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Review Article

From Oil to Active Extracts: A Review of the Physiochemical Properties to Therapeutic Activities of *Ricinus communis*

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ABSTRACT

Castor oil, derived from the castor bean plant, has been used for centuries and is known for its wide range of medicinal and cosmetic benefits. The castor oil plant is monotypic, it can vary greatly in growth, habitat and appearance. Ricinolic acid is the major contributor of castor oil. Castor bean plant contains many secondary metabolites like tannins, glycosides, triglycerides, lignin, alkaloids, flavonoids etc., out of these alkaloids have significant role. The quality of castor oil is commonly assessed using parameters such as acid value, p-anisidine value, iodine value, saponification value and Thio-barbituric acid value. Castor oil shows different biological activities, like anti-bacterial, anti-inflammatory, anti-oxidant, anti-microbial and anti-biotic sensitivity assay. This review, therefore, encapsulates the composition of castor oil including its triglycerides, various fatty acids, and bioactive compounds along with the extraction methods, physiochemical characteristics, and biological properties.

INTRODUCTION

Plant Profile:

Scientific name: *Ricinus communis*

Synonyms: Oleum Ricini, castor oil seed, oil of palm cristi, castor bean oil

Biological source: It is a species of perennial flowering plant in the spurge family, Euphorbiaceae.

Botanical Classification:

- Kingdom: Plantae
- Phylum: Magnoliophyta
- Class: Magnoliopsida
- Subclass: Rosidae
- Order: Euphorbiales
- Family: Euphorbiaceae
- Genus: *Ricinus*
- Species: *Ricinus communis*

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Figure-1: Castor; (A) Young Castor plant; (B) matured castor capsules; (C-F) different colors and varieties of castor seeds; (G) castor oil (Akwasi Y, Sheng Y et al.,2021)

Geographical Distribution

Plant is native to India and southeastern Mediterranean Basin, Africa and now is far reaching all around tropical locales and broadly become somewhere else as a fancy plant (Sabina EP et al.,2019)

Plant description:

The castor plant, scientifically named *Ricinus communis*, is a flowering plant in the spurge family (Euphorbiaceae). Its seed is the castor bean which, despite its name, is not a true bean (Philips et al.,1999). The castor oil plant is monotypic, it can vary greatly in its growth, habitat and appearance. It is fast growing perennial shrub. It can reach the size of small tree around 12m/ 39ft and it can reach a height of 2-3 meter in a year. (Christopher B, 1996: LA Betancur et al., 2009: Odungbemi T, 2006). Castor seed is elongated, oval, ovoid and square in shape, and size is around 0.5 to 1.5 cm long. Its seed colour comprises a base colour that varies from brown or red to black, brownish yellow, grey, and white. The pattern as such ranges from fine to coarse vein-like or finely dotted to broad splotches. (Naik B.,2018: Salihu B 2014). The shape of the fruit is globe-like resembling a spiny capsule. The capsule which

encloses the seeds cracks when fully matured. (Akwasi Y, Sheng Y et al.,2021). Based on the content of anthocyanin pigmentation colour of castor leaves changes to pale green to dark red. (Sabihi et al., 2018). The flowers grow in clusters at the ends of the plant and are either green or red in colour, depending on the variety. Castor oil is a colourless or faint yellow liquid with a viscid texture, a faint and mild odour, and a taste that is initially bland but later becomes acrid and nauseating, which is obtained by crushing and mechanically pressing the seeds. (Joshi M, Waghmare S., et al 2004) It grows well at temperature around 20 °C to 25 °C and temperature lower than 12 °C or higher than 38 °C affects its germination and yield. (Severino et al., 2012; Yin et al., 2019)

Castor bean contains 40-60% of oil that is rich in fatty acid triglycerides, mainly ricinolein. It contains toxic compound known as ricin, which is present in higher concentrations in various parts of the plant, although linoleates and oleate are also other important composition of castor oil.

Ricinolic acid is the major contributor of *R.communis* oil, which is 18 carbon containing fatty acid having unsaturation at single point. Ricinolic acid is different from other fatty acid

because it holds -OH on 12th carbon atom. It has more polarity compared to other fatty acid due to the presence of -OH group. (Aplin PJ et al., 1997)

R. communis seed oil primarily consist of ricinoleic acid (85 -95%), along with smaller amounts oleic acid (2-6%), linoleic acid (1-5%), steric acid (0.5-1%), palmitic acid (0.5-1%), linolenic acid (0.5-1%), ecosanic acid (0.3-1%), dihydroacetic acid (0.3-0.5%) and other minor compounds. (Aplin PJ et al., 1997)

Castor bean plant contains many secondary metabolites like tannins, glycosides, triglycerides, lignin, alkaloids, flavonoids etc. out of these alkaloids have significant role.

Castor oil is used for making of cleansers, brake solvents, paints, nylon fibre, anti-low temperature e safe plastics, inks and colour pigments, coatings and in aroma. (Aplin PJ et al., 1997).

Castor oil is recognized as a traditional remedy for various ailments, including gas trophy such as amadosa, constipation, irritations, strangury, fever bronchitis, chest infections, skin diseases, coxalgia, colic and lumbago. Its leaves are beneficial for burns, talopia and bathing, especially in cases of rheumatoid joint swelling, arthralgia and urodynia. The flowers are useful for treating arthralgia and urodynia, while the seed are effective for aiding digestion and preparing medicinal crams for arthralgia. Additionally, the seed oil is a highly effective laxative for conditions caused by vata and is commercially utilized in the production of lubricating agents. (Warrier PK et al., 1996; McGuine N et al., 2007)

Extract preparation:

Castor oil is commonly sold as a cold pressed oil, but research indicates that other extraction methods are also used such as pressing, solvent

extraction with n-hexane, and super critical carbon dioxide (SC-CO₂). (Danlami et al., 2015a) Before carrying out extraction, seeds are first washed to remove unwanted material. Then seeds are added into decorticating machines to dehull the shells leaving the kernels. Increased efficiency in the decorticating process results in a lighter oil colour. Currently, more than 90% of castor oil is typically obtained using the solvent extraction technique. However, the high price and sustainability concerns associated with biodiesel-based solvents are major drawbacks of this technique. (Patel et al., 2016) Consequently, various alternative solvents, including ethanol and supercritical carbon dioxide (SC-CO₂), have been studied and adopted for castor oil extraction. The use of aqueous solvents has proven to be as efficient as hexane, offering the additional benefit of a low solvent requirement. Nevertheless, a significant drawback of aqueous solvents is the high energy production needed to separate the liquid from the oil. (Mutlu & Meier, 2010; Patel et al., 2016) Among the alternatives, SC-CO₂ is often preferred over organic solvents such as ethylene monomethyl ether, diethyl ketone, and methyl acetate, because it is cost effective, non-expensive and non-toxic. (Danlami et al., 2015a; Maleki et al., 2013)

Oil content in castor seeds varies widely, from 34.6% to 56.6% when extracted using n-hexane. (Panhwar et al., 2016; Sabhi et al., 2018; Severino et al 2015) This range likely results from differences in climate, geographical location, and variety type. (Severino et al 2015) A key factor influencing oil yield is the particle size of the ground seed; a size of 0.35mm or less is less desirable for maximum output. Researchers suggest that the 1mm particle size used in some studies (Danlami et al,2015a) may explain the low yields. Other operational conditions, such as temperature, time range and moisture content, also affect the final yield. Therefore, further



investigation into these specific conditions could improve castor oil seed yield with SC-CO₂ extraction, and additional studies are needed on both the extraction process and its effect on oil quality. (Danlami et al., 2015a)

Physiochemical Properties:

Throughout the literature density and refractive index of castor oil seed at 28⁰c are reported as 961kg/mg³ and 1.476, respectively (Omari et al., 2015; Torrentes-Espinoza et al., 2017). Castor oil exhibits a viscosity of 1.86 St/dPas at 30⁰c (Yusuf et al., 2015) and 9.3-10St/dPas at 25⁰c (Omari et al., 2015). Its high viscosity makes castor oil suitable for applications such as diesel fuel formulation and surface coating (Naik et al., 2018). The quality of castor oil is commonly assessed using parameters such as acid value, p-anisidine value, iodine value, saponification value and Thio barbituric acid value.

i. Iodine Value

The iodine value measures the degree of unsaturation in fats and oil, and is expressed in grams of iodine absorbed per 100grams of oil. A higher iodine value indicates greater level of unsaturation, whereas a lower value reflects fewer unsaturated bonds. In castor oil seed, the iodine value typically ranges from 83-93g I₂/100g oil (Omotehinse et al., 2019; Yusuf et al., 2015) suggesting that the proportion of iodine absorbing unsaturated fatty acids is relatively low. Since its iodine value is below 100, castor oil is classified as a non-drying oil, making it suitable for application such as hydraulic brake fluids and lubricants. The iodine value may vary among different castor varieties. For instance, Zanzibar castor seeds (ZCOH and ZCOE) grown in the same region in Saudi Arabia showed no significant difference in Iodine values (Sbihi et al., 2018). However, Imala castor seeds (ICOH and ICOE),

despite belonging to the same variety and being cultivated under similar conditions, exhibited variation in iodine value, which was attributed to difference in their PUFA content (Sabihi et al., 2018).

ii. Acid value

The acid value indicates the concentration of free fatty acids in oil and is expressed as mg KOH/g oil. It is key quality parameter, as vegetable oils with high acid values are considered poor in quality and result in greater losses during refining (Omari et al., 2015; Sbihi et al., 2018). Generally, low acid values reflect good quality oil suitable for efficient processing. Reported acid values for castor oil typically range from 0.14 to 1.97mg/g (Omari et al., 2015; Panhwar et al., 2016; Perdomo et al., 2013; Yusuf et al., 2015). However, castor seeds grown in Nigeria showed unusually high values of 14.80-15.57mg/g, likely due to poor handling and delayed processing (Nangbes et al., 2013; Omohu and Omale, 2017). According to ASTM standards, acceptable acid values for vegetable oil should not exceed 2 (Yusuf et al., 2015).

High acid value results from delayed extraction, which activates lipase enzymes that hydrolyse triglycerides into free fatty acids (Omari et al., 2015). Similar observations were reported in chufanuts, where enzymatic hydrolysis of amygdalin contributed to an acid value of 9.12mg/g (Aremu et al., 2016). Furthermore, the choice of extraction solvent affects the acid value; hexane-extracted castor oil produced higher-quality oil compared to ethanol extraction (Sbihi et al., 2018).

iii. Anisidine Value

The anisidine value (AnV) measures secondary oxidation products and is useful for assessing the stability of oils, particularly those containing non-



volatile oxidation compounds formed during frying (Schramm & McGrath., 2013). For an oil to be considered good quality, Its (AnV) should be below 2. Castor oilseed shows an AnV of 1.66meq/kgm (Sedeek et al.,2012), which is lower than values reported for cotton seed (4.45meq/kg) and jojoba oil (2.03meq/kg), indicating greater oxidative stability. A negative AnV was once reported (Yeboha et al., 2012), likely due to water inference during testing, as negative values are usual. Deep frying studies further confirmed that castor oil exhibit better AnV and overall oxidative stability compared to other tested oils (Sedeek et al.,2012)

iv. Thio barbituric acid value

Anisidine and acid values are commonly used to assess vegetable oil quality, and the Thio barbituric acid (TBA) test is another widely applied method for evaluating secondary oxidation products. The TBA value measures malondialdehyde (MDA) and related aldehydes formed during lipid oxidation (Sedeek et al., 2012). During deep frying, castor oil showed a TBA value of 0.58mmol/kg, which was considerably lower than shea butter (4.39mmol/kg) and soyabean oil (11.0mmol/kg) (Ikya et al.,2013; Sedeek et al.,2012). This low value indicates that castor oil has a longer keeping quality and under goes less oxidative deterioration.

Blending studies demonstrated that peroxide, acid, iodine and TBA values decreased when castor or jojoba oils were mixed with cotton seed oil in 9:1 and 8:2 ratios during deep-frying (Sedeek et al., 2012). The improved oxidative stability of cotton seed oil was attributed to the natural antioxidants and favourable fatty acid profiles present in castor and jojoba oils.

v. Saponification Value

The saponification value is an important chemical property used to characterize castor oil, as it reflects the molecular weight of its triglycerides. A low saponification value indicates higher molecular weight, where as a high value corresponds to lower molecular weight (Omari et al., 2015). In castor oil seed, reported saponification values range from 165.50 to 187mg KOH/g oil (Omari et al., 2015). Planting location significantly influences this parameter, with castor seeds from Morogoro showing the highest value (187.46mg KOH/g) and those from Kagera the lowest (165.50mg KOH/g). Since low saponification values suggest limited industrial suitability, the relatively high values observed in castor oil support its use in soap production and cosmetic formulations.

Phytochemical Screening

Different chemical tests were carried out on seeds oil sample by using authentic or standard method for the identification of chemical constituents.

a. Detection of Alkaloids

The detection of alkaloid was done by method which is proposed by Trease and Evans. 2 mL of oil and 1 mL of Dragon Roff's reagent was taken in China dish. Appearance of reddish-brown coloration detects the presence of alkaloid.

b. Detection of cardiac glycoside

Detection of cardiac glycosides test is also called as Keller-Kiliani test. 2.5 mL of seed oil was treated with 1 mL glacial acetic acid in a beaker. Few drops of ferric chloride were added in beaker. After that 1 mL of concentrated sulphuric acid was added, this gave a brown ring at interface. This indicates the presence of cardiac glycosides.

c. Detection of Tannins



This method was put forth by Edeoga. According to this methodology, about 1mL of oil was boiled in 20 mL of distilled water, filtration was done after boiling and then few drops of 0.1% freshly prepared ferric chloride was added in filtrate. A bluish black or brownish black colour indicates the presence of tannins.

d. Detection of Flavonoids

Appearance of yellow coloration indicates presence of flavonoids in each method. A portion of filtrate was taken in beaker and then few drops of aluminium chloride were added. A yellow colour detects flavonoids in given sample.

e. Detection of Steroids

Two mL of acetic anhydride was added in 1mL of seed oil in beaker. 2 mL of concentrated sulphuric acid was added in it. The colour changing from violet to blue or green detects presence of steroids

f. Detection of Saponins

This method was also given by Edeoga. According to this method 2mL of R. communis oil was boiled in 20 mL distilled water in water bath and filtered, after this, the 5 mL distilled water was added in filtrate and shaken for stable_froth. The frothing was mixed with three drops of olive oil, froth formation indicates the presence of saponins.

g. Detection of Anthraquinone

This detection test was given by Trease and Evans Red, pink and violet colour shows the presence of anthraquinone. According to this method, the seed oil was taken in china dish and 0.5 mL of ether was mixed well in this sample, then water was added and shaken with glass rod to detect anthraquinone.

h. Detection of Reducing Sugar

Detection of reducing sugar is also called as Fehling test proposed by Khan et al According to this method the appearance of red or violet coloration indicates the presence of reducing sugar. Seed oil (1 mL) and 5 mL of distilled water were taken in beaker and a few drops of Fehling solution was added to it and heating is required for some time to detect presence or absence of reducing sugar.

i. Gas Chromatography-Mass Spectrometry analysis

The R. communis seed oil was subjected to GC-MS analysis on a GC- MS Clarus 500 Perkin Elmer system comprising an AOC- 20i autosampler and gas chromatograph interfaced to a mass spectrometer (GC-MS) instrument employing the following conditions: Restek RtxR – 5, (30-meter X 0.25 mm) (5% diphenyl / 95% dimethyl polysiloxane), running in electron impact mode at 70eV; helium (99. 999%) was used as carrier gas at a constant flow of 1mL/min and an injection volume of 1.0 µl was employed (split ratio of 10:1); injector temperature 280 0 C. The oven temperature was programmed from 40°C (isothermal for 5 min.), with an increase of 6 0 C/min to 280 0 C, then ending with an isothermal for 15min at 280 °C. Mass spectra were taken at 70 eV; 0.5 seconds of scan interval and fragments from 40 to 550 Da. Total GC running time was 60 minutes.

j. Identification of Compounds

Interpretation on mass spectrum GC-MS was conducted using the database of National Institute of Standard and technology (NIST). The mass spectra of the unknown components were compared with the spectra of the known components stored in the NIST library.

Biological activity:



a. Anti-bacterial activity

M I Fitranda et al (2020) reported that the antibacterial activity of castor oil derivatives against *Escherichia coli* is higher than that against *Staphylococcus aureus*. Furthermore, among the three castor oil derivatives, potassium soap exhibits the highest antibacterial activity compared to its corresponding fatty acids and methyl esters. The higher the polarity of a substance, the stronger its antibacterial properties. Therefore, potassium soap, which possesses the highest polarity, shows the greatest antibacterial activity, followed by fatty acids, while methyl ester exhibits the weakest activity.

b. Antibiotic sensitivity assay

Antimicrobial sensitivity testing of castor oil is explained by Momoh, A O et al, (2012), which was reported that, the antimicrobial activity of the extract varied significantly among the tested organisms. Bacteria were generally more sensitive to the extract than fungi. The lower susceptibility of fungi may be due to their eukaryotic nature, which gives them more complex cellular and molecular structures compared to bacteria, which are prokaryotic.

The susceptibility of certain organisms may also be related to their genetic makeup and the absence of resistance transfer factors. *Streptococcus* species showed moderate susceptibility to the extract, possibly because they produce various enzymes and toxins capable of degrading some active components of the essential oil. *Bacillus* species exhibited low susceptibility, likely due to their ability to form spores that protect them from the extract. Although fungi were less susceptible to the castor oil extract than bacteria, none of the fungal species tested were completely resistant.

The results of the antibiotic sensitivity assay on Gram positive, some antibiotics exhibited higher anti-microbial activity than the castor oil extract. Streptomycin, norfloxacin, chloramphenicol, gentamycin and ciprofloxacin showed greater activity, while rifampin, linomycin, and floxapen displayed lower activity than the extract. Erythromycin and ampiclox had nearly the same effect as the extract on the test bacteria.

For Gram negative bacteria *tarivid*, streptomycin, nalidixic acid, gentamycin and ciprofloxacin showed higher antimicrobial activity than the extract. However, some test organisms were resistant to ampicillin, peflacin and ceporex making the extract more effective than those antibiotics.

c. Anti-inflammatory activity

Anti-inflammatory activity of castor oil explained by Venkatarama S et al. Anti-inflammatory and free radical scavenging activity of *Ricinus communis* root extract. According to this research article, oleic acid present in castor oil can suppress the production of key inflammatory cytokines such as tumour necrosis factor alpha (TNF- α) and interleukins IL-6, which are responsible for triggering inflammation in the body. Additionally, linoleic acid, another component, inhibits the activity of cyclooxygenase enzymes, preventing the release of arachidonic acid, which otherwise promotes the formation of inflammatory compounds like leukotrienes, TNF- α . Experimental studies on rats with carrageenan induced paw oedema revealed that oral administration of castor oil significantly reduces the inflammation. This study shows that castor oil has a natural anti-inflammatory activity.

d. Anti-oxidant activity



Castor oil possesses antioxidant activity due to the presence of bioactive compounds like tocopherols and other phenolics. Anti-oxidant activity well explained by Jamshed Iqbal et al. Results of this study shows that, the percentage radical scavenging activity and degree of discolouration of free radicals by different extract of *R. communis* were estimated against DPPH. The highest discolouration of DPPH was seen in the extract of *R. communis* n-butanol extract and lowest in chloroform extract of the same plant. Regression equations to derive the IC_{50} value shows the inverse relationship between percentage scavenge potential and IC_{50} value of sample.

e. Anti-fungal activity

It is carried out by using Potato Dextrose Broth (PDB) media and methanolic extract of castor oil. With increase in concentration like 0, 0.5, 5 and 7.5mg/ml the growth of fungus (*Aspergillus niger*) was reduced and zone of inhibition was increased with dose (Carolina A et al 2019).

f. In vitro inhibitory effect of castor oil on test organisms

This activity explained by Olutiola P O et al (2000), which says that extracted castor oil demonstrated inhibitory effects against all tested organisms. Among the gram-positive bacteria, *Staphylococcus aureus* showed the highest sensitivity with zone of inhibition of 7mm, while *Micrococcus luteus* was the least sensitive, showing a zone of inhibition of 2.50mm. For the gram-negative bacteria, *Escherichia coli* shows the greatest sensitivity with a zone of inhibition of 6.50mm and *Proteus vulgaris* showed lowest sensitivity with a 3mm zone. Among the tested fungi, *Fusarium oxysporum* was the most sensitive, displaying a 4mm inhibition zone, while *Aspergillus niger* was the least affected, with a zone of inhibition measuring 1.50mm.

Other application of castor oil

1. Castor oil in skin disease

Castor oil has been used in the treatment and prevention of various skin conditions, including acne, wrinkles, stretch marks, sun burn, dry skin, boils, athlete's foot, warts, and chronic itching. It is also applied as a wound disinfectant and skin moisturizer.

2. Castor oil in hair treatment

For promoting the growth of eyebrows, eyelashes and scalp hair, oils such as coconut oil, almond oil and castor oil are often combined. Castor oil contains omega-6 essential fatty acids, which are believed to enhance hair growth, improve bald patches, darken hair and increase blood circulation to the hair follicles.

3. Castor oil in medicine use

Castor oil has traditionally been used as a potent laxative and as an adjunct remedy for various ailments, including age spots, cerebral palsy, gastrointestinal disturbances, migraines, inflammation, multiple sclerosis, menstrual disorders, rheumatic pain, skin abrasions and Parkinson's disease. Its use in these conditions is largely based on traditional or supportive practices rather than established clinical evidence.

4. Industrial use of castor oil

In the polyurethane industry, castor oil widely utilized as a bio-based polyol. In the food industry, it is used to inhibit mold growth and to flavour certain foods and confectionery products (Wilson R et al., 1998). Castor oil also helps prevent spoilage in pulses, rice and wheat. Additionally, the nylon and paint industries employ castor oil and its derivatives-such as castor wax as solid lubricants and in the production of carbon paper,



polishes and electrical condensers (Ogunniyi DS 2006). furthermore, the natural hydroxylated fatty acids derived from castor bean oil have broad applications in the manufacture of coatings, cosmetics, greases, lubricants, soaps, polymers, paints, linoleum, printing inks, plastics and polyurethane products. (Glaser LK et al.,1993: Dole KK et al., 1950: Barnes D et al., 2009: FAO 2016).

5. As a source of food condiment

White castor seeds can be used to prepare ogiri, an important food condiment in South-Eastern Nigeria. In traditional practice, ogiri is sometimes believed to support eye health. The preparation process involves deshelling the seeds, boiling the cotyledons for 8-10hours, and then allowing them to cool for 12-14 hours before grinding them into a paste. The condiment is highly valued in Igboland, as the oil in the seeds inhibits microbial growth, allowing ogiri to remain stable for several months (ICOA 1989).

Castor seeds contain a high level of monounsaturated fatty acids, comparable to other vegetable oils. Their triglyceride and fatty acid profiles indicate that ricinolein and Ricinolic acid are the major components, while the bioactive constituents include polyphenols, tocopherols and phytosterols. These compounds contribute to the oil's antioxidant and anti-inflammatory properties, as well as its extended shelf life. The stability of castor oil is further enhanced by its low acid content. (Akwas Y, Sheng Y, Jiannong L et al., 2021)

CONCLUSION

The review thoroughly establishes the castor oil plant (*Ricinus communis*) as a critically important and versatile global resource. Its significance stems from the unique chemical composition of its

seed oil, which is enormously rich in ricinoleic acid. This hydroxylated fatty acid gives the oil distinct properties like high polarity and viscosity.

Physiochemical analysis, using parameters like the iodine value, classifies it as a non-drying oil, making it ideal for applications such as lubricants and hydraulic fluids. The oil is low Anisidine and Thio barbituric acid(TB values also confirm its oxidative stability and longer keeping quality.

Beyond its industrial utility in products like cleansers and nylon fibre, the oil possesses significant biological activities, including being anti-bacterial and anti-inflammatory. These effects are attributed to compounds like oleic and linoleic acids. Castor plant is vital and multifaceted resource.

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