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Physicochemical Characteristics of Tropical *Jatropha curcas* Seed Oil

(Sifat Fizikokimia Minyak Biji *Jatropha curcas* Tropika)

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ABSTRACT

The oil fraction of Jatropha curcas *seeds from Malaysia, Indonesia and India were extracted by using cold press method. Their chemical and physical properties such as oil content, % water, specific gravity at 28°C, refractive index at 25°C, colour at 28°C, viscosity at 28°C, iodine value, acid value, triacylglycerol (TAG) composition, free fatty acid, saponification, and unsaponifiable value were examined. The results showed that the Malaysian seed sample contained high oil percentage, 33.7%. On the other hand, the oil content from Indonesian and Indian seeds were 32.7% and 30.5%, respectively. The physicochemical properties showed iodine value of 103.2, 99.8 and 97.9, acid value of 2.4, 9.9 and 7.6, FFA% of 1.68%, 6.99% and 5.35%, saponification value of 197.8, 183.2 and 156.2 and unsaponifiable value of 1.99%, 2.15% and 2.35% for Malaysian, Indonesian and Indian crude oil respectively. Although, the percentage of the TAGs and fatty acids of tropical* Jatropha curcas *oil were different, both oleic (43.5%-43.8%) and linoleic (33.1%-34.7%) acids were detected as the dominant unsaturated fatty acids, while palmitic (14.7%-14.9%) and stearic (7.0%-7.2%) acids were the saturated fatty acids found in the oil. Unlike most* Jatropha curcas *oils, tropical* Jatropha curcas *oil also contained palmitolic acid (0.8%) as part of minor fatty acids in the oil. Polyunsaturated* TAG_{ss} *of PLL, OOL and OLL were the major* TAG_s *found in the tropical* Jatropha curcas *oil.*

Keywords: Chemical properties; triacylglycerol profile; tropical Jatropha curcas

ABSTRAK

Fraksi minyak Jatropha curcas *dari Malaysia, Indonesia dan India telah diekstrak menggunakan kaedah tekanan sejuk. Sifat fizik dan kimia seperti kandungan minyak, peratus air, graviti spesifik pada 28°C, indek biasan pada 25°C, warna pada 28°C, kelikatan pada 28°C, nilai iodin, nilai asid, komposisi triasilgliserol (TAG), asid lemak bebas, nilai penyabunan dan taktersabun telah ditentukan. Hasil kajian menunjukkan bahwa sampel biji dari Malaysia mengandungi kandungan minyak yang tinggi, 33.7%. Sebaliknya kandungan minyak dari Indonesian dan India adalah masing-masing sebanyak 32.7% dan 30.5%. Sifat fisikokimia masing-masing menunjukkan nilai iodin sebanyak 103.2, 99.8 dan 97.9, nilai asid (2.4, 9.9 dan 7.6), %FFA (1.68%, 6.99% dan 5.35%), nilai penyabunan (197.8, 183.2 dan 156.2) dan nilai taktersabun (1.99%, 2.15% dan 2.35%) bagi masing-masing minyak mentah Malaysia, Indonesia dan India. Walau bagaimanapun, peratus TAG dan asid lemak minyak jarak* Jatropha curcas *tropika berbeza, tetapi asid oleik (43.5%-43.8%) dan linoleik (33.1%-33.7%) merupakan asid lemak dominan sementara asid palmitik (14.7%-14.9%) dan asid stearik (7.0%-7.2%) adalah asid lemak tepu yang ditemui dalam minyak. Tidak seperti minyak* Jatropha curcas *lain, minyak* Jatropha curcas *tropika juga mengandungi asid palmitolik (0.8%) bagi asid lemak minornya.* TAG_s *politaktepu PLL, OOL dan OLL adalah TAG yang dominan dalam minyak* Jatropha curcas *tropika.*

Kata kunci: Jatropha curcas *tropika; profil triasilgliserol; sifat kimia*

INTRODUCTION

Jatropha curcas known as Barbados nut, or Physic nut, is a shrub belonging to the Euphorbiaceae or spurge family. The plant, originating in Central America, is mainly grown in Asia and in Africa. At the present time, the government of Malaysia is looking into *Jatropha curcas* in order to avoid the problems associated with palms biodiesel, besides its potential in non food industrial.

Jatropha curcas oil is a type of plant oil produced from the seeds. The seed's kernel of the plant contains about 60% oil (Jumat & Rozaini 2008). Solvent extraction (particularly hexane) will be able to extract all of the oil content, whereas cold press extract not more than 75% of the total oil (Gunstone et al. 2007). The oil can be converted into biodiesel and use as a substitute for petroleum diesel fuel (Emil et al. 2009), medicinal uses such as to cure diseases like dysentery, hemorrhoids, gonorrhoea, coated tongue, infertility, small pox and skin infections. It is also used for candles and soap making (Gubitz et al. 1998). However, the use of the seed oil for cooking purposes is not possible due to the content of toxic compounds (Martinez et al. 2005). The seed cake remaining after oil extraction is an excellent source of plant nutrients (Martinez et al. 2005). However, the presence of high levels of anti-nutrient prevents its use in animal feeding. Although phorbol esters have been identified as the major toxic compounds in

Jatropha (Makkar et al. 1997; Wilhelm & Martin 2000), but their content depend on the type of soil and climatic conditions (Martinez et al. 2005).

Most studies on *Jatropha curcas* oil have been focused on its uses as biodiesel and modern methods for their oil extraction. Few studies have been reported on its physicochemical characteristics. In fact there are two reports on the physicochemical characteristics of Malaysian *Jatropha curcas* oil (Jumat & Rozaini 2008; Emil et al. 2009). In this paper comparison of physico-chemical characteristics of various tropical (Malaysia, Indonesia and India) *Jatropha curcas* seeds oil including their triacylglycerol and fatty acids composition profile were investigated.

MATERIALS AND METHODS

SEED MATERIAL

Malaysian *Jatropha curcas* seeds were obtained from UKM Biobased lubricant experimental plot, Indonesian *Jatropha curcas* seed were obtained from south Sumatra (Indonesia) and Indian *Jatropha curcas* seeds were obtained from obtained from market (Bionas Company, Kuala Lumpur). The fruit seeds were sun-dried for three days. Afterward all the seeds were de-hulled and dried at high temperature of 100-105°C for 30 min seeds were ground into powder prior to extraction.

OIL EXTRACTION (COLD PRESS METHOD)

The dried seeds (powdered) of Malaysian, Indonesian and Indian *Jatropha curcas* were used for cool mechanical oil extraction. The oil extraction was carried out at room temperature using homemade screwed-press extruder at about 5 tan/cm^2 and the extracted oil was stored in a cool room at -5°C until needed for further analysis.

CHEMICAL CHARACTERISTICS ANALYSIS

Oil Content The weight of oil extracted from seeds powder was determined to calculate the oil content. The result was expressed as the percentage of oil in the dry matter of seeds powder.

Acid value & % FFA Acid value of seeds oil was determined according to AOCS Official methods cd3a-63. Free fatty acids percentage (FFA %) was calculated oleic acid.

Iodine value Iodine value of seeds oil was determined according to AOCS Official methods cd1-25.

Saponification value The saponification value was determined according to BS684 2.6:1977 (Jumat et al. 2006).

Unsaponifiable matter The unsaponifiable mater was determined according to AOCS Official methods Ca 6a-40 (1989).

Fatty acid composition The fatty acid composition was determined by conversion of oil to fatty acid methyl esters (FAME) prepared by adding 1mL of n-hexane into 0.1 mL of oil followed by 1 mL of 0.78 N sodium methoxide according to AOAC 969.33 method. The mixtures were vortexed for 10 s and allowed to settle for 10 min. The top layer (1 µL) was injected into a gas chromatograph (Model GC14A, Shimadzu Corporation, Kyoto, Japan) equipped with flame ionization detector and a polar capillary column BPX70 (30 m × 0.25 mm × 0.25 µm) (SGE Incorporated, USA) to obtain individual peaks of fatty acid methyl esters. The column, detector (FID) and injector temperatures were set at 180, 280 and 250°C, respectively. Gas flow was at 1 mL/min and ran for 60 min. The fatty acid methyl esters peaks were identified by retention times by means of comparing them with authentic standards analyzed under the same conditions.

PHYSICAL CHARACTERISTICS ANALYSIS

Color The oil color was determined according to AOCS Official method Cc 13b-45(97) using a Lovibond tintometer 181059 Model F (U.K). Frozen oil samples were melted by placing them at 60°C in an oven and were then gently shaken. The liquefied samples were placed into an inch cell up to three quarter full and the color was determined at 28ºC by achieving the best possible match with the standard colour slides provided.

Viscosity Viscosity of seeds oil was carried out using Brookfield model RV DV-I (U.S.A). Spindle no. 3 was used at 1 minutes and 100 rpm at room temperature.

Refractive Index Refractive index was determined according to AOCS Official methods Cc 7-25 using Refractometer (TAGO Co. Ltd. Series No.11506, connected with digital thermometer model DTM-1T, Japan).

Specific gravity Specific gravity of seeds oil was carried out using analytical microbalance, 1 mL of oil was put on the balance and its weight was recorded at room temperature.

TAGs composition TAGs profile of seeds oil was determined according to AOCS Official methods Ce5b-89 by using high performance liquid chromatography (HPLC-ELSD Ultimate 3000 DIONEX) equipped with evaporative light scattering detector (ELSD) and an auto-injector. The TAGs of the seeds oil was separated using commercially packed C18 column 5 µm × 120Å (4.6 × 250 mm)(Germany) and performed at room temperature. The mobile phase used was a mixture of acetone:acetonitrile (63.5:36.5) set at a flow rate of 1 mL/min. Sample preparation involved sample dilution with acetone:acetonitrile (63.5:36.5) mixture before put it into HPLC and auto-injection with the total running time of 30 minutes. TAG peaks were identified based on the retention time of available commercial TAG standards. The relative composition percentages of TAG peaks were evaluated from

all peaks appeared after 8 minutes (retention time of the first TAG peak appeared).

Results and Discussion

Oil Extraction

Table 1 shows that the physical properties of *Jatropha curcas* oil studied. In the current work the percentage of oil extracted was in the range of 32.71 – 33.73% obtained from tropical *Jatropha curcas* seeds. The percentage of oil extracted from Malaysian *Jatropha curcas* seeds by cold mechanical press method (MH-10, CAP ton B, Japan) was found to be 33.73% compared to the Indonesia *Jatropha curcas* seeds (IndoJC) of 32.7% and Indian *Jatropha curcas* seeds (IJC) of 30.32%. The oils yields are low compared to that of obtained by solvent extraction, 60% (Jumat & Rozaini 2008). The cold press extraction produced about 75% of the total oil extracted by the solvent (Gunstone et al. 2007). This is because the organic solvent used has a greater ability to extract most of the oil available in the oil seed. However, the advantage of mechanical extraction (cold pressed) over solvent extraction has been highlighted in several studies. The extraction can be made at room temperature, flammable solvents are not required and harmful waste are not produced (Gunstone et al. 2007). The disadvantage of using mechanical press methods, although safer, is that not all oil will be extracted (Gunstone et al. 2007).

Chemical and Physical Characteristics

Table 2 presents the chemical properties of tropical *Jatropha curcas* seeds oil. The physicochemical properties of selected *Jatropha curcas* samples from Malaysia, Indonesia and India were not significantly different ($p<0.05$) although there were slight differences in their specific parameters values. The results showed its quality as good as commercial vegetable oil with high iodine value was ranging from 97.9-103. This was due to its high content of unsaturated fatty acids and comparable with others for various *Jatropha curcas* seeds oil such as 111.6 (Adebowale & Adedire 2006), 105.2 (Akintayo 2004) and 91.7 (Jumat & Rozaini 2008). These values were comparable with other unsaturated seed oil such as soybean (134), cotton seed oil (99-113) and corn oil (127-133) (Gunstone 2002). Saponification values of studied tropical *Jatropha curcas* seed oils were in the range of 156.5-197.8, which is low compared to *Jatropha curcas* seed oil from Nigeria (Akintayo 2004) but higher compared to *Jatropha curcas* seed oil from Northern Nigeria (Adebowale & Adedire 2006). In general, the Saponification value for *Jatropha curcas* seed oil was comparable to typical commercial seed oil such as corn seed oil (187-193) and cottonseed oil (189-198) (Gunstone 2002). Unsaponification value showed a low value of 1.99-2.35% compared to *Jatropha curcas* seed oil from Nigeria (Adebowale & Adedire 2006). The value was comparable to typical seed oils such as corn seed oil (1-3%) and higher than cotton seed oil (0.5-0.7) and soybean seed oil (1.6%) (Gunstone 2002). Malaysian *Jatropha curcas* seeds oil (MJCO) acid value showed low number of 2.4 compared to India *Jatropha curcas* seeds oil (IJCO) and Indonesia *Jatropha curcas* seeds oil (IndoJCO) which are 7.6 and 9.9 respectively. However these values were comparable to that of Nigeria *Jatropha curcas* seed oil (Adebowale & Adedire 2006; Akintayo 2004).

As for the physical properties, *Jatropha curcas* seeds oil is in a liquid state at room temperature. IJCO shows high viscosity at room temperature (63cp) compared to 58cp for MJCO and 38cp for IndoJCO. The refractive indices of

TABLE 1. Physical properties of tropical *Jatropha curcas* oil

Characteristic	MJCO	IndoJCO	IJCO
Oil content	33.7%	32.7%	30.3%
%water	4.1 %	3.3%	4.2%
SP. gravity at 28°C	0.8750	0.9190	0.8895
Refractive Index at 25°C	1.472	1.463	1.465
Viscosity at 28°C	58 ±1	38 ±1	63 ±1
Color at 28°C	3.2Y- 0.5R	20Y,2R	20Y, 0.5R

Note: MJCO (Malaysian *Jatropha curcas* seed oil), IndoJCO (Indonesian *Jatropha curcas* seed oil), IJCO (Indian *Jatropha curcas* seed oil); Cold press extracted oil.

TABLE 2. Chemical properties of tropical *Jatropha curcas* seeds oil

Characteristic	MJCO	IndoJCO	IJCO
Iodine value (wijs)	103.2±0.6	99.8±0.5	97.9±0.7
Acid value mg NaOH/g	2.4±0.2	9.9±0.3	7.6±0.1
Free fatty acid as oleic %	1.68±0.02	6.99±0.03	5.35±0.05
Saponification value mg/g	197.8±0.1	183.2±0.2	156.2±0.2
Unsaponifiable matter %	1.99±0.15	2.15±0.06	2.35±0.08

the seed oils at 25.6°C were close to each other with value of 1.472, 1.465 and 1.467 for MJCO, IJCO and IndoJCO respectively. These values were comparable with other seed oil such as cottonseed (1.472), corn oil (1.4726) and soybean oil (1.4728) (Gunstone 2002) due to their close iodine value. In general high value in the refractive index will also high in iodine value (O'Brien 2004). The oil colors from those countries studied gave insignificant difference values.

FATTY ACID COMPOSITION

Fatty acid compositions of *Jatropha curcas* oils are shown in Table 3. The major fatty acids are oleic and linoleic acids, followed by palmitic, stearic and palmitoleic acids. Oleic acid shows the highest percentage in oil composition with 43.47 % (MJCO), 43.47% (IndoJCO) and 43.67% (IJCO). Unlike most *Jatropha curcas* oils, tropical *Jatropha curcas* oil also contained palmitoleic acid $C_{16:1}$ (0.8%, 0.78% and 0.81%) as part of minor fatty acids in the MJCO, IndoJCO and IJCO extracted oil respectively. Fatty acids composition of studied tropical *Jatropha curcas* oil were comparable with other *Jatropha curcas* seed oil from Nigeria ($C_{16:0}$ 11.3%, $C_{16:1}$ 0.00%, $C_{18:0}$ 17.0% $C_{18:1}$ 12.8%, $C_{18:2}$ 47.3% (Adebowale and Adedire 2006). Fatty acids composition is also comparable with other typical seed oil such as soybean ($C_{16:0}$ 11%, $C_{16:1}$ 0.1%, $C_{18:0}$ 4% $C_{18:1}$ 23.4%, $C_{18:2}$ 53.2% and other acids 8.3%)(Gunstone 2002), peanut ($C_{16:0}$ 11.6%, $C_{16:1}$ 0.2%, $C_{18:0}$ 3.1%, $C_{18:1}$ 46.5%, $C_{18:2}$ 31.4. % and other acids 7.1%) (Gunstone 2002) and corn ($C_{16:0}$ 10%, $C_{16:1}$ 0.00%, $C_{18:0}$ 1.8% $C_{18:1}$ 24.2%, $C_{18:2}$ 58 % and other acids 0.7%) (Gunstone 2002). The differences in fatty acids composition were expected due to differences in soil and climate conditions. However, there was no significant difference in total percentage for unsaturated and saturated fatty acid composition of tropical *Jatropha curcas* oil from Malaysia, Indonesia and India. Due to the high content of unsaturated fatty acids in the *Jatropha curcas* oil indicated by high percentages of oleic and linoleic acids, the oil can be classified as oleic–linoleic oil and used for a semi drying oil (Jumat & Rozaini 2008). It is plausible that the *Jatropha curcas* oil is suitable and potentially useful for surface coating materials and low pour point biodiesel (Gunstone 2004).

TRIACYLGLYCEROL PROFILE

The triacylglycerol (TAG) profile of tropical *Jatropha curcas* seed oil was determined by reversed phase HPLC of Malaysian *Jatropha curcas* seed oil (Jumat and Rozaini 2008). Table 4 shows the TAGs detected in tropical *Jatropha curcas* oil. From the chromatograph obtained, major TAGs peaks in tropical *Jatropha curcas* oil were the polysaturated TAGs of PLL, OOL, OLL, POL+SLL, OOO and

TABLE 3. Fatty acid composition (%) of tropical *Jatropha curcas* oil

Composition %	MJCO	IndoJCO	IJCO
Palmitic acid (C16:0)	14.9±0.1	14.9±0.1	14.7±0.2
Palmitolicacid(C16:1)	0.8±0.1	0.8±0.1	0.8±0.1
Stearic acid (C18:0)	7.2±0.1	7.3±0.2	7.0±0.1
Oleic acid (C18:1)	43.8±0.5	43.5±0.2	43.7±0.2
Linoleic acid(C18:2)	33.2±0.1	33.1±0.2	34.7±0. 6

TABLE 4. TAGs Composition (%) of tropical *Jatropha curcas* oil

TAGs	ECNs	Composition%		
		MJCO	IndoJCO	IJCO
LLL	42	5.02	3.97	3.88
OLL	44	22.54	19.11	18.51
POL+SLL	44	8.19	7.83	7.97
PLL	44	25.41	21.54	19.27
OOL	46	23.06	22.40	21.39
PPL	46	1.54	1.74	1.87
OOO	48	8.02	8.14	10.90
POP	48	2.14	9.12	12.02
PPP	48	2.90	3.05	2.54
SOO	50	0.85	0.16	0.79
POS	50	0.10	0.13	0.00
Unknown	-	0.24	1.82	0.75

ECNs = equivalent carbon number, L: Linoleic acid, O: Oleic acid, P: palmitic acid, S: Stearic acid.

LLL, followed by the monosaturated TAGs of POP, POS and PLL. The results showed that the types of the TAGs were not different in the three samples of tropical *Jatropha curca*s oil studied, however the percentages of the TAGs were significantly different due to differences in soil and climate conditions (Martinez et al. 2005*)*. The PLL with 25.4 % and OLL with 22.5% are high in Malaysian *Jatropha curcas* oil compared to Indian and Indonesian samples.

CONCLUSION

The results showed that the physicochemical properties of selected *Jatropha curcas* samples from various countries (Malaysia, Indonesia and India) were not significantly different. However some parameters such as oil content, acid value and saponification value were slightly different due to the quality of the extracted oil dependent to the soil and climate conditions where the samples were collected. The dominant fatty acids in tropical Jatropha oil were oleic and linoleic acids. Triacylglycerol of Malaysian *Jatropha curcas* oil, in general contain high polyunsaturated TAG compared to Indian and Indonesian samples.

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