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Extraction and Characterization of Castor (*Ricinus Communis*) Seed Oil

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----------ABSTRACT----------

The castor seeds collected in Kapil – Lankan District in Pankshin LGA of Plateau State, Nigeria. The seeds were prepared for use by removing the endocarp, sun-drying for seven days and milled to flour. A soxhlet extraction was used for the extraction of the oil, using hexane as solvent. The oil was recovered by simple distillation of the solvent. The residual oil obtained was investigated for physicochemical parameters and fatty acid composition. The results obtained for physical parameters were: moisture content (0.300± 0.01%), specific gravity (0.948± 0.02), refractive index @28^{o}C (1.792± 0.01), fire point (256.000± 1.20^{o}C), flash point (225.000 ± 2.10 ^{o}C), smoke point (215.000 ± 1.00 ^{o}C), viscosity @ 28 ^{o}C (0.425 ± 0.12), pH (5.800 ± 0.00), turbidity (5.000 ± 1JTU). For the chemical parameters, results obtained were: free fatty acid (7.400 ±0.07% as oleic acid), acid value (14.800± 0.14 % as oleic acid), saponification value (180.770± 0.32mgKOH/g oil), peroxide value (158.640 ± 2.20Meq/Kg), iodine value (58.390 ± 0.71wijs) and total fatty acid composition of 88.41%identified. The extraction yield of 48.32±1.85% makes the commercialization of the seed in Nigeria possible and profitable. Also, the result of the analysis confirms the oil to be of good quality and can find application in food industry as food additives as well as industrial purposes such as cosmetics, soaps, paint and even energy generation.

KEYWORDS: *castor seed, extraction, oil, physicochemical properties, fatty acid composition*

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I. INTRODUCTION

Castor plant (*Ricinus communis*), from which castor beans and oil are native to the Ethiopian region of east Africa, is now grown in tropical and warm temperate regions throughout the world and is becoming an abundant weed in the south western united state (Salunke and Desai, 1992). It grows naturally over a wide range of geographical regions and may be activating under a variety of physical and climatic regions. Salunke and Desai (1992) reported that castor beans contains about 30-35% oil which can be extracted by variety of processes such as cold press and solvent extraction. Also, Kularni and Sawant (2003) reported that the castor bean contains 35-55% oil by weight for high yield breed types and has one of the highest viscocities among vegetable oils, with a molecular weight of 298. Castor oil is one of the few naturally occurring triglycerides that approach being a pure compound, since the fatty acid portion is nearly nine-tenths ricinoleic (Bagali et al, 2010). Its crude form is a pale straw colour that turns colourless or slightly yellowish after refining and bleaching. According to Marter (1981), Castor oil pale amber viscous liquid derived from the seeds of the plant *Ricinus communis* is sometimes known as ricinus oil. Castor oil is one of the few naturally occurring glycerides that approach being a pure compound, since the fatty acid portion is nearly nineteenths ricinoleic acid (Wood, 2001). Crude castor seed oil is pale straw colour which turns colourless or yellowish after refining and bleaching (Rial et al, 1999). The crude oil has a distinct odour, but it can easily be deodorized in the refining process like any other vegetable oils (Salunke and Desai, 1992).

It contains triglycerides, which chemically is a glycerol molecule with each of the three hydroxyl groups esterified with long chain fatty acids. Their major fatty acid is the unsaturated fatty, hydroxylated 12-hydroxy, 9-octadecenic acid, known familiarly as the ricinoleic acid (Robertus, 1991), containing between 87-90% ricinoleic acid (Rial et al, 1999; Conceicao et al, 2007). The presence of a hydroxyl group at C12 of the recinoleic acid, the ester linkages, doublebonds and hydroxyl groups provide reaction sites that makes it usually polar, which provide sites for the production of a wide range of natural and synthetic resins, waxes, polymers and elastomers. It also has excellent emollient and lubricating properties, a marked ability to wet and disperse dyes, pigments and fillers (Azumbuja and Dias, 2006; Oguniniyi, 2006) as well as several medicinal values (Brown, 1995). Castor oil has excellent solubility in methanol and hence theoretically an ideal oil for

transesterification to biodiesel (Bello and Makanju, 2011), requiring a minimum amount of catalyst and heating which can reduce cost for production. The extraction and commercialization of oils from castor seeds have been carried out extensively, relating its properties to the geographical origin and the method of extraction from oil bearing material. It becomes important to obtain the specific data for sample of oil from a particular area, because there is a range of free fatty acid content of the oil related to the geographical origin (Lucas, 2002). The characterization based on different fatty acid group gives an insight into the distribution of acid as in the unsaturated and saturated fractions. Though, it is not a conclusive pointer but it can be used to classify the oil under fatty acid group predominant in them. Such group can be itemized as milk fat, lauric acid, oleicacid, linoleic acid, ricinoleic acid and animal fat, to mention but few (Sandvig and van Deurs, 2002). Castor oil and its derivatives find outlet in industries and pharmaceuticals because of the ricinoleic acid, which predominates to about 89% (Conceicao et al, 2007), and is unusual because of the fact that it has a hydroxyl functional group on the twelfth carbon.

The functional group causes ricinoleic acid to be unusually polar, and also allows chemical derivatization that is not practical with most other seed oils. It is this hydroxyl group which makes castor oil ricinoleic acid valuable as chemical feed stocks (Vitetta and Thorpe, 1991). Therefore, dehydration process is carried out at about 250^{o}C in the presence of catalysts such as concentrated sulphuric acid or activated earth, and under an inert atmospheric condition or vacuum. The process is referred to as sulphonation. The hydroxyl group and an adjacent hydrogen atom from the C-11 or C-13 position of the ricinoleic acid portion of the molecule are removed as water. This yield a mixture of two acids each containing two double bonds that results in oil called Turkey-red oil having the properties of tung oil (Dole and Keskar, 1976). Thus, the oil can be used in the production of vanishes, lacquers, protective coatings, lubricants, soaps, cosmetics, paints, inks, and it is a primary raw material for the production of nylon and other synthetic resins and fibers and a basic ingredient in racing motor oil for high-performance automobile motorcycle engines (Wiley and Oeitmann, 1991). The castor meal or cake is mainly used as fertilizer; this is because it is unsuitable as an animal feed because of the presence of toxic protein called ricin and toxic allergen often referred to as castor bean allergen (CBA). However, it is noteworthy that none of the toxic components is carried into the oil (Sandvig and van Deurs, 2002). This work is however aimed at extraction and characterization of the castor seed oil, through the Extraction of castor oil from castor bean by solvent extraction process; determination of physicochemical parameters and fatty acid composition of the castor seed oil extract. Results obtained shall be X-rayed critically with the aim of bringing out the industrial potentials of the oil for economic gains.

II. MATERIALS AND METHODS

The castor seeds used for this work were obtained in Kapil – Lankan District in Pankshin LGA of Plateau State of Nigeria. They were prepared for use by removing the endocarp, sun-drying for five days to reduce the moisture contents, winnowing to separate the shell from the nibs (cortyledon). This was carried out using tray to blow away the cover in order to achieve very high yield and milled to flour using hand grinding machine. A Soxhlet extractor was used for solvent extraction of the oil. The solvent used was hexane and it was repeated several times and at the end of the extraction the resulting mixture called micelle containing the oil was distilled to recover the oil. The residual oil was collected and used for analytical work. The PH, moisture content, specific gravity, were determined according to AOAC, (1990). Refractive index was determined by Abbe Refractometer coupled with thermometer, calibrated specimen and light source. The colour was determined using lovibond tintometer and half inch cell. The colour which was in unit was calculated based on this formula (5R+Y-B), where R is the red pigment (Carson, 1995). The flash and fire points were determined using Gallenkamp Automatic Pensky-Martens Flash points American Standard of Testing Materals ASTM, (1984).

The equipment used for the determination of the smoke point was SETA 104000 Smoke Point Apparatus and (ASTM D1322), the sample was introduced into the candle stand, the SETA wick trimmer inserts wick and automatically set to correct length. The measuring scale was viewed through the SETA mirror of the lamp body and chimney to detect the first indication of smoke. The temperature was recorded as the smoke point. Turbidity was determined using Palin test Turbidity Tube. The tube was held vertically over a white surface and viewed downward, gradually pour the sample until the black cross was no longer visible. The graduation corresponding to the height of the sample in the tube was recorded as Jackson Turbidity Units (JTU).The viscosity was determined using an equipment called Viscometer , A clean ,dried viscometer with a flow time above 200 seconds for the fluid to be tested was selected. The chemical properties of the oil sample were determined using the method specified by the Association of Official Analytical Chemists (AOAC) Official method of analytical chemists, (1990). The chemical parameters determined include free fatty acid, acid value, Iodine value, saponification value and peroxide value. Fatty acid composition of the oil was determined as described by Akintatyo, (1995). Analytical test method for fatty acid methyl esters, the fatty acid methyl

esters were analysed using Agilent 6890 series Gas chromatography filled with a flame ionization detector and enhanced integrator. Helium gas was used as carrier gas. The column initial temperature was 250^{o}C rising at 10^{o}C/mm to a final temperature at 300^{o}C while the integrator and the detector were maintained at 250^{o}C respectively. A polar capillary column (30mX0.25mm) was used to separate the esters. The peaks were identified by comparism with standard fatty acid methyl esters obtained from Johnson wax West African limited, Isolo-Lagos.

III. RESULTS AND DISCUSSION

Table 1: physicochemical parameters of castor seed oil.

S/No.	Physical and Chemical Parameters	Average Result
1	Moisture %	0.300 ± 0.01
2	Density g/cm^3	0.948 ± 0.02
3	Refractive index @ 28^{o}C	1.792 ± 0.01
4	Fire point (^{o}C)	256.000 ± 1.20
5	Flash point (^{o}C)	225.000 ± 2.10
6	Smoke point (^{o}C)	215.000 ± 1.00
7	Viscocity (cps)	0.425 ± 0.12
8	Colour (TU)	14.000 ± 0.00
9	pH	5.800 ± 0.00
10	Turbidity	5.000 ± 1.00
11	Free fatty acid (as % oleic)	7.400 ± 0.07
12	Acid value (as % oleic)	14.800 ± 0.14
13	Saponification value(mgKOH/g oil)	180.770 ± 0.32
14	Peroxide value(Meq/Kg)	158.640 ± 2.20
15	Iodine value (Wijj's value)	58.64 ± 0.71
16	Extraction yield (%)	48.320 ± 1.85

Mean ± standard deviation of quintuplet determinations

Table 2: Fatty acid composition of castor oil

S/No.	Fatty acid	Carbon Number	Result (%)
1	Recinoleic	18:1	83.97
2	Palmitic	16:0	0.46
3	Oleic	18:1	2.28
4	Linoleic	18:2	0.61
5	Linolenic	18:3	0.33
6	Stearic	18:0	o.52
7	dihydroxylstearic	18:0	0.24
			88.41

Table 1 presents the result of the yield and the physicochemical parameters of castor seed oil. The result obtained for the percentage oil content was 48%. This high yield may be as a result of environmental factor which enhance the growth and productivity of the seed. This value falls within the range value of 30-55% reported by Aldrich, (2003). This yield makes the industrial practice of the oil recovery a profitable venture. The moisture content of the crude oil was 0.30%, indicating low moisture or volatile content might be as a result of effectiveness of the distillation apparatus used for oil recovery. Again, the low moisture or volatile content is an indication of good shelf life characteristic. The specific gravity was 0.948±0.02. This was in line with 0.9587 reported by Salunke, (1992). This density can further be rduced by esterification to 0.85 so as to meet the biodeasel energy application (Bello and Makanju, 2011). The refractive index was determined to be 1.792±0.00. This value is an indication of the level of saturation of the oil. The fire, flash and smoke points of the oil have linear relationship with the content of the free fatty acid present in the oil because thes are parameter indicative of combustion (AOAC, 1990). The viscosity was determined at 28^{o}C using viscometer. The value obtained was 0.425± 0.12cps, showing that the oil light and so probably highly unsaturated; the high value might be as a result of suspended particles still present in the crude oil sample. The colour was determined using lovibund tintometer and the value was 14.00TU. The high value was as a result of the presence of high number of red

pigment. The PH of the sample was 5.8 ± 0.00; the low level was an indicative of the presence of reasonable quantity of free fatty acid in the oil, which is a good indicator of the advantageous utilization of the oil in soap making. Turbidity of the oil was 5.00±1.00JTU AOAC, (1990). All these physical parameters are

indications that the oil to be used for industrial purposes. The free fatty acid and acid values was determined to be 7.4±0.07 % oleic acid and 14.8±0.14% oleic acid respectively. This can be used to check the level of oxidative deterioration of the oil by enzymatic or chemical oxidation. These values fall within the free fatty acid of oil is expected to range between 0.00 -3.00% before it finds application in corking, but on the contrary the value is high for the oil under study. However, the free fatty acid can be modified to edible oil by subjecting it to refining and this will also improve its quality for industrial usage. The saponification value of the oil was 180± 0.770 mg KOH/g oil, which is within the range of values 156 to 185 mgKOH/g oil as reported by other scholars (Weisis, 1971; Jumat et al, 2010). The iodine value is a measure of the degree of unsaturation and it an identity characteristic of seed oils, making it an excellent raw material for soaps cosmetics industries (Hamilton, 1999). Research has shown that oils with high saponification value are valuable raw materials for soaps and cosmetics (Abayeh et al, 1998). The Iodine value determined for the castor seed oil was 58.39 ±0.71 wijs. This value could be used to quantify the amount of double bond present in the oil which reflects the susceptibility of oil to oxidation. Also, it enables us to classify the oil in the non-drying groups, since I V obtained is < 100, which are useful in the manufacture of soaps (Kochhar, 1998) and can be regarded as liquid oil. Thus, the oil may find its application in the manufacturing of lubricants, hydraulic fluids and coating (Ibiyemi et al, 1992). The peroxide value was found to be 158.64 ± 2.20 Meq/kg. The high peroxide value of the oil sample shows that the oil is prone to rancidity and thus less stable.Table 2 depicts the result of fatty acid composition of castor seed oil. The saturated fatty acids detected in the sample were palmitic, stearic, linoleic, linolineic and dihydroxylstearic acids. The values were 0.46%, 0.52%, 0.61%, 0.33% and 0.24% respectively. The unsaturated fatty acids detected were ricinoleic acid (83.97%), which may be due to the rude form of the oil, as compared to about 89% (Conceicao et al, 2007) and oleic acid (2.28%). The total fatty acids detected was 88.41%, this is to say that we have 11.59% fatty acids undetected. The reason might be as a result of impurities that are present in the crude castor seed oil (Cooper and Johnson, 1994). Knowledge of the fatty acid content is also important for soaps, cosmetics and energy industries. In the soaps and cosmetics industries, knowledge of the fatty acid content could guide the product formulator as to the type of oil and what ingredients to include in the formulation (Butler, 1987). Also, fatty acid profile is important because of the dependence of biodiesel properties on the structure and type of fatty acid alkyl esters (Knothe, 2005).

IV. CONCLUSION

The result of the investigation carried out on crude castor seed oil confirms the presence of ricinoleic acids, oleic acid, palmitic acid, stearic acid and dihydroxylstearic acid; this is an indication of good quality that can be modified so as to be useful in food industry as additives in food as well as transportation, cosmetics and pharmaceutical industries. The result also shows that the oil can be classified as drying oil which can be hydrated by sulphonation to give semi-drying or drying oil which can be used extensively in paint and vanishes. Considering the high percentage yield of the castor seed oil (48%), farming castor plant should be encouraged to boost the commercialization of castor seed to enhance the economic growth of individual and the country at large particularly in this era of biotechnology and industrialization to feed these industries.

REFERENCES

[1]. Abayeh, O. J., Aina, E. A. and Okuoghae (1998): Oil Content and Oil Quality Characteristics of Some Nigerian Oil Seeds. *Journal of Pure and Applied Sciences* **1**(1): 17-23

[2]. Aldrich (2003): Handbook of Fine Chemical Laboratory Equipment, Sigma- Aldrich. Akintayo, E. T., (2004): Characteristics and composition of Parkia biaglobbosa and Jatropha

[3]. curcas oil and seeds. *Bioresour. Technol.*, **92**: 307-310.

[4]. AOAC (1990): Official Method of Analysis. 14th Edn. Vol. 67, Association of Official

[5]. Analytical Chemists Arlington, VA, pp 1-45. Washington D.C., U.S.A ASTM, (1984): American Standard of Testing Material (ASTM,s D1322 , ASTM ,D93)

[6]. Azumbuja, M and Dias, A.A. (2006): Uses of Castor Oil-based Polyurethane Adhesive in the Production of Glued Laminated Timber Bims. *Mat. Res*. **9** (3):287-291

[7]. Bagali, S. S., Binna, K. V., Anita, M. V., and Paramjeet, K. B. (2010): Optimization and Characrerization of Castor Seed Oil. *Leonardo Journal of Sciences*; Issue 17 p59-70. ISSN1583-0233

[8]. Bello, E. I. and Makanju, A (2011): Production, Characterization and Evaluation of Castor oil Biodiesel as Alternative Fuel for Diesel Engines; *Journal of Emerging Trends in Engineering and Applied Sciences* (JETEAS) **2** (3): 525-530

[9]. Brown, D. (1995): Encyclopedia of Herbs and their Uses. New York: DK Publishing inc. pp 488-489.

[10]. Butler, H. (1987): Pounchers Perfumes, Cosmetics and Soaps vol. 3 9th edition. Blackier Academics and Professional, London 393-395, 451-452, 454-457, 464-468 and 481-82.

[11]. Carson, K.F., (1991): Fat and Oil processing INFORM.
Conceicao, M.M.; Candeia, R.A.; Silver, F.C.; Bezerra, A.F.; Fernandes, V.J.; and Souza, A.G. (2007): Thermochemical Characterization of Castor Oil Biodiesel Renewable and Sustainable Energy Reviews 11 (5): 964-975

[12]. Dole K.K., Keskar V. R., (1976): Dehydration of Castor Oil. *Curr Sci*., pp242-243

[13]. Hamilton R. J., and Cast, J., (1999). Spectral Properties of Lipid. Welley Interscience; pp273- 280.

[14]. Ibiyemi S.O., Adepoju T.O., Okanlawon S.o., and Fadipe V.O.,(1992): Emulsion Preparation

[15]. And Stability, *Journal of Nutritional Science*. **13**,(1-2), 31-34.

[16]. Jumat, S., Dina, A. M. N.,Nazrizawati, A. T.Firdaus, M. Y. M. andNoraihah, A. (2010): Fatty

[17]. Acid composition and Physicochemical Properties of Malaysian Castor Bean Ricinus communis L. Seed Oil. *Sains Malaysiana,* **39** (5) 761-764
[18]. Knothe, G. (2005): Dependence of Biodiesel Fuel Properties on the Structure of Fatty Acid Esters. *Fuel Proc Tech*. 8690; pp 1059-1070
[19]. Kochhar, S. L. (1998): Economic Botany in the Tropics. 2nd Edition, Macmillan India Ltd. Pp 354-355.
[20]. Kulkarni, M.G.and Sawant, S.B. (2003): Some Physical Properties of Castor Oil Esters and Hydrogenated Castor Oil Esters. Eur. J. Lipids Sci. Technol. 105:214-218
[21]. Lusas, E.W., (2002): Oil seeds and oil bearing materials, A handbook of Cereal Science and
[22]. Technology, K., Kulp and J.G.,Ponte, Jr (Ed), Marcel Dekker, Inc, NewYork, pp297-362.
[23]. Mater A.D.,(1981): Castor market, Utilization and prospects; Tropical Product Institute, G 152, p 55-78.
[24]. Rial , Ghetie, Victor and Lauterbach, Brenda,. (1999): Selection of Castor for Divergent Concentrations of Ricin and *Ricinus communis* Agglutinin and References therein. *Crop Science* **39**: 353-357.
[25]. Robertus, J.D., (1991): The structure and action of ricin, A cytoxic N-glycoside. Seminar in cell Biology 2: 23-30.
[26]. Salunke D.K.,Desai B.B.,(1992): Post- harvest Biotechnology of oil seeds. CRC Press, p.161-170.
[27]. Sandvig, K.,and van Deurs.(2002,): Transport of Protein Toxins Into Cells: Pathways Used by
[28]. ricin, cholera toxin. FEBS Letter 529: 49-53
[29]. Vitteta E.S., and Thorpe P.E., (1991): Immunotoxins containing ricin or it A chain. Seminar in Cell Biology 2: 47-58.
[30]. Wiley, R,G., and Oeitmann T.N.,(1991): Ricin and related plant toxins : Mechanisms of action And Neurobiological Applications. Handbook of natural toxins (vol) 6. Pp346-348.
[31]. Wood M.,(2001): "High-Tech castor plants May Open Door to domestic production" Agricultural Research magazine 49 (1).