Investigation on Quantity and Property of Jatropha Oil from Extraction Method for Study Property of Jatropha seed and oil from Various Storage Durations

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Abstract

The extraction of Jatropha oil from Jatropha seed could be done by three typical methods namely, Soxhlet Extraction, Hydraulic Press, and Screw Press. Each method provided Jatropha oil with different quantity and property. Soxhlet extraction and hydraulic press provided highest and lowest quantity of Jatropha oil respectively. Jatropha oil extracted by the screw press was found to have the best chemical and physical properties with medium quantity.

The study of storage time for both Jatropha seed and (extracted) oil were conducted in parallel. The storage durations for the seed were 0^{th}, 1^{st}, 3^{rd}, 6^{th}, 10^{th}, 12^{th}, 15^{th}, 18^{th} month. This Jatropha seed was extracted by screw press and storage time for the extracted oil was 24 months except extracted oil from seed at 15^{th}, 18^{th} month which storage time of extracted oil was 9 months because this project was finished. Consequently, certain amount of Jatropha seed at month 0th was sampled and extracted, then properties of extracted oil, i.e. water content, acid value and oxidation stability, were analyzed and recorded. Jatropha oil from seeds those stored durations reached the 0^{th}, 1^{st}, 3^{rd}, 6^{th}, 9^{th}, 10^{th}, 12^{th}, 15^{th} and 18^{th} month were sampled, extracted analyzed and recorded.

The results in the analysis indicates that water content, acid value and oxidation stability, of oil extracted from seed at month 0^{th} were 0.07 % (wt.), 1.31 mg of Potassium/ gm oil, 13.9 hours respectively. Water content and acid value of Jatropha oil extracted from seed at month 18th were 14.29 and 129.77 % higher than those extracted from seed at month 0th, but the oxidation stability was 39.21 lower than oil extracted from seed at month 0th.

Keywords: Screw press, storage Jatropha, various time, acid value and oxidation stability

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Introduction

Nowadays, there is an idea to encourage farmers to use raw materials available in the country for use as alternative energy instead of petroleum. Jatropha is another alternative of renewable energy to be used for agricultural machinery (Chumsanti Thaweesuk et al 2005) or as raw materials for biodiesel production. Since this time, bio-energy from agricultural materials is still more expensive than diesel because the productivity is still at a low level compared to the demand for the fuel needed for industrial investment.

Jatropha is a type of oilseed plants that can be extracted oil for used with diesel engines. When the diesel engine is operated by Jatropha oil, its performance and fuel consumption are not affected once returning to use diesel again. Due to such reason, it thus, receives attention from many groups who decide to use Jatropha oil as biological energy. Therefore, this study has been conducted to obtain the best quantity and properties of Jatropha oil with the idea to study the quantity and properties of Jatropha oil during various periods of storage.

This project is aimed to study the quantity and properties of oil made from Jatropha seeds when stored at different period and to study the properties of Jatropha oil when stored at different intervals and. And the scope of the research is to study and compile methods for extracting Jatropha oil from Jatropha seeds and proceeding with extraction of Jatropha oil from the seeds in order to study the properties of Jatropha oil when stored at different intervals and to analyze the properties of Jatropha oil such as acid value, water content and stability to the oxidation reaction, etc. In which, these three key qualities, if they do not meet the requirements, will result in the damage to engine components. For example, if the acidity is higher than standards, it will result in corrosion in the engine and reduction in the life-cycle of pump and oil filter. It also results in the deterioration of oil due to the hydrolytic reaction from the amount of water mixed in the oil.

And the effect of storage conditions, in terms of the amount of water, if higher than the specifications, will negatively cause corrosion in the engine and is a catalyst for oxidation which is one of the causes of clogging at the nozzle.

The expected benefit of this project is the process of extracting Jatropha oil and time interval for collecting Jatropha seeds Jatropha oil in order to study the quantity and properties of Jatropha oil from various seeds for the storage of Jatropha oil at various intervals

Methods for Jatropha oil extraction

Jatropha oil is widely popular in use as renewable energy to replace palm oil or other oilseed plants. Since Jatropha oil is non-edible oil, therefore, the study is aimed to explore the method of extracting Jatropha oil to obtain get good quantity and quality of Jatropha oil. The study of the extraction will explore in 3 extraction methods which are; 1.Solvent extraction (Soxhlet extraction) 2.Extraction by hydraulic machine (Hydraulic press) 3. Extracting with a screw press machine (Screw press). From all 3 extraction methods, we can summarize the best method for extracting Jatropha oil in the method in using a screw press which can be described as follows.

Screw press extraction method will yield approximately 25-30 percent of the oil, with 5-10

percent of the residual oil. This process of oil extraction is started with bringing the Jatropha seed to peel off, leaving only the seeds. After that, the seeds are baked or dried in the sunlight before being extracted with screw press method, then filter out the sediment before bringing Jatropha oil for application. From the analysis of the properties of the oil extracted from this method, the results find that there are distinctly different properties, namely 1.96 milligrams of potassium hydroxide/gram, oxidation stability at 110 C 13.90 hours. That is, the above method is regarded as an approach in extracting Jatropha oil that provides the best properties of Jatropha oil. As for the method of solvent extraction, the highest amount of Jatropha oil is obtained in which the extraction using a solvent can be described as follows.

Soxhlet extraction method will yield about 35 percent of oil from total seeds (J.B.KANDPAL and MIRA MADAN, 1995) by drying the seeds in a coarse grinder. After that, the coarse grinded Jatropha seeds will be extracted with extractors. The principle of solvent extraction is to choose solvent that can extract oil from Jatropha seeds perfectly and easily evaporated. When the solvent evaporates and becomes condensed into liquid falling into Jatropha seeds that need to be extracted causing the solvent to be dissolved out. Then evaporate to remove the solvent and then the desired oil will be obtained. From the analysis of the properties of the oil extracted by this method, it is found that the acidity will be 56.085 milligrams of potassium hydroxide/g, the value of stability to oxidation reaction at temperature of 110 °C is 1.26 hours

Methods and materials, chemicals

1. The study of the effect related to Jatropha oil content extracted by the screw press method.

1. Jatropha seeds used in this experiment are stored for a total period of 18 months, but for the duration of Jatropha oil extraction, the Jatropha seeds at 0,1,3,6,10, 12,15, 18 months will be used for extraction to produce Jatropha oil which will be stored for a period of 24 months, except Jatropha seeds from the month of 12,15,18 where the oil will be stored for only 9 months due to the ending of the project. In this extraction method, the screw press machinery of the Engineering Department Thailand Institute of Scientific and Technological Research will be used.

2. Before extraction, Jatropha seeds must be heated to 60-70ºC for easier extraction by using the UNB400 oven, MEMMERT brand and after baking, the seeds will be processed in the Desicator and then leave it cool and bring the seeds to the extraction process.

3. Jatropha oil obtained from this extraction must be filtered or left to be precipitated before the experiment process.

2. The study of the effects of storing Jatropha seeds and oil at different periods

2.1 Trial in collecting Jatropha seeds

1. Storing Jatropha seeds at different period since 0,1,3,6,10,12,15, and 18 months respectively.

2. When the Jatropha seeds are stored after the specified period; extract Jatropha seeds for oil by using a screw extraction machine. Then filter the Jatropha oil to remove the sludge.

2.2 Storing of Jatropha oil obtained from the extraction of Jatropha seeds under 3.2.1

1. Store Jatropha oil obtained from the extraction of Jatropha seeds under 3.2.1 to different periods from 0,1,6,9,12,15,18,21, and 24 months respectively by storing in a 5-liter white plastic bucket and close the lid tightly.

2. Analysis for the properties of Jatropha oil from under Clause1.The Analysis includes; acidity (ASTM D 664) using the Auto-Metric Titrator model DL53, Metler-Toledo (Thailand) Co., Ltd. ; stability to oxidation (EN 14112) using the Rancimat machine, model 743, Mettorm Siam Company Limited; water content (EN ISO 12937) using the Karl-Fisher Titrator Model 831 KF Coulometer, Metler-Toledo (Thailand) Company Limited; water content and evaporation at 105°C (TIS. 44: 2516) using the UNB 400 oven, MEMMERT brand, Wijs iodine value (AOAC 993.20); specific gravity at 25°C (TIS. 44: 2516) using a Hydrometer; viscosity at 25°C (ASTM D 445), color (Lovibond scale) (TIS. 44: 1973); free fatty acids (AOAC: 2005); saponification value (AOAC 920.160); the composition of fatty acids (AOAC: 2005). From the properties of the oil analyzed above to study the properties of Jatropha oil that vary to the duration of the Jatropha seed and oil storage

Results and Discussion

1. Extraction of Jatropha oil using the screw press extraction method.

Oil extraction with a screw press extraction is the most convenient and fastest way and capable to extract large quantities of Jatropha oil at a time according to the manufacturer's requirements. The results of the extraction of Jatropha oil by screw press extraction indicate that the amount of Jatropha oil extracted is an average of 28.50 percent of the weight of Jatropha seeds with a standard deviation value of 0.4082. This appears to be less than solvent extraction but more than in the hydraulic extraction method. Therefore additional experiments are conducted by bringing Jatropha waste extracted by the screw press method for extraction by means of solvent extraction again in order to find the amount of Jatropha oil remaining in the Jatropha residue.

Findings from the experiment indicate that the amount of oil remained in the Jatropha residue is an average of 7.33 percent of the weight of Jatropha residue and the standard deviation is 0.0962. And when combining the amount of Jatropha oil left in the Jatropha with the amount of Jatropha oil extracted from the seeds, the net amount of Jatropha oil is 35.83 percent. This indicates that the extraction by screw press methods requires trials to find the suitable conditions for extraction to obtain the most amount of Jatropha oil and lose the least amount of Jatropha oil. From table 1, presenting the chemical and physical properties of Jatropha oil from 3 methods of extraction, it is found that extracting Jatropha oil using a screw press method provides the best properties of Jatropha oil. That is, important features of Jatropha oil include acid, acid value, water content, free fatty acids, and low iodine values which are 1.96 milligrams of potassium hydroxide/gram, 0.07 percent, 1.49 percent, 97.51 grams of iodine / 100 grams, respectively. These main features, if high, will affect the engine system. The stability of the oxidation reaction at 105C has the highest value of 13.90 hours, but on the other hand, if this value is low, it will affect the engine system as well.

2 Effects of storage of Jatropha seeds and oil at different times

The results of the analysis of the properties of Jatropha oil that stored in the period of 0-18 months show that the main components of fatty acids contain Palmitic acid (C16: 0) for14.20-14.40 percent , Stearic acid (C18: 0) for 6.50-6.60 percent , Oleic acid (C18: 1) 46.0 - 46.30 for percent and Linoleic acid (C18: 2) for 30.50 - 30.81 percent respectively. This indicates that the Jatropha oil contains more than 98 percent unsaturated fatty acids, making it easier to oxidation reaction when exposed to sunlight, oxygen, or heat. Thus, the stability of the oxidation reaction of Jatropha oil is further studied and it is found that the oxidation stability provides the values of approximately 13.90 hours. As for seeds stored at 0 month and oil stored at 0 month and when the duration of storage has passed until the 18th month and when oil stored reaches 9 months, the stability of the oxidation reaction of Jatropha oil decreases to 8.75 hours. When comparing the stability to the oxidation reaction of crude palm oil, it is found that it is as low as twice times. Because crude palm oil contains fatty acids, which are mostly saturated fatty acids and contains beta-carotene which is an antioxidant that helps stop oxidation. In addition, as the duration increases, the amount of water and acid also increase but the amount of water increases slightly only from 0.07% to 0.08% since Jatropha oil receives moisture from the air area above the surface of oil and the increased acid content is the result of the free fatty acid content in Jatropha oil. It also indicates that the deterioration of oil due to the hydrolytic reaction from the amount of water mixed in the oil and from the result of storage conditions.

In addition, the iodine value can also reflect the number of double bonds or unsaturated fatty acids of the oil as well. If the oil has high iodine content, it will reflect a high amount of double bonds or high unsaturated fatty acids for Jatropha oil with high iodine values. That is, iodine values are greater than 90 grams, iodine / 100 grams of samples which shows that there are a lot of double bonds or high amounts of unsaturated fatty acids and it also shows a much faster polymerization reaction than in vegetable oil with lower iodine values as compared with crude palm oil, which includes an iodine value of approximately 50-60 and contains a low content of unsaturated fatty acids (Pissamai Jennawanich Panjakul and et al. 2009).

From the storage of Jatropha oil at different time intervals, the results of Jatropha oil obtained from the screw press extraction indicates that the factors that change over time are water content, acid value, and stability to oxidation reaction at a temperature of 110 °C. Therefore, the comparison between the storage period of Jatropha seeds from the 0-18 months and the Jatropha oil storage period from 0-24 months is conducted as shown in Figure 1-3.

The graph in Figure 1,2,3 shows the amount of water, the value of acid and stability to oxidation reaction at 110°C of Jatropha oil stored from the 0th month to the 18th month and in bringing Jatropha seeds stored in the period from 0,1,3,6,10,12,15,18 months for oil extraction.

Table 1 The chemical and physical properties of jatropha oil obtained using the extractions of Soxhlet, hydraulic press and screw press methods

	Properties of Jatropha oil extracted with 3 methods		(Soxhlet Extraction)	Hydraulic Press Method	Screw Press Method
1	Specific Gravity at 25°C		0.917	0.914	0.91
2	Viscosity at 25°C	Centistokes	53.92	35.09	50.40
3	Acid Value	Mg, Potassium hydroxide/g	56.085	3.0	1.96
4	Free fatty acid	Percentage	28.18	1.51	1.49
5	Saponification Value	Mg, Potassium hydroxide/sample g	197.40	198.16	190.08
6	Iodine Value	Iodine gram /100 sample grams	97.14	97.51	97.51
7	Refractive index at 25°C		1.466	1.467	1.47
8	Water Content (Karl Fisher Titration)	Percentage	0.07	0.055	0.07
9	Water and volatile content @ 105°C	Percentage	0.245	0.045	0.07
10	Color (Lovibond scale, cell 5 ¼)		Y=37 R=4.2	Y=12 R=2	Y=39.0 R=3.4
11	Stability to oxidation reaction at 110°C	hour	1.26	6.5	13.90
12	Fatty acid composition	Percentage			
	Palmitic Acid (C16:0)		13.80	13.85	14.20
	Palmitoleic Acid (C16:1)		0.66	0.67	0.60
	Heptadecanoic Acid (C17:0)		0.13	0.12	0.10
	Stearic Acid (C18:0)		6.19	5.98	6.40
	Oleic Acid (C18:1)		45.26	45.15	47.50
	Linoleic Acid (C18:2)		32.84	33.28	30.50
	Linolenic Acid (C18:3)		0.23	0.18	0.20
	Arachidic Acid (C20:0)		0.22	0.19	0.20
	Others		0.67	0.58	0.30

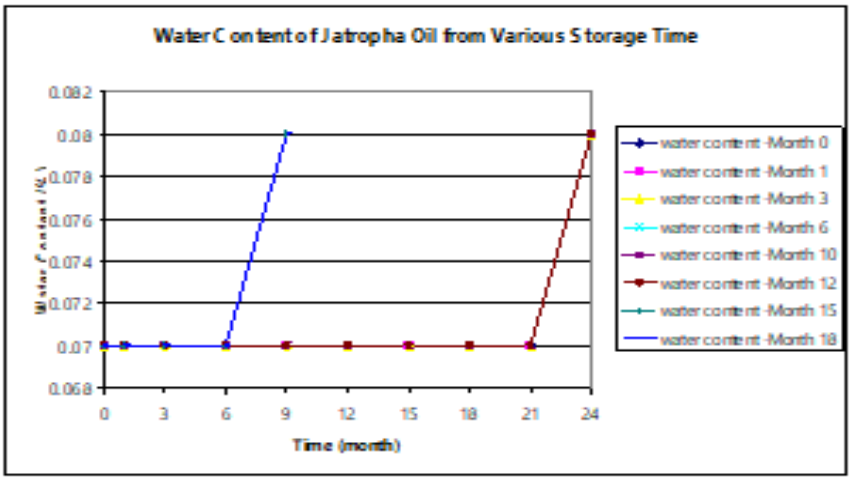

Figure 1 The amount of water of Jatropha oil at the period from 0 - 24 months

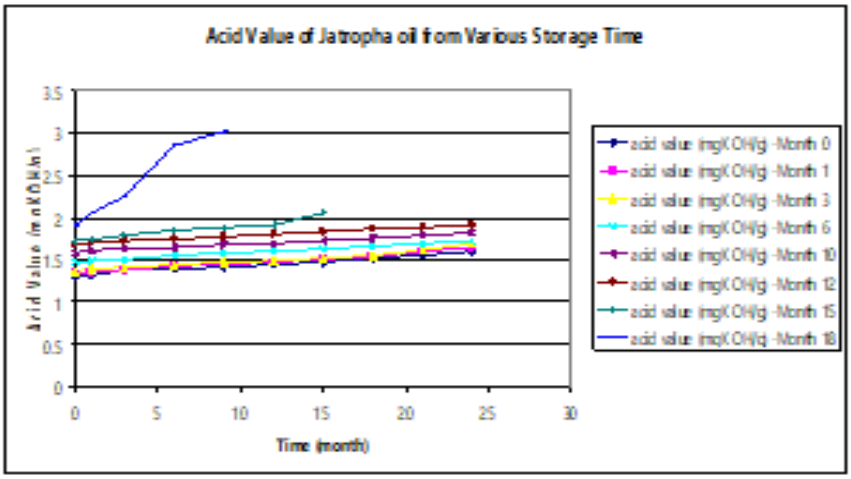

Figure 2 Acid value of Jatropha oil at the period from 0 - 24 months

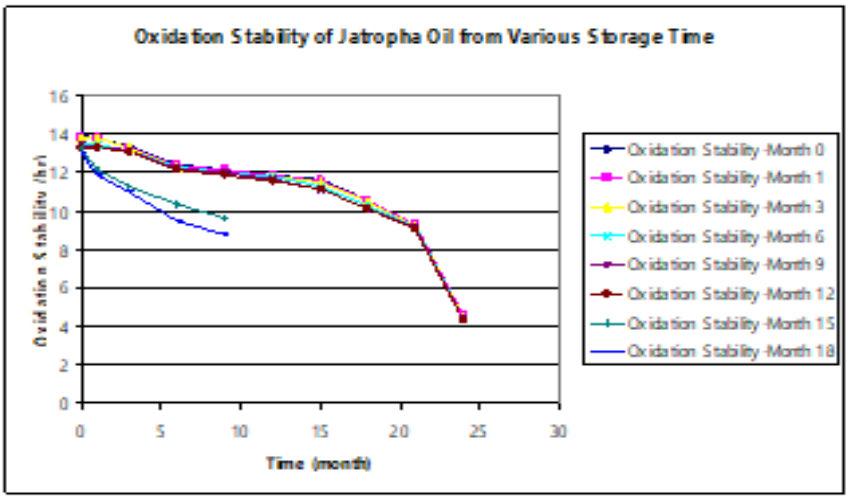

Figure 3 Stability of oxidation reaction at 110°C of Jatropha oil during 0 - 24 months

And when extracting the Jatropha oil from the seed stored as above durations, then the Jatropha oil is stored for 24 months, except for the Jatropha oil from the seed storage for the 15th and 18th months, Jatropha oil can be collected for only 9 months due to the ending of the project. In evaluating the properties of oil stored for 24 and 9 months, the test will be conducted for the periods of 0,1,3,9,12,15,18, 21, 24, respectively. From graph 1, it is found that the number of water increases only a little. That is in the 0th month the water content is 0.07 percent until the 24th month which contains the water content of 0.08 percent. Graph in figure 2 shows the acid value of Jatropha oil which is found that when the storage duration of Jatropha seeds and the Jatropha oil increase, the acid value of Jatropha oil increases too.

And from graph 3, it indicates the stability of oxidation reaction at 110 C of Jatropha oil which is found that when the storage duration of Jatropha seeds and oil increases, the stability of the oxidation reaction at 110°C decreases. Therefore, the storage duration of Jatropha seeds and oil should not be too long, as this will prevent the properties of Jatropha seeds and oil not to be used for the engine or not to be produced as biodiesel to meet the quality standards. And it will also waste many chemicals for production to meet biodiesel for good quality standards.

Summary

The analysis results of Jatropha oil obtained from screw press extraction method indicate that the main components of the fatty acids are palmitic acid (C16: 0) equal to 14.20%, stearic acid (C18: 0) equal to 6.4%, oleic acid (C18: 1) equal to 47.50%, Linoleic acid (C18: 2) equal to 30.50% and other components of 0.3% respectively. And the values of acid, water content, free fatty acids, and low iodine values are 1.96 milligrams of potassium hydroxide/gram, 0.07 percent, 1.49 percent, 97.51 grams of iodine / 100 grams sample, respectively. These main properties, if the values are high, it will affect the engine system. For example, if the value of acid is high, it will result in corrosion or swelling of various components inside the engine. The value of the acid is related to the value of free fatty acids. That is, if the free fatty acids are high, the acid value will also be high. As for the amount of water, if the value is high, it will cause the hydrolytic reaction with oil to form free fatty acids resulting in higher acid values until causing the corrosion of the internal components of the engine and causes poor performance of combustion. And another important property of Jatropha oil is the stability to oxidation. The screw press extraction yields the highest value (13.90 hours) for this property when comparing the 3 extraction methods as shown in Table 1. For the stability of oxidation, if this value is low, it results in insoluble polymers and solids in oil which will result in clogging of the nozzle, cylinder, or valves inside the engine.

As for the results in collecting Jatropha seeds and oil at different times, it is found that the Jatropha seeds and oil storing at the 0th month is experimentally stable with oxidation reaction for 13.90 hours, the acid value is 1.31 milligrams of potassium per oil gram and the water content is 0.07 percent. And when storage period of the Jatropha seeds reaches 18 months and the oil storage reaches 24 months, the composition of fatty acids has slightly changed, but the values of acids, water content, and stability to oxidation reactions are changed as follows;

the acid value, after 24 months, increases from 1.31-3.01 mg potassium hydroxide / g accounting for 129.77%, the amount of water increases only slightly, from 0.07- 0.08% accounting for 14.29% increased and the stability of oxidation reaction at 110°C decreases from 13.90 - 8.75 hours, representing 37.05% decreased.

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