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Kapok Seed Oil Extraction using Soxhlet Extraction Method: Optimization and Parametric study

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ABSTRACT

Arising conflict between food and oil industries was emphasized that edible oil is not suitable to be used as the main alternative for biodiesel production. *Ceiba Pentandra* or Kapok seed is one of the suitable and reliable non-edible feedstock for biodiesel production. A soxhlet extraction was used as a conventional way to extract oil from the seeds and results in the better oil yield within lesser energy utilization. Current research focused on the kapok seed oil extraction by using conventional soxhlet extraction technique. The parameters which effects the oil yield was studied and such as extraction time, solvent to seed ratio and drying time for the seeds. The solvents used for oil extraction was n-hexane and water. The experiments were designed by central composite design and response surface methodology was used for optimization.

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INTRODUCTION

Recent growths in population along with industrial development are important factors that contribute towards the depletion of fossil fuel reserve of the world (Bokhari *et al*., 2014). Different types of energy sources such as water, solar, wind and biofuels have the potential to replace the fossil fuel (Ahmad *et al*., 2014a). These fuels are largely utilized as transportation fuel (Chuah *et al*., 2015a). Currently, biodiesel is mainly prepared from conventionally (Chuah *et al*., 2015b) grown edible oils such as rapeseed, soybean, sunflower and palm thus leading to alleviate food versus fuel issue (Yusup *et al*., 2015). About 7% of global vegetable oil supplies were used for biodiesel production in 2007 (Ahmad *et al*., 2014b). The uses of seeds from *Ceiba pentandra* (kapok tree) as one of the non-edible oil source have become important studies in finding the alternative in replacing edible oil and also fossil fuel. *Ceiba pentandra*, or locally known as kekabu is native in tropical America and West Africa (Kumar *et al*., 2015). There are many new sources for biodiesel that have been discovered from current research. Oil extracted from both edible and non-edible oil sources has been proven to reach the standard of existing commercial biodiesel (Bokhari *et al*., 2012). The selection of kapok seed as the source will leads to the selection of the best method that can be use for producing biodiesel. In the standard procedure before pursuing the transesterification reaction, oil extraction from the seed itself is also very important and many studies that have been done by researches in order to find the best extraction method that can give the optimum conditions to obtain the maximum extraction yield (Bokhari *et al*., 2012). Most common method that has been for extraction purposes is a soxhlet extraction method. This method is usually time consuming which the range of the extraction around 3 to 6 h. The longer time of solvent extraction becomes one of the disadvantages in using soxhlet extraction method. In current study, parameters of the soxhlet extraction method were optimized using response surface methodology (RSM).The optimization of the parameters could improve in determine the most sufficient condition in extracting the oil form Kapok seeds.

Experimental:

The crushed kapok seeds were dried in an oven at 105^{o}C to remove any moisture presence at different interval of time. A 10 g of dried kapok seeds was placed onto a thimble and the thimble was put into the sohxlet extractor. N-hexane solvent was poured into three-neck- round bottom flask that is joined with the extractor and flask along with the condenser on the top to avoid any solvent losses. The

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whole assembly was then placed on the temperature controller heater to provide the required temperature. The temperature was measured by a thermometer that was inserted in one of the necks of the round bottom flask. After certain interval of the time the experiment was stopped and the trapped oil in the solvent was separated. The mixture of solvent and oil was separated using rotary evaporator under vacuum at temperature of 65^{o}C.

The oil obtained after evaporation was weighed and the oil yield was calculated using Eq. (1):

$$\text{Oil yield (wt\%)} = \frac{\text{Mass of extracted oil}}{\text{Mass of rubber seed fed}} \times 100 \quad (1)$$

RESULTS AND DISCUSSION

Generally, ANOVA or analysis of variance is a collection of statistical models used to analyse the differences between group means and their associated procedures (such as “variation” among and between groups). For this experiment, ANOVA is the statistical analysis carried out to assess the statistical significance of individual independent process variable with respect to output response. The significance of model is proved by analysing the model probability value (p-value) and F-value. Quadratic model of the experimental data was said to be significant when its p-value was less than 0.005 with high F-value and 95% confidence level of the model with respect to oil yield. ANOVA analysis also predicted the significance of individual process variables and their interactions. The smaller the p-value of the

variable or interaction, the larger the influence of that variable on the output response. Among all the affecting variables of the soxhlet Extraction process, extraction time has the lowest p-value which is 0.0031 and thus has maximum influenced on the oil yield of the kapok seeds. Drying time of the seeds has the second lowest p-value which is 0.7608 and has the marginal significance (0.005 < p-value < 0.1) on the response. Solvent to seed ratio has 0.9658 for the p-value which fall under the category of marginal significance (0.005 < p-value < 0.1). The detail experimental design and model interactive terms with marginal significance is shown in Table1 and 2.

Table 1: Detailed experimental runs

Run	Extraction time (h)	Solvent/seed (v/w)	Drying time for seeds (h)	Response of oil yield (wt%)
1	4	52	2	19.1
2	4	22	4	16.25
3	1	52	4	14.6
4	1	22	2	17.2
5	0.4	37	3	10.05
6	4.6	37	3	26.4
7	2.5	15.8	3	25.95
8	2.5	58.2	3	24.25
9	2.5	37	1.6	22.25
10	2.5	37	4.4	23.75
11	2.5	37	3	21.50
12	2.5	37	3	25.25
13	2.5	37	3	22.50
14	2.5	37	3	22.70
15	2.5	37	3	24.25

Table 2: ANOVA analysis

Source	Sum of squares	df	Mean square	F-value	P-value Prob.>F
Model	329.80	9	36.64	7.57	0.0191
A-Extraction time	138.28	1	138.28	18.58	0.0031
B- Solvent/seed	9.8×10^{-3}	1	9.8×10^{-3}	2.026×10^{-3}	0.9658
C-Drying time for seeds	0.50	1	0.50	0.10	0.7608

The 3-D surface plots in this experiment study the effect of extraction time and solvent to seed ratio on oil yield. From Figure 1 and Table 2, the extraction time is shown to be the most important factor that affects the response with respect to the solvent to seed ratio and drying time of the seeds.

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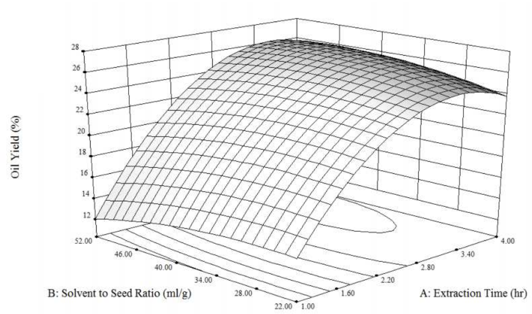

Fig. 1: Effect of extraction time and solvent to seed ratio on oil yield

The increase in extraction time results in more oil yield as the process sufficient resident time to carry out oil extraction for better yield. Figure 2 also shows the effect of the solvent to seed ratio on the response which is the oil yield. At lower solvent to seed ratio increase, the oil yield also increase because the amount of vapour contacted with the seeds increase.

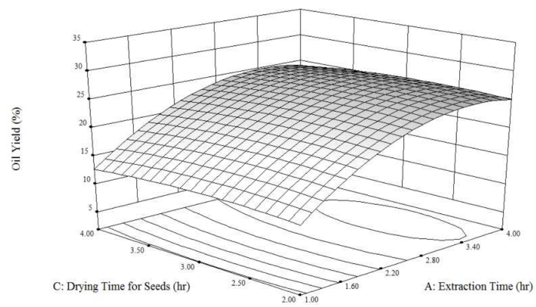

Fig. 2: Effect of extraction time and drying time for seeds on oil yield

But through very high solvent to seed ratio, the oil yield decrease due to more time need to be taken for the solvent to vaporise and contacted with the seeds. The results depicted in Figure 2 indicate that kapok seeds oil yield increased in the range of 22 to 37 mL/g at the constant extraction time of 1 h. Similarly at constant solvent to seed ratio of 22 mL/g, the oil yield increased from varying extraction time from 1 to 3 h. The results show that it is more significant at lower solvent to seed ratio by varying the extraction time. Nevertheless, the oil yield is observed to increase until some point if the solvent to seeds ratio is increase. From Figure 3 it can be observed that the oil yield increase as the extraction time increase at the constant drying time of the seeds of 1 h. The effect of extraction time and drying time of the seeds is not affecting the oil yield as compared to effect of extraction time and solvent to seeds ratio. Moreover, the oil yield slightly decreases as the drying time of the seeds is increase at constant extraction time of 1 h.

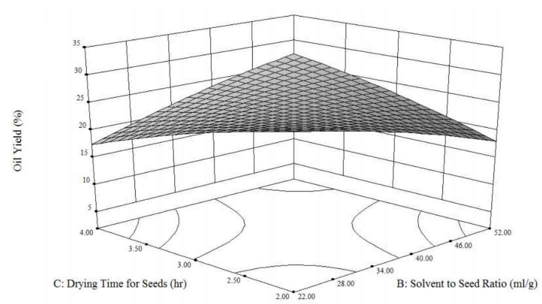

Fig. 3: Effect of solvent to seed ratio and drying time for seeds on oil yield

The 3-D plot determined that it is more significant to have low drying time of the seeds as the effect will give a better oil yield. For the effect of solvent to seeds ratio and drying time of the seeds, both are factors that give less effect to the oil yield but still the effect can be seen in the Figure 3. The oil yield is decreasing with the decrease of both factors but the decrement is not too drastic and this also shows that the increasing of both factors will not highly affect the oil yield.

Conclusion:

From the results obtained for soxhlet extraction method, there were 15 runs that have been conducted based on RSM approach. The independent variable which gives more affect to the response variable which is oil yield is the extraction time. Based on the 3-D surface plots using RSM approach, the optimum condition for

soxhlet extraction to extract the oil from kapok seeds is when the extraction time was at 3 h and the solvent to seeds ratio was 37 mL/g. Better oil yield can be obtained at the optimum condition.

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