International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 6, October 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Effect of Oil Extraction Method on the Functional Properties of Biodiesels of Selected Oilseeds

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ABSTRACT

Owing to the rise in demand for petroleum and environmental concerns, the search for alternative fuels has gained prominence. This study examined the effect of the method of extraction of the base oil on the functional properties of biodiesel produced from Jatropha, Yellow oleander and Castor oilseeds. The study revealed that the method of extraction had significant effect on the properties of the oil extracted and hence the biodiesel produced from the oil. Hydrogenation during oven heating after solvent extraction affected the unsaturation of the base oils and the biodiesels produced from them. The kinematic viscosities of the biodiesel samples obtained from the oil samples extracted by solvent extraction were generally higher than those obtained from the oil samples extracted by mechanical extraction. The flash and fire points of the biodiesel samples obtained from the oil samples extracted by solvent extraction were higher than that obtained from the oil samples extracted by mechanical extraction. The pour points of the biodiesels produced from the oils extracted by mechanical extraction were lower than those produced from the oils extracted by solvent extraction.

KEYWORDS: *Mechanical Extraction, Solvent Extraction, Jathropha, Yellow oleander, Castor, Oilseed, Chemophysical Properties, Transesterification, Biodiesel*

Symbols: J: Jatropha, **Y:** Yellow Oleander, **C:** Castor, **ME:** Mechanical Extraction, **SE:** Solvent Extraction

How to cite this paper: Gbashi M. Samuel | Yanshio T. Emmauel | Kingsley N. Nwankwo "Effect of Oil Extraction Method on the Functional Properties of Biodiesels of Selected Oilseeds" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-6, October 2019, pp.393-397, URL: https://www.ijtsrd.com/papers/ijtsrd25252.pdf

IJTSRD25252

1. INTRODUCTION

In recent years, the use of biodiesels as alternative fuels as opposed to conventional diesel has been extensively investigated with the goal of ensuring energy security and reducing the environmental impacts of emission [1].

Biodiesel is mono-alkyl esters of fatty acids derived from vegetable oils or animal fats, produced by the transesterification of vegetable oils or animal fats with an alcohol [2]. It is a clear amber-yellow liquid obtained from vegetable oils, animal fats or grease. It's non-flammability, biodegradability, non-toxicity and non- explosiveness makes it more environmentally friendly compared to petroleum diesel [3]. Emil et al. [4] noted that the cost of feedstock account for a large percent of the direct biodiesel production costs; current trend is towards the use of inedible vegetable oils for biodiesel production.

Jatropha (*Jatropha curcas*) is a non-edible oil bearing shrub. It grows under (sub) tropical conditions and can withstand conditions of severe drought and low soil fertility. Oil yield from Jatropha depends on climate, soil, rainfall and treatment during sowing and harvesting [5]. Yellow oleander (*Thevetia peruviana*) is a non-edible oil-bearing and drought-evergreen tropical shrub that belongs to the Apocynaceae family. It thrives well in all the climatic and vegetation belts of Nigeria. The plant starts flowering after one and a half year from plantation and there after blooms thrice a year [6]. Castor (*Ricinus communis*) is a specie of flowering plant in the spurge family (Euphorbiaceae) mostly native to the tropics. Castor is a hardy crop, easy to establish on the field, resistant to drought, tolerates different types of soil even marginal soil and yields 350 – 900 kg oil per hectare. Castor is an important oilseed crop with great utilitarian value in industry, pharmaceutical and agricultural sectors [7].

Two techniques are commonly employed in extracting oil from oilseeds, these are: mechanical and solvent extraction. Mechanical extraction is the most conventional method of oil extraction. It involves the application of pressure to already pre-treated oil-bearing products. It employs the use of devices like screw and hydraulic presses as a means of applying the pressure. The seeds are conveyed by a horizontally rotating metal screw into a barrel shaped outer casing with perforated walls. The products are continuously fed to the expeller, which crushes and presses the oil out as it passes through the machine. The pressure ruptures the oil matrix in the product and oil flows through the perforations in the casing and is collected in a trough underneath [8]. Solvent extraction is the technique of removing one constituent from a solid by means of a liquid solvent. In this process, a chemical solvent such as n-hexane is used to saturate the crushed seed and pull out the oils. After completion of the extraction process the solvent is condensed and reclaimed. The liquid chosen should be a good selective solvent and its viscosity should be sufficiently low for it to circulate freely [9].

Biodiesel can be produced from vegetable oil by the process of transesterification. Transesterification is a term used to describe the reaction between alcohols and vegetable oil to yield esters (biodiesel) and glycerol. Base catalyzed transesterification refers to the process of reacting vegetable oil with an alcohol in the presence of a base catalyst and is used when the free fatty acid content of the oil is less than 1 %. In handling high free fatty acid content feedstock however, two-step acid-base catalyzed transesterification is often used [10].

Two-step acid-base catalyzed transesterification involves acid-catalyzed esterification followed by base catalyzed transesterification. In acid catalyzed esterification, the oil is reacted with an alcohol in the presence of a strong acid catalyst like sulphuric acid; this converts the free fatty acids to esters, yielding water as a by-product. The next step involves performing a base catalyzed transesterification [11].

This study compares the chemophysical and thermal properties of biodiesel produced from oils gotten from the selected vegetable oil seeds after mechanical extraction with those properties gotten after solvent extraction.

2. METHODOLOGY

2.1. Seeds Source

Seeds of Jathropha (*Jatropha curcas*), Yellow oleander (*Thevetia peruviana*) and Castor (*Ricinus communis*) plants were sourced locally.

2.2. Seeds Preparation

The seeds were cleaned and dried for several days until constant weights were obtained.

2.3. Oil Extraction

Two methods were used for the extraction of oil from the collected oilseeds namely: solvent extraction and mechanical extraction.

2.3.1. Solvent extraction

The seeds were dried and ground into powder. The ground seeds were dissolved in ethanol and left for 24 hours. The following day, the mixture was filtered and the chaff discarded. The filtrate, consisting of extracted lipids, dissolved in ethanol was sun-dried for 3 days after which it was dried in an electric oven to ensure the complete evaporation of ethanol and moisture.

2.3.2. Mechanical extraction

The dried seeds were cleaned, roasted and fed into a mechanical oil press without removing the husk. The crude oil extracted was refined and made ready for blending and characterization.

2.4. Generation of Samples

For each method of extraction, 12 oil samples were generated by blending the oils with each other in different proportions as shown in Table 1.

2.5. Determination of Chemophysical and Thermal Properties of Oil

The Chemophysical and Thermal properties of the oil samples were determined using standard ASTM, AOAC and AOCS methods.

2.6. Production of biodiesel

The oil samples generated were used to produce biodiesel by two-step acid-base catalyzed transesterification [12]. This method of transesterification was chosen because most of the oil samples contained high free fatty acids.

2.6.1. Acid pre-treatment

A solution of concentrated H_2SO_4 (1 % based on the oil weight) in methanol was mixed with each of the oil samples at 70 % w/w of methanol to oil ratio in a reaction bottle. The mixture was agitated at room temperature on an electrically operated flask shaker for about 30 minutes. The mixture was then poured into a separating funnel and allowed to stand till phase separation occurred. The bottom layer was drained for the next step transesterification.

2.6.2. Base catalyzed transesterification

In the second step, KOH pellets (1.4 % based on oil weight) were dissolved in methanol. The solution was mixed with the oil at a methanol to oil ratio of 24 % w/w. The mixture was agitated on a flask shaker for 1 hr at room temperature, poured into a separating funnel and allowed to stand for 24 hrs. The next day, the bottom layer (containing glycerol, excess methanol and unreacted catalyst) was drained out. The top layer (containing biodiesel and excess methanol) was collected for purification.

2.7. Determination of Chemophysical and Thermal Properties of Biodiesel

The chemophysical and thermal properties of the biodiesel samples were determined using standard ASTM, AOAC and AOCS methods.

3. RESULTS/DISCUSSION

The result of the percentage biodiesel yield for mechanical and solvent extraction is presented in Table 2. The iodine values of the base oil samples for mechanical and solvent extraction are compared in Figure 1. The viscosities of the biodiesel samples for mechanical and solvent extraction of the base oil are compared in Figure 2. The flash points of the biodiesel samples for mechanical and solvent extraction of the base oil are compared in Figure 3. The fire points of the biodiesel samples for mechanical and solvent extraction of the base oil are compared in Figure 4. The pour points of the biodiesel samples for mechanical and solvent extraction of the base oil are compared in Figure 5.

Table1: Blending Proportion

Sample No	Proportion
S1	J100%
S2	Y100%
S3	C100%
S4	J50% + Y50%
S5	J50% + C50%
S6	Y50% + C50%
S7	J70% + Y30%
S8	J30%+ Y70%
S9	J70% + C30%
S10	J30%+ C70%
S11	Y70% + C30%
S12	Y30%+ C70%

Table2: Percentage Biodiesel Yields - Mechanical and Solvent Extractions

Sample Code	Percentage Biodiesel Yield (%)	
	ME	SE
J	68	65
Y	66	50
C	50	50

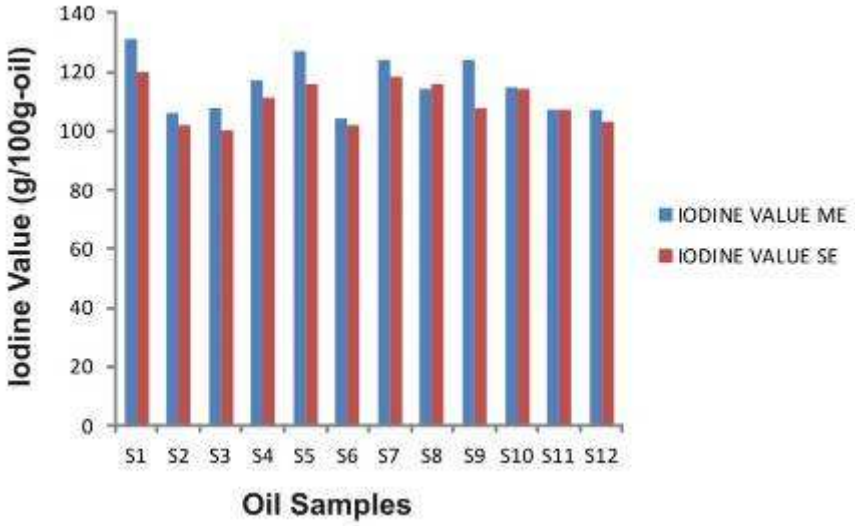

Figure1: Iodine Values of Oil Samples - Mechanical and Solvent Extractions

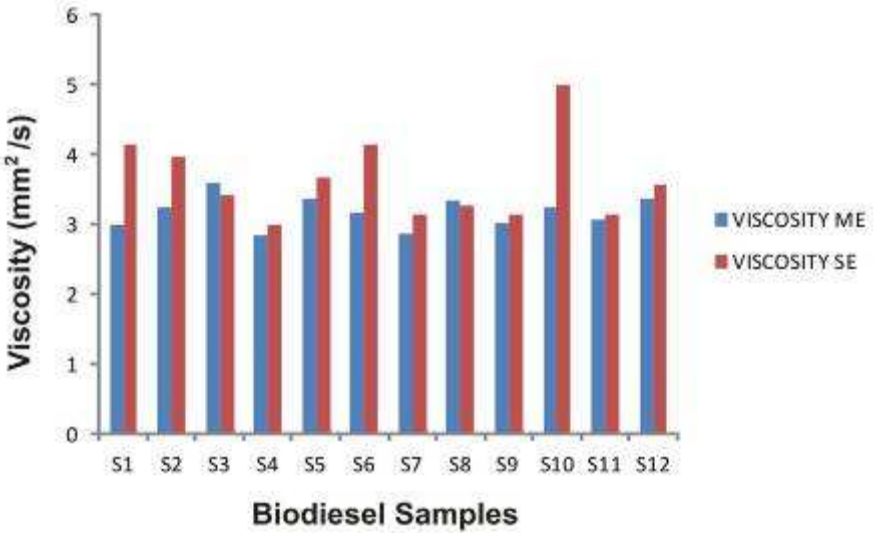

Figure 2: Viscosity of Biodiesel Samples - Mechanical and Solvent Extractions

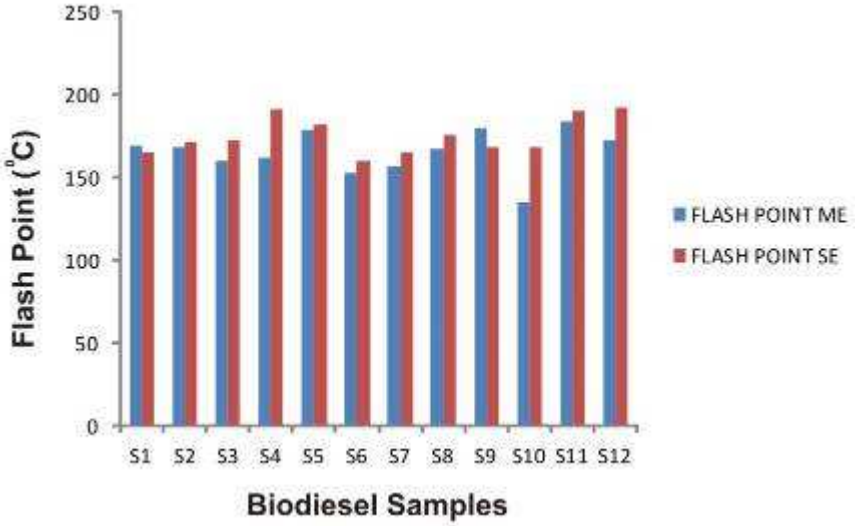

Figure3: Flash Point of Biodiesel Samples - Mechanical and Solvent Extractions

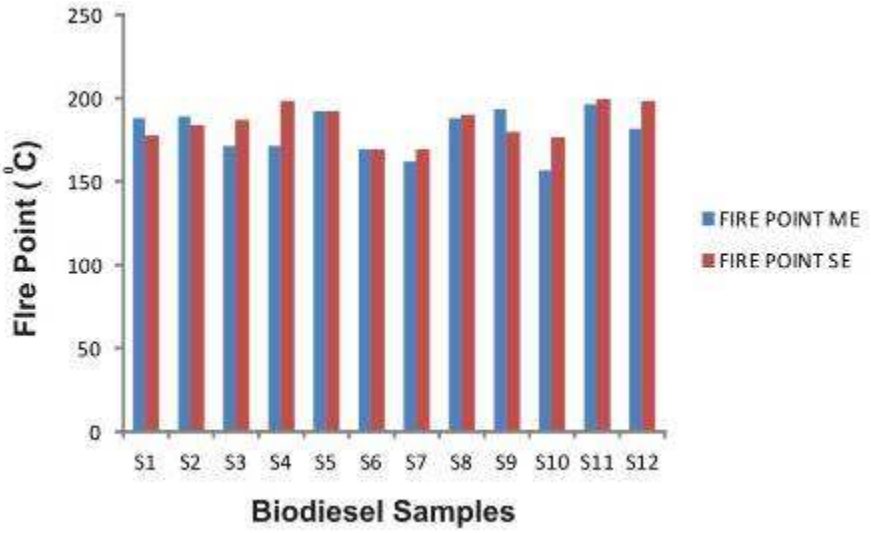

Figure4: Fire Point of Biodiesel Samples - Mechanical and Solvent Extractions

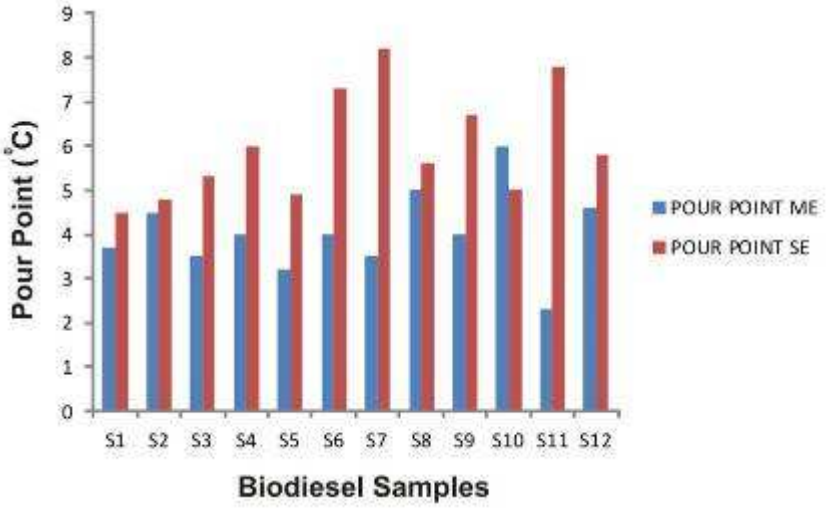

Figure5: Pour Point of Biodiesel Samples - Mechanical and Solvent Extractions

From Table 2, the average biodiesel yield from the oil samples obtained by mechanical extraction was 61 % whereas that from the oil samples obtained by solvent extraction was 55 %. Higher yields were obtained from the samples extracted by mechanical extraction because of the lower free fatty acid content of the oil samples which resulted in minimal refining loss during acid pre-treatment [10].

The iodine values of the base oil samples for mechanical and solvent extraction are compared in Figure 1. From the result, it is seen that the iodine values of the base oil samples extracted by solvent extraction are comparatively lower than those of the base oil samples extracted by mechanical extraction. This shows that the oil samples extracted by solvent extraction had lower concentration of unsaturated fatty acids. The lower concentration of unsaturated fatty acids in the oil samples extracted by solvent extraction may be attributed to hydrogenation in the oil samples during the drying process done after solvent extraction. The heating of vegetable oils results in a marginal decrease in their unsaturated fatty acids due to hydrogenation [13], [14] and [15]. After production of biodiesel, it was observed that the concentration of unsaturated fatty acid esters of the biodiesel samples were proportionate to the concentration of unsaturated fatty acids in the base oils. Hence, biodiesel samples obtained from the oil samples extracted by mechanical extraction had a higher concentration of unsaturated fatty acid esters than those obtained from oil samples extracted by solvent extraction.

In figure 2, the kinematic viscosities of the biodiesel samples for mechanical and solvent extraction of the base oil are compared. The result shows that the biodiesel samples produced from oil samples extracted by mechanical extraction had lower viscosities compared to those produced from oil samples extracted by solvent extraction. The lower viscosities of the biodiesel samples obtained from the oil samples extracted by mechanical extraction compared to those from the oil samples extracted by solvent extraction may be linked to the higher concentration of unsaturated fatty acid esters in the former. The decrease in kinematic viscosity with increase in unsaturation was observed by Zdzislaw and Anna [16].

Figure 3 compares the flash points of the biodiesel samples obtained from the oil samples extracted by mechanical extraction with those from the oil samples extracted by solvent extraction. Figure 4 likewise compares the fire points of the biodiesel samples obtained from the oil samples extracted by mechanical extraction with those from the oil samples extracted by solvent extraction. The flash and fire points of the biodiesel samples obtained from the oil samples extracted by solvent extraction were generally higher than

those obtained from the oils samples extracted by mechanical extraction. This can be linked to the high viscosities of the biodiesel samples obtained from the oil samples extracted by solvent extraction compared to those obtained from the oil samples extracted by mechanical extraction.

Since the biodiesel samples obtained from the oil samples extracted by mechanical extraction had higher concentration unsaturated fatty acid esters, they had lower pour points and better flow properties compared to the biodiesel samples obtained from oil samples extracted by solvent extraction [17].

4. CONCLUSION

The study revealed that the method of extraction had significant effect on the properties of the oils extracted and hence the biodiesels produced from the oil. Mechanical extraction of the base oil resulted in oil samples that yielded more biodiesel than solvent extraction. The kinematic viscosities of the biodiesel samples obtained from the oil samples extracted by solvent extraction were generally higher than those obtained from the oil samples extracted by mechanical extraction. The flash and fire points of the biodiesel samples obtained from the oil samples extracted by solvent extraction were higher than that obtained from the oil samples extracted by mechanical extraction. The pour points of the biodiesel produced from the oils extracted by mechanical extraction were lower than those of the biodiesels produced from the oils extracted by solvent extraction.

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