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ORIGINAL ARTICLE

Parametric Investigations of Drying Calophyllum Inophyllum Fruit for The Oil Extraction Process

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ABSTRACT – Lubricant is a chemical that reduce the friction. Lubricant is made of petroleum, this petroleum-based lubricant is dangerous, It will affect the ecology system. The demand of lubricant is kept increasing but the petroleum is decreasing over the years. The alternative way needs to find out. One of the alternative way is bio-lubricant. Bio-lubricant can be biodegradable by the bacteria and no pollutionCallophyllum inophyllum (CI) can be one of the ingredient to manufacture bio-lubricant because it has higher oil yield. To extract the oil of CI, drying process is necessary to carry out. In this project, a dryer is built to investigate the best parameter to dry CI and also find out which parameter is the most suitable to dry CI through the experiment. Drying curve is plotted to provide more understanding for the behaviour of drying of Calophyllum Inophyllum Fruits. Furthermore, the quantity of heat and the latent heat of vaporization were calculated to determined how much heat were needed to raise temperature and vaporize the moisture content inside callophyllum inophyllum.

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INTRODUCTION

Lubrication is the process that putting a substance to reduce the friction between two surfaces as well reducing wear in the machine, the substance is called lubricant. Lubricant is made of mineral oil from a distilled product of crude oil [1]. This mineral oil based lubricant is poorly biodegradable and contain high toxic that will cause negative. impact to the ecological system. The demand for the petroleum-based product increases also. Therefore, an alternate source must be found to reduce the use of petroleum [2].

Bio-based lubricant are biodegradable lubricants that are derived from edible and non-edible plant. Edible plant is the plant that can be eaten while non-edible plant is the plant that cannot be eaten due to it has toxic. To produce bio-lubricant, there are various feedstock to produce it. Edible plant is not suitable due to it will disturb human food cycle and cause deforest to plant crops to get food [3]. Choosing non-edible plant will be more suitable to produce bio-diesel [4].

Callophyllum inophylluim fruit seed contain 65% of oil. Callophyllum inophyllum has some advantages, high survival potency in nature, it can up 50 years. Besides, it has longer productivity. The tree will always produce the fruit whole year. It has high oil yield than J. Carcaca [5].

METHODOLOGY

A heating device is designed and developed for the purpose of drying the seed kernels of Calophyllum Inophyllum fruits prior to producing the biolubricant feedstocks[6]. The machine must consist of heating elements, heat dissipation strategy and power and voltage control. This is to ensure the distribution of heat across the seed kernels that are being dried in the machine are uniformly dried during the drying process.

The three parameters that were studied in this project in order to optimize the drying efficiency of callophyllum inophyllum. Three parameters listed below:

1) No of lamp used as a heat source.
2) Power of the lamp that provided.
3) Distance between the bed of the dryer and the heat source.

The mass changes for every hours are recorded through the drying experiment to better understanding the drying behaviour of every parameter. The procedure is listed below:

1) The callophyllum inophyllum is collected from UMP Pekan Campus.
2) The fruit that is collected is weighted.
3) The callophyllum inophyllum is put into the dryer and the heat sources is switched on.
4) The power parameter is determined by using multimeter and the power is calculated by using P = IV.
5) The callophyllum inophyllum is left for drying process and is dried until it gets a constant mass.
6) The callophyllum inophyllum is taken out taken out for every 1 hours.
7) The drying time taken is recorded into the table and the experiment is carried again with different parameters.

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8) The calculation of moisture removed can be calculate by using this formula:

$$Moisture\ removed = \frac{mass\ before(MO) - mass\ after(MD)}{mass\ before(MO)} \quad (1)$$

$$Wet\ basis, WB = \frac{weight\ of\ water(W)}{Total\ weight\ of\ material(T)} \quad (2)$$

$$Dry\ basis, db = \frac{weight\ of\ water(W)}{weight\ of\ dry\ solid(D)} \quad (3)$$

$$Water\ removal\ rate, wrr = \frac{water\ removed}{solid\ weight/time} \quad (4)$$

The data collected will be collected and recorded in excel file every hours or few hours. There will be at least 9 excel files because the experiments have 9 different parameters. After collecting the result, the drying will be plotted as well wet basis, dry basis and water removal rate.In each parameter, the final temperature is determined by using a DHT22 sensor, thus the quantity of heat to heat up Calophyllum Inophyllum to certain temperature is given the formula below:

$$Q = mc\Delta T \quad (5)$$

Where m is the mass of Calophyllum inophyllum fruit, c is the specific heat capacity of Calophyllum inophyllum and ΔT is change in temperature. While to determine the specific heat capacity of Calophyllum inophyllum,the calculation can be make as below:

$$Cp = 1.424\,mc + 1.549\,mp + 1.675\,mf + 0.837\,ma + 4.187\,mw + 2 \quad (6)$$

Where mc is mass of carbohydrate, mp is mass of protein, mf is mass of the fat, ma is the mass of ash,mw is the mass of water and mi is the mass of ice.

RESULT AND DISCUSSION

Table 1. Drying performance on the 50W lamp.

	50 W		
No of lamp	1	2	3
Temperature (°C)	36.80	50.70	60.50
Humidity (%)	26.00	25.50	25.90
Yield of CI (%)	33.09	40.40	52.20

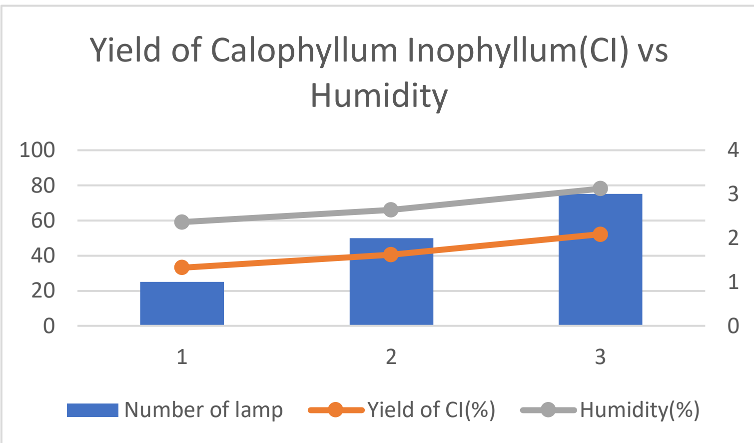

Figure 1. Yield of CI vs humidity chart

Table 2. Drying perfomance of 75W lamp.

	75 W		
No of lamp	1	2	3
Temperature (°C)	46.00	62.00	78.30
Humidity (%)	23.50	26.70	22.50
Yield of CI (%)	34.00	40.74	57.39

Table 3. Drying performance of 100W lamp.

	100 W		
No of lamp	1	2	3
Temperature (°C)	53.00	70.40	88.00
Humidity (%)	23.40	20.00	19.30
Yield of CI (%)	40.60	57.39	59.00

From the result above, the 100W of lamp have the highest performance of drying from 40.69%, 57.39%, 59.06% when the number of lamp increased. The temperature from 53°C, 70.4°C, and 88°C when increased the number of lamp. The humidity dropped from 23.4% – 19%. Based on the result obtained from the experiment, 100W is the best parameter in terms of drying performance. But the suitable parameter was 2 lamps 75 watt. The number of lamp increased will improve the performance of drying as well efficiency. This is due to the light is brighter and the light distribution can cover more on the surface on the Calophyllum Inophyllum. Thus increase the efficiency of drying. When the lamp was switched on, the light and heat is transfer to the surface of the Calophyllum Inophyllum. The water on the surface the Calophyllum Inophyllum evaporated, the water inside the Calophyllum Inophyllum flowed to the surface to replace the moisture surface of Calophyllum Inophyllum. After a certain time, the water content inside the calophyllum Inophyllum was not enough to maintain the moisture due to the evaporation of the water. The fruit started to dry, the fruit at the outer surface would become harder and the fruit was dried.

Table 4. Drying time based on each watt used

Number of lamp	Watt used (W)	Time taken to reach 0.2 Kg(Hours)
3	100	5
3	75	9
3	50	15
2	100	9
2	75	11
2	50	23
1	100	18
1	75	33
1	50	48

To calculate the amount of heat required:

$$Q = mc\Delta T \tag{7}$$

Where m is mass of the sample, c is specific heat capacity and ΔT is change in temperature after the time duration for each experiment conducted. For each experiment, the amount of heat required was calculated in the table below. The heaviest mass is the optimum condition needed as the masses are attracted by the heaviest mass and converged to better solution.

Table 5. Quantity of heat required for 50W.

	50 W		
No of lamp	1	2	3
Mass of CI collected (Kg)	0.408	0.405	0.406
Specific heat capacity of CI fruit (Cp)	2.81	2.81	2.81
Change in temperature, ΔT (°C)	11.80	25.70	35.50
Amount of heat required (kJ)	13.52	29.537	39.902

Table 6. Quantity of heat required for 75W

75 W			
No of lamp	1	2	3
Mass of CI collected (Kg)	0.408	0.405	0.410
Specific heat capacity of CI fruit (Cp)	2.81	2.81	2.81
Change in temperature, ΔT (°C)	21.00	37.00	53.30
Amount of heat required (kJ)	24.08	42.11	61.41

Table 7. Quantity of heat required for 100W

100 W			
No of lamp	**1**	**2**	**3**
Mass of CI collected (Kg)	0.403	0.406	0.408
Specific heat capacity of CI fruit (Cp)	2.81	2.81	2.81
Change in temperature, ΔT (°C)	28.00	45.40	65.00
Amount of heat required (kJ)	31.71	51.80	74.52

From the table for each parameter, we observed that the higher the temperature, larger quantity of heat needed to heat up to that temperature. Specific Heat of Vaporization gived us information that how much heat needed to evaporate the water to vapor. The Latent heat of Vaporization can refer to Steam table to get the value for different temperature. The formula to calculate the latent heat of vaporization is

$$Heat\ of\ vaporization = hv - hc \tag{8}$$

Where hv is the specific entalphy of staurated steam while *hc* is specific entaplhy of saturated water. These value can be obtained from the steam table.

Table 8. Latent heat of vaporization for 50W.

50 W			
No of lamp	1	2	3
Mass of CI collected (Kg)	0.408	0.409	0.406
Specific heat capacity of CI fruit (Cp)	36.80	50.70	60.50
Change in temperature, ΔT (°C)	2415.56	2381.97	2357.69
Amount of heat required (kJ)	985.55	974.23	957.22

Table 9. Latent heat of vaporization for 75 W.

75 W			
No of lamp	1	2	3
Mass of CI collected (Kg)	0.408	0.405	0.410
Temperature in dryer(°C)	46.00	62.00	78.30
Heat of vaporization for 1Kg(KJ/Kg)	2391.61	2352.80	2313.11
Heat of vaporization for mass of CI,(KJ/Kg)	975.50	952.88	948.38

From the result that obtained in the table above, lower temperature had higher laten heat of vaporization. This is because it consumed more heat or energy to evaporate from water molecules to water vapour.

Table 10. Latent heat of vaporization for 100W.

	100 W		
No of lamp	**1**	**2**	**3**
Mass of CI collected (Kg)	0.403	0.406	0.408
Temperature in dryer(°C)	53.00	70.40	90.00
Heat of vaporization for 1Kg(KJ/Kg)	2374.72	2332.09	2282.56
Heat of vaporization for mass of CI,(KJ/Kg)	957.01	946.83	931.28

CONCLUSION

The drying mechanism for every parameters were studied. The suitable parameter was 2 lamp 75 Watt and the parameter below. 2 lamps 75 watt was the most suitable because the drying time was low and the temperature was acceptable for drying the fruits. The quantity of heat needed to heat the fruits increased as the parameter increased. The lower the temperature of the drying parameter, the higher the latent heat of vaporization because the water molecules needed more energy to brake the bond of the water molecule.

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