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An Analysis of Ricinus Communis L. Reveals its Diverse Phytochemicals and Wide-Ranging Pharmacological Properties

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Abstract: *The maintenance of human health depends heavily on medicinal herbs. There are over 7,500 species and 300 genera in the broad family Euphorbiaceae. The castor bean plant, Ricinus communis L., is one of the most valuable traditional and medicinal plants for promoting a society free of illness. The castor bean plant exhibits a range of beneficial properties, including antifertility, antiimplantation, antinociceptive, anticancer, antioxidant, immunomodulatory, hepatoprotective, antidiabetic, antiulcer, antimicrobial, insecticidal, molluscicidal and larvicidal, bone regeneration, central analgesic, antihistaminic, antiasthmatic, cytotoxic, lipolytic, antiinflammatory, and wound healing properties. Furthermore, the components found in this plant have no negative effects on the body and are helpful for contraception. The goal of this study is to examine the pharmacological properties, phytochemical components, and potential applications of the R. communis L. plant.*

Keywords: Phytochemicals, Pharmacological properties, Diverse compounds.

I. INTRODUCTION

Plants help humans survive by providing them with food, fuel, and medicine from the prehistoric era. Plants have always been a significant source of medicine, and this is still the case today1. Many societies have developed the ability to employ medicinal herbs to prevent disease and preserve health over many years. Because of their natural source and generally fewer side effects when compared to chemical-based drugs, natural products have become increasingly important in the treatment of disease. This has led researchers worldwide to concentrate on the study of medicinal plants. Indigenous and rural people rely heavily on these easily accessible, culturally significant traditional medicines as a source of economical treatment and as a means of subsistence. Between 50,000 and 80,000 blooming plants are utilised medicinally worldwide. Naturally, using wild plant species as both a treatment and a defence against illness is nothing new. Over 80% of the population in South Asia lacks access to contemporary medical treatment, depending instead on traditional medicine made from local plants. Actually, a great deal of traditional knowledge from several indigenous and local people may be used to advance biotechnology, agriculture, pharmaceutical research, and health care2. Numerous physiologically active substances found in plants have the potential to be developed into therapeutic medicines. In underdeveloped nations, herbal medicines have long served as the foundation for therapeutic usage; nevertheless, in the industrialised world, their use has recently increased as well3. The practice of using plants as medicine has been passed down through the generations and is a vital part of India's healthcare system. Since the majority of medical professionals in Indian systems create and administer their own recipes, this calls for accurate record-keeping and investigation. Approximately 40% of people in the western world report using herbs to address medical conditions in the previous year, indicating a steady increase in the usage of herbal medicines4. The increasing frequency of adverse medication responses and the financial strain of the current medical system has led to a rising interest in traditional remedies among the public, academia, and government.

India is home to a wide variety of aromatic and medicinal plants, and its ancient medical system gives it a special position in the globe. Studies have shown the socioeconomic applications of plants, both for medical and non-medicinal purposes.6–9. Traditional knowledge derived from plants is now widely used to find medications and neutraceuticals10.

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Up to 80% of people worldwide still rely on traditional medicine for their basic medical requirements, according to the World Health Organisation. Comparatively speaking, natural remedies are safer than synthetic ones11,12. Ricinus communis L. [Family: Euphorbiaceae, popularly known as 'castor plant' and commonly known as 'Palm of Christ', Verenda (Bengali), Arand, Erand, Andi (Hindi), Errandi (Marathi), Diveli (Guajarati), Urdu (Be danjir, Arand) and Punjabi (Arind)] is one of the many natural crude drugs that have the potential to treat a variety of diseases and disorders in traditional medicine. (Picture 1). This plant is common in all tropical climates.13, 14. The five-meter-tall castor bean is an evergreen herbaceous or semi-woody small tree or big shrub. This plant grows quickly, usually starting out as a straight stalk before branching out. The palmate leaves have five to eleven deeply cut lobes. They are glossy, 30 to 75 cm in diameter, green to purple or reddish-green, and have long petioles. The colour of the stem ranges from green to reddish-purple, and its internodes are hollow. Greenish yellow flowers, up to 30 cm in length, are carried in greenish yellow spikes towards the tips of the stems of the inflorescence, which is not very spectacular. The female flowers have prominent red stigmas and are located on the upper part of the spike. The male blooms feature striking yellow anthers on the lowest portion of the spike. The reddish-brown, egg-shaped capsules, which are around 2.5 cm long and heavily coated in soft, flexible spines, follow pollinated female flowers. Three lethal toxic seeds—which resemble large, obese dog ticks—are included in each capsule15. If the dosage is kept appropriately, this plant offers a wide range of therapeutic applications that may be used to prevent illness and have no negative health consequences (below the dangerous threshold). The current review paper offers a thorough explanation of the pharmacological and phytochemical characteristics of R. communis.

Taxonomic Classification

Kingdom: Plantae Order: Malpighiales Family: Euphorbiaceae

Sub Family: Acalyphoideae

Tribe: Acalypheae Sub Tribe: Ricininae Genus: Ricinus

Species: Ricinus communis L

Geographical Distribution

R. communis is a plant that is likely native to Africa. It is grown in many tropical and subtropical regions of the globe and often arises on its own. It grows up to 2400 metres in India, both in the wild and under cultivation. It has gotten out of control and established itself as a weed almost anywhere in the globe with a tropical or subtropical climate16.

Ancient Use of Ricinus Communis

For millennia, the great toxicity of castor beans has been recognised. Farmers used to know that if they kept their animals near the castor plant, they ran the danger of losing them. Folk medicine has used its seeds to treat a broad range of illnesses17. Since ancient times, the potential medicinal benefits of castor bean seed proteins have been investigated. They subsequently played significant roles in the early stages of immunological research and the discovery of several basic immunological principles. Over the last thirty years, the poisons' mode of action has been clarified. This prompted significant efforts to direct the poisons towards cancerous cells. Additionally, ricin has been utilised in bioterrorism. Toxins have recently been used as valuable experimental models to clarify the intracellular trafficking of endocytosed proteins18. The toxicity that is left in the castor meal after the oil has been extracted using hexane or carbon tetrachloride may be readily eliminated using a simple salting-out process. Castor oil is still produced in significant amounts all over the globe. This plant's fruit, leaves, seeds, and oil are all useful in a variety of contexts. In addition, the treated oil may be applied to oiled textiles, linoleum, patent leather, flypaper, typewriter ink, printing inks, greases, and speciality lubricants17.

Additionally, the leaves have been suggested for use by women as an application to boost milk supply and as a decoction or poultice. Especially in India, the castor cake is used as manure throughout this subcontinent. It has been discovered that this rich source of minerals and nitrogen may be used as manure for tobacco, sugarcane, rice, and other crops. The leaves are powdered and used to repel rust mites, mosquitoes, aphids, and white flies. It is stated that the leaves are used to wounds, boils, and swellings as a poultice or fomentation. Children who have flatulence might get relief by applying castor oil topically to the abdomen19. Chemical Components According to a preliminary phytochemical analysis, R. communis contains steroids, flavonoids, alkaloids, saponins, and glycosides. Six flavones, including glycosides, were present in the dried leaves along with two alkaloids, ricinine (0.55%) and N-

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demethylricinine (0.016%). Quercetin-3-O-β-D-xylopyranoside, Quercetin-3-O-β-D-glucopyranoside, Quercetin-3-O-β-D-glucopyranoside, Quercetin-3-O-β-Rutinoside, Quercetin-3-O-β-Rutinoside, and Quercetin-3-O-β-Rutinoside20. The main phenolic components recovered from the leaves are the monoterpenoids (1, 8-cineole, camphor, and α-pinene), asesquiterpenoid (β-caryophyllene), gallic acid, quercetin, gentisic acid, rutin, epicatechin, and ellagic acid. The roots have been used to extract indole-3-acetic acid21, 22. Fifty percent of the fixed oil in the seeds and fruits is made up of lipases, the crystalline alkaloid ricinine, and glycosides of ricinoleic, isoricinoleic, stearic, and dihydroxystearic acids. The ester form of palmitic (1.2%), stearic (0.7%), arachidic (0.3%), hexadecenoic (0.2%), oleic (3.2%), linoleic (3.4%), linolenic (0.2%), ricinoleic (89.4%), and dihydroxy stearic acids were found in the castor oil GLC (Gas Liquid Chromatography) investigation. Ricineine is also present in the stem. The ergost—5-en-3-ol, stigmasterol, Y-sitosterol, flucosterol, and one probucol that was separated from the seed ether extract. Using capillary columns, the GC-MS studies of R. communis essential oil reveal the presence of chemicals such as α-thujone (31.71%) and 1, 8-cineole (30.98%), α-pinene (16.88%), camphor (12.92%), and camphene (7.48%). The coat of the castor bean17 yields luteol and 30-Norlupan-3β-ol-20-one.

Medicinal Purposes

The following describes the several pharmacological actions of R. communis L.:

Antifertility activity

Alkaloids and steroids were detected in a methanol extract of R. communis seeds. The antifertility effects of steroids in the methanol extract of R. communis seed may be created by the sex hormone, phytosterols, which are steroidal compounds23. In one investigation, ethanol extracts of R. communis were shown to have antifertility effects in male rats. During the investigation, the sperm count decreased and information on their motility, mode of movement, and morphology was discovered. Decreases in testosterone and fructose levels were indicative of worse reproductive function24.

Figure 1: Photo of Ricinus communis L. plant.

Antiimplantation activity

The ether soluble fraction of the methanol extract of R. communis var. minor, when subcutaneously administered at doses up to 1.2 g/kg body weight and 600 mg/kg body weight, in divided doses, respectively, possesses antiimplantation, anticonceptive, and estrogenic activity in adult female rats and rabbits25.

Antinociceptive activity

Significant antinociceptive action is shown by the methanol leaf extract of R. communis against the mice's acetic acid-induced writhing test, formalin-induced paw licking, and tail immersion techniques. Antinociceptive action was observed since precursor phytoconstituents such as alkaloids, steroids, and saponins were present26.

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Anticancer activity

According to the lectin's ED50 values for tumour and non-transformed cells, the lectin that was isolated from R. communis, ricin A, has anticancer activity and is more hazardous to tumour cells than to non-transformed cells27.
Activity of antioxidants

The ferric thiocynate technique of lipid peroxidation and the free radical scavenging impact on 2,2 diphenyl-1-picrylhydrazyl radical (DPPH) and hydroxyl radical produced by hydrogen peroxide are how R. communis seed extracts develop their antioxidant activity. The R. communis seed has strong antioxidant activity at low concentrations, suggesting that it may be particularly helpful in treating diseases brought on by oxidative stress. The chemical components of R. communis that are accountable for the production of antioxidant activity include methyl ricinoleate, ricinoleic acid, 12-octadecadienoic acid, and methyl ester. The presence of flavonoids in the stem and leaf extracts of R. communis contributes to their antioxidant activity as well28. Gallic acid, quercetin, gastisic acid, rutin, epicatechin, and ellagic acid are the main phenolic components that provide R. communis dry leaves their antioxidant action, according to several studies22.

Immunomodulatory activity

Immunomodulatory drugs derived from plants and animals often boost the body's defences against infections by stimulating the non-specific immune system. The phagocytic activity of human neutrophils was greatly enhanced by the presence of tannins in R. communis leaves, and this may have had an immunomodulatory effect17.

Hepatoprotective activity

The hepatoprotective effect of ethanol leaves extract of R. communis was investigated by Prince et al. at varying doses. The presence of flavonoids and tannins was observed to have an inhibitory effect on the activities of serum transaminases, liver lipid peroxidation level, and the activities of acid and alkaline phosphatase in the liver, which were induced by carbon tetrachloride29. N-demethyl ricinine exhibited anticholestatic and hepatoprotective potential in paracetamol-induced hepatic damage30-32.

Antidiabetic activity

The ethanol root extract of R. communis has a substantial impact on fasting blood glucose, total lipid profile, liver and kidney functions, and alkaline phosphatase. However, there was no significant difference in serum bilirubin, creatinine, serum glutamate oxaloacetate transaminases, serum glutamate pyruvate transaminases, and total protein even after the extract was administered at a dose of 10 g/kg body weight33.

Antiulcer activity

The R. communis seeds oil exhibits substantial antiulcer properties at doses of 500 mg/kg body weight and 1000 mg/kg body weight (both of which are below the toxic level). However, the 1000 mg/kg body weight dose was more effective in preventing ulceration caused by pylorus ligation, aspirin, and ethanol in rats. The results indicated that the antiulcer activity is a consequence of the drug's cytoprotective action or the fortification of the gastric mucosa, thereby enhancing the mucosal defence.

Antimicrobial activity

The antimicrobial potential of the R. communis plant extract is demonstrated against a diverse array of microorganisms. Petroleum ether and acetone extracts demonstrated a greater zone of inhibition than the ethanol extract. By employing the well diffusion method, the various solvents root extracts of R. communis exhibit antimicrobial activity against pathogenic microorganisms, including Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Salmonella typhimurium, Proteus vulgaris, Bacillus subtilis, Candida albicans, and Aspergillus niger. The maximum antimicrobial activity was demonstrated by the hexane and methanol extracts, while the aqueous extracts exhibited no significant antimicrobial activity35.

Molluscicidal and larvicidal activity

Molluscicidal activity against Lymnaea acuminata is exhibited by the leaf extract of R. communis. However, the seed extracts exhibited superior molluscicidal activity against S. frugiperda as a result of the active constituents, including ricinine and castor oil. The aqueous leaf extracts of R. communis exhibit appropriate larvicidal activity against Anopheles arabiensis, Callosobruchus chinensis, and Culex quinquefasciatus mosquitoes17, 37.

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Bone regeneration activity

Ricinus communis polyurethane (RCP) has been investigated for its biocompatibility and its capacity to promote bone regeneration. The results indicated that RCP, when combined with calcium carbonate or calcium phosphate, could facilitate matrix mineralisation and are biocompatible materials38. The biological properties of RCP21 could be enhanced by incorporating alkaline phosphatase into the RCP and subsequently incubating it in synthetic body fluid. The advantage of RCP over demineralized bone is that the former has a delayed reabsorption process39.

Central analgesic activity

In the tail flick response paradigm to radiant heat, the crude root bark extract of R. communis exhibits central analgesic activity at a dose of 250 mg/kg body weight. The ethanol pericarp fruit extract of R. communis exhibits the typical stimulant and neuroleptic effects of the central nervous system17. The presence of the alkaloid ricinine appears to be responsible for the stimulant effects, which include exophthamus, hyperreactivity, memory enhancement, and clonic convulsions. The primary toxic compound in the extract appears to be ricinine, as the animals that perished following the administration of either the extract or ricinine exhibited comparable symptoms: they all succumbed to clonic convulsions that were followed by an apparent respiratory arrest. Conversely, the neuroleptic-like effects of the extract may be attributed to compounds other than ricinine, as ricinine did not induce a decrease in locomotor activity or catalepsy in the mice40.

Antihistaminic Activity

The antihistaminic activity of the ethanolic root extract of R. communis L. was observed at doses of 100, 125, and 150 mg/kg body weight when administered intraperitoneally to rodents with clonidine-induced catalepsy26. Antiasthmatic properties R. communis' ethanol root extract is effective in the treatment of asthma due to its antiallergic and mast cell stabilising potential activity. The apigenin and luteolin-like flavonoids generally inhibit the release of histamine from basophils and beta glucuronidase from neutrophils, and they also exhibit in vivo antiallergic activity. Saponins have a stabilising effect on mast cells, while flavonoids have smooth muscle relaxant and bronchodilator properties. The ethanolic extract of R. communis exhibits antiasthmatic activity and reduces milk-induced leucocytosis and eosinophilia, which are attributed to the presence of saponins or flavonoids17,26.

Cytotoxic activity

The cytotoxic effect of the leaves extract of R. communis on SK-MEL-28 human melanoma cells was observed by Darmanin et al. The leaves exhibited the presence of cytotoxic phytochemicals, which induce apoptosis by translocating phosphatidyl serine to the external surface of the cell membrane and resulting in the loss of mitochondrial potential. These compounds consisted of three monoterpenoids: 1, 8-cineole, camphor, and α-pinene, as well as a sesquiterpenoid: β-caryophyllene21.

Lipolytic activity

Ricine generates lipolytic activity by employing a variety of substrates, including (i) a triacylglycerol analogue, BAL-TC; (ii) chromogenic substrates, including p-NP esters of liphatic short to medium-chain acids; and (iii) monomolecular films of a pure natural diacylglycerol, DC 10, in an emulsion and membrane-like model. It indicates that ricin from R. communis functions as a lipase and is capable of hydrolyzing various lipid classes. The action of ricin on membrane phospholipids may be mediated by a phospholipase activity, which is frequently a minor activity of lipases41.

Antiinflammatory activity

The antiinflammatory activity of the leaves and root extract of R. communis in rodents was reported by Ilavarasan et al.42. The 250 and 500 mg/kg doses of R. communis methanol leaves extract exhibit a protective effect in the prevention of cellular events during the formation of edoema and in all phases of acute inflammation43. Flavonoids were responsible for the anti-inflammatory properties of the R. communis methanolic extract in the context of carrageenan-induced paw edoema in rats44.

Wound healing activity

The wound-healing activity of R. communis is attributed to the active constituent of castor oil, which inhibits lipid peroxidation and produces antioxidant activity. The excision wound model was used to investigate the wound healing activity of castor oil in terms of scar area, scar closure percentage, and epithelization. The wound healing process is facilitated by the tannins, flavonoids, triterpenoids, and sesquiterpenes in castor oil, which are responsible for wound contraction and an increased rate of epithelialization, as a result of their astringent and antimicrobial properties. The

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study found that castor oil exhibited wound healing activity by minimising the scar area and epithelialization time in the excision wound model45.

II. CONCLUSION

A natural plant of India is R. communis, or the castor plant. The medicinal properties of the R. communis plant have been a significant aspect of human existence since the prehistoric era and have provided valuable insights into the use of plants or plant products as medicine. This plant has a variety of pharmacological actions, some of which are reviewed here. However, it still has a significant amount of novel potential that has yet to be explored. The therapeutic value of R. communis is highly significant, as evidenced by the pharmacological activities reported in the present review. Therefore, it has a leading potential for the development of a new, safe, effective, and cost-effective drug in the future. However, it requires additional elaborative research, pharmacological investigations, clinical trials, public awareness, and further exploration to optimise its medicinal properties. In general, the pharmacological activities and phytochemical constituents that R. communis exhibits have significant potential and importance in the field of medicinal plant research. Consequently, industrial enterprises should also develop novel concepts and strategies to optimise the utilisation of this prospective medicinal plant.

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