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Synthesis and characterization of the oil and biodiesel from *Ricinus communis* Seeds

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Abstract

The targets of this paper is to identify sustainable sources of energy from natural resources and with less harmful environmental effects. The oil from seeds was extracted utilizing three techniques; chemical soxhlet extraction, cold chemical extraction, and mechanical pressing. Percentage yields were 49.0%, 35.5 % and 31.2% respectively. Fatty Acids profile displays that the oil contained, approximately, 82.14% saturated fatty acids 73.70, 5.01, 3.77, 0.26, 0.20, 0.08, 0.05, 0.03, 0.01, 0.01, 0.01, 0.01 and 17.85% unsaturated fatty acids 9.95,3.12,2.52,2.23,0.03. The results indicate that the physicochemical properties of *Ricinus communis* oil are: Density 0.059, Viscosity 9.1, Specific gravity 0.954, Refractive index 1.47, PH 5.63, Moisture content 0.21, Fat content 43.25, Acid value 0.561, Free fatty acid 1.09, Peroxide value 1.68, Saponification value 156.50 and Iodine value 80.61. Also, the physicochemical properties of *Ricinus communis* Biodiesel are Density 0.931, Viscosity at 40C 17.37,
Viscosity at 100C 17.37, X-ray sulfur 0.026, Acidity 0.026, Flashpoint 143.0, CCR 0.02, Clout point
-13.6, Absorbance 0.051, Copper strip corrosion 1a, Color ASTM 0.5, Density at 15C 931.4, Water content <0.05 and Free fatty acid 0.02.

Keywords: biodiesel, extraction, caster oil

1. Introduction

Power derived from the utilization of physical or chemical resources, provides light and heat or derived machines are, rapidly, increasing due to fast industrialization and the increased number of vehicles on the roads locally and globally [1]. Fossil fuels are hydrocarbons, fuel oil, natural gas or coal, formed from the remains of dead animals and plants [2]. Fossil fuels are declining with the daily increasing demand due to the non-renewable nature of it [3]. Recently, several researchers are looking for a renewable, alternative, economically applicable and environmentally friendly sources of energy to avoid environment pollution [4]. Biodiesel is a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl esters. It is, prepared by reacting lipids (monoalkyl ester) [5]. Biodiesel can be produced from animal,and vegetable oils, fats, tallow and waste oils. There are basicallythree ways ofbiodiesel production from the oils and fats eg. Basic and acids catalyzed trans esterification of the oil, conversion of the oil to its fatty acids and then to biodiesel. The Trans esterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol figure 1 [6].

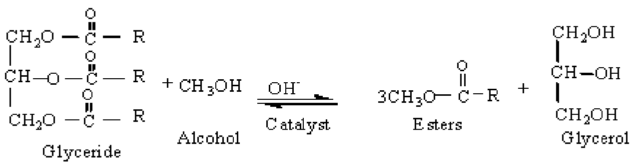

Fig 1: Base catalyzed Trans esterification of fats and oil [6].

A successful Trans esterification reaction is signified by the separation of the ester and glycerol when the reaction is complete. Fig 2. Below is an example for Production Process.

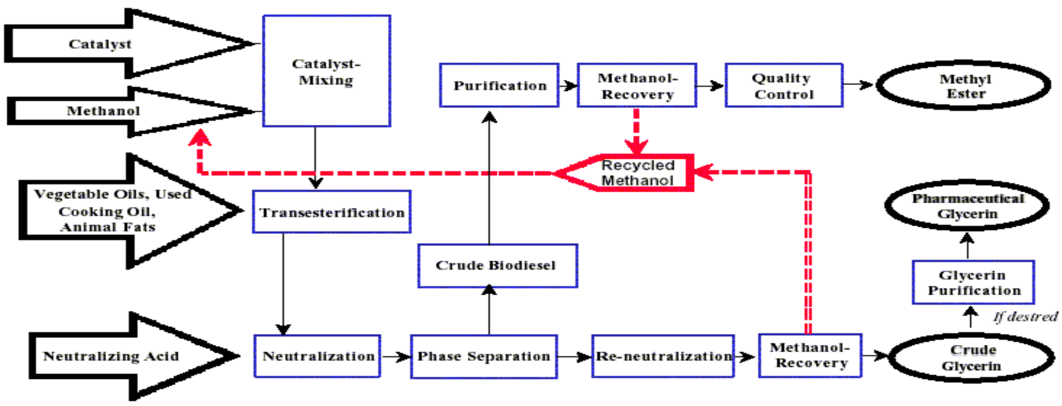

Fig 2: A simple production flow chart of Production Process [6].

There are many advantages of using biodiesel as vehicle fuel such as increases air quality, low emission profile, biodegradability, non-toxicity and provides safety benefits [7, 8, 9]. *Ricinus communis*, the castor bean or castor oil plant is a species of perennial flowering plant in the *spurge family*, *Euphorbiaceae*. It is the sole species in the monotypic genus, *Ricinus*, and subtribe, *Ricininae.* The evolution of castor and its relation to other species are currently being studied using modern genetic tools [10, 11, 12, 13]. This species probably originated in Africa but is now widespread throughout the tropical and subtropical regions of the world. It is a fast-growing, suckering perennial shrub which can reach the size of a small tree (around 12 meters tall), but it is not cold hardy. The glossy leaves are 15-45 cm long, long-stalked, alternate and palmate with 5-12 deep lobes with coarsely toothed segments. Castor seed is the source of castor oil, which has a wide variety of uses [14]. The seeds contain between 40% and 60% oil that is rich in *triglycerides*, mainly ricinolein. The seed also contains ricin, a water-soluble toxin, which is also present in low concentrations [15]. Castor oil has a number of medicinal, industrial and pharmaceutical uses [16].
Materials and methods

1.2 Materials
Castor seeds were collected from the forests of Dongola, Northern state, Sudan. All chemical used were from SIGMA ALDRICH and SDFCL.

2. Methods
2.1 Oil Extraction
Castor seeds were oven desiccated for 12 hours. The oil was extracted by using chemical extraction and mechanical pressing mechanisms. The chemical extraction mechanisms were cold Solvent extraction and Soxhlet, system, Solvent extraction. N-Hexane was used as a solvent in both mechanisms. Cold extraction carried out using 250 g of seeds. the seeds were placed in1 liter beaker and 500 ml of N-Hexane were added, and then left for 36 hours at room temperature and center huge at 1000rpm. The solvent was evaporated [17]. In the Soxhlet mechanism; 1kg of the seeds was added to 2 l of n-Hexane in the Soxhlet round bottom flask, heated to 60 **C** for 8 hours. The extracted oil and solvent were transferred to a rotatory evaporator remove n-Hexane [18]. In the mechanical pressing mechanism, the Chinese automatic presser model ZX 10 of 3-ton capacity was used. 5 kg of seeds were pressed and the oil was filtered. Equation (1) was used to calculate the oil yield from all oil extraction mechanisms.

$$Oil\ yield = \frac{Weight\ of\ oil}{Weight\ of\ seeds} \times 100 \qquad (1)$$

2.2 Fatty Acid Profile of *Ricinus communis* Seed Oil
0.3g of crude oil sample was weighed into a 250 ml round bottom flask, 6 ml of 0.5 M methanolic NaOH were add to the sample and boiled for 2.5 min. 1% Sulfuric acid, in methanol, was added to the mixture, shaken, and kept overnight at 50°C. 2 ml of hexane were added and well Steered. 1 ml of the upper Hexane layer was transferred to a glass stoppered tube; anhydrousNa_2SO_4 was added to the Hexane layer and kept in a vial. The dried sample was subjected to GC analysis.

2.3 Trans esterification Reaction
500 ml of acid-treated oil were placed into a 1 L beaker and heated up to 60 C, 100 ml of fresh methanolic Sodium Hydroxide were added under stirring at 3000 rpm for two hours. The mixture was transferred to a separating funnel and kept for 24 hours. Then the lower, glycerol layer was drained and the upper biodiesel layer was washed, three times, with warm distilled water to remove soap, methanol and remaining glycerol [19].

2.4 Physicochemical properties of Ricinuscommunis oil and Biodiesel
Free fatty acid was specified according to AOCS Ca-5a-40 and compute as oleic acid. Acid number was determined according to ASTM D 974. Saponification number was specified according to ASTM method D 94. Iodine number was determined according to ASTM D5554. Density @ 15**C** and Kinematic Viscosity was accomplished according to ASTM D 4052 and D 445 respectively. Calorific value was determined according to ASTM accomplished D2015. The water content of Crude oil was specified by Coulometric Karl Fischer Titration according to the AOCS method Ca 2e-84. Flashpoint, Copper strip corrosion, Kinematic viscosity, Sulphated ash, Acid Number, density, cloud point (CP), pour point (PP), cold filter plugging point (CFPP), Water content, Color, and Sulphur Content were determined according to ASTM D 6751.

3. Results and Discussions
Table 3.1 shows that solvent extraction is the method to be used with 49% output.

Table 1: Oil yield from Ricinuscommunis Seeds Using different extraction methods

No.	Extraction method	Oil yield, wt%
1	Soxhlet solvent Extraction	49.0
2	Cold Solvent Extraction	35.5
3	Mechanical Pressing	31.2

Table 1 displays fatty acid composition of Castor oil with 82.14% saturated fatty acids concentration, Methyl tetradecanoate, Pentadecanoic acid, methyl ester, 7-Hexadecenoic acid, methyl ester, (z)-, 9-Hexadecenoic acid, methyl ester, (z)-, Hexadecenoic acid, methyl ester, Heptadecanoic acid, methyl ester, Methyl stearate, Cis-10-Nonadecenoic acid, methyl ester, 9-Octadecadienoic acid, 12-hydroxy-, methyl ester, Tricosanoic acid, methyl ester, Tetracosanoic acid, methyl ester, Squalene
and 17.85% of unsaturated acid, 13-hexyloxacyclotridec-10en-2-one, 9,12-Octadecadienoic acid (z,z)-, methyl ester, 9-Octadecadienoic acid (z)-, methyl ester, 9-Octadecadienoic acid, methyl ester (E)- and 13-Docosenoic acid, methyl , ester, (z)-. These acids are generally available in vegetable oils.

Table 2: Table 3.2 and Fig 3.1 display the fatty acids composition of crude *Ricinus communis* oil.

No	Fatty Acids	Formula	Structure	Area %
1	9-Octadecadienoic acid, 12-hydroxy-, methyl ester	$C_{19}H_{36}O_3$	C_{19}=1	72.70
2	9,12-Octadecadienoic acid (z,z)-, methyl ester	$C_{18}H_{32}O_2$	C_{18}=0	9.95
3	Methyl stearate	$C_{19}H_{38}O_2$	C_{19}=0	5.01
4	Hexadecenoic acid, methyl ester	$C_{17}H_{32}O_2$	C_{17}=1	3.77
5	9-Octadecadienoic acid, methyl ester (E)-	$C_{19}H_{34}O_2$	C_{19}=2	3.12
6	9-Octadecadienoic acid (z)-, methyl ester	$C_{19}H_{34}O_2$	C_{19}=2	2.52
7	13-Docosenoic acid, methyl , ester, (z)-	$C_{23}H_{44}O_2$	C_{23}=1	2.23
8	Squalene	C30H50	C_{20}=6	0.26
9	Cis-10-Nonadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	C_{19}=1	0.20
10	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	C_{18}=0	0.08
11	Tetracosanoic acid, methyl ester	$C_{25}H_{50}O_2$	C_{25}=0	0.05
12	Tricosanoic acid, methyl ester	$C_{14}H_{28}O_2$	C_{14}=0	0.03
13	13-hexyloxacyclotridec-10en-2-one	$C_{18}H_{32}O_2$	C_{18}=1	0.03
14	Methyl tetradecanoate	$C_{15}H_{30}O_2$	C_{15}=0	0.01
15	Pentadecanoic acid, methyl ester	$C_{16}H_{32}O_2$	C_{16}=0	0.01
16	7-Hexadecenoic acid, methyl ester, (z)-	$C_{17}H_{32}O_2$	C_{17}=0	0.01
17	9-Hexadecenoic acid, methyl ester, (z)-	$C_{17}H_{32}O_2$	C_{17}=1	0.01

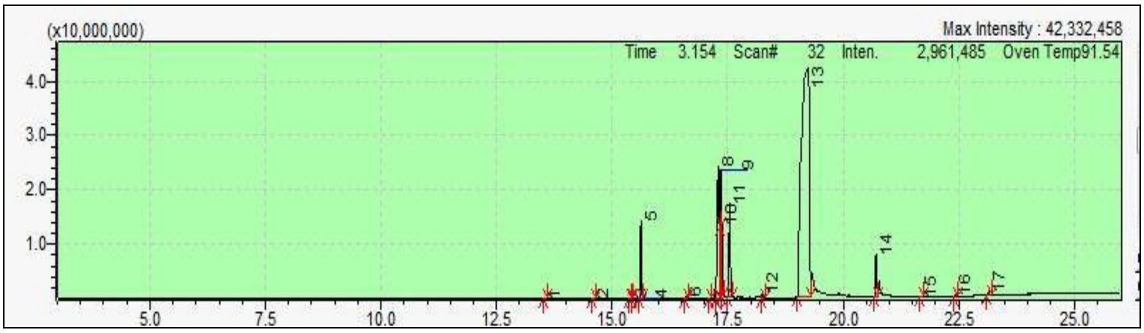

Fig 1: GC Spectrum of *Ricinus communis* seed oil.

Fig 2 represents the FTIR spectrum of castor oil. It is show the similar absorbance peaks at 3500,3300 due to O-H, and absorbance around 2918.2 and 2954 act of C-H Alkane group, and absorbance peaks at 2.975, 2.850 due to C-H also. New peak appeared at 1742.37 which represent of C=O group.

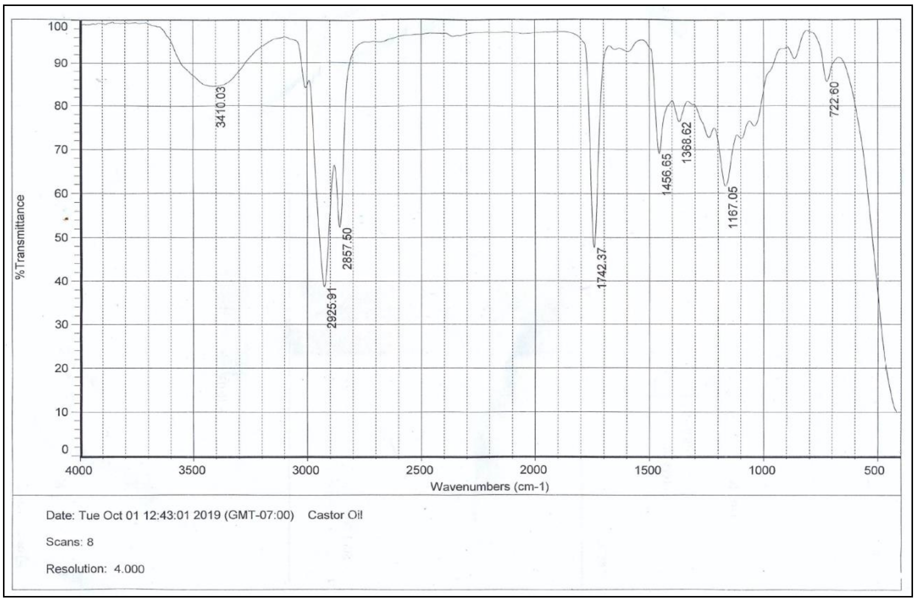

Fig 2: FTIR Spectrum of *Ricinus communis* seeds oil.

3.1 Physicochemical characteristics of *c* and *Ricinus communis* Biodiesel

Table 3 shows the physical and chemical properties of *Ricinus communis* oil with high saponification value 165.5 mgkoH/g and very low free fatty acid content of 1.09m similar Density and Specific gravity. The oil is slightly acidic and viscous.

Table 3: Physical and Chemical properties of *Ricinus communis* Oil.

Parameter	Value of raw oil
Density at 30 **C** (g/cm^3)	0.959
Viscosity at 30 **C** kg/m	9.1
Specific gravity	0.954
Refractive index	1.47
PH	5.63
Moisture content	0.21
Fat content (%)	43.25
Acid value mg KOH/g	0.561
Free fatty acid	1.09
Preoxide value Meq/Kg	1.68
Saponification value mg Koh/g oil	165.50
Iodine value (g/100g Oil)	80.61

Table 4 shows the physicochemical properties of Ricinuscommunis oil biodiesel a high flash point at 143 C compared with that of the oil and similar acid value and low free fatty acid content.

Table 4: Physical and Chemical properties of *Ricinus communis* Biodiesel.

Parameter	Value of raw oil
Density at 40 **C**	0.931g/cm^3
Viscosity at 40 **C**	17.37 mm^2/s
Viscosity at 100 **C**	3.498 mm^2/s
X ray sulfur	0.026 %
Acidity	0.61 mg/koh/g
Flsh point	143.0C
CCR	0.02 m/m%
Cloud point	-13.6 C
Absorbance at 656.1 nm	0.051
Copper strip corrosion	1 a
Color ASTM	0.5
Density at 15 c^0	931.4
Water content	< 0.05 vol
Free fatty acid	0.02

4. Conclusions

From the results obtained it is possible to conclude that:

- Oil yield obtained from solvent extraction is higher than that obtained from cold extraction and mechanical pressing methods.
- Castor oil contains 82.14% of saturated fatty acids and 17.85% of unsaturated fatty acids.
- Castor biodiesel was, successfully, synthesized utilizing Alkali transesterification and proven utilizing FTIR.
- Castor oil Biodiesel show very low sulfur content and fatty acid and meets both ASTM D6751 and EN 14214 standards.

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