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THE QUALITY OF SEEDS AND CRUDE JATROPHA OIL (CJO) BASED ON VARIOUS HYBRIDE OF *Jatropha curcas* L. AS A BIODIESEL SOURCE

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Abstract

Jatropha curcas L. is a woody shrub from the tropics that has extraordinary potency as a producer of biodiesel. Crude *Jatropha* Oil (CJO) about 30%-40% in the seed, and 40%-50% in the kernel. CJO is produced by dry seeds extraction, mechanically or chemically. Mechanical extraction by pressing was easier and cheaper, because it was not require complicated technology. This research was aimed to analyze the quality of seeds and CJO based on various hybrid of *J. curcas* as a source of biodiesel. The material was dry seeds from 4 genotypes of J. curcas hybrid from Kedung Pengaron, Pasuruan District, East Java Province, namely G5-A, G5-B, G6-A and G6-B. This research consisted 2 stages, started with observing *Jatropha curcas* L. seeds quality (water and oil content),followed by CJO production and analyzed (acid number, Free Fatty Acid, saponification number, ester number, and water content). Completely Randomized Design with 3 replications were applied. The results defined that *Jatropha curcas* hybrid was not significantly affect on the oil content, but gave significantly effect on the water content of seeds. Furthemore, *J. curcas* hybrid was also gave significantly effect on the acid number, FFA, and water content of CJO properties.

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Keywords: free fatty acid, saponification number, ester number

1. INTRODUCTION

The biggest potency of biodiesel raw material for Indonesia comes from palm oil. The properties of palm oil was 314 ºC for ignition point, 88.6 (10^{-6} m^2 s^{-1}) for kinematic viscosity, 54.2 mg g^{-1} iodine number, 199.1 mg g^{-1} saponification number, Gross calorific value 39.54 (MJ kg^{-1}) [1]. *Jatropha curcas* L. is a tropical plant that also has potency as biodiesel raw material. *Jatropha* seeds contain about 35% oil that easy to convert as biodiesel [2]. Crude *Jatropha* Oil (CJO) commonly is obtained from extraction using a solvent, pressing, or a combination of both. The compression of *Jatropha* seeds that apply hydraulic presses at low temperature can produce 23-35 % oil in the seeds. Furthemore, extraction at high temperature (hot press), able to produce higher CJO about 75-80 % [3].

Meanwhile, *J. curcas* L. strength is, it includes in the non-edible oil category, so it would not compete with the needs of edible oil [4]. Therefore, its availability and sustainability would not interfere with Indonesian agricultural production. *Jatropha* fruit consisted of 3 chambers, and each chamber contains one seed, in other word one fruit resulting 3 seeds. Hartati et al., (2009) defined that the high oil content causes the seeds cannot be stored for a long time. The *Jatropha* seed characteristics mostly are oval, and blackish brown. These seeds contain a lot of oil about 35-45% and are toxic [6]. In addition, the biodiesel based on *Jatropha* seeds have environmental friendly properties with much lower emissions. In general, the cetane number is higher resulting combustion becomes more efficient, helps lubricate the piston engine, is easier to decompose, and renew [4]. It also consisted 35% oleic acid, and a lot of linoleic, which is very suitable to be applied as biodiesel [7].

The biodiesel production based on *Jatropha* seeds in Indonesia still encounter several obstacles, such as the low availability of seeds. The need of seeds for plant cultivation in the field is quite high. The effort to meet *Jatropha* needs in Indonesia should be supported by large-scale cultivation of superior varieties with high level of oil productivity. The breeding activity also was applied to produce superior varieties resulting raw materials supply can be guaranteed.

The quality of seeds and crude *Jatropha* oil greatly affects the quality of biodiesel produced. The saponification number is the amount of oil that can be saponified which defined the molecular weight. Achten et al. (2008) stated that the average of *J. curcas* saponification number ranged from 102.9-209 mg g^{-1}. While, previous studies informed that saponification number of *J. curcas* for the caboverde var. was 192.4 mg g^{-1}, *nicaragua* var. was 190.1 mg g^{-1} [9]; *nicaragua* var. 198.85 ± 1.4 mg g^{-1} [10], 183-191 mg g^{-1} [11]. Crude *Jatropha* oil characteristics consisted ignition point 340 ºC, Kinematic viscosity 75.7 (10^{-6} m^2 s^{-1}), Iodine number 103.0 mg g^{-1}, Saponification number 198 mg g^{-1}, Gross calorific value 39.65 (MJ kg^{-1}) [1]. The value of the water content of vegetable oil should not to be more than 2%. The high water content in vegetable oil is feared to cause hydrolysis, which will increase free fatty acid levels. The high content of water and free fatty acids will trigger the formation of soap (saponification) and cause problems in the separation of glycerol [12]. The research aimed to identify the seed and crude jatropha oil quality of various hybrid *J. curcas* L. as a source of biodiesel.

2. MATERIAL AND METHODS

The research was conducted at the Chemistry Laboratory, University of Muhammadiyah Malang. Completely Randomized Design (CRD) with one factors *J.curcas* L. hybrid that consisted four level (G5-A, G5-B, G6-A, G6-B) [13] with 3 replications were applied. The *J. curcas* L. seeds used as samples was collected from Kedung Pengaron, Kejayan Sub-district, Pasuruan District, East Java, Indonesia. In addition, the various types of chemicals were prepared for analysis several parameters such as oil content, free fatty acids, saponification number, acid number and ester number. The raw material charectiristics were explained at Table 1.

Table 1. The Characteristics of *Jatropha curc*as L. Used As Biodesel Raw Material.

Seed Hybrid	Number of Fruit	Number of Seed	Seed Dry Weight (g/plant)
G-5-A	669	1740	966.7
G-5-B	758	1828	1086.8
G-6-A	545	1368	740.8
G-6-B	816	2047	1105.4

This research started from seeds drying at oven for 1x24 hours at a temperature 75 ºC, then the dry weight was measured. After the drying process, it followed seeds water content [14] and oil content analysis [15]. Furthermore, dried Jatropha seeds were pressed to obtain crude jatropha oil (CJO) and analyzed acid number, free fatty acid [16], saponification number, ester number, and water content [17]. The data obtained were analyzed using Analysis of Variance (ANOVA), then the significant parameters were continued with LSD test 5%.

3. RESULTS AND DISCUSSION

3.1 *Jatropha* Seed Characteristics

The results showed that the treatment of several genotypes from the *J. curcas* cross did not significantly affect the oil content, and had a significant effect on the water content of the seeds (Table 2). The data showed that the lowest water content of Jatropha seeds was in the G6-A, and the highest was in G5-B which was not significantly different from B5-A. While the seed oil content did not show any significant difference.

Table 2. Water Content and Oil Content ± Standard Deviation of *Jatropha curcas* L. Seed Genotypes.

Seed Genotypes	Water Content(%)		Oil Content (%)	
G5-A	8.42 ± 0.06	c	26.69 ± 0.73	a
G5-B	8.54 ± 0.15	c	27.92 ± 0.83	a
G6-A	7.52 ± 0.13	a	25.75 ± 1.93	a

Note: numbers followed by the same letter in a column were not significantly different on Duncan Test of 5%.

The genus *Jatropha* is sprout throughout the tropics and sub-tropics and can grow on marginal land. *J. curcas* is a potential bioenergy crop worldwide, due to its adapt ability to marginal soils and environments [18]. *J.curcas* seeds consisted of 75% seed flesh and 25% seed coat, with oil composed of fat 47.25 ± 1.34%, protein 24.60 ± 1.40%, crude fiber 10.12 ± 0.52%, water 5.54 ± 0.20% and 7.99% carbohydrates, this percentage was influenced by genetic and environmental factors [10]. The variety in seed weight in the same amount was due to differences in the chemical composition of *Jatropha* seeds, which were caused by diversity in variety, genetics, age and environmental of plant growth [8].

In general, *J. curcas* sprout flower at the age 3-4 months, fruit arise at 4-5 months, and fruit ripening after 5-6 months. This plant is an annual plant that can live more than 20 years if cultivated properly and intensively. Crop productivity ranges from 3.5–4.5 kg of dry seeds/tree/year. Production will be stable after the plant is more than 1 year old [19]. The first harvest begins at the age of 8-9 months. Peak production will start in the 5th year and the amount of harvest in 1 hectare depends on many factors including the intensity of sunlight [20]. Productivity per plant reaches 2-2.5 kg of dry seeds. If the population 2000 plants/ha will produce 4-5 tons of dry seeds in one year and in one ton of dry seeds resulted 200-300 liters of oil. As the result in one hectare of land was produced 1000 - 1500 liters of crude oil [21]. The JCUMM18 genotype produced the highest seed dry weight (328.5 kg/ha/year) without watering. Cultivation in North Lombok-NTB produced a higher number of fruits and dry weight of 100 seeds than planting in Pasuruan, but the crude oil content produced in NTB was lower [18].

The water content of *J. curcas* seeds is one of the important factors before the seed pressing process. Gerpen et al., (2004) described that the optimum water content for oil-extracted grains was 6-7%. Seed water content mostly was influenced by fruit maturity at harvest period, drying and storage time. The lowest results of water content was in the G6A genotype (7.52% ± 0.13). The water content was tend to be high, this was influenced by seed harvesting during the rainy season and post-harvest handling which tends to humid with a long storage time resulted increasing in water content of seeds. The increase in humidity in the storage space causes an increase in seed water content. On the other hand, storage at low humidity will reduce seed water content [23].

The oil content of *J. curcas* seed is one of the important factors before the quality crude *jatropha* oil analysis. The results showed that the seed oil content was not significantly different. According to Putri et al., (2017) *Jatropha* produce seeds with oil content up to 37%, which was twice higher than soybeans and almost the same as Camelina. In preliminary research, the oil content of JC-18 *jatropha* seeds can reach 32.09% (planted in East Java) and 33.04% (planted in West Nusa Tenggara) [25]. The low seed oil content in this study was presumably due to harvesting process in the rainy season that resulted significantly increasing water content of the seed although it had been given drying treatment.

3.2. Crude *Jatropha* Oil Acid Number

The treatment of various genotypes of *J. curcas* showed that there was no significant effect on the ester number and saponification number of crude *jatropha* oil. Furthemore it gave significantly effect on the acid number, FFA (Free Fatty Acid) and water content of crude *jatropha* oil (Table 3).

Crude jatropha oil was obtained through compression and extraction processes using solvents, or a combination of both. Table 3 described that various hybrid of *J.curcas* gave significant effect on the acid number. This parameter was measuring the amount of free fatty acids, and is calculated based on the molecular weight of the fatty acid or fatty acid mixture. Acid Number is the number of milligrams of Base (KOH/NaOH) required to neutralize free fatty acids from one gram of oil or fat [26]. SNI standard 04-7182-2006 requires the acid number should not to exceed 0.80 mg KOH/g. In this study, the lowest acid value (3.70 mg KOH g^{-1} ± 0.5) was found in the plant genotype G6-A, which means it was exceed the standard [27]. The acid number indicates the amount of KOH required to neutralize free fatty acids. The greater value of acid number means more free fatty acids contained in the fat, so the fat quality is getting worse [28]. The acid number also showed that the oil/fat contained organic acids. This is due to the hexane solvent used during extraction will contribute and participate in free fatty acids extracting, especially oleic and linoleic fatty acids [29].

Table 3. Crude Jathropha Oil Properties

Treatment	Acid Number (mg-KOH g^{-1})		Free Fatty Acid (%)		Ester Number (mg-KOH g^{-1})		Saponification number (mg-KOH g^{-1})		Water Content (%)	
G5-A	4.22 ± 0.6	b	1.53 ± 0.16	b	63.14± 1.21	a	65.84 ± 0.55	a	0.43 ± 0.02	a
G5-B	4.22 ± 0.4	b	1.54 ± 0.16	b	60.90± 1.99	a	65.12 ± 1.61	a	0.50 ± 0.05	ab
G6-A	3.70 ± 0.5	a	0.69 ± 0.16	a	64.54± 1.21	a	66.24 ± 1.61	a	0.56 ± 0.06	b
G 6-B	5.63 ± 0.4	b	2.01 ± 0.15	b	62.86± 1.22	a	68.46 ± 1.60	a	0.63 ± 0.05	b

Note: numbers followed by the same letter in a column were not significantly different on Duncan Test of 5%.

3.3. Crude Jatropha Oil Free Fatty Acid

The analysis of variance (Table 3) defined that various hybrid of *J.curcas* gave significant effect on FFA parameters. Free Fatty Acid test was used to determine the free fatty acid content in the oil. The level of FFA indicates the damage level of oil due to the breakdown of tryacilglycerol and fatty acid oxidation. The higher FFA value in the oil showed that oil quality was lower, conversely lower FFA value defined better oil quality [30]. FFA is an important factor in determining the quality of CJO. Based on Table 3, the lowest FFA was genotype G6-A

(0.69% ± 0.16). This result exceeded the Indonesian National Standard [27], the FFA content should be 0.2-0.4%. FFA is formed due to the hydrolysis process of oil into its acids.

3.4. Crude *Jatropha* Oil Ester Number

The results showed that there was no significant effect of genotype hybrid of *J. curcas* on the ester number. SNI standard 04-7182-2006 [27] determined that minimum ester number was 96.5. The ester number described about KOH are needed to saponify the ester in 1 gram of oil/fat. The purpose of determining the esters number or bound fatty acids is to calculate the esterified glycerol. In this study, the highest ester value was found in the G6-A (64.54mg KOH g^{-1} ± 1.21). The ester number defined organic acids number that are compounded as esters, which related to acid number and saponification number. The ester number can be calculated as the difference between saponification number and the acid number [26].

3.5. Crude *Jatropha* Oil Saponification Number

Based on the analysis of variance, it showed that there was no significant effect of various genotype hybrid of *J. curcas* on the saponification number. In this study, the range value of the saponification number was from 65.12 ± 1.61 (G5-B) to 68.46 ± 1.60 (G6-B). Generally, the saponification number ranged from 102.9-209 mg g^{-1} [8]. The saponification number interpreted the amount of oil that can be saponified, so it defined the oil molecular weight. The previous research found that the saponification number of *J.curcas nicaragua* var. was 198.85 ±1.4 [10]. The saponification number is expressed the amount (mg) of KOH needed to saponify 1 gram of oil or fat, the alcohol in KOH serves to dissolve the hydrolyzed fatty acids and facilitate the reaction with bases to form soap [26]. Therefore, greater saponification number, expressed smaller fatty acid and better quality of oil. Contrary, if the saponification number was small, defined that fatty acid was higher and the quality decreased. The number of saponification was influenced by the molecular weight of the oil [31]. Oils composed of short chain fatty acids mean that have lower molecular weight, as the result it will have a relatively higher saponification number and conversely. The saponification number is determined by the molecular weight of the constituent fatty acids. In addition, the number of saponification are influenced several factors such as cultivation, location to grow, climate, harvest time, season, genetic factors and the oil extraction process [32].

3.6. Crude *Jatropha* Oil Water Content

Based on analysis of variance (Table 3) showed that there was significant effect on the oil water content. The water content of the oil is the difference between the initial weight and the weight after evaporation of crude *jatropha* oil. The lowest water content was genotype G5-A (0.43% ± 0.02. This was due to the harversting process at the rainny season, which resulted increasing water content. Although already gave oven drying treatment, it was not significantly decreased water content.

4. CONCLUSION

The various genotypes of *J.curcas* hybrid showed unsignificantly effect on seed oil content, but it affect seed water content significantly. The lowest water content of *Jatropha* seed (7.52%) was achieved by genotype G6-A, and the highest was at G5-B (8.54%). Various genotypes of *J.curcas* hybrid defined significantly effect on acid number, Free Fatty Acid and water content of crude *jatropha* oil (CJO), but unsignificant on the saponification number and ester number. In this study, the lowest acid number (3.70 mg KOH/g) was in the G6-A genotype. The lowest free fatty acid content was genotype G6-A (0.69%). The various genotypes of *J.curcas* was unsignificant affect on the ester number and saponification number. In this study the highest ester number (62.83 mg KOH/g) was in the G6-B genotype. The saponification range values was 65.12 mg KOH/g (G5-B genotype) to 68.46 mgKOH/g (G6-B genotype). The lowest average water content of CJO (0.43%) was in the G5-A.

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