Chemistry and Materials Research
ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online)
Vol.7 No.2, 2015

Physico-Chemical and GC/MS Analysis of Castor Bean (Ricinus communis L.) Seed Oil

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Abstract
The hexane extract of the castor bean seed oil yielded 42.23 ± 0.208%. The physico-chemical characteristics of the hexane extract I reported here were: saponification, iodine and acid values of 123.3 ± 3.428 mgKOH/g , 76.93 ± 0.397g I_2/100g and 2.39 ±0.065 mgKOH/g respectively. The Major fatty acids derived from the castor bean oil as indicated by the GC-MS results were Oleic acid ($C_{18}H_{34}O_2$), Palmitic acid ($C_{16}H_{32}O_2$), Stearic acid ($C_{18}H_{32}O_2$) , Undecylenic acid ($C_{11}H_{20}O_2$),–Methyl ricinoleate ($C_{19}H_{36}O_3$), Behenic acid ($C_{23}H_{46}O_2$), Tridecylic acid ($CH_3(CH_2)_{11}COOH$), Nonadecanoic acid($CH_3(CH_2)_{17}COOH$). The results showed the potential of the hexane extract of the seed oil in cosmetics, perfumery and pharmaceuticals.
Keywords: Castor bean oil, Physico-chemical, GC-MS, cosmetics, pharmaceuticals.

INTRODUCTION

Castor bean oil is obtained from the bean of castor plant (*Ricinus communis L.*) a member of the Spurge family of plants (Euphorbiaceae). The castor bean oil is water resistant. In Nigeria, it is grown in the northern and middle belts where the weather is favourable (Annongu and Joseph,2008). It is grown commercially for the oil contained in the seed primarily for industrial purposes and in the manufacture of cosmetics (European Food Safety Authority, 2008). The principle constituents of the oil are the triacylglycerols of ricinolic, stearic, dihydroxystearic, oleic and linoleic acids (Behera , 2010) The extracted oil has a very consistent viscosity and won't freeze even in Russia's severe climate. This makes it ideal lubricating oil in industrial equipment. Medicinally, the oil is added to products to restore hair (Williams, 1995). One of its uses is in the manufacture of transparent soaps (Warra *et al*., 2013). Splitting ricinoleic acid from castor oil with steam gives C7 and C11 products. This splitting process has been much improved by the development of a continuous steam cracking process. Heptanal is used in perfumes, and 10-undecenoic acid can be converted to a polyamide (Rilsan) while its salts show antifungal properties (Caupin, 1997). The work is aimed at extraction, Physico-chemical, GC-MS analysis of castor bean oil to exploit its cosmetic potential.

2.0 MATERIALS AND METHOD

2.1 Sample collection

Indigenous Castor beans were plucked directly from plant during three consecutive years (2007-2009) harvesting seasons. The plant was identified and authenticated by a Botanist at the Biological Science Department, Bayero University, Kano Nigeria. Confirmation of taxonomic identity of the plant was achieved by comparison with voucher specimen (voucher No. 225) kept at the Herbarium of the Department of Biological Sciences, and use of documented literature (Kochhar, 1998). Castor bean variety, which ripens from late October until late December, was obtained from a test Garden in Aliero town of Aliero Local Government Area of Kebbi State, Nigeria. Good seeds were selected, cleaned, de-shelled, dried and ground using laboratory plastic pestle and mortar prior to extraction.

2.2. *Oil Extraction Procedure*

The oil content was obtained by complete extraction using the Soxhlet extractor (Konte, USA). The 50 g of each powdered seed sample was put into a porous thimble and placed in a Soxhlet extractor, using 150 cm^3 of n-hexane (with boiling point of 40- 60^oC) as extracting solvent for 6 hours repeatedly . The oil was obtained after evaporation using Water bath at 70^oC to remove the excess solvent from the extracted oil. The oil was then stored in refrigerator for subsequent physicochemical analyses

2.3 Percentage Yield

The oil which was recovered by complete distilling of most of the solvent on a heating mantle was transferred to measuring cylinder. The measuring cylinder was then placed over water bath for complete evaporation of solvent for about 2-3 hours in accordance with the method reported (Behera , 2010) and volume of the oil was recorded and expressed as oil content(%) as follow

$$\text{Oil content (\%)} = \frac{\text{Oil weight}}{\text{Sample weight}} \times 100$$

2.4 Physico-chemical Analysis

The chemical analysis of the oils was carried out using the methods reported (Bassir, 1978; AOAC, 1998; Akpan *et al*., 2006).

2.5 GC-MS Analysis of the Oil

For the analysis of the fatty acids in the oil sample which was done at National Institute of Chemical Technology (NARICT) , Zaria, Nigeria, a Shimadzu QP2010 plus series gas chromatography coupled with Shimadzu QP2010 plus mass spectroscopy detector (GC-MS) system was used. The temperature programmed was set up from 70 oC to 280 oC. Helium gas was used as carrier gas. The injection volume was 2 µL with injection temperature of 250 oC and a column flow of 1.80 mL/min for the GC. For the mass spectroscopy ACQ mode scanner with scan range of 30-700 amu at the speed of 1478 was used. The mass spectra were compared with the NIST05 mass spectral library (NIST, 2012).

RESULTS AND DISCUSSION

Table 1: Physical Properties of Castor bean oil

Parameter	Value
Colour	Colurless
Odour	Odourless
Percentage yield (%)	42.23 ± 0.208

Values are expressed as mean and ± standard deviation of triplicates determinations

Table 2: Physicochemical characteristics of the indigenous castor seed oil

Parameter	Values
Saponification value mg KOH/g	123.3 ±3.428
Iodine value g I_2/100g	76.93 ± 0.397
Acid value mg KOH/g	2.39 ± 0.065
Physical state at room temperature	Liquid

The values are expressed as mean and ± standard deviation of triplicates determinations.

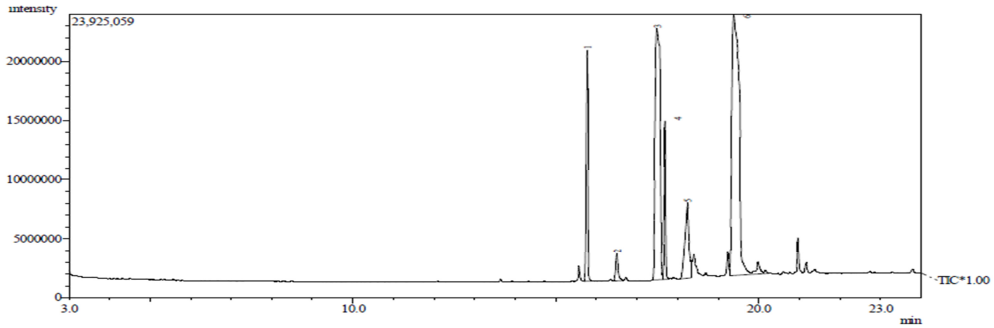


Figure 1. Typical GC-MS total ionic chromatogram (TIC) of Castor bean oil.

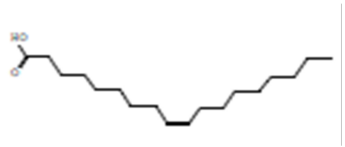
Table 3 Major fatty acids derived from castor bean oil

S/N	Name of fatty acid	Molecular formula	MW	RI	SI% to T.C.
1.	Oleic acid	$C_{18}H_{34}O_2$	282	2175	86
2.	Palmitic acid	$C_{16}H_{32}O_2$	270	1968	91
3.	Stearic acid	$C_{18}H_{32}O_2$	284	2167	89
4.	Undecylenic acid 5. Methyl ricinoleate	$C_{11}H_{20}O_2$ $C_{19}H_{36}O_3$	184 312	1461 2247	87 91
6.	Behenic acid	$C_{23}H_{46}O_2$	354	2475	90
7.	Tridecylenic acid 8. Nonadecyclic acid	$C_{14}H_{28}O_2$ $C_{19}H_{38}O_2$	228 298	1580 2266	91 90

Note: S/N = Serial number, M.W. = Molecular weight, RI= Retention index SI% = Similarity index, T.C. = Target compound.

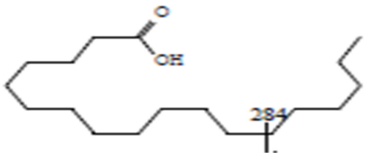
Figure 2. Chemical structures of the major fatty acids derived from the Wild castor seed oil

1. Oleic acid

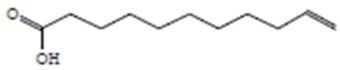


2. Palmitic acid

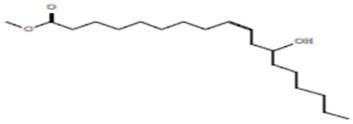
3. Stearic acid



4. Undecylenic Acid

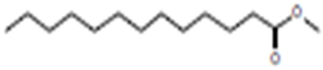


5. Methyl ricinoleate

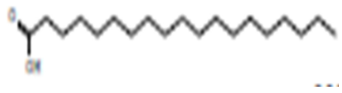


6. Behenic acid

7.Tridecylenic acid



8. Nonadecyclic acid



DISCUSSION

The Percentage yield (%) of hexane extract of the castor bean seed oil was 42.23 ± 0.208 (Table 1) lower than the value obtained for Wild castor seed oil (Warra,2015) and 49.3% for *parinari macrophylla* seed oil (Warra,2012), higher than 41.67 reported for Sesamum indicum L. (Brown) seed oil (Warra *et al*., 2012) recommended for cosmetic industries.

The physicochemical analysis [Table-2], for the hexane extract of castor beans seed oil includes; Saponification value of 123.3 ±3.428 mgKOH/g the value obtained was lower than that of *Terminalia catappa* seed oil 207± 0.13 mgKOH/g suggested for use in the production creams (Nzikou *et al*.,2010), but higher than that of beeswax (93 mgKOH/g), which were commonly used for soap making (Mabrouk ,2005). Iodine value of 76.93 ± 0.397g I2/100g (less than 100) was obtained, which made the oil to be classified as Non-drying suggested for the manufacture of soaps [8]. Castor oil has only one double bond in each fatty acid chain and so is

classified as nondrying oil. An Acid value of 2.39 ± 0.065 mgKOH/g was obtained which is lower than that of *Demettia tripetala* fruit oil (Pepper fruit) 5.34± 0.04 mgKOH/g (Nwinuka and Nwiloh, 2009). and Shea butter 10.3mgKOH/g (Warra *et al*.,2009), higher than that of Palm kernel seed oil 0.834± 0.004mgKOH/g reported (Afolabi,2008). suitable for soap production.

The fatty acids obtained from the GC-MS fragments are; (1). Oleic Acid (also known as cis-9-Octadecenoic acid,cis-Oleic acid,oleate, Elaidoic acid, Metaupon, Delsauere. An unsaturated fatty acid that is the most widely distributed and abundant fatty acid in nature . It is used commercially in the preparation of oleates and lotions, and as a pharmaceutical solvent (PubChem (2014). Oleic Acid's high lipid count makes it a great moisturizer, and a number of cosmetic companies add it to lotions and soaps in order to boost their ability to nourish the skin. (2) Palmitic acid (Palmitic acid also known as n-Hexadecoic acid is mainly used to produce soaps, cosmetics, and release agents. These applications utilize sodium palmitate, Hydrogenation of palmitic acid yields cetyl alcohol, which is used to produce detergents and cosmetics (National Institute for Standard Technology, 2014). (3) Stearic acid (stearic acid is the most common saturated fatty acid (Bockisch, 1998) is a saturated fatty acid with an 18-carbon chain and has the IUPAC name octadecanoic acid, Stearic acid is mainly used in the production of detergents, soaps, and cosmetics such as shampoos and shaving cream products. Soaps are not made directly from stearic acid, but indirectly by saponification of triglycerides consisting of stearic acid esters. Esters of stearic acid with ethylene glycol, glycol stearate, and glycol distearate are used to produce a pearly effect in shampoos, soaps, and other cosmetic products. They are added to the product in molten form and allowed to crystallize under controlled conditions. Detergents are obtained from amides and quaternary alkylammonium derivatives of stearic acid. surfactants, cosmetics and personal hygiene products are infact prospects of stearic acid (Gunstone, 2004). (4) Undecylenic Acid a common name for 10-undecenoic acid a monomer derived from ricinoleic acid (Gunstone, et al., 2007) is an organic unsaturated fatty acid pyrolysis product of ricinoleic acid from castor oil, , it is used in the manufacture of pharmaceuticals, cosmetics and perfumery, including antidandruff shampoos and antimicrobial powders (5) Methyl ricinoleate or Ricinoleic acid methyl ester is a naturally occuring12-hydroxy fatty acid constituting about90% of the fatty acids in castor oil (Santa Cruz Biotech, 2014).

(6)Behenic acid (is a carboxylic acid the saturated fatty acid with formula $C_{21}H_{43}COOH$. In appearance, it consists of white to cream color crystals or powder with a melting point of 80 °C and boiling point of 306 °C. It is soluble in both ethanol and ether. It is a major component of Ben oil which is extracted from the seeds of the *Moringa oleifera* tree. Behenic acid is often used to give hair conditioners and moisturizers their smoothing properties. Also used as anti-foam in the manufacturing of detergents (Rulis, 2001).

(7)Tridecylic acid, or tridecanoic acid, is a 13-carbon saturated fatty acid with the chemical formula $CH_3(CH_2)_{11}COOH$. It is commonly found in dairy products especially milk (Jocelyne and Ralph, 2014)

(8)Nonadecyclic acid, or nonadecanoic acid, is a 19-carbon long-chain saturated fatty acid with the chemical formula $CH_3(CH_2)_{17}COOH$. It forms salts called *nonadecylates*. Nonadecylic acid can be found in fats and vegetable oils. It is also used by insects as pheromones. A C_{19} straight-chain fatty acid of plant or bacterial origin. An intermediate in the biodegradation of n-icosane, it has been shown to inhibit cancer growth (ChEBI, 2014) .

CONCLUSION

From the results of the Physico-chemical and GC/MS Analysis of Castor (*Ricinus communis* L.) Bean Oil, it can be concluded that the seed oil has potential in the production of cosmetics, perfumery and pharmaceuticals

ACKNOWLEDGEMENT

The author wish to acknowledge the effort of Mr Ibrahim of the Central Laboratory National Institute of Chemical Technology (NARICT) , Zaria, Nigeria.

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