Design and Fuel Consumption Analysis of Betel Nut Dryer With Capacity 25 kg

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***Abstract*— The purpose of betel nut drying is to make it easier to separate the contents of betel nut with the betel nut skin. There are 2,000 Rupiah value added for every kg of dried betel nut compared to wet betel nut price. Drying time using dryers is less than conventional drying by using sunlight which need two days for drying, our dryer only needs 1,5 hours. Drying cost is expected to reduce by using biomass materials for dryer fuel. The cheapest drying cost obtained by using rambutan twigs, there are need 8,7 kg rambutans twigs with 1740 Rupiah cost per cycle. Liquid petroleum gas (LPG) gives the best drying uniformity with 3.05 standard deviation.**

Keywords— *Betel Nut Drying, Dryer, Biomass Fuel, LPG.*

Introduction

Betel nut is a tropical plant that is planted to get fruit and its beauty. Farmers use betel nut as a fence or garden boundary. Areca nut contains polyphenol compounds, namely flavonoids and tannins, antioxidant activity and functions as a delay in aging for the skin. The use of areca nut as a natural colorant is one of the efforts to diversify products to increase the added value of betel nuts and can meet the needs of domestic dyes which are still imported from abroad (1).

Dyes from betel nut can be obtained through the extraction process. Betel nut is extracted into powder by drying. Betel nut extract in powder form can reduce the volume, weight, and make it easier when packaging, handling and transportation also can be store for long time (2).

In the drying process need to settings the temperature, humidity and air flow. Changes in water content in food are caused by changes in energy in the system. For this reason, need to do the calculation for mass and energy balance to achieve balance (3).

Riau Province is known as one of the areca-producing productive areas. The amount of areca nut production in Riau Province in 2014 of 12,409 Ha planted area of smallholder plantations was 6,328 tons totaling 27,471 farmers.

Traditional drying by sun's heat in open areas requires a long time and will be more susceptible to contamination by the environment. Drying optimization requires complete knowledge of the entire drying process so that it leads to saving energy, time and avoiding environmental pollution by using appropriate technology in the form of drying ovens.

Drying is the occurrence of evaporation of water into the air due to differences in the content of water vapor between the air and the dried material. In this case the water vapor content is less or air has low humidity resulting in evaporation (4).

From field observations, the price of whole wet areca nut is 1,000 Rupiah, while for dried skinless areca nuts is 10,000 Rupiah. Yield of areca nut drying process after separated the skins approximately 30% of the wet betel nut. Based on this data it can be calculated the addition of selling value of drying areca nut. Every 1 kg of betel nut will produce 0.3 kg of dried betel nut with a selling price of 3,000 Rupiah. This means that there is a value increase of 2,000 Rupiah for every kilo gram of dried betel nut.

In this research we will be design and manufactured of nut drying oven with a capacity of 25 kg per hour. Testing the amount of fuel needed to determine the type of fuel that is most suitable for use.

I. Research Methodology

A. Design and manufacture of Dryers

The specifications of this frame have dimensions of 700 x 650 x 25 mm and use angled steel and wire counters as the base. The L profile steel used in the

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manufacture of the oven rack frame and has a shelf base made of white window counter material. A 20 mm square hole counters wire is used so that the heat from the combustion results easily spreads upwards.

This frame design is square in shape with each frame using 37 mm x 37 mm plate with a thickness of 1.70 mm. The concept of this frame is to support the strength of the frame used to support the weight of the betel nut with an outer dimension of 860 x 750 x 600 mm. The inner stem has dimensions of 800 × 700 × 560 mm. Dimensions of the drying chamber size are obtained from the initial calculation, which refers to the size of the baking pan by: baking area + pan width × fire gap area = cross-sectional area of the frame.

The manufacturing process begins by providing the equipment and materials used in the manufacture of drying ovens.

Complete figure of betel nut dryer shown in “fig. 1”.

Fig. 1. Betel Nut Drying

B. *Data Collection and Processing*

The data needed from testing:

1. Drying oven temperature on all types of fuel used.
2. Areca weight before drying and areca weight after drying.
3. Fuel consumption for areca drying.
4. The time needed for drying.

C. *Dryer Fuel Consumptions*

- Moisture Content Calculation

Betel nut moisture content calculated by the following formula:

$$\text{Moisture Content} = \frac{A - B}{A} \times 100\%$$

Where,
A : Dried Betel Nut, kg
B : Solid Content, kg

- Heat Needed Calculation

Calculation of heat needed for areca drying is to add up three types of heat requirements, which are the equation:

$$Q_{Total} = Q_1 + Q_2 + Q_3$$

Where,
Q_1 : Heat to raise the temperature of the betel nut from 30°C to 65°C
Q_2 : Heat to increase the water temperature from 30°C to 65°C.
Q_3 : Heat to evaporate water.

Calculations for Q_1 can be done like the following equation:

$$Q_1 = m_{nut} \times C_{nut} \times \Delta T$$

Where,
m_{nut} : Betel nut mass AD, kg
C_{nut} : Specific heat of Betel nut, kkal/kg ˚C
ΔT : Temperature difference, ˚C

Calculations for Q_2 can be done like the following equation:

$$Q_2 = m_{water} \times C_{water} \times \Delta T$$

Where,
m_{nut} : Water nut mass, kg
C_{nut} : Specific heat of Water, kkal/kg ˚C
ΔT : Temperature difference, ˚C

Calculations for Q_3 can be done like the following equation:

$$Q_3 = m_{water} \times L_{water}$$

Where,
M_{water} : Water nut mass, kg
L_{water} : Latent heat of evaporation, kkal/kg

- Fuel Needed Calculation

Calculations to determine the fuel requirements needed are as follows (5):

$$F = \frac{Q}{\eta \times \eta_{ex} \times C_n}$$

Where,
F : Fuel Needs, kg/hour
Q : Calorie needs for drying, kcal/hour
η : Combustion Efficiency, %
η_{ex}: Efficiency of Heat Exchanger, %

- Fuel Cost Calculation

Calculations to determine the fuel requirements needed are as follows:

Fuel Cost = Fuel Consumption × Fuel Price

II. RESULT AND DISCUSSION

The final product from the design and manufacture of an economical type of areca nut dryer oven specifications are shown by “Table. 1”:

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TABLE I. OVEN SPECIFICATION

No	Specification	Remark / Dimension
1	Oven Dimension	860 × 750 × 600 mm
2	Drying Chamber Dimension	800 × 700 × 560 mm
3	Blower	150 watt
4	Voltage	220 volt
5	Heating Temperature	70°C to 120 °C
6	Kapasitas Pengeringan	25 kg
7	Fuel	Wood Waste
8	Drying Time	±1 Hour 30 Minute
9	Operation	Manual

This dryer is easier for ordinary people because it is intended for betel farmers. The design and manufacturing is very sturdy and strong and equipped with wheels and holders to makes it easier for farmers can move easily to reach places where farmers will do the drying process. This is also can be used as a dryer rental business in rainy season, so farmers only need to rent it and do not need to buy the dryer.

To find out how big the economic value of the dryer is then made a comparison between the cost of the dryer and the price of similar devices that are already on the market. From the calculation of the production cost of betel nut dryer, the cost of the tool above is Rp. 2,534,000. This price is still cheaper than similar devices in the market which have a price of Rp. 15,000,000 to Rp. 25,000,000.

A. Drying Time and Temperature

From the oven test results obtained the results of temperature and drying time as described in "fig. 2".

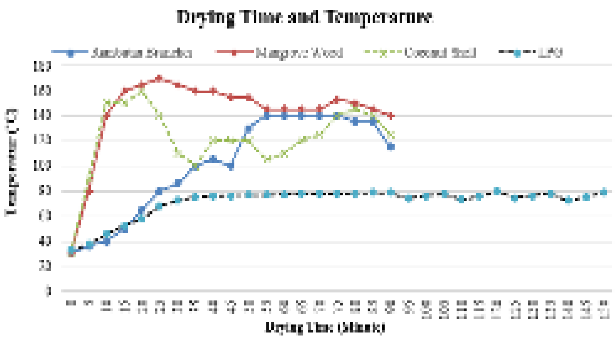

Fig. 2. Drying Time and Temperature

From "fig. 2" Comparison of Drying Temperature, it is seen that the highest oven temperature is reached when using mangrove with a maximum temperature of 170 ˚C. While the lowest temperature occurs when using LPG fuel which has an average drying temperature of 82.2 ˚C. Even so, the oven temperature using LPG is more stable and easier to operate because controlling combustion is easier. While for rambutan branches, mangrove and shell fuels, stricter controls are needed to control fire by control fuel feeding in accordance with the desired large fire. If too much fuel is added, the oven temperature will be too high and reduce the quality of the areca nut produced, if too little, the drying time will be longer. Coconut shell is the fuel most needed for supervision to request fuel.

Higher oven temperatures in the use of rambutan branches, mangrove and coconut shell provide an advantage in shorter drying times of 90 minutes, while for LPG fuels take 150 minutes. This happens because of the low drying temperature when use LPG fuel.

B. Betel Nut Drying Quality

From the results of the calculation of the data obtained from the test results are obtained as described in the following "fig. 3".

"Fig. 3" explained that drying using mangrove wood fuel produces the lowest moisture content of 68.92%. However, the difference in water content produced from each fuel used is not significantly different. letters for table footnotes.

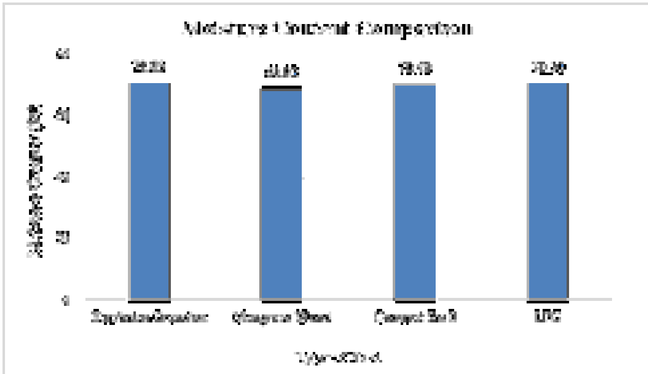

Fig. 3. Moisture Content Comparison. (*figure caption*)

One of the factors that determines the quality of the drying product is the uniformity of the areca nut drying in one batch. To find out the uniformity level of drying, it is necessary to calculate the standard deviation of water content in each pan in one batch drying. From the calculation of the data obtained from the test we get the standard deviation values as described in the "fig. 4".

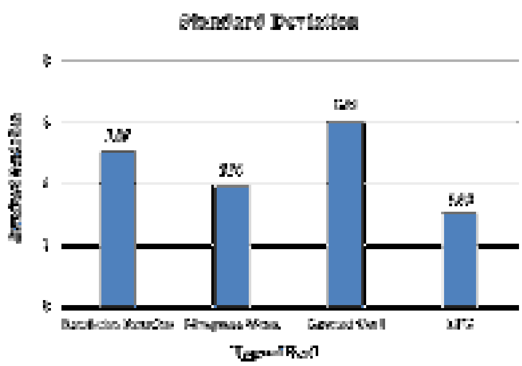

Fig. 4. Standard Deviation Comparison. (*figure caption*)

From "fig. 4" can be seen that the standard deviation of the results of drying using LPG fuel has the lowest standard deviation of 3.05. This shows that the betel nut drying using LPG has better drying uniformity.

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Coconut shell has the highest standard deviation value of 6.04, this means that the quality of drying produced by using coconut shell fuel is at least uniform.

C. Betel Nut Drying Cost

Drying costs are calculated only the cost of fuel, while the cost of electricity for blowers is ignored. Drying costs for each fuel can be seen in the "fig. 1":

TABLE II. DRYING COST WITH DIFFERENT FUEL

Fuel Type	Fuel Cosumption (kg)	Price (Rupiah)	Fuel Cost (Rp/Cycle)
Rambutan Branches	8.7	200	1,740
Mangrove Wood	7.2	500	3,600
Coconut Shell	6.8	500	3,400
LPG	1.6	8,333	13,333

Table. II explain the the biggest fuel consumption data obtained is the use of rambutan branches while the least is when using LPG. Lowest fuel cost is when using rambutan twigs as much as 1740 Rupiah, this is because rambutan branches price is very low compare than other fuel. While the highest cost is the use of LPG fuel, amounting to 13,333 Rupiah. The high cost of LPG is due to the high price of LPG compared to other biomass fuels.

D. Drying Efficiency

Comparison of the total Q with the heat used in the drying process can be seen in the "fig. 5".

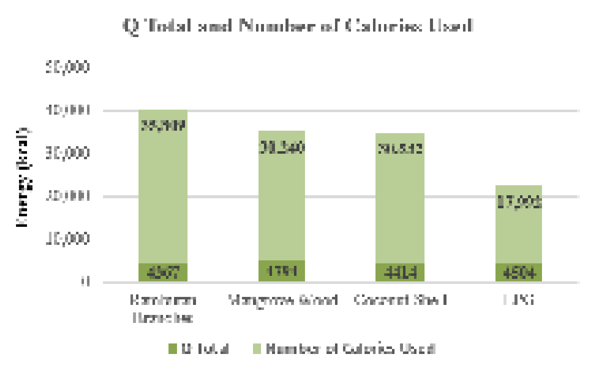

Fig. 5. Standard Deviation Comparison. (*figure caption*)

From "fig. 5", can be seen the greatest calorie consumption is when using rambutan fuel which is equal to 35,809 kcal, while the lowest is when using LGP fuel with a value of 17,992 kcal. This will affect the value of drying efficiency. As for the Q total required, the value will depend on the mass of the dried areca nut, the mass of the evaporated water, and the difference in initial and final drying temperatures.

By comparing the number of calories used with the ideal number of calories needed, the drying efficiency value can be determined. Drying efficiency shown in "fig. 6".

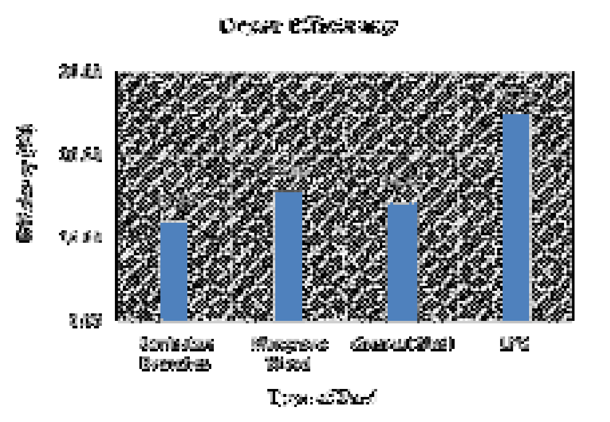

Fig. 6. Standard Deviation Comparison. (*figure caption*)

In "fig. 6" explain that the highest drying efficiency value is drying using LPG gas which is 25.03%. Whereas the lowest efficiency value is drying when using rambutan fuel which is 12.19%.

The drying efficiency value shown is the total efficiency value, which is the combining of the combustion efficiency (furnace) value and the heat transfer efficiency (oven) value. The drying efficiency value shown is the total efficiency value, which is the combining of the combustion efficiency (furnace) value and the heat transfer efficiency (oven) value.

III. CONCLUTION

From the results and discussion it can be concluded:

- The cost needed to make this betel nut dryer is Rp. 2,534,000. This is very much different compared to the selling price in the market which reaches Rp. 15,000,000 to Rp. 20,000,000.
- This dryer is capable of drying 25 kg of betel nuts in 1.5 hours.
- This dryer can be a solution for drying areca nuts in the rainy season. The drying process can be done at any time without being affected by the weather.
- The lowest fuel cost is rambutan branches which is 1740 Rupiah.
- The highest drying efficiency value is drying using LPG gas, which is 25.03%.
- Based on economic factors, the recommended fuel for use is rambutan twigs with the lowest cost and faster drying time.

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