

Production, Purification and Evaluation of Castor Oil from Castor Bean Seeds

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Abstract - Production, purification, and evaluation of castor oil were carried out using soxhlet apparatus and petroleum spirit as solvent. The extraction was done at constant temperature using various weight of the sample. Degumming, neutralization, and bleaching refined the extracted oil. Both physical and chemical properties were evaluated. The iodine value (84.86) showed that the oil was non drying oil and so it could be used as a lubricant, protective coating. The boiling point of the extracted oil was 316°C as against the ASTM specification of 313°C. All other physical and chemical analysis carried out on the oil as compared to ASTM standard, confirmed that the property of the oil was within specification.

I. INTRODUCTION

The castor bean plant, *ricinus communis* native to tropical African cultivated in several varieties for the oil found in the leaves. It is also grown in tropical and subtropical areas such as central Asian, Tanzania, Brazil and southern Kazakhstan to name a few. It occurs as a perennial or annual plant and considered as drought resistant crop in India. The stalked leaves consist of unusual eight radiating pointed leaflets, and prominent central veins. Many varieties are green and inconspicuous but pink or

red in pigmented varieties. Many stamens are near the base and branching pistils are near the top flower. The soft spines contain attractive mottled seeds (Moshkin, 1986). Castor bean contains 50 - 55 % of oil and the extraction of oil from seed is done in similar manner to most other oil seeds (Weiss, 1983). The seed are collected when ripe as capsules dry, they open and discharge the seed. The seed are then cleaned, decorticated, cooked and dried prior to extraction. Cooking is done to coagulate protein, which is necessary to permit efficient extraction, and to free the oil for efficient pressing it is done at 80°C under airtight conditions. After drying the material at 100°C to moisture content of approximately 4 - 5 %, the extraction can be done by varieties of processes or combination of processes. Processes such as continuous screw press expeller, hydraulic press and solvent extraction are employed. The first stage of extraction is pre-pressing using high-pressure continuous screw press expeller which usually consists of barrel containing a stainless steel helical screw (Fellow, 1996). Extracted oil is filtered and collected in a settling tank. The material discharged from the press called cake which contains 8 - 10% oil is crushed into coarse meal, and subjected to

solvent extraction with solvent such as hexane, heptane, and petroleum spirit e.t.c. After extraction the solvent is removed by distillation, and the resulting oil is processed in similar manner as oil from pressing steps (Weiss, 1971).

Once the oil has been extracted from the seed it is necessary to remove any impurities from the oil. The oil is essentially a pure triglyceride, and contains almost 90% glyceryl tricinoteate. It is the ricinolic triglyceride that is needed in order to produce high quality castor oil that could be used for chemical reaction. Common properties of castor oil include high density and viscosity. These properties are exploited when refining the oil. The process of refining a crude oil includes settling, degumming, bleaching, neutralization and deodorization of the oil (Nawar, 1996).

The uses of castor oil have changed over the years. Sixty years ago castor oil was used for medicinal purposes and as general industrial lubricant. Soon after, chemical engineers were able to produce derivatives of the oil that were of even more benefit to man sulfonated castor oil, or Turkey red oil, was the first synthetic detergent to be produced after which ordinary soap and other forms of oil become important for treatment of leather, industrial lubricants and other industrial uses. Today chemical engineers have come up with many uses of castor oil together with its derivatives such as polyamide, (Nylon 11), engineering plastics, coating, inks, and emulsifiers. Castor oil has even made it way into cosmetics industries and related products. The medicinal purposes include its use as a soothing emollient for dry skin and other skin diseases. Obviously castor oil and its derivatives have

become important commodities and items of interest to chemical industries (Vignolo and Naughton, 1991).

II. EXPERIMENTAL METHODS

A. Preparing bean for extraction

The castor bean seed contained some foreign material and dirt's which were separated by hand picking. They were then dried under the sun, until their capsules split and shaded their seeds. The seeds were decorticated manually to remove the coats. The shells were separated from the nibs using tray to blow away the shells in order to obtain clean seeds. The cleaned seeds were cooked under airtight condition at a temperature of 80 – 90°C. This was done to coagulate the protein, which was necessary to permit efficient extraction.

B. Determination of Moisture Content

500g of the seed were weighed. This was dried in an oven at 100°C for 7 hours and the weight taken after every three hours. The process was repeated until a constant weight was obtained. At three hours interval the sample was removed from the oven and placed in the desiccators for 20 minutes to cool. The sample was then removed and re-weighed. The percentage moisture content in the seed was calculated.

C. Experimental Procedure

35g of the sample was placed in a thimble and about 250ml of petroleum spirit was poured into a round bottom flask. The apparatus was heated at about 80 – 90°C and allowed for 2 hour continuous extraction. The experiment was repeated with different weights of the sample i.e. 35.5g, 30g, 25g and 20g. The solvent was distilled and percentage of oil extracted was calculated.

D. Refining of Extracted Oil

(i) Preparation of Clay

The clay was ground and sieved using sieve machine of mesh 250-micrometer size, the clay was then mixed with water to remove dirt and stone particle. The clay was activated; 2M hydrochloric acid was added to clay slurry in a round bottom flask. The mixture was boiled for 1 hour 30 minutes at a temperature of about 120°C after which the mixture was washed with distilled water to remove the acid. The recovered clay was dried in the oven for 2 hours at a temperature of 100°C and later ground.

(ii). De-gumming

The extracted oil was de-gummed by addition of boiled water. The mixture was allowed to stand in a separating funnel for 5 minute with agitation and allowed to cool. The gum and water was removed. The procedure was repeated to remove the gum completely from the oil.

(iii). Neutralization

About 50g of de-gummed oil was poured into a beaker and heated at 90°C with 35ml of 1M NaOH which was constantly stirred. This was transferred into a separating funnel and allowed to stand for 2 hour. The soap formed was separated from the oil. Hot water was added repeatedly to oil solution until the soap in the solution was removed leaving the neutral oil which was later poured into a beaker.

(iv). Bleaching

The neutralized oil was poured into a beaker and heated to about 80°C. 7g of the activated clay was poured into a beaker; the mixture was stirred for 30 minutes. The temperature was allowed to rise to 100°C for 30 minutes. The content was then filtered hot.

H. Evaluation of Extracted Castor Oil

(i) Determination of Iodine Value

The method specified by International standards organization (ISO) 3961 (1986) was used. 0.4g of the sample was weighed into a conical flask. 20ml of carbon tetrachloride was added to dissolve the oil and 25ml of dam's reagent was added to the flask using a pipette in a fume chamber. Stopper was inserted into the flask and the content was vigorously swirled. The flask was then placed in a dark for 2 hour. At the end 20ml of aqueous potassium iodide and 120ml of water was added. The content was titrated with 0.1M sodium thiosulphate solution until the yellow colour almost disappeared. Few drop of 1% starch indicator was added and the titration continued until blue coloration disappears at constant shaking.

(ii) Determination of pH Value

30ml of the sample was poured into a cleaned dried beaker and 13ml of hot distilled water was added to the sample and stirred to 5°C slowly.

The pH probe was standardized with buffer solution and probe inserted into the oil, the pH value was then determined.

(iii) Determination of Saponification Value

3g of the sample was weighed into a conical flask, 30ml of 0.1M ethanolic potassium hydroxide was added to the sample. The mixture was allowed to boil for 70 minutes with constant shaking. A reflux condenser was then placed on the flask containing the mixture. Few drop of phenolphthalein was added to the warm solution and then titrated with 0.5M hydrochloric acid until the pink colour of the indicator just disappeared. The same procedure was used for other samples and a blank solution.

(iv) Determination of Acid Value

2ml of diethyl ether was mixed with 25ml of ethanol in a 250ml beaker. The mixture was poured on 10g of oil in a 250ml conical flask and few drop of phenolphthalein indicator was added to the mixture. The mixture was titrated with 0.1M NaOH with constant shaking until a dark colour was observed and the volume of 0.1M NaOH (V_0) used noted.

(v) Determination of Specific Gravity

Density bottle was used to determine the density of the oil. A cleaned, dried bottle of 25ml capacity was weighed (M_0). It was filled with the oil then the bottle and its content and re-weighed to give (M_1). The oil was substituted with water of the same volume and re-weighed to give (M_2).

(vi) Determination of Refractive Index

Refractometer was used in determining the refractive index of the oil, few drop of the sample was placed on glass slide of the refractometer. Water at 300°C was circulated around the glass slide to keep its temperature uniform. The refractometer was viewed through the eyepiece; the dark portion viewed was adjusted to be in line with the intersection of the cross. At no parallax error, the pointer to the scale pointed on the refractive index. This procedure was repeated and the mean value was taken.

(vii) Determination of Viscosity

The sample was filtered through a sintered glass (fine mesh) to eliminate solid materials in the liquid oil. The viscometer was charged with the oil by inverting the tube's thinner arm into the oil and suction force was drawn up to the timing mark of viscometer. The instrument was then turned to normal vertical position.

The viscometer was placed into a holder and inserted into a constant temperature bath set at 27°C. A period of 5 minutes was given to allow the sample attain the same temperature of the bath. The suction pressure was applied to the thinner arm to draw the liquid level above the upper timing mark. The afflux time the oil as it flows freely from the upper timing mark to the lower timing mark, and the reading was recorded.

III RESULT AND DISCUSSION OF RESULT

A. Results

TABLE 1 PERCENTAGE VOLUME OF OIL EXTRACTED

Weight of sample		Weight of oil extracted (g)	% oil extracted
Before extraction (g)	After extraction (g)		
35.5	28.87	8.63	24.31
30.0	21.68	8.32	27.73
25.0	16.45	8.55	32.2
20.0	13.10	6.9	34.5

TABLE 2 COMPARING THE PHYSICAL PROPERTIES OF REFINED OIL AND STANDARD VALUE.

Property	Refined castor oil	Standard value
Viscosity at 25°C	6.5847st	6.3 - 8.8st
Refractive index 27°C	1.469	1.473 - 1.477
Specific gravity	0.9584	0.958 - 0.968
Boiling point	316°C	313°C

TABLE 3 COMPARING THE CHEMICAL PROPERTIES OF REFINED OIL AND STANDARD VALUE.

Property	Refined castor oil	Standard value
Iodine value	84.86	81 - 91
Acid value	0.861mg NaOH/g of oil	0.4 - 4 mg NaOH/g of oil
Saponification value	182.73mg KOH/g of oil	176 - 187 mg KOH/g of oil
pH value	6.3	-

B. Discussion of Result

The result obtained for moisture content was 4.7%. This shows deviation from report of Weiss (1983) who reported the moisture content of the range of 2.3 – 3.7% for some varieties. This result may depend on the rate of drying or the variety of the seed. The result obtained for the percentage oil content for different weights of sample extracted within the same period showed that the smaller the sample the higher the percentage of oil extracted. For instance with 30g, 24.3% of oil was obtained, with 20g, 34.5% of oil was obtained. The result was tabulated in Table 1. The total percentage oil content was found to be 32.1%. This result shows deviation from the literature value of 50 – 55%. This may depend on the variety of seed used; hence different varieties contain different percentage oil content. It may also depend on the method of extraction. Fellows in 1996 reported that the most efficient method of extraction was screw press expeller or combination screw press expeller and solvent extraction, which yielded more oil.

Table 3 shows the comparison between physical properties obtained during research work and the standard value (ASTM). The viscosity value obtained was 6.5847st. This falls within the range of the standard value found in the literature 6.3 – 8.8st found.

The refractive index obtained during the research work was 1.469, this result deviate a little from the result reported in Table 3 for standard value which was 1.473 – 1.477. This deviation may be as a result of impurity present in the oil. The result of specific gravity obtained during the research work was 0.958, this result fall within the range of the standard value 0.958 – 0.968 shown in table 3. The boiling point obtained was 316°C; the value shows deviation from the standard value, which was

reported to be 313°C., this deviation may be as a result of some impurities contained in the oil.

Table 2 shows the comparison between the evaluated chemical properties obtained during the research work and the standard value, reported in the literature. The iodine value obtained was 84.86 compared to the result of the standard value, which was 81 – 91. This result is within the range and reflects the amount of iodine that can be absorbed by unsaturated acid. The oil could be classified as non-drying oil, since the iodine value is lower than 100. This unique property makes it possible for castor oil to be used as lubricants and hydraulic break fluids.

Saponification value obtained was 182.793mg KOH/g of oil. The value still falls within the range of standard value, which was reported in Table 3 to be 176 – 187 mg KOH/g of oil.

The acid value obtained was 0.86mg NaOH/g of oil. This value is higher than the standard value. This may be as a result NaOH used during the refining.

IV. CONCLUSION

The percentage of oil content extracted was 32.1%. This result is far below the value found in the literature. Combined method of solvent extraction and continue screw press expeller, yield more oil from the seed. The castor oil extracted is evaluated; it gives viscosity value of 6.5847st, specific gravity of 0.9584, refractive index of 1.469 at 27°C, boiling point of 316°C, acid value of 0.861 iodine values of 84.86, and saponification value of 182.79. Most of these values fall within the range of the standard specification values of ASTM except boiling point. Since the oil extracted is not solvent free, it cannot be used for cosmetics.

However, the refined castor oil could be suitable for industrial purposes to produce other material that does not have direct

contact with the skin e.g. lubricating grease, printing ink, hydraulic fluid etc.

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