

Effect of Extraction Method on the Functional Properties of Oils of Selected Oilseeds as Potential Feedstock for Biodiesel Production

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ABSTRACT

This study examined the effect of extraction on the functional properties of Jatropha, Yellow oleander and Castor oilseeds as potential feedstock for biodiesel production. Solvent and mechanical extraction. The study revealed that the three oilseeds are suitable for use as feedstock for biodiesel production and the method of extraction affects the properties of the oil extracted. Solvent extraction yielded more oil than mechanical extraction but the free fatty acid contents of the oil samples extracted by solvent extraction were comparatively higher than those of the samples extracted by mechanical extraction. The high free fatty acid content of the oils extracted by solvent extraction will result in more refining loss in the oil pre-treatment to be done before transesterification. The iodine values of the oil samples extracted by solvent extraction were generally lower compared to those of the samples extracted by mechanical extraction. Variation in iodine values and hence degree of unsaturation of the vegetable oils obtained from the two methods of extraction will affect the flow properties of the biodiesels produced from the oils. Other properties also affected by the method of extraction include: flash and fire points, pour point, kinematic viscosity and specific gravity.

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Introduction

The growth in the world's population has led to a surge in energy demand and for more than two centuries, the world's energy supply has relied heavily on non-renewable crude oil derived from fossil fuels, out of which 90 % is estimated as being consumed for energy generation and transportation; sequel to this, the world is presently confronted with the crises of fossil fuel depletion and environmental degradation [1]. Current trend in energy consumption is towards biofuels as opposed to conventional energy sources such as hydrocarbons, which are non-renewable [2].

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 [3]. 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 [4]. Emil et al. [5] noted that the cost of feedstock account for a large percent of the direct biodiesel production costs. Consequently, 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 [6]. 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 [7]. 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 [8].

Two techniques are commonly employed in extracting oil from oilseeds, these are: mechanical and solvent extraction. Mechanical extraction is the most conventional technique of oil extraction. It involves the application of pressure to already pre-treated oil-bearing products. It employs 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 [9]. 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 [10].

This study compares the chemophysical and thermal properties of oils gotten from the selected vegetable oil seeds after mechanical extraction with those properties gotten after solvent extraction in relation to their potential for use as base oils for biodiesel production.

Materials and Methods

Seeds of Jatropha (*Jatropha curcas*), Yellow oleander (*Thevetia peruviana*) and Castor (*Ricinus communis*) plants were purchased from a supplier in Makurdi, Benue State, Nigeria. The seeds were cleaned and dried for several days until constant weights were obtained.

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

For mechanical extraction (expression), 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 characterization.

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

Results and Discussion

The result for the percentage oil yield is presented in Table 1, that for the chemophysical properties is presented in Table 2 and that for the thermal and other properties is presented in Table 3. From Table 1, the percentage oil yield for Jatropha oilseed was 56 % for solvent extraction and 48 % for mechanical extraction. This percentage oil yield from Jatropha is slightly higher than that reported by [11]. Oil yield from Jatropha depends on climate, soil, rainfall and treatment during sowing and harvesting [11]. The percentage oil yield for Yellow oleander oilseed was 60 % for solvent extraction and 57 % for mechanical extraction. This result is close to that reported by [12]. The percentage oil yield for Castor oilseed was 73 %

for solvent extraction and 68 % for mechanical extraction. Percentage oil yield obtained with mechanical extraction was within the range of 48 % to 68 % whereas that obtained with solvent extraction was within the range of 56 % to 73 %. Solvent extraction yielded more oil than mechanical extraction for the 3 oilseeds. Castor oilseed yielded the highest amount of oil followed by Yellow oleander oilseed and Jatropha. The oil contents of the three oilseeds are satisfactory, making them suitable to be used as feedstock for biodiesel production.

Table 1: Percentage Oil Yields - Mechanical and Solvent Extractions

Sample Code	Percentage Oil Yield (%)	
	ME	SE
J	48	56
Y	57	60
C	68	73

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

From Table 2, oil samples obtained from solvent extraction had higher moisture contents compared to those extracted by mechanical extraction although there were no obvious reasons for this variation.

Oil samples extracted by solvent extraction had relatively higher kinematic viscosities compared to those extracted by mechanical extraction. The higher kinematic viscosities of the oil samples extracted by solvent extraction compared to those extracted by mechanical extraction may be attributed to the lower concentration of unsaturated fatty acids in the former as revealed by their iodine numbers. The kinematic viscosity of oil rise with decrease in degree of unsaturation [13].

The Free fatty acid contents of the oil samples extracted by solvent extraction were comparatively higher than those of the samples extracted by mechanical extraction. The relatively higher free fatty acid contents of the oil samples extracted by solvent extraction compared to those extracted by mechanical extraction may be linked to (1) hydrolysis of fatty acids in the former due to moisture or (2) hydrolysis of fatty acids in the former as a result of the heating process done after solvent extraction. Choe and Min [14] reported increase in free fatty acid content of oil with oven heating.

The saponification values of the oil samples obtained by solvent extraction were slightly higher than those of the samples obtained by mechanical extraction. Variation in

saponification values of the oil samples extracted using the two methods of extraction may be linked to the difference in their free fatty acid contents [15]. Oil samples extracted by solvent extraction were more acidic and required more KOH for their neutralization - this accounts for their relatively higher saponification values.

Table 2: Chemophysical Properties – Mechanical and Solvent Extractions

Code	PH		VIS (cSt)		FLP (°C)	
	ME	SE	ME	SE	ME	SE
J	7.3	7.4	30.1	50.8	288	300
Y	7.3	7.0	30	57.6	270	253
C	7.7	7.1	63.4	78.5	240	243
Code	FRP (°C)		PP (°C)		SHC (kJ/kg/K)	
	ME	SE	ME	SE	ME	SE
J	295	312	3.5	5	2.85	2.40
Y	279	288	4.5	6.5	2.10	2.30
C	250	250	5.5	3.5	2.72	2.23

J: Jatropha, **Y:** Yellow Oleander, **C:** Castor, **ME:** Mechanical Extraction, **SE:** Solvent Extraction, **VIS:** Viscosity, **PH:** pH, **FLP:** Flash Point, **FRP:** Fire Point, **PP:** Pour Point, **SHC:** Specific Heat Capacity.

The iodine values of the oil samples extracted by solvent extraction were generally lower compared to those from the samples extracted by mechanical extraction; the reason is not far-fetched. After solvent extraction, the oil was heated in the oven to reduce its moisture content and volatile matter. The heating of vegetable oils results in a marginal decrease in their unsaturated fatty acids due to hydrogenation [16, 17]. The heating process done after solvent extraction must have reduced the unsaturated fatty acids in the oil samples, accounting for their relatively lower iodine values.

From Table 3 the flash and fire points of the oil samples extracted by solvent extraction were higher than those of the samples extracted by mechanical extraction owing to the relatively higher viscosities of the samples extracted by solvent extraction.

Oil samples extracted by mechanical extraction had relatively lower pour points than samples extracted by solvent extraction. Variation in the pour points of the oil samples may be linked to variation in the degree of unsaturation of the oils [18]. Since the oil samples obtained through mechanical extraction had higher concentration of unsaturated fatty acids, their pour points were generally lower.

Table 3: Thermal and Other Properties - Mechanical and Solvent Extractions

Code	SG		MC (%)		FFA (%)	
	ME	SE	ME	SE	ME	SE
J	0.900	0.880	0.07	0.04	10.99	46.53
Y	0.903	0.880	0.04	0.10	10.71	16.77
C	0.902	0.890	0.01	1.88	19.17	5.07
Code	SV (mg-KOH/g-oil)		PV (mEq/kg)		IV (g/100g-oil)	
	ME	SE	ME	SE	ME	SE
J	256	266	3.5	5	131	120
Y	256	251	4.5	6.5	106	102
C	246	265	5.5	3.5	108	100

J: Jatropha, **Y:** Yellow Oleander, **C:** Castor, **ME:** Mechanical Extraction, **SE:** Solvent Extraction, **SG:** Specific Gravity, **MC:** Moisture Content, **FFA:** Free Fatty Acid Content, **SV:** Saponification Value, **PV:** Peroxide Value, **IV:** Iodine Value.

Conclusion

The study revealed that the three oilseeds are suitable for biodiesel production and the method of extraction has a significant effect on the properties of the oil extracted. Solvent extraction yielded more oil from Jatropha, Yellow oleander and Castor oilseeds than mechanical extraction. The free fatty acid contents of the oil samples extracted by solvent extraction were comparatively higher than those of the samples extracted by mechanical extraction. Oil samples extracted by solvent extraction had relatively higher kinematic viscosities compared to those extracted by mechanical extraction. The iodine values of the oil samples extracted by solvent extraction were generally lower compared to those from the samples extracted by mechanical. The flash and fire points of the oil samples extracted by solvent extraction were higher than that of the samples extracted by mechanical extraction.

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