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Experimental Study of Castor Oil from Plant Seed *Ricinus Communis*: Extraction and Chemical Modification

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KEYWORDS

Castor beans, Specific gravity, pH, Acid value, Viscosity, Saponification Value

ABSTRACT:

Background: In this research we have prepared sulphonated castor oil or Turkey red oil, by the continuous addition of concentrated sulphuric acid to castor oil with continuous stirring for 3 h at a temperature of 25-30 °C. Since this continuous reaction is stoichiometry, there is no formation of waste product, thus eliminating any consequences related pollution.

Objectives: This research paper is carried out by experimental study of castor oil, through extraction of oil from castor beans, characterization and chemical modification of extracted castor oil.

Methods: The n-hexane or petroleum ether was used as a solvent for the extraction process. After extraction the castor oil was purified through degumming, neutralization and bleaching process using adsorbent activated clay. The extracted oil was chemically modified to produce Turkey red oil with the help of sulphonation reaction.

Results: The physico-chemical analysis revealed that all the physico-chemical properties of the extracted oil such as pH, acid value, iodine value, saponification value and specific gravity, viscosity, have almost similar values. In case of sulphonated castor oil the parameters like specific gravity, pH, iodine value, and acid value shows slight increase with respect to the standard values as per Indian Pharmacopoeia (IP), whereas viscosity value has slight decrease. Remaining all parameters like reaction time, color of product and solubility were similar.

Conclusions: The synthesized sulphonated castor oil (Turkey red oil) could be valuable as additive in food industry (as excipient or additives), cosmetics (as a pigment remover), and in pharmaceutical industries as coating agent, polymer, antifungal agent, laxative, immunity booster, etc.

1. Introduction

Vegetable oils [1] play an important role in the production of the national economy because seed oils bring great benefits to human existence and reduce the burden on people's lives today. Castor seed oil belongs to the vegetable oil family [2]. Generally, vegetable oils or fats are common plant-derived lipid substances that are physically found to be in a liquid state at room temperature, whereas fats are in a solid state at room temperature [3]. Vegetable oils are composed of triglycerides that do not contain glycerin in their structure [4]. Many commodities from plant sources such as soybeans [5], rapeseed [6], palms [7], corn [8], jatropha [9], and castor seeds [2] have been considered petroleum candidates. Among these sources, castor oil is a potentially promising raw material as it is known

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among vegetable oils for its high concentration of ricinoleic acid [10] (85 % or higher). Castor seed oil contains high percentage of fatty hydroxy acids as compare to any other seed oil [11]. Castor oil is the thickest oil compared to other vegetable oils [12].

India is the largest producer of castor oil all over the world and is in demand around the world. India produces nearly 7, 50,000 tonnes annually, that accounts about 60 % of the world's total production. In essence, all generations of castor oil in the United States have been deployed by a combination of economic variables, allergic reactions from field and preparation experts, and the toxic quality of seed milling. The destructive interior of castor seeds, known as ricin [13, 14], is extremely dangerous to humans, and chewing two or three castor can kill humans. Due to the huge importance of vegetable oils in industry, pharmaceuticals, nutrition and even the restoration industry, it is important to produce more oil from castor bean. *Ricinus communis (R. communis)* [13, 14] has many advantages such as renewable-ness and environmental friendliness, and can be produced in areas where modern energy is needed (rural areas). The essential use of castor oil is an integral part in the preparation of nylon 11 [15], plasticizers [16], sebacic acid [17], and lubricants of jet engine [18]. Castor oil has excellent lubricant property that increases friction compared to other natural (vegetable) and synthetic (petroleum-based) oils [19].

Castor seed oil is an important organic raw material and has been used to produce more new bio-chemicals or materials than any other vegetable oil [14]. Previously, the use of castor oil was primarily limited to the production of lamp oils, lubricants and pharmaceuticals. However, a better overview of the chemical structure has extended its use and produced more by-products that are beneficial to humans. Castor oil is widely used in the treatment and management of various diseases in health-related fields such as medicine as it possesses anti-inflammatory activity. Castor products are used to treat acute problems such as menstrual cramps, gastrointestinal infections, athlete's foot, sunburn and labor. It also possesses laxative property and is suitable for the treatment of constipation. In Nigeria, the detoxified castor beans are being used as a spice and are useful substances for human vision [19].

2. Material and Methods

Collection of castor beans

The seeds of castor plant (*R. communis*) were collected from various localities of Nadaun, Hamirpur (H.P). The collected seeds were dried under shade at room temperature for about a time interval of 4-5 days. After that the seeds were grinded to make fine powder. This seed powder was used for further studies.

Extraction of castor oil by using Soxhlet apparatus

First collection of castor fruit from castor plant, then peel the castor fruits and collect the seeds. Clean the seed and dry them under the sun.

- ❖ Extraction of castor oil was performed by using Soxhlet extractor assembly shown in Fig. 1.
- ❖ Approximately 300 mL of petroleum ether as solvent was placed into round bottom flask (RBF).
- ❖ 10 g of dried powder of castor beans was packed in thimble and placed in the extraction assembly.

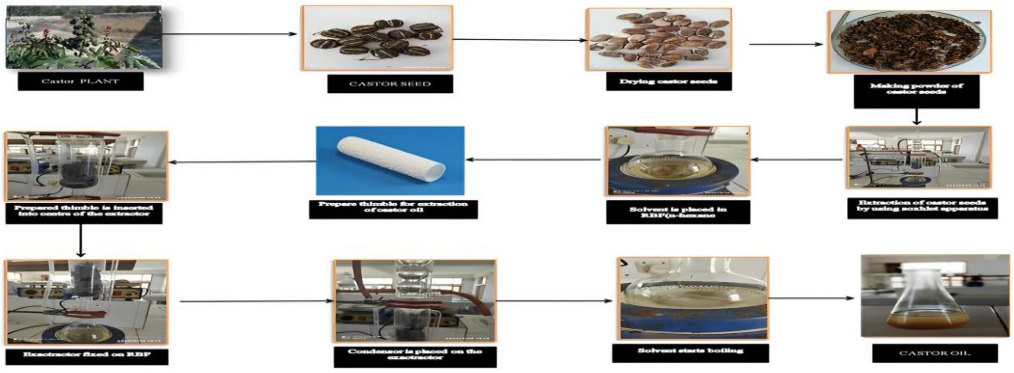

Fig. 1: Laboratory setup for the extraction of castor oil

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❖ The RBF and the extract fixed to the condenser were placed on top of the extractor.
❖ Then the assembly was fitted to heating mantle and temperature was maintained between 50-60 °C to bring the solvent to a boil.
❖ After reaching to a certain temperature, the steam rises from the vertical to the condenser.
❖ Extraction process is continued for about 8 h.
❖ Then the solvent-containing extract is freed from solvent by using Rota-evaporated and the total yield of extracted oil [20].

Characterization of castor oil

The characterization of raw castor oil includes physical and chemical tests. The tests were carried out in the college premises in the department of pharmaceutical chemistry. The entire tests were performed at 20 °C and 60 % relative humidity [21].

Phyto-chemical analysis of the chemical constituents

The solvent extract was prepared in n-hexane at room temperature. 10 g of dried seeds powder was mixed with 100 mL of the solvent (n-hexane) in 250 mL conical flask and plugged with cotton. The flasks containing different extract were magnetically stirred for at least 5 h. After that the sample were filtered and centrifuged for 15-20 min at 5000 rpm. The supernatant liquid was filtered, and evaporated using rotary evaporator (45 °C). The polyphenolic compositions of the castor seeds (alkaloids, flavonoids, glycosides, saponins, and tannins) were carried out.

Modification of castor oil by sulphonation process

Sodium hydroxide was taken in a 500 mL beaker for the preparation of 1 N solution. The catalyst was added to the beaker containing 1 N solution of sodium hydroxide. The catalyst was used in the concentration of 1 % of castor oil which we are using in the reaction. The measured quantity of castor oil was added slowly to the beaker containing the catalyst and sodium hydroxide. The reaction mixture was allowed to stir at 1000 rpm on magnetic stirrer. After that sulphuric acid was added drop wise to the beaker. The reaction was stirred for about 2 to 3 h. The reaction was allowed to cool at 20 to 25 °C. When the reaction mixture is totally mixed up, the color of the solution becomes reddish brown. Then the resultant mixture was transferred to a separating funnel. The reaction mixture took whole night time for separation process. After the separation was done, the solution was separated as two layers [22, 23]. The upper layer in the separating funnel was the sulphonated castor oil (Turkey red oil) and lower layer was aqueous layer shown in Fig. 2.

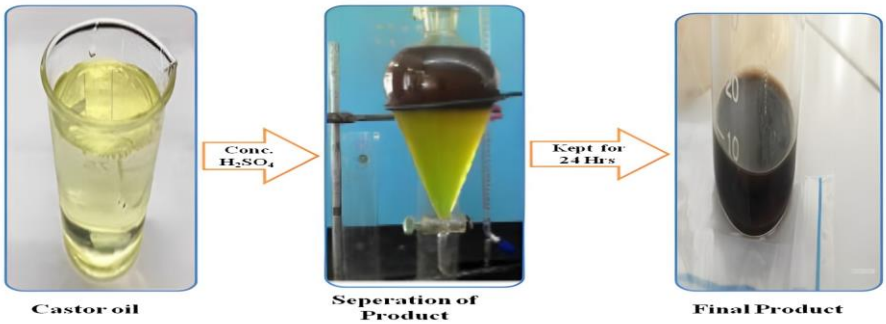

Fig. 2: Synthesis of Turkey red oil

Characterization of Sulphonated Castor oil

The characterization of sulphonated [24, 25] castor oil includes physical and chemical tests. The tests were carried out in the college premises in the department of Pharmaceutical chemistry. All the tests were performed at 20 °C and 60 % relative humidity.

3. Result and Discusssion

Results obtained for various test performed on the extracted castor oil and sulphonated castor oil are tabulated below (Table 1-4):

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Table 1. Amount of castor oil obtained after extraction

Sr. No.	Amount of castor beans used (g)	Amount of solvent used (mL)	Total amount of oil extracted (g)	Average (g)
1	10	300	9.0	
2	10	300	9.2	9.1
3	10	300	9.0	

Table 2. Physico-chemical characterization of Indian castor oil

Sr. No.	Parameter	Standard sample (IP)	Marketed sample (Royal castor products ltd.)	Extracted castor oil
1	Specific gravity kgm^{-3}	0.946	1.001	1.596
2	Viscosity at 25 °C (poise)	6-8	7-8	7-8
3	pH	6.0-8.1	6.0-8.0	6.2-7.9
4	Acid value	1.854	1.56	1.20
5	Alkaline impurities	0.13	0.15	0.75
6	Iodine value	86.5	88	76.55
7	Extraction time (h)	8	8	8
8	Reaction temperature (°C)	25-30	25-30	25-30
9	Solubility	n-Hexane, Methanol	n-Hexane, Methanol	n-Hexane, Methanol
10	Color of the product	Pale Yellow	Pale Yellow	Pale Yellow

Table 3. Phyto-chemical analysis of Castor seed extract

Sr. No.	Identification test	Procedure	Observation	Identification test
1	Steroids and triterpenoids (Salkowski test)	Extract + chloroform + conc. H_2SO_4	Reddish brown color	Steroids and triterpenoids (Salkowski test)
2	Tannins ($FeCl_3$ test)	Extract + distilled water + boil + ferric chloride	Bluish black color	Tannins ($FeCl_3$ test)
3	Protein	Extract + Biuret reagent	Violet or pink color	Protein
4	Saponins (foam test)	Extract + distilled water, shake it	Foam appearance	Saponins (foam test)
5	Flavonoids	Extract + few drops of $AlCl_3$	Yellow color	Flavonoids
6	Cardiac glycosides	Extract + Ferric chloride (3.5 % solution) + Glacial acetic acid + 2 mL of conc. H_2SO_4	Reddish brown ring at inter phase	Cardiac glycosides
7	Reducing sugar	Extract + 5 mL of Fehling solution A and B (1:1), boiled for 5 min	Reddish brown color	Reducing sugar
8	Indole alkaloids	Extract + conc. H_2SO_4 + potassium dichromate	Color change	Indole alkaloids
9	Phlobatannins	Extract + dil. HCl	Red ppt	Phlobatannins
10	Coumarin	Extract + NaOH	Yellow color	Coumarin

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Table 4. Physicochemical characterization of sulphonated Indian castor oil

Sr. No.	Parameter	Standard sample (IP)	Extracted sample
1	Specific gravity kgm^{-3}	0.96	1.40
2	Viscosity at 25 °C (poise)	192	185
3	pH	7.24	8.5
4	Acid value	0.20	0.31
5	Iodine value	68	77
6	Reaction time (h)	3	3
7	Reaction temperature (°C)	25-30	25-30
8	Solubility	Miscible in water	Miscible in water
9	Color of the product	Brownish red color	Brownish red color

4. Conclusion

In the present research work, chemical modification of castor oil was carried out by extracting castor oil with petroleum ether and n-Hexane. The extracted oil was then further investigated for physico-chemical properties. On interpretation of the physico-chemical properties such as pH, acid value, iodine value, saponification value, specific gravity, and viscosity, it has been observed that all the physicochemical properties showed almost similar values.

Whereas in case of sulphonated castor oil the parameters like specific gravity, pH, acid value, and iodine value shows slight increase with respect to the standard values (IP), whereas viscosity value has slight decrease. Remaining all parameters like reaction time, color of product and solubility were similar. Thus the above investigation indicates good quality of the product that can be used as an additive in food industry (as excipient or additives), cosmetics (as a pigment remover), and in pharmaceutical industries (coating agent, polymer, antifungal agent, laxative, immunity booster, etc). The results also suggest that sulphonated castor can be used extensively as biodiesel and fuel.

Conflict of interest

Regarding the publication of this article, the authors declare that there are no conflicts of interest.

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