (Figure-3).

Table-1. Drying Test Data of Sago Cassava

No	Source of Sago	Variable						Ratio		
		Water Content (%)	Fuel (gr)	Running Time (minute)	Berat sago (gr)	Amount of Sago	Water Reduced Content (%)	Fuel/time (gr/menit)	Fuel/Weight (gr/gr sago)	Fuel/Amount (gr/piece)
1	Neg. Pia	21.39	1,750	151.86	3,900	61	16.67	11.52	0.45	28.69
2	Neg. Oma	29.72	1,800	361.22	2,699	158	25.45	4.98	0.67	11.39
3	Neg. Haruku	30.52	1,975	250.62	4,028	236	22.96	7.88	0.49	8.37

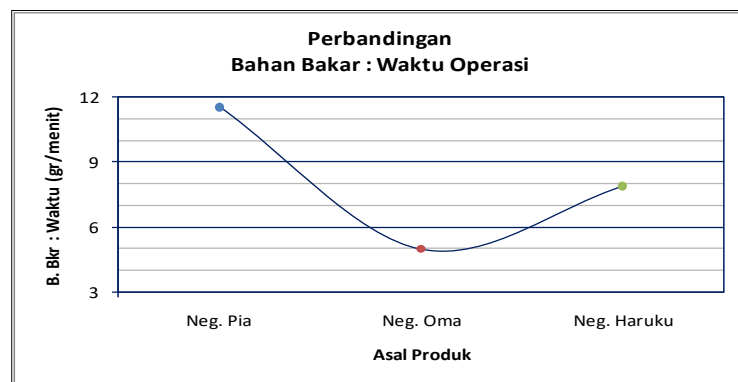


Figure-2. Comparison graph of fuel weight against operating time

From the graph above, the most economical rocket stove operational results in sago drying are in sago kasbi from Negeri Oma, while the largest fuel consumption in drying sago from Negeri Pia.

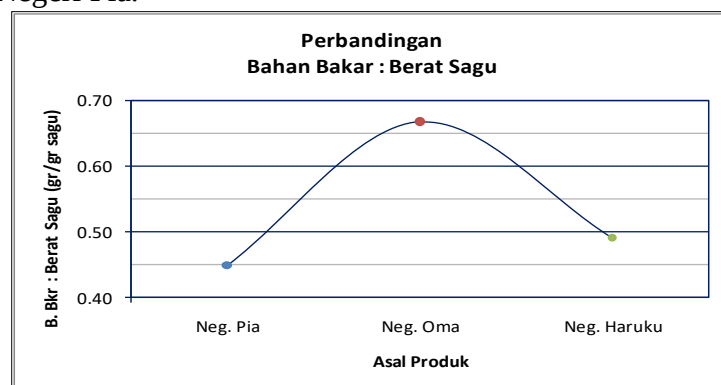


Figure-3. Comparison chart of fuel weight to sago weight

From the figure above, it can be seen that the productivity of fuel against the weight of sago dried, the lowest from Negeri Pia and the highest from Negeri Oma. The following is a summary of the comparison of fuel consumption (gr) to operating time (gr/min), sago weight (gr/gr sago), and the amount of sago (gr/fruit) of sago kasbi products from Negeri Oma, Pia, and Haruku (Figure-4).

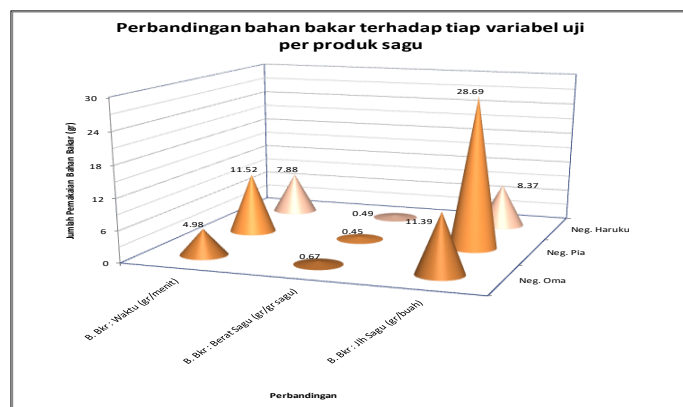


Figure-4. Graph of test variables on sago products

In general, Negeri Oma's sago kasbi drying operation has the greatest economic value compared to the results from Negeri Haruku and Negeri Pia.

CONCLUSIONS

The modified rocket stove design, in its operation of the sago cassava drying process with the highest fuel consumption efficiency value is in the sago cassava product of Negeri Oma which is 4.98 gr/minute of combustion, while the highest sago drying productivity efficiency is from Negeri Pia, which is 0.45 gr/gr of fuel dried sago. The size and weight of the product unit to be processed greatly affect the efficiency of the sago kasbi drying production process. More research models are needed to produce appropriate technology products in the future to answer the need for access to appropriate technology that is relatively easy and inexpensive to operate, especially for small home industries.

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