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Gmail

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With kind regards,
Assoc. Prof. Dr. Mohd Fadzli Bin Abdollah, CEng MIMechE (UK)
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Physicochemical properties of *jatropha curcas* oil as a potential feedstock for biodiesel production

Amiera Husna Abdul Halim[1], Mahanum Mohd Zamberi[1,*], Mohd Haizal Mohd Husin[1], Nor Faizah Haminudin[1], Febrian Idral[1], Sharin Ab Ghani[2]

[1)] Fakulti Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2)] Fakulti Kejuruteraan Elektrik, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

[*]Corresponding e-mail: mahanum@utem.edu.my

Keywords: Biodiesel; free fatty acid; physiochemical; jatropha curcas

ABSTRACT –Crude *Jatropha curcas* oil (JCO) is known as a wonder crop in biodiesel production. This plant could grow in all forms of soil and water, making it a potential sustainable biofuel. In this study, the physicochemical properties of crude JCO were analysed according to the ASTM D6751, EN 14214, and American Oil Chemists' Society (AOCS) method. The crude JCO was distinguished by acid value (36.5 mg KOH/g), kinematic viscosity (34.94 mm^2/s), density (0.9133 kg/L), water content (0.3 wt.%), iodine value (106.3 g Iodine/100g) and color (Golden Yellow). The findings imply that crude JCO is a promising alternative fuel for biodiesel feedstock.

1. INTRODUCTION

Jatropha curcas is a major biodiesel feedstock in tropical and subtropical regions and emerging as the most favored due to its high oil yield per hectare, ease of propagation, hardiness, drought tolerance, rapid growth, and ability to adapt to a variety of climate conditions, making it a popular option among biodiesel producers [1]. To effectively substitute for diesel, biodiesel should have a higher cetane number. It is reported that *Jatropha curcas* has a high cetane number of 55, comparable to that of diesel engines [2]. The composition of fatty acids is the essential property in determining the efficiency and productivity of the process to produce a high yield and quality biodiesel. Saturated fatty acids of JCO account for roughly 20% of the seeds' composition, and 80% are composed of unsaturated fatty acids (oleic and linoleic). The seeds are estimated to yield up to 40% oil by weight. Therefore, the highlight of this research is to focus on the physicochemical properties of JCO as raw feedstock in producing alternative biodiesel that has the same quality as conventional diesel.

2. METHODOLOGY

The raw JCO was purchased from Bionas Sdn Bhd Malaysia, and all the chemicals used in this research include methanol of 99.9% purity, sulphuric acid of 95-98%, Sigma Aldrich (phenolphthalein), isopropyl alcohol, and potassium hydroxide (KOH) pellets were purchased from Polyscientific Chemicals Sdn Bhd. The raw JCO was sent for product characterization using Gas Chromatography-Mass Spectrometry (GC-MS) [3]. Apart from that, the raw feedstock physicochemical properties such as acid number, kinematic viscosity, density, water content, and iodine value were also determined.

3. RESULTS AND DISCUSSION

3.1 Physicochemical properties of crude JCO

The test results were tabulated in Table 1 for crude JCO. For the data confirmation, several tests were assigned, such as acid number, kinematic viscosity, and density. The assessments were determined according to the ASTM D6751, EN 14214, and American Oil Chemists' Society (AOCS) method [4].

Table 1 Physicochemical properties of crude JCO.

Properties	**Unit**	**Testing Method**	**Crude JCO**
Acid value	mg KOH/g	ASTM D 664	36.5
Kinematic viscosity at 40°C	mm^2/s	ASTM D 445	34.94
Density at 15°C	kg/L	ASTM D 4052	0.9133
Water content	wt.%	EN ISO 12937	0.30
Iodine value	g Iodine/100g	AOCS Cd 1d-92	106.3
Color	-	-	Golden Yellow

The acid value (AV) always depends on the FFA content of the feedstock. The AV obtained for the crude JCO was significantly higher which is 36.5 mg KOH/g which is far beyond the limit (0.5 max). High AV and FFA are associated with common problems such as soap formation and separation of end products. The density, kinematic viscosity, and water content obtained were 0.9133 kg/L, 34.94 mm^2/s, and 0.3 wt.%, respectively which was predictable with high FFA feedstock. However, lowering both, the density and kinematic viscosity values to the acceptable limits is critical to achieving ideal air-to-fuel ratios. Low water content was preferred since it ensured storage stability while also reducing engine corrosions. By looking at the iodine value, it was clearly shown that high amounts of unsaturated fatty acids caused a significant increase in the iodine value, which contributed to the low cetane number (CN). The crude JCO appears as a golden yellow liquid at room temperature.

Table 2 Fatty acid composition for crude JCO

Fatty acids	Structure	JCO (%)
Caprylic	8:0	0.16
Capric	10:0	0.74
Lauric	12:0	0.57
Myristic	14:0	1.13
Palmitic	16:0	10.22
Palmitoleic	16:1	0.66
Oleic	18:1	24.88
Linoleic	18.2	20.51
Linolenic	18:3	2.4
Arachidic	20:0	0.7
Saturated fatty acid, SFA (%)		21.82
Monounsaturated fatty acid, MUFA (%)		41.21
Polyunsaturated fatty acid, PUFA (%)		36.97

Ten fatty acids were found in the JCO sample with the highest was 24.88% oleic acid, followed by linoleic with 20.51%, and palmitic acid with 10.22% as tabulated in Table 2. These results are similar to those reported by Baill et al., (2015), which recorded the fattiest acid content for all types of JCO raw oil, mainly consisting of oleic, linoleic, and palmitic acids [5]. JCO can be classified as oleic-linoleic oil due to the large oleic and linoleic fatty acids.

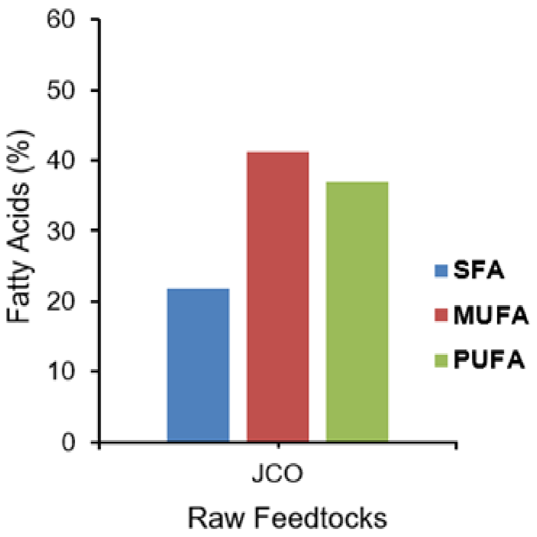

Figure 1 Fatty acids composition of crude JCO

Figure 1 demonstrated the structural features of saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acids. These fatty acids' composition plays a significant role in the physicochemical properties of the FAME produced [6]. The raw feedstock of JCO mainly consisted of monounsaturated (41.21%) and polyunsaturated acids (36.97%) which will contribute to a low cetane number. Compared with monounsaturated fatty acids, the high content of polyunsaturated fatty acids strongly influences engine performance, especially in cold weather countries.

It was worth mentioning that the fatty acid composition of the crude JCO will remain the same even though the feedstock had undergone the pre-treatment and transesterification process. Only the conversion of glycerol by methanol occurs. These compositions were critically important and significantly impacted the methyl ester's critical characteristics, especially cetane number and cold flow properties [7].

4. CONCLUSIONS

The utilization of crude JCO as feedstock in biodiesel production was promising with their physicochemical properties that were compelling to standards in terms of acid value (36.5 mg KOH/g), kinematic viscosity (34.94 mm^2/sec), density (0.9133 kg/L), water content (0.3 wt.%), iodine value (106.3 g Iodine/100g) and color (Golden Yellow). The crude JCO is common for having very high unsaturated fatty acids and in particular, has the potential to be widely utilized as raw feedstock in biodiesel production in Malaysia.

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