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Physicochemical Characterization and Evaluation of Castor Oil (*R. communis*) for Hair Biocosmetics

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Abstract: This study reports the characterization of oil from Castor (*Ricinus Communius L*) seed oil. The biocosmetic potential of the castor oil was evaluated for hair through physico-chemical characterization. The various physicochemical parameters (iodine value, pH value, specific gravity, refractive index, peroxide value, etc) were tested in accordance with American standard testing method specifications and compared with argan oil. Accordingly, the parameters tested comply with some journals dealing with cosmetics. Biocosmetic has high potential as a raw material for synthetic cosmetics or blend stock substitution for cosmetics without any modification. The advantage of castor oil over other oils (sunflower, olive, soy bean, corn) would lie in the oil price.

Keywords: Caster Oil, Castor Beans, Biocosmetic, Nonedible Oil, Soxhlet Extractor, Argan Oil

1. Introduction

History tells us that, a long time ago, plants and plant products have been used as the primary source of food, shelter and transport materials, clothing, fragrances, flavors and ingredients of medicinal substances for humankind [1]. Today plant products, essential oils, plant extracts, natural resins and their preparations have a wide range of applications mainly in perfume and cosmetic, food, aroma and pharmaceutical industries. This large spectrum of uses therefore stimulated researchers to conduct some studies on natural products [2]. The methods used in the analysis of plants that started at the end of the 19th century, only allowed investigations on crystalline constituents isolated from these extracts. Subsequent developments on vacuum distillation techniques provided the possibility to determine the volatile components of these extracts [3].

Oil extracted from plant sources has a rich history of use by local people as a source of food, energy, medicine and for cosmetic applications. It has been used in the production of lubricants, soaps and personal care products, as well as in the topical treatment of various conditions such as hair dandruff, muscle spasms, varicose veins and wounds [4, 5]. In recent years, demand for seed oils as ingredients for food, cosmetics has greatly increased as industry seeks natural alternatives.

During the last century, synthetic substitutes have become available and have been used to replace natural seed oils. Due to toxic effects of synthetic oils, there is a growing trend to replace them and revert to the use of natural oils in the cosmetic and pharmaceutical industries [6]. There is increasing consumer demand for high-quality cosmetic products of natural origin which industry is responding to. Natural oils are ideally suited to satisfy this need due to their high fatty acid content.

In this study, the use of castor oil obtained from castor seed for Biocosmetics will be evaluated through its physicochemical parameters because castor seed is economically viable and it is easily obtained from the local market.

Castor oil is plant oil derived from the castor bean. Although it's often thought of as an unpleasant laxative, castor oil has beneficial uses for the hair and skin. Despite being oil, it actually has cleansing and antibacterial properties that make it a popular ingredient in soaps and it can be used alternatively to benefit the skin and hair [1].

It is also a component in a facial cleansing routine called the oil cleansing method, which is considered an alternative to traditional skin-care regimens. The theory behind the oil cleansing method is that "washing" the face with oils will help get rid of dirt and oil better than washing with soap and

water, because oil dissolves other oil more effectively. Although this theory has not been scientifically proven, the oil cleansing method may be worth a try if you're unsatisfied with your current skin-care products. Castor oil is used due to its cleansing and anti-inflammatory properties, but may actually dry out some skin types; to clean your skin with the oil cleansing method, mix a small amount of castor oil with an equal amount of olive oil and massage into your skin [3].

1.1. Castor Seed

R. communis (the only species of the monotypic genus Ricinus) belongs to the Euphorbiaceae, or spurge, family, containing a vast number of plants native to tropics (where it grows wild and considered as merely a weed or as a shade-giving agent for more sensitive low growing cash crops). It is a warm-season plant indigenous to eastern Africa and probably originated in Ethiopia (UNIDO, 1974) [4].

It is herbaceous annals, with height displayed as genetically dwarf, semi-dwarf or tall ranging from one to several meters and warm region perennial (with cultivation area between 40^{o}N and 40^{o}S), but is now cultivated up to 52^{o}N. Castor can survive under rather dry conditions because of its very strong root system, its resistance to loss and its ability to withstand substantial water stress. As a peasant crop in the warmer regions of the world, castor can be grown almost anywhere if land is available, and this is perhaps its greatest virtue (the castor plant can be considered as an easily cultivated, adaptable cash crop, on well drained soils in frost-free seasons. It grows best in areas with clear sunny days and without untimely frosts. In such circumstances, it grows from sea level at the coast to high inland mountains. One of the reasons that castor plants have become so successful is their extremely viable seed that germinates readily in a variety of soils. More often castor is inter-planted with crops, sown round the borders and margins of fields on areas unsuitable for other crops [4].

Varieties of castor should be grown at distances of at least 30 m from each other, since it is subject to cross pollination, and that open pollination may cause differences in the size and degree of maturity of the pods and seeds formed on the same plant. The most favorable rate of annual rainfall requirement is from 500 to 800 mm (UNIDO, 1974) and any altitude from sea level to 1500 masl. The plant can grow well on very poor soil; whilst a very fertile soil may even render a lower yield of seed (chemical fertilization for castor is not normally recommended).

The common seed yield was from 1000 to 1,500 kg per ha, while new varieties obtained with yield of 5,000 to 6,000 kg per ha and 50 to 52 percent oil content. The castor meal is poisonous, since it contains the toxic protein ricin, the effect of which drives from dissolution of erythrocytes, it is even more poisonous than hydrocyanic acid. The unique characteristics of castor derives from it is nearly 90% ricinoleic acid ($C_{17}H_{32}OHCOOH$) content. It has highest viscosity and highest density of all oils (UNIDO, 1974). Castor has numerous industrial uses, namely; for production of paints, and varnishes, nylon type synthetic polymers, resins and lubricants, cosmetics, textile dyeing, insecticides, in leather industry as well as for medicinal purposes-as a laxative. Leaves of the castor plants have been used for feeding silkworms and cattle, as human food (where fresh green food is scarce), the branches and stem can be used for the production of low grade paper as well as for fuel. The residual meal after oil extraction contains 5% nitrogen that used as a fertilizer, and 30-45% protein that, if detoxified, can be used as a feed [3].

1.2. Castor Oil and Its Uses

Castor oil (*ricinus oil, phorboyl, tangantangan oil*) is natural oil derived from the seeds of the castor bean by cold pressing (for medicinal use) or hot pressing (for industrial purposes). Chemically, castor oil is a triglyceride characterized by a high content of ricinolein (a glyceride of 12-hydroxy-9-octadecenoic acid). It has the approximate fatty acid composition of ricinoleic acid (87%), oleic acid (7%), linoleic acid (3%), palmitic acid (2%), stearic acid (1%), with trace amounts of dihydroxystearic acid. As a home remedy, castor oil is used widely for a number of problems and ailments. To name a few, castor oil helps deal with problems related to hair, skin, joints and intestine. Edgar Cayce, a medical intuitive, recommended castor oil packs for treatment of many problems and played a vital role in making castor oil popular in 1940s and 1950s [7].

Figure 1. *Castor oil (right) from caster seed (left).*

1.3. Castor Oil for Hair

The use of castor oil for hair has its roots in ancient Egypt, according to the e-museum at Minnesota State University. Egyptian women used castor oil, along with rosemary, sweet almond and fir oils, to stimulate hair growth due to its fatty acid and Vitamin E content. When applied on hair and scalp it charges up blood circulation and frees the scalp of any bacterial and fungal infections and dandruff. The usage checks hair loss and split ends. The oil traps the moisture of the hair and prevents it from becoming dry. The same theory comes into force when castor oil is applied on eyebrows. Topical application of castor oil helps in thickening of eyebrows. Today, it's recommended in a manual on African children's skin and hair care from the University of Pittsburgh. In infants of African descent, castor oil can be used as a hair conditioner; apply after shampooing and comb through with a soft-bristle baby brush [5, 6].

1.4. Castor Oil as Laxative

Castor oil is known for its laxative benefits. When taken orally, ricinoleic acid gets released in the intestine and then it starts functioning as a laxative. Its hotness initiates action by digesting the undigested food residue and cleanses the system by helping in proper bowel movement. Many women tend to complain about constipation after delivery. If they consume castor oil prior to going to bed at night, the acid helps in proper bowel movement [6].

1.5. Castor Oil for Skin

Application of castor oil on skin keeps it hydrated and free from infections, thus a remedy for acne. It is also used to do away with dry skin of hands and legs. It is used to treat ringworms and clear away stretch marks formed after delivery. Regular use helps in keeping off wrinkles. Using the oil locally treats painful cracks in nipples. It also heals cuts and wounds. It can come into help to treat severe cases of diaper rash in babies.

Castor oil is considered minimally toxic when administered orally to humans; the estimated lethal oral dose is 1-2 pints of undiluted oil. Several instances of sensitization to castor oil in cosmetics have been reported, including an allergic reaction to a make-up remover, and contact dermatitis caused by use of a lipstick containing castor oil. Hypersensitivity reactions such as angioedema, rhinitis, asthma, and scarlatiniform rashes have been reported in factory workers involved in the extraction of castor oil, or in association with ingesting it [6].

1.6. Physicochemical Properties of Castor Oil

1.6.1. Iodine Value

The iodine value of an oil or butter is a measure of the saturation of the fatty acids. As we go up on the iodine value scale, we'll see more double bonds or more unsaturation in the oils. Something like coconut oil, which has a high degree of saturated fatty acids, will have a lower iodine value (10.4) than grape seed oil (135) and caster seed oil (above 100) which have a lot of unsaturated fatty acids. For the most part, looking at the iodine value of your oil or butter can give you a lot of information about its shelf life. The lower the iodine value, the longer this oil is likely to last [7].

1.6.2. Saponification Value

High saponification value indicated that oils are normal triglycerides and very useful in production of liquid soap and shampoo industries. Saponification number represents the number of milligrams of potassium hydroxide or sodium hydroxide required to saponify 1g of fat under the conditions specified. It is a measure of the average molecular weight (or chain length) of all the fatty acids present. The long chain fatty acids found in fats have low saponification value because they have a relatively fewer number of carboxylic functional groups per unit mass of the fat as compared to short chain fatty acids [8].

1.6.3. Refractive Index

The refractive index of fats and oils is sensitive to composition. The refractive index of a fat increases with increasing chain length of fatty acids in the triglycerides or with increasing unsaturation. This makes it an excellent spot test for uniformity of compositions of oils and fats. Further, the refractive index is an additive as well as constructive property, thus it can be used as a control procedure during hydrogenation processes [1].

1.6.4. Acid Number

To maintain healthy skin, achieving a slightly acidic pH of around 5.5 is critical. When we wash our skin with water (typically pH 6-9) or cleansing products (typically pH 7-11), pH of the skin's surface raises, and it takes time for the skin to restore its protective "Acid Mantle". Therefore it is recommended to use skin care products with acidic pH value (typically pH 3-6) that help to restore this natural defense mechanism quicker. For the body it is usual to apply skin moisturizing creams or lotions. Facial skin tends to be more sensitive, more severely impacted by the environment (sunlight, cold/hot air, wind, pollution etc) and more inclined to develop breakouts, impurities or inflammations. Therefore, it is recommended to apply toner (typically pH 3-5) after cleansing that normalizes the pH of the skin and acts on individual skin-type related problems like dryness, oiliness, sensitivity etc. Moisturizing product is applied after the toner to ensure enough supply of moisturizing, nourishing and antioxidant ingredients to the skin [10].

1.6.5. Peroxide Value

Oxidation is the most important cause of oil and fat deterioration. The primary lipid oxidation products are hydroperoxides, which are very unstable and further react to form secondary products such as hydrocarbons, alcohols, ketones and aldehydes, which can be oxidized to carboxylic acids [5, 6]. The peroxide value is useful in monitoring the initial stage of oxidation, because primary oxidation products are measured [7]. The changes in fats and oils after heating or frying procedures have been the subject of numerous studies and experimental investigations [8]. All chemical changes of fats and oils at elevated temperatures originate in oxidation, hydrolysis, polymerisation, isomerisation or cyclisation reactions [9; 10]. These reactions affect the sensorial, nutritional and safety properties of oil [11]. All these reactions may be promoted by oxygen, moisture, traces of metal and free radicals [12]. Several factors, such as contact with air, temperature and length of heating, type of vessel, degree of oil unsaturation, and the presence of pro-oxidants or antioxidants, affect the overall performance of oil [13].

2. Experimental Method

2.1. Extraction of Oils from R. communis Seeds

2.1.1. R. communis Seeds Preparation for Extraction

The castor seeds used for this work were purchased from a market at Arba Minch town of the SNNP State of Ethiopia. *R.*

communis seeds had some foreign materials and dirt which was separated by hand picking. The cleaned seeds were sun dried in the open, until the casing splits and sheds the seeds. The beans were further dried in the oven at 60°C for 7hrs to a constant weight in order to reduce its moisture content, which was initially at about 5 to 7%. 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. The seeds were crushed into a paste (cake) with mortar and pestle in order to weaken or rupture the cell walls to release *R. communis* fat for extraction.

2.1.2. Castor Seed Oil Extraction

10g of the paste (cake) sample was taken for extraction in laboratory scale, as per the following procedure. The grounded (finely powdered) sample was dried for 7h at 40°C. For the continuous extraction of the oil, the soxhlet apparatus was employed and 200 mL hexane was used as solvent in the extraction process. The soxhlet device temperature was adjusted at 60°C and the overall process lasted 24h. At the end of the process, the oil was separated from the organic solvent using a rotary vacuum evaporator, dried at 60°C and weighed. Yield was calculated on dry weight basis.

2.1.3. Characterization of Castor Oil

i Determination of the Castor Oil Content (% w/w)

Oil extraction was conducted at the Arba Minch University, Chemistry laboratory. Soxhlet extraction method (Horowitz, 1984), was used with n-hexane as extracting solvent. Each extraction was preceded for 4 hrs. It was then removed from the apparatus, cooled in the desiccators and solvent removed using Rotavapor (BUCHI). The experiment was conducted in triplicate. The weight of oil extracted was determined for each replicate, and the mean value was recorded and the percentage of oil extracted was determined using (Eq 1). Sample weight was taken dry base, based on the moisture content determined and the data was tabulated.

$$\text{Seed Oil Content} = [\text{Wo}/\text{Ws}] \times 100\% \quad (1)$$

Where, W_o = Weight of oil extracted,

W_s = Weight of sample (dry base),

% of Hexane recovered= remain hexane (mL) / volume used for extraction *100.

ii Determination of Iodine value (IV)

Wij's Method was applied to determine IV (Lawson, 1985). The weighed amount (0.25 g) of substance (W) was dissolved in 15 mL carbon tetrachloride in a conical flask. 25.00 mL of 0.2N Wijs solution (prepared by dissolving 9g of iodine trichloride in a mixture of 700 mL glacial acetic acid (purity at least 99%) and 300 mL carbon tetrachloride) was added from a burette. The flask was closed, mixed, and allowed to stand in the dark at about 20°C for 1hr. After standing, 20 mL potassium iodide solution and approximately 150 mL water were added. The iodine liberated by the process was titrated with sodium thiosulphate solution while shaking and starch indicator was added towards the end of titration (and volume Va was recorded). Blank determination was made with the same quantities of reagents at the same time and under the same conditions (and volume V_b was recorded). Finally the iodine value (IV) was calculated using

$$\text{I.V.} = \frac{12.69 \times \text{N} \times (\text{Va} - \text{Vb})}{\text{W}} \quad (2)$$

Where, W = weight (g) of sample taken.

Va =Volume (mL) of thiosulphate solution used in test.

Vb =Volume (mL) of thiosulphate solution used in blank.

N =Normality of thiosulphate solution.

iii Determination of Saponification Number (SN)

The SN determination was conducted by dissolving the fat or oil in an ethanol solution which contains a known excess of KOH. The solution was then heated so that the reaction goes to completion. The unreacted KOH was then determined by adding an indicator and titrating the sample with HCl (Lawson, 1985). About 40 g filtered oil (W) was weighed into a 200 mL conical flask with an accuracy of 1mg. 50 mL of 0.5 N ethanolic potassium hydroxide solution was added to the cold oil and the reflux condenser attached to the flask. The mixture was heated, and as soon as the ethanol boils, the flask was occasionally shaken until the oil was completely dissolved, and the solution boiled for half an hour.

After the oil was completely dissolved, 1mL phenolphthalein indicator was added and the hot soap solution obtained was slowly titrated with 0.5N hydrochloric acid (and volume Va was recorded). And a blank determination was carried out upon the same quantity of potassium hydroxide solution at the same time and under the same conditions (and volume Vb was recorded). The final result was calculated using.

$$\text{S.N.} = \frac{56.1 \times \text{N} \times (\text{Va} - \text{Vb})}{\text{W}} \quad (3)$$

Where, W = weight (g) of oil taken.

V_a= Volume (ml) of hydrochloric acid used in test.

V_b= Volume (ml) of hydrochloric acid used in blank.

N = Normality of hydrochloric acid.

iv Determination of Cetane Number (CN)

Determinations using empirical formulas (Kalayasiri et al., 1996) using the results for Saponification number (SN) and Iodine value (IV) of oils, the CN was calculated with the help of:

$$\text{CN} = 46.3 + \frac{5458}{\text{SN}} - 0.225 \times \text{IV} \quad (4)$$

v Determination of Specific Gravity (SG)

The sample was filled into graduated cylinder (250 mL) and its temperature was recorded. Hydrometer was used to measure the SG of the fuels specified. Then, temperature correction factors (according to tables from (ASTM D 1250-80, 1980; Petroleum Measurement Tables, 1963)) were applied to convert the measured specific gravities to the reference temperature of 60/60 °F and densities were taken at temperatures of 15°C and 20°C.

vi Determination of Moisture Content

50 g of the clean sample was weighed and dried in an oven

at 40°C for 7 hrs and the weight was taken after every 2 hrs. The procedure was repeated until a constant weight was obtained. At the end of every 2 hrs, the sample was removed from the oven and placed in the desiccator for 30 min. to cool. The weight of the sample was then recorded and the percentage moisture content was calculated from the formula;

$$\text{Moisture} = \frac{W1-w2}{w2} \times 100\% \quad (5)$$

Where W_1 original weight of the sample before drying.

W_2 weight of the sample after drying.

vii Determination of pH Value

20 mg of the sample was poured in to a clean dry 25 mL beaker and 13 mL of distilled water was added to the sample in the beaker and stirred slowly. It was then cooled in cold water bath to 25°C. The pH electrode was standardized with buffer solution and the electrode immersed into the sample and the pH value was recorded.

viii Determination of Refractive Index

Refractmeter was used in this determination of refractive index. Few drops of the sample were transferred into the glass slide of the refractometer at 25.9°C. This was done in triplicate and the mean value noted and recorded as the refractive index.

3. Results and Discussions

The castor oil was examined in order to evaluate its use as a blend stock in hair cosmetics. All properties (Specific gravity at 20°C, Acid value, pH value, Iodine value, Peroxide value, Cetane number, Moisture content) of the oil were evaluated in accordance with the laboratory test methods and the results are summarized in table 1.

Table 1. *Summary of Physico-chemical parameters and results of Castor Oil and Argan Oil.*

Parameters	Results	
	Cosmetic argan oil	Castor seed oil
Specific Gravity	0.967	1.05
Saponification Value [mg KOH/g of Oil]	-	181
Iodine Value g [I_2/100g of Oil]	87.12	80
pH value	6.1	6.0
Refractive Index	-	7.5
Moisture Content	-	5.93%
Seed Oil Content	-	47.6%
Cetane number	-	33.8

Table 1 presents the result of the yield and the physicochemical parameters of castor seed oil. The result obtained for the specific gravity was 1.05. This was in line with 0.9587 for argan oil reported by Salunke, et. al (1992) [14]. The refractive index was determined to be 7.5. This value is an indication of the level of saturation of the oil. The PH of the sample was 6.0, 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. All this physical parameters is an attribute of the oil to be used for cosmetic purposes. This can be used to check the level of oxidative deterioration of the oil by enzymatic or chemical oxidation. The saponification value of the oil was 181 mg KOH/g oil. This project reported that the castor oil is good in such an areas as soap making and in the detection of adulteration in the oil. However, it was within the range value of 156 to 185 mg KOH/g oil reported by Wejsis, (1971). The iodine value of the oil (80 wij's) shows the oil to be in the semi-drying category. This is further confirmed by the fact that the viscosity of the oil increases gradually when it is exposed to air. This is the result of the reactions of the multiple bonds present in the chemical compounds in the oil [15].

4. Conclusions

The result of the investigation carried out in the present study is in line with the result of other paper worked on similar species for similar purpose [16]. This confirms that castor seed oil can be used as an alternative cosmetic for hair, skin, etc. The oil contains fatty acid and Vitamin E which are useful for stimulation of hair growth. When applied on hair and scalp it charges up blood circulation and frees the scalp of any bacterial and fungal infections and dandruff. The usage checks hair loss and split ends. The oil traps the moisture of the hair and prevents it from becoming dry.

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