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EXTRACTION AND PURIFICATION OF CASTOR OIL FROM CASTOR SEEDS TO STUDY ITS NUTRITIONAL AND BIOMEDICAL IMPORTANCE.

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ABSTRACT

Castor oil, derived from the seeds of Ricinus communis, is a versatile natural product with significant nutritional and biomedical importance. This study focuses on the extraction and purification of castor oil to evaluate its physicochemical properties and potential applications. The oil was extracted using a cold-press method to retain its bioactive components, followed by purification to remove impurities and enhance its quality. The nutritional profile of castor oil, rich in ricinoleic acid, essential fatty acids, and antioxidants, was analyzed to explore its health benefits, including its roles in boosting immunity, improving skin health, and aiding digestion. Additionally, its biomedical applications, such as its use as a bio-lubricant, drug carrier, and wound-healing agent, were investigated. This research highlights the significance of castor oil in pharmaceutical formulations and as a sustainable alternative to synthetic compounds. The study also addresses the challenges of large-scale production, storage stability, and standardization of quality parameters. Prospects involve optimizing extraction techniques to enhance yield and exploring their potential in developing advanced biomedical materials. This work contributes to the growing interest in natural products as eco-friendly and multifunctional resources for health and industry.

Keywords: *Castor oil extraction, Biomedical applications, Cold-press purification, Nutritional properties.*

INTRODUCTION

Castor oil has long been used commercially as a highly renewable resource for the chemical industry [1].It is a vegetable oil obtained by pressing the seeds of the castor oil plant (Ricinus communis L.) that is mainly cultivated in Africa, South America, and India.3,4 Major castor oil-producing countries include Brazil, China, and India [2]. This oil is known to have been domesticated in Eastern Africa and was introduced to China from India approximately 1,400 years ago.4 India is a net exporter of castor oil, accounting for over 90% of castor oil exports, while the United States, European Union, and China are the major importers, accounting for 84% of imported castor oil [3]. Castor is one of the oldest cultivated crops; however, it contributes to only 0.15% of the vegetable oil produced in the world. The oil produced from this crop is considered to be of importance to the global specialty chemical industry because it is the only commercial source of hydroxylated fatty acid [4]. Even though castor oil accounts for only 0.15% of the world production of vegetable oils, worldwide consumption of this commodity has increased more than 50% during the past 25 years, rising from approximately 400,000 tons in 1985 to 610,000 tons in 2010.9,10 On average, worldwide consumption of castor oil increased at a rate of 7.32 thousand tons per year [5]. In general, the current rate of castor oil production is not considered sufficient to meet the anticipated increase in demand. Various challenges make castor crop cultivation difficult to pursue. Climate adaptability is one of the challenges restricting castor plantations in the U.S. [6]. The plant also contains a toxic protein known as ricin, providing a challenge to being produced in the U.S. It also requires a labor-intensive harvesting process, which makes it almost impossible for the U.S. and other developed countries to pursue castor plantations [7]. Castor plant grows optimally in tropical summer rainfall areas. It grows well from the wet tropics to the subtropical dry regions with an optimum temperature of 20°C–25°C [8]. The high content of the oil in the seeds can be attributed to the warm climate conditions, but temperatures over 38°C can lead to poor seed setting. Additionally, temperatures low enough to induce the formation of frost are known to kill the plant [9]. Castor beans are cultivated for their seeds (Figure 1), yielding a viscous, pale yellow nonvolatile, and non-drying castor oil.18 The physical properties of castor oil have been studied. Comparative analysis showed that the values of viscosity, density, thermal conductivity, and pour point for castor oil were higher than the values of a standard lubricant (SAE 40 engine oil) [10].

Figure 1: Castor Beans [11].

The structure of castor oil is made up of triglycerides that lack glycerin. The triglyceride molecule has a long 18-carbon chain with a double bond [12]. Its chemistry is based mainly on the ricinoleic acid structure, carboxyl group, hydroxyl group, and a single point of unsaturation Figure 2 [13]. The carboxylic group in castor oil molecule allows the production of a wide range of esterification products [14]. The hydroxyl (-OH) group on the 12th carbon can be acetylated or eliminated through a dehydration process to upsurge the unsaturation to give a semi-drying oil [15]. Through caustic fusion and high-temperature pyrolysis, the reactive site of the hydroxyl group can be splited to generate useful products with shorter chains [16]. In addition, the hydroxyl group provides more strength to the structure to prevent the formation of hydroperoxides [17]. The double bond in the structure can be modified through the process of carboxylation, epoxidation or hydrogenation [18][19]. Lastly, the single point of unsaturation can be altered through the process of epoxidation and hydrogenation. Hydrogenated castor oil, which is a wax-like substance, can be obtained from the oil via hydrogen reduction [20].

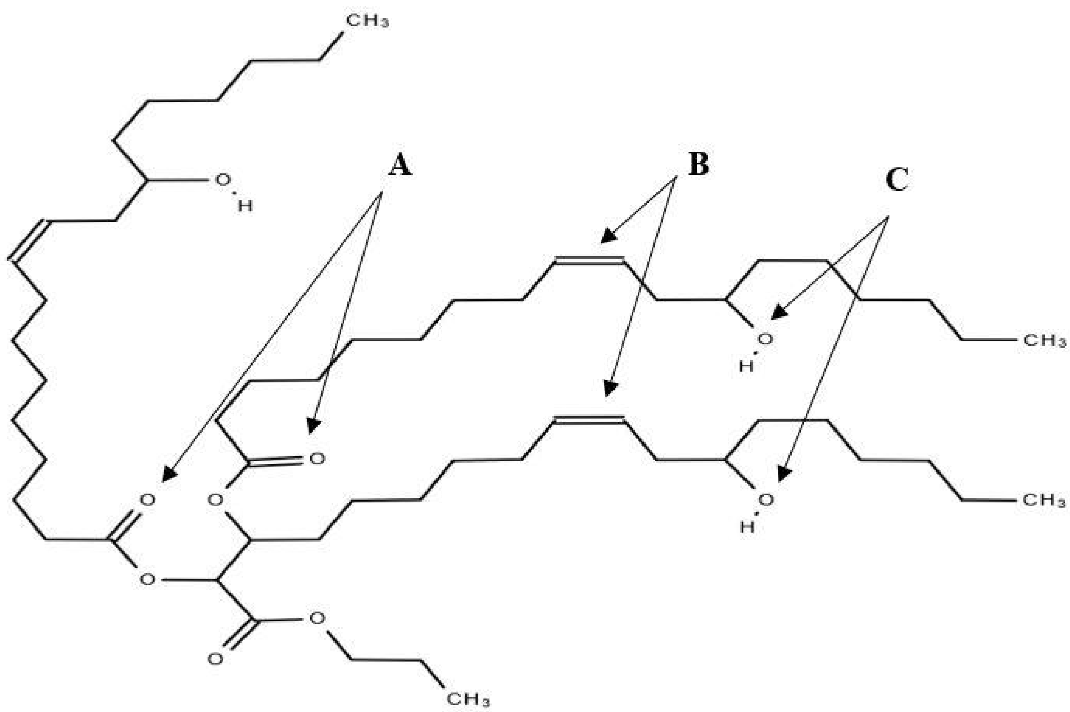

Figure 2: Structure of castor oil molecule. (A) indicates carboxylic groups; (B) indicates double bonds; (C) indicates hydroxyl groups [21].

Castor oil, derived from the seeds of *Ricinus communis*, is renowned for its diverse therapeutic, cosmetic, and industrial applications due to its unique composition, particularly its high content of ricinoleic acid, a monounsaturated fatty acid [22]. In the biomedical domain, castor oil serves as a natural moisturizer, effectively hydrating the skin and enhancing its barrier function. It exhibits potent antimicrobial and antifungal properties, making it beneficial for reducing acne and combating fungal infections [23]. Its anti-inflammatory and analgesic effects help alleviate pain and inflammation, while its wound-healing properties accelerate tissue repair [11]. Additionally, castor oil is used as a natural remedy for ailments such as eye irritation and is sometimes administered to pregnant women to stimulate labor [24].In personal care, ricinoleic acid from castor oil is a key ingredient in creams, jellies, lipsticks, perfumed hair oils, and soaps. It promotes scalp and hair health, addressing dryness and enhancing hair growth. As a stimulant laxative, castor oil is used to treat constipation and prepare the bowel for medical procedures. Its ability to clean the intestines efficiently underscores its utility in gastrointestinal health. Industrially, castor oil serves as a lubricant in paints, enamels, varnishes, greases, polishes, printing inks, and hydraulic and brake fluids. Aromatic castor oil is utilized in specialized formulations, including capsule production, demonstrating its versatility across sectors [23].This study aims to develop sustainable methods for extracting and purifying castor oil from Ricinus communis seeds while analyzing its nutritional and biomedical properties. It seeks to optimize processes to enhance yield and quality while minimizing environmental impact. Addressing gaps in existing research, the study explores eco-friendly extraction methods and the oil's multifaceted applications in pharmaceuticals and healthcare. By bridging these gaps, it promotes sustainable practices and expands the potential uses of castor oil in diverse fields [24][25].

2 Materials and method:

2.1 Materials:

Castor seeds are produced in all tropical and subtropical countries like Brazil Thailand Us, India, etc..Castor oil is a fixed oil obtained by the old expression of the seeds of Ricinus communis.castor seeds (Ricinus communis) as the primary raw material. For the extraction process, essential equipment includes a cold press machine or mechanical expeller, Soxhlet extractor (if solvent-based extraction is used), heating mantle, rotary evaporator, beakers, funnels, and filter paper or cheesecloth.

Chemicals: hexane or ethanol (for solvent extraction), distilled water, sodium chloride (for purification), and activated charcoal (for decolorization) are necessary for efficient extraction and purification.

Analytical instruments like Gas Chromatography-Mass Spectrometry (GC-MS), High-Performance Liquid Chromatography (HPLC), UV-Vis spectrophotometer, pH meter, viscometer, and refractometer are used to analyze the physicochemical properties of the extracted oil. For biomedical and nutritional testing, materials such as agar plates, microbial strains, cell culture media, and standard biochemical reagents are essential.

General laboratory supplies including gloves, lab coats, pipettes, measuring cylinders, and a weighing balance, are also required to ensure precision and safety during the experiments. These materials collectively facilitate the extraction, purification, and comprehensive analysis of castor oil for its nutritional and biomedical applications.
The extraction and purification of castor oil from *Ricinus communis* seeds involved several steps to ensure a high-quality and impurity-free product. Castor seeds were washed and ground into a smooth paste using a grinder, blender, or mortar and pestle. The paste was then mixed with water to achieve a running consistency and heated to loosen the oil. After approximately 60–70 minutes of heating, the mixture was strained using a muslin cloth to remove seed residues. If the paste was too thick, additional hot water was added to facilitate straining.The strained liquid was transferred to a funnel separator, and acetone was added to aid separation. The setup was left undisturbed for 24–48 hours, allowing the oil to separate and rise to the top of the liquid. The oil was then collected using a dropper and stored in a beaker. This process was repeated over a week to ensure the complete extraction of pure castor oil.The extracted oil underwent further purification steps, including boiling and repeated straining, to remove any remaining impurities. The resulting biologically prepared castor oil was characterized for its physical and chemical properties to confirm its quality and suitability for nutritional and biomedical applications.

Figure 2.1: illustrates the funnel separation process employed to isolate castor oil from the aqueous mixture after the initial extraction steps.

The setup features a separating funnel containing the mixture, with the castor oil forming a distinct layer at the top due to its lower density compared to water. Acetone is introduced to enhance the separation by reducing surface tension and facilitating the movement of oil to the upper layer. The figure also highlights using a collection mechanism, such as a dropper or outlet valve, to carefully extract the separated oil without disturbing the underlying aqueous layer. This process ensures efficient isolation of castor oil, yielding a purer product for subsequent purification and analysis. The role of acetone in improving separation efficiency and product quality is a key aspect of this method. Figure 2.2(a) illustrates the separation process of castor oil from an aqueous solution following extraction with acetone. This figure highlights a funnel separator where the lighter castor oil rises to the top, separating it from impurities and residual water. The use of acetone as a solvent is emphasized due to its low boiling point and ability to facilitate efficient extraction, ensuring a clear distinction between the oil and water phases. Figure 2.2 (b) presents the timeline of oil yield during the extraction process. This graph likely indicates how varying extraction times impact both the quantity and quality of castor oil obtained. It suggests that while longer extraction durations can enhance yield, there are diminishing returns after a certain point, which is critical for optimizing extraction methods to balance efficiency with resource use.

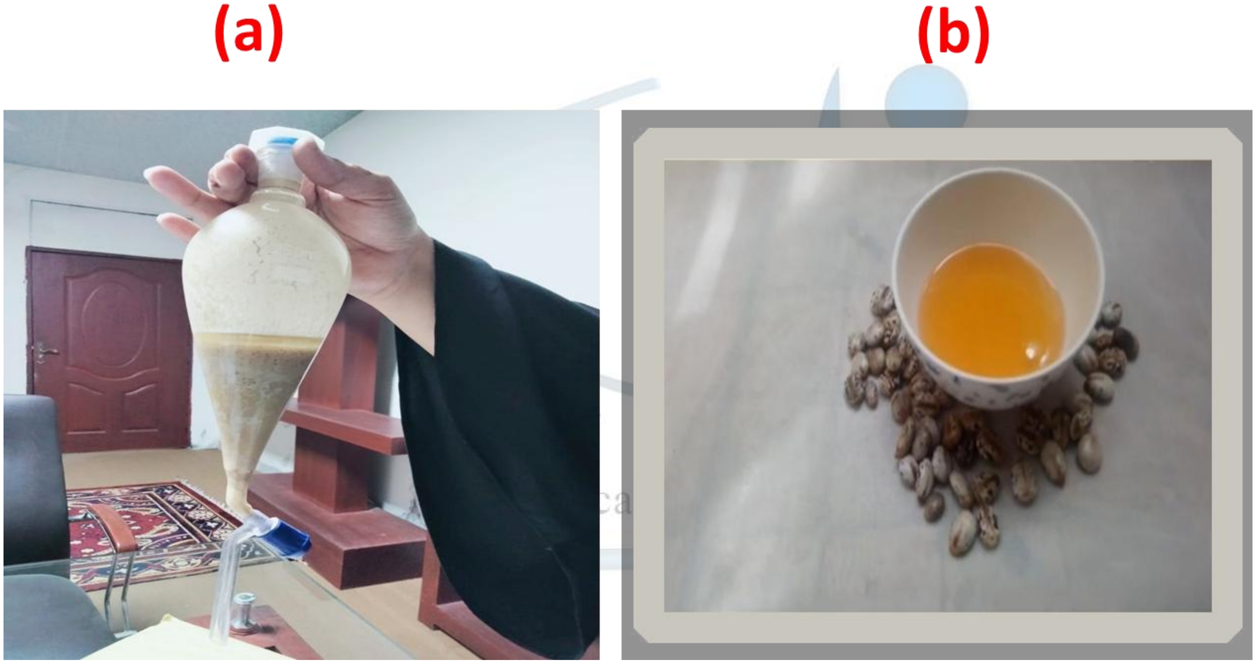

Figure 2.2: (a)illustrates the separation process of castor oil from an aqueous solution following extraction with acetone. (b) the timeline of oil yield during the extraction process is presented.

Figure 2.3 focuses on the chemical composition of castor oil, detailing its primary fatty acid components. The analysis shows that ricinoleic acid constitutes approximately 85-90% of the total fatty acids present in castor oil, with smaller amounts of linoleic, oleic, stearic, palmitic, and linolenic acids. This composition underscores the nutritional and biomedical significance of castor oil, particularly its applications in various industries due to its unique fatty acid profile.

Figure 2.3: The chemical composition of castor oil, detailing its primary fatty acid components.

3 Results and discussion:

The study explored the effectiveness of different solvents, including hexane, ethanol, petroleum ether, and water, in extracting castor oil. It was found that acetone emerged as a particularly effective solvent due to its low boiling point and ability to minimize impurities, resulting in a high yield of quality oil. The extracted castor oil exhibited a distinct yellow color and a slight odor, with specific chemical properties such as an acid value not exceeding 2 and an iodine value ranging from 80 to 90. The composition analysis revealed that ricinoleic acid constitutes approximately 85-90% of the total fatty acids present in the oil, with linoleic and oleic acids being significant components as well. This unique fatty acid profile underscores the nutritional and biomedical significance of castor oil, making it a valuable ingredient in various applications, including cosmetics, pharmaceuticals, and biodiesel production.Moreover, the discussion highlighted the broader implications of castor oil in industrial contexts, particularly its potential as a renewable source of biodiesel due to its low cost and environmental benefits. Recent advancements in converting castor oil hydroxyl functions to β-ketoesters using T-butyl acetate were noted for their ability to enhance yield in coatings within the paint industry. The biomedical applications of castor oil were also emphasized, including its efficacy as a natural moisturizer rich in ricinoleic acid, its role in promoting wound healing, and its use as a natural remedy for various ailments such as eye irritation and constipation. Additionally, castor oil is known for its anti-inflammatory properties and is utilized in hair care products for maintaining healthy hair and scalp.The composition of castor seeds was discussed, revealing that they contain toxic substances such as ricin, which necessitates careful handling during extraction processes. The study's results indicated that effective extraction methods could yield a product that retains the beneficial properties of castor oil while minimizing risks associated with toxicity. Future research directions were proposed to further investigate the diverse applications of castor oil across industries, particularly focusing on its renewable nature and potential for sustainable practices. Overall, this research underscores the importance of optimizing extraction techniques to enhance both the quality and utility of castor oil in various sectors while highlighting its promising role in addressing contemporary challenges in nutrition and industry.

Conclusion:

The study on the extraction and purification of castor oil from castor seeds has highlighted its significant nutritional and biomedical importance, as well as its vast industrial applications. The research demonstrated that acetone is an effective solvent for extracting high-quality castor oil, yielding a product rich in ricinoleic acid, which constitutes 85-90% of its composition. This unique fatty acid profile contributes to the oil's numerous benefits, including its use as a natural moisturizer, anti-inflammatory agent, and laxative. The findings indicate that optimizing extraction methods not only enhances yield but also ensures the safety and quality of the final product, addressing concerns related to solvent contamination associated with conventional techniques. Furthermore, the potential of castor oil as a renewable biodiesel source was emphasized, suggesting its future role in sustainable energy solutions. The study underscores the necessity for continued research into the diverse applications of castor oil across various industries, including cosmetics, pharmaceuticals, and biofuels. Overall, this work reinforces the importance of castor oil as a versatile resource with significant implications for health and industry, paving the way for further exploration of its properties and uses in sustainable practices.

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