JOURNAL OF CHEMICAL ENGINEERING VOL.2 NO.1 JANUARY 2014
ISSN 2166-4358 (Print) **ISSN** 2166-4366 (Online) http://www.researchpub.org/journal/jce/jce.html

Extraction, Refining and Characterization of Sudanese Castor Seed Oil

Abdelaziz*,A .I. M., Elamin, I. H. M., Gasmelseed**, G. A., Abdalla*, B. K.**

*College of Graduate Study and Scientific Research, Karary University, Khartoum, Sudan,

**Chemical Engineering Department, University of Science and Technology, Khartoum, Sudan,

Abstract: **The extraction and refining of castor oil using stage wise equipment was carried out. The analysis of the crude and refined oils according to the American Society for Testing and Materials (ASTM) and the British pharmacopeia 2007, was done. The results obtained from these two methods were compared with the properties obtained from the literature. All the results were tabulated, discussed and compared with published data using standard Lubricating oils. Good agreements were obtained which mean that Castor oil is a very promising candidate for industrial applications as lubricating oil.**

***Keywords*: *Castor oil, Ricinus Communis, Bio lubricant, Biodegradability, Extraction* .**

I. INTRODUCTION

Castor oil is a vegetable oil obtained from the castor bean (or *castor seed*) that has a characteristic structure and many uses. It is obtained by pressing and solvent extracting the seeds of the castor plant, *Ricinus communis*. Sometimes called castor bean oil, this plant is not a member of the bean family [1].

The castor-oil plant is easy to grow and is resistant to drought, which makes it an ideal crop for the extensive semi-arid regions globally. That area holds about twenty million hectares of appropriate land that could yield up to 1.5 tons of castor beans per hectare, compared to the global average of 0.750 tons per hectare. Castor beans could become a farming alternative, providing income for over one hundred million people who suffer hunger in the poorest regions globally [2] . Castor oil is colorless to very pale yellow liquid with mild or no odor or taste. Its boiling point is 313 ^{O}C (595 ^{O}F) and its density is 961 kg/m^3. It is a triglyceride in which approximately 90 percent of fatty acid chains are ricinoleate. Oleate and linoleates are the other significant components [1].

The castor seed contains ricin ; a toxic protein. Heating during the oil extraction process denatures and inactivates the protein. However, harvesting castor beans may not be without risk. Allergenic compounds found on the plant surface can cause permanent nerve damage, making the harvest of castor beans a human health risk. India, Brazil, and China are the major crop producers, and the workers suffer harmful side effects from working with these plants. These health issues, in addition to concerns about the toxic byproduct (ricin) from castor oil production, have encouraged the quest for alternative sources for hydroxyl-fatty acids. Alternatively, some researchers are trying to genetically modify the castor plant to prevent the synthesis of ricin [1] .

With the world becoming more environment conscious and with increasing replacement of synthetic products with naturally derived products , castor oil based derivatives could find increasingly attractive markets worldwide .So because of this it needs to be treated and environmentally friendly [3].

II. Experimental work

A. Castor Bean Processing.

The castor beans undergo various processing in the course of its preparation for extraction. The unit operations involved are: [4] .

• *Clearing*: The castor beans had some foreign materials and dirt which was separated by hand picking.

• *Drying:* The cleaned beans were sun dried in the open, until the casing splits and sheds the seeds. The beans were further dried in the oven at 60^{O}C for 7hrsto a constant weight in order to reduce its moisture content, which was initially at about 5 to 7%.

• *Winnowing:* The separation of the shell from the nibs (cotyledon) was carried out using Tray to blow away the cover in order to achieve very high yield.

• *Grinding (size reduction):* Mortar and pestle were used to crush the beans into a paste (cake) in order to weaken or rupture the cell walls to release castor oil for extraction.

B. **Extraction of castor oil.**

910 gms of crushed castor bean were placed into a round bottom flask contain 2.35 liters n-hexane and the equipment was heated at 60 ^{O}C . When the solvent (n-hexane) was boiling the vapor rises through the vertical tube into the condenser at the top , the liquid condensate drips into the filter paper thimble in the center , which contain the solid sample to be extracted . The extracted seeps through the pores of the thimble and fills the siphon tube , when it flow down into the round bottom flask . This was allowed to continue for six hours .It was then removed from the tube , dried in the oven , cooled in the desiccators and weighed to determine the amount of oil extracted .

C. **Refining of extracted oil**

A clay sample was obtained from river Nile (Sudan) , and was ground and then mixed with water . Impurities such as sand and stone were removed . To activate clay 2M HCl was added to the clay slurry and the mixture was boiled for 2 hrs at about 100 ^{O}C . Then the mixture was then washed with water to remove acid , dried and ground [4] .

- Degumming**:** Castor oil contains gum material that affect utilization of the oil as lubricant . The oil was degummed by the addition of boiling water (gum dissolve in hot water) . The mixture was stirred for 2 minutes and allow to stand in the separating funnel . Thereafter the aqueous layer was removed . The procedure was repeated to ensure removal of most gum . For neutralization About 60 gm of degummed oil was poured into a beaker and heated to 80 ^{O}C , after which 40 gm of 0.1 M NaOH was added and stirred to uniform solution. This was transferred into a separating funnel and allow to stand for 1 hr , the soap formed was separated from the oil . Hot water was added again and again to the oil solution until the soap remaining in solution was removal . The neutralized oil was then drawn off into a beaker [4].
- Bleaching: 50 gm of neutralized oil was poured into a beaker and heated to 90 ^{O}C . Activated clay (15% by weight) was added . The mixture was stirred continuously for 30 min . The content was filtered hot at 70 ^{O}C. All these experiments were carried out in the National Centre of Research in Khartoum – Sudan.

D. **Characterization of crude and refined oils**

These analysis were done for both crude and refined oil using the BRITISH PHARMACOPIEA 2007 , version 11) method , Then other samples (crude and refined) oils were taken to the Central Laboratory of Science, Environmental and Soil Research(CLSER) where the analysis were done according to American Standard Testing Methods (ASTM) .

III. Result and Discussion

A. Results

Table 1: percentage of castor oil extracted (oil content)

Weight of castor seed(gm)	Weight of oil (gm)	Yield	Remarks
910	291.08	31.99%	Sample: castor seed

Table 2 : physical properties of crude and refined castor oil

Properties of castor oil	Test method	Crude oil	Refined oil
Water content	Crackle Test	-ve	-ve
Specific gravity	(ASTM D4052).	0.963	00.96
Viscosity at 40 ^{O}C (cSt)	(ASTM D445).	234.07	209.6
Viscosity at 100 ^{O}C (cSt)	(ASTM D446).	18.79	18.30
Viscosity index	(ASTM D2270).	89.33	089.46
Ester value	British pharmacopeia 2007	178.09	177.65

Table 3 :Chemical and thermal properties of crude and refined castor oil

Properties of Castor Oil	Test Method	Crude Oil	Refined Oil
Iodine Number	British Pharmacopeia 2007	86.98	84.23
Peroxide Value	British Pharmacopeia 2007	6.93	5.90
Flash Point (^{O}C)	ASTM D93	305	-
Pour point (^{O}C)	ASTM D97	05.00	07.00
TBN	ASTM D974	0.62	0.34
Acid Value	British Pharmacopeia 2007	1.231	0.916
Saponification Value	British Pharmacopeia 2007	179.33	178.56

Table 4 :ASTM properties of quality castor oil [4],[5], [7]

Property	Ranges	Selected
Specific Gravity 20/25 ^{O}C	0.957-0.968	0.962
Saponification Value	175-187	181
Iodine Value	82-88	85
Acid Value	0.4-4.0	3
Viscosity at 40 ^{O}C (cSt)	240.12	-
Viscosity at 100 ^{O}C (cSt)	20.00	20.0
Viscosity Index	90	90
Flash Point	320 ^{O}C	320 ^{O}C
Pour Point	-21.7 ^{O}C	-21.7 ^{O}C

B. Discussion

The percentage OF oil content 31.97% fall within the range of the percentage oil content (30 – 55%) of castor beans found in literature [4], depending on the variety . Though, something close to 100% yield (basing on 55% oil content of the castor bean) would have been expected, the mode of extraction is a very important parameter affecting the yield as reported [4]. It is reported that the best available method foe extraction of castor oil at present is by the use of hydraulic pressing [4]. Table 2,3 presents a comparison between the physical and chemical properties of the crude and refined castor oil obtained in this work. The specific gravity values for both crude and refined oil are obtained to be approximately the same, (0.963 and 0.9641). This is in agreement with the standard reported in literature that 0.962 [4]. Differences were observed between the value obtained for the viscosity of the crude and refined oil. The value of the viscosity of the crude and refined castor oil 234.07 ,224.16(cSt) at 40 ^{O}C and 18.79 , 18.3 cSt at 100 ^{O}C respectively was found to be near bye the recommended standard range of 240.12–20.0cSt [7], This may be attributed to the fact that extraction produce high quality oils with little impurities.

The chemical properties analysis shown in Table 3 indicates that the acid value of crude and refined oil is 1.231mg NaOH/g of oil and 0.916mg NaOH/g of oil respectively. Both values fall within the range specified in literature that are 0.40-4.0 [7]. Table 3 shows the results for the saponification value of the crude and refined oil that were found to be 179.33mg KOH/g of crude oil and 178.56mg KOH/g of refined oil respectively. This shows that, no different observed for both crude and refined castor oil. The saponification value of both crude and refined castor oil, are nearby comparable with the result specified for quality castor oil [7] as shown in Table 4. Also, the result obtained for the Iodine value of crude oil 86.98 shows increase in the average degree of un-saturation of the oil, as such the amount of iodine which can be absorbed by unsaturated acids would be higher, compared to 84.23 after it was refined . As a result of their agreement with standard, both the crude and refined oil could be classified as a non-drying oils [7], since their iodine values are lower than 100. Certainly, the oil could be used extensively as lubricants and hydraulic brake fluids.

V. Conclusion

The percentage oil content of castor seed was found to be 31.98% of the total weight of 910g. As such a satisfactory result cannot be achieved by solvent extraction process using laboratory Soxhlet apparatus. The castor oil produced in this research work was analyzed for specific gravity, Viscosity at 40 and 100 ^{O}C, acid value, saponification value and iodine value. Their values are tabulated above. Most of the values comply with the standard specified by ASTM (1952). The oil is of good quality and could be recommended suitable for industrial usage.

Vegetable oil is much desired for its application as a lubricant in metal forming process and internal combustion engines, because it is a renewable resource and has high biodegradability compared to mineral oil.

REFERENCES

[1] Castor oil : From Wikipedia, the free encyclopedia, "http://en.wikipedia.org/wiki/Castor_oil", (Jan. 07, 2014 – 11:30 GMT) .

[2] Dovebiotech Ltd. Thailand, "Castor bean (ricinus communis) an international botanica answer to biodiesel production and renewable Energy, "www.dovebiotech.com.", (Jan. 07, 2014 – 13:00 GMT).

[3] D. S. Chinchkar, S.T. Satpute, N. R. Kumbhar, "Castor Oil as Green Lubricant: A Review" International Journal of Engineering Research and Technology (IJERT), Vol. 1 Issue 5, July, (2012).

[4] U. G. AKPAN, A. JIMOH, and A. D. MOHAMMED "Extraction, Characterization and Modification of

ISSN 2166-4358 (Print) **ISSN** 2166-4366 (Online) http://www.researchpub.org/journal/jce/jce.html

Castor Seed Oil" Leonardo Journal of Sciences, Issue 8, (January-June 2006) p. 43-52.

[5] A. Deligianne, G. Anastopoulos, G. Karavalkis, L. Mattheou, D. Karonis, F. Zannikos, S. Stournas and E. Lois, "Castor (Ricinus Communis) Seed Oil as an Alternative Feedstock for the Production of Biodiesel", Proceeding of the 11th conference on environmental science and technology, chaina, Crete, Greece (3-5 September, 2009).

[6] Amrit Goswami, " An Alternative Eco-Friendly Avenue for Castor Oil Biodiesel: Use of Solid Supported Acidic Salt Catalyst", Biodiesel - Feedstock and Processing Technologies, (2011).

[7] José André Cavalcanti da Silva, "Biodegradable Lubricants and Their Production Via Chemical Catalysis", Tribology - Lubricants and Lubrication, (2011).