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Review Article

A Review on Phytochemical Constituents and Pharmacological Activities of *Ricinus communis* L. Plant

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ABSTRACT
The medicinal plants have a vital role to take care of the healthy human life. The large family Euphorbiaceae contains nearly about 300 genera and 7,500 species. Amongst all, *Ricinus communis* L. or castor bean plant has high traditional and medicinal values towards a disease free community. The castor bean plant is effective as antifertility activity, antiimplantation activity, antinociceptive activity, anticancer activity, antioxidant activity, immunomodulatory activity, hepatoprotective activity, antidiabetic activity, antiulcer activity, antimicrobial activity, insecticidal activity, molluscicidal and larvicidal activity, bone regeneration activity, central analgesic activity, antihistaminic activity, antiasthmatic activity, cytotoxic activity, lipolytic activity, antiinflammatory activity, and wound healing activity. In addition, the constituents present in this plant are beneficial for the purpose of contraception, leaving no detrimental effects on the body. The objective of the present review focuses on the phytochemical constituents, pharmacological activities and future perspectives of the *R. communis* L. plant.

Keywords: Medicinal plant, *Ricinus communis* L., Chemical constituents, Pharmacological activities, Future perspectives.

INTRODUCTION

Plant is man's friend in survival, giving him food, fuel and medicine from the days beyond drawn of civilization. Plant continue to be a major source of medicine, as they have throughout human history[1]. Over centuries, cultures around the world have learned how to use medicinal plants to fight illness and maintain health. The importance of natural product in the treatment of disease has been increased because of its natural source and comparatively lesser side effects as compared to the complexity in formulating chemical based drugs as well as uprising cost has led worldwide researchers to focus on the medicinal plant research. These are readily available and culturally important traditional medicines form the basis of an accessible and affordable healthcare regime and are an important source of livelihood for indigenous and rural populations. Worldwide, between 50,000 to 80,000 flowering plants are used medicinally. Of course, the use of wild plant species to cure and resist disease is nothing new. More than eighty percent of South Asia's people have no access to modern health care; they rely instead on traditional medicine using native species. In fact, many indigenous and local communities are immense reservoirs of traditional knowledge that can benefit biotechnology, agriculture, pharmaceutical development, and health care[2]. Plants contain many biologically active compounds which have potential for the development as medicinal agents. Herbal medicines have already formed the basis of therapeutic use in the developing countries, but of recent, there has been an increase in the use of herbal medicines in the developed world too[3]. Use of plants as a source of medicine has been inherited and is an important component of the health care system in India. In the Indian systems of medicine, most practitioners formulate and dispense their own recipes; hence this requires proper documentation and research. In western world also, the use of herbal medicines is steadily growing with approximately 40 percent of the population reporting use of herb to treat medical illnesses within the past year[4]. Public, academic and government interest in traditional medicines is growing exponentially due to the increased incidence of the adverse drug reactions and economic burden of the modern system of medicine[5].

India has a rich diversity of medicinal as well as aromatic plants and holds a unique place in the world in the traditional system of medicine. Socioeconomic uses of plants, i.e. medicinal and, other than medicines have been reported in many studies[6-9]. Plant based traditional knowledge has become a recognized tool in search of drugs and neutraceuticals[10]. Today, according to World Health Organization as many as 80% of the world's people depend on traditional medicine for primary health care needs. The herbal medicines are comparatively safer than synthetic drugs[11,12].

In traditional medicine, there are many natural crude drugs that have the potential to treat various diseases and disorders, one of them is *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)] (Figure 1). This plant is widespread throughout the tropical

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regions[13,14]. Castor bean is an evergreen herbaceous or semi-woody, large shrub or small tree that reaches 5 meters tall. This is a fast growing plant that tends to grow straight up at first, and then develops branches later. The leaves are palmate, with 5-11 deeply incised lobes. They are glossy, green to purplish or reddish-green and 30 to 75 cm across, with long petioles. Stem is green to reddish-purple in color and have hollow internodes. The inflorescence (not particularly showy) has greenish yellow flowers that are borne in spikes up to 30 cm long near the tops of the stems. Female flowers are on the top half of the spike and have conspicuous red stigmas. The male flowers on the lower half of the spike have showy yellow anthers. Pollinated female flowers are followed by reddish brown, egg-shaped capsules, about 2.5 cm long, thickly covered with soft flexible spines. Each capsule contains three seeds that look like fat, swollen dog ticks and are deadly poisonous[15]. This plant has numerous medicinal uses that are potential for the prevention of diseases, leaving no baleful effects on the health if the dose is maintained properly (below the toxic level). The present review article provides the comprehensive information on phytochemical and pharmacological aspects 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

The plant *R. communis* is probably native to Africa, and is cultivated in many tropical and subtropical areas of the world, commonly appearing spontaneously. It is found in India, cultivated as well as wild, up to 2400 meters. It has escaped cultivation and become naturalized as weed almost everywhere in the world that has a tropical or subtropical climate[16].

Ancient Use of Ricinus Communis

The castor beans are known for their high toxicity for centuries. In ancient times, farmers knew to keep their livestock away from the castor plant or else they would risk losing them. Their seeds have been used in folk medicine against a wide variety of diseases[17]. The use of the castor bean seed proteins has been reviewed for medical treatments since ancient times. Later, their important roles in the early days of immunological research and some of the fundamental principles of immunology were discovered. During the last three decades, the mechanism of action of the toxins was elucidated. This led to a major effort to target the toxins to malignant cells. Ricin has been used in bioterrorism also. Recently, the toxins have played important roles as experimental models to elucidate the intracellular trafficking of endocytosed proteins[18]. Castor oil is still produced in large quantities throughout the world and the toxin which remains in the castor meal after the oil has been extracted with hexane or carbon tetrachloride is easily removed through a simple salting-out procedure. There are versatile uses of this plant (oil, leaf, seed and fruit) in different aspects of life. The treated oil can also be used as paints, enamels and varnishes, oiled fabrics, linoleum, patent leather, flypaper, typewriting, printing inks, greases and special lubricants[17].

The leaves have also been recommended in the form of a decoction or poultice and as an application for women to increase the secretion of milk. The castor cake is used as manure in this sub-continent especially in India. It is rich in nitrogen and other minerals, and has been found to be suitable as manure for paddy, sugarcane, tobacco, etc. The powdered leaves are used for repelling aphids, mosquitoes, white flies and rust mites. The leaves are said to be used in the form of a poultice or fomentation on sores, boils and swellings. Castor oil is commonly applied over the abdomen to give relief in the flatulence in the children[19].

Chemical Constituents

The preliminary phytochemical study of *R. communis* revealed the presence of steroids, saponins, alkaloids, flavonoids, and glycosides in it. The dried leaves showed the presence of two alkaloids, ricinine (0.55%) and N-demethylricinine (0.016%) and six flavones: glycosides kaempferol-3-O-β-D-Xylopyranoside, kaempferol-3-O-β-D-glucopyranoside, quercetin-3-O-β-D-xylopyranoside, quercetin-3-O-β-D-glucopyranoside, kaempferol-3-O-β-rutinoside and quercetin-3-O-β-rutinoside[20]. The monoterpenoids (1, 8-cineole, camphor and α-pinene) and asesquiterpenoid (β-caryophyllene), gallic acid, quercetin, gentisic acid, rutin, epicatechin and ellagic acid are the major phenolic compounds isolated from the leaves. Indole-3-acetic acid has been extracted from the roots[21, 22]. The seeds and fruits contain 45% of fixed oil, which consist glycosides of ricinoleic, isoricinoleic, stearic, dihydroxystearic acids, and also lipases and a crystalline alkaloid, ricinine. The GLC (Gas Liquid Chromatography) study of castor oil showed the presence of 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. The stem also contains ricinine. The ergost- 5-en-3-ol, stigmasterol, Y-sitosterolfucosterol; and one probucol isolated from the ether extract of seeds. The GC-MS analyses of *R. communis* essential oil (using capillary columns) are identified compounds like α-thujone (31.71%) and 1, 8- cineole (30.98%), α-pinene (16.88%), camphor (12.92%) and camphene (7.48%). Lupeol and 30-Norlupan-3β-ol-20-one are obtained from coat of castor bean[17].

Pharmacological Activities

The various pharmacological activities of *R. communis* L. is described below:

Antifertility activity

Methanol extract of *R. communis* seed revealed the presence of steroids and alkaloids. The sex hormone being steroidal compound's (phytosterols) and the presence of steroids in the methanol extract of *R. communis* seed may

Figure 1: Photo of *Ricinus communis* L. plant.

be produced antifertility effects[23]. One of the study reported antifertility effects of ethanol extracts of *R. communis* in male rats. The sperm count reduced, the motility, mode of movement and morphology of the sperms were found during the study. Reductions in the fructose and testosterone levels were suggestive of reduced reproductive performance[24].

Antiimplantation activity

The ether soluble portion of the methanol extract of *R. communis* var. *minor* possesses antiimplantation, anticonceptive and estrogenic activity in adult female rats and rabbits when administered subcutaneously at a dose upto 1.2 g/kg body weight and 600 mg/kg body weight, in divided doses, respectively[25].

Antinociceptive activity

Methanol leaves extract of *R. communis* possesses significant antinociceptive activity against acetic acid induced writhing test, formalin induced paw licking and tail immersion methods in mice. The antinociceptive activity showed due to the presence preliminary phytoconstituents like saponins, steroids and alkaloids[26].

Anticancer activity

Lectin isolated from *R. communis* is ricin A, possesses antitumor activity, which was more toxic to tumor cells than to non-transformed cells, judged from the ED50 of the lectin towards tumor cells and non-transformed cells[27].

Antioxidant activity

R. communis seed extracts produce the antioxidant activity by using lipid per oxidation via ferric thiocynate method and free radical scavenging effect on 2,2 diphenyl-1-picrylhydrazyl radical (DPPH) and hydroxyl radical generated from hydrogen peroxide. The high antioxidant activity of the *R. communis* seed at low concentration shows that it could be very useful for the treatment of disease resulting from oxidative stress. The responsible chemical constituent of *R. communis*, which produces antioxidant activity, is methyl ricinoleate, ricinoleic acid, 12-octadecadienoic acid and methyl ester. *R. communis* stem and leaf extracts also produce antioxidant activity due to the presence of flavonoids in their extracts[28]. Some studies revealed that gallic acid, quercetin, gastisic acid, rutin, epicatechin and ellagic acid are the major phenolic compounds responsible for the antioxidant activity of the *R. communis* dry leaves[22].

Immunomodulatory activity

The plant and animal origin immunomodulatory agents generally increase the immune response of the human body against pathogens by activating the non-specific immune system. The presence of tannins in the leaves of *R. communis* significantly increased the phagocytic function of human neutrophils and resulted in production of a possible immunomodulatory effect[17].

Hepatoprotective activity

Prince et al. studied the hepatoprotective effect of ethanol leaves extract of *R. communis* at different doses, the presence of flavonoids and tannins exhibited an inhibitory effect on the activities of serum transaminases, liver lipid peroxidation level and the activities of acid and alkaline phosphatase in liver induced by carbon tetrachloride[29]. N-demethyl ricinine showed anticholestatic and hepatoprotective potential in paracetamol-induced hepatic damage[30-32].

Antidiabetic activity

Ethanol roots extract of *R. communis* possess significant effects on fasting blood glucose, total lipid profile, liver and kidney functions and no significant difference on alkaline phosphatase, serum bilirubin, creatinine, serum glutamate oxaloacetate transaminases, serum glutamate pyruvate transaminases and total protein which was observed even after the administration of the extract at a dose of 10 g/kg body weight[33].

Antiulcer activity

The *R. communis* seeds oil possesses significant antiulcer properties at a dose of 500 mg/kg body weight and 1000 mg/kg body weight (below the toxic level), but at the dose 1000 mg/kg body weight was more potent against the ulceration caused by pylorus ligation, aspirin and ethanol in rats. The result showed that the antiulcer activity is due to the cytoprotective action of the drug or strengthening of gastric mucosa and thus enhancing the mucosal defense[34].

Antimicrobial activity

The *R. communis* plant extract shows the antimicrobial potential against a wide variety of microorganisms. The petroleum ether and acetone extracts exhibited higher zone of inhibition than ethanol extract. The different solvents root extracts of *R. communis* possess antimicrobial activity by using the well diffusion method against pathogenic microorganisms such as *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Proteus vulgaris*, *Bacillus subtilis*, *Candida albicans* and *Aspergillus niger*. The hexane and methanol extracts showed maximum antimicrobial activity whereas the aqueous extracts have no significant antimicrobial activity[35].

Insecticidal activity

The insecticidal value of the castor oil in controlling the termites which damage the wood of *Mangifera indica* and *Pinus longifolia* were examined. In comparative trials, the order of insecticidal activity was: DDT = BHC > castor oil + castor cake (1:1) > castor oil > castor leaves > castor cake > neem oil > neem leaves[36].

Molluscicidal and larvicidal activity

The leaf extract of *R. communis* possess molluscicidal activity against *Lymnaea acuminata* and the seed extracts showed better molluscicidal activity than the leaf extracts against *S. frugiperda* due to the active ingredients like castor oil and ricinine. The aqueous leaves extracts of *R. communis* possess suitable larvicidal activity against *Anopheles arabiensis*, *Callosobruchus chinensis* and *Culex quinquefasciatus* mosquitoes[17, 37].

Bone regeneration activity

Ricinus communis polyurethane (RCP) has been studied for its biocompatibility and its ability to stimulate the bone regeneration. Results showed that RCP blended with calcium carbonate or calcium phosphate could promote matrix mineralization and are biocompatible materials[38]. Incorporating alkaline phosphatase to RCP with subsequent incubation in synthetic body fluid could improve the biological properties of the RCP[21]. The advantage seen in RCP as compared to demineralized bone is that the former has a slower reabsorption process[39].

Central analgesic activity

The crude root bark extract of *R. communis* possesses central analgesic activity in tail flick response model to radiant heat at a dose of 250 mg/kg body weight. The ethanol pericarp fruit extract of *R. communis* possesses typical central nervous system stimulant and neuroleptic effects[17]. The stimulant effects, such as exophthamus, hyperreactivity, memory improvement, and clonic seizures, seem to be due to the presence of alkaloid ricinine. The main toxic compound of the extract also seems to be ricinine, because animals that died after administration of the extract or ricinine showed similar signs: they all died after the occurrence of clonic seizures followed by an apparent breathing arrest. On the other hand, compounds other than ricinine may be responsible for the neuroleptic-like effects of the extract, because ricinine did not cause a reduction of locomotor activity or catalepsy in the mice[40].

Antihistaminic Activity

The ethanolic root extract of *R. communis* L. has the antihistaminic activity at the dose 100, 125, and 150 mg/kg body weight when inserted into the body intraperitoneally by using clonidine induced catalepsy in mice[26].

Antiasthmatic activity

Ethanol root extract of *R. communis* is effective in the treatment of asthma because of its antiallergic and mast cell stabilizing potential activity. Saponins has mast cell stabilizing effect and the flavonoids possess smooth muscle relaxant and bronchodilator activity; the apigenin and luteolin like flavonoids generally inhibit basophil from histamine release and neutrophils from beta glucuronidase release, and finally shows *in vivo* antiallergic activity. The ethanolic extract of *R. communis* decreases milk induced leucocytosis and eosinophilia and possess antiasthmatic activity due to the presence of flavonoids or saponins[17,26].

Cytotoxic activity

Darmanin et al. observed cytotoxic effect of leaves extract of *R. communis* on SK-MEL-28 human melanoma cells. The leaves showed the presence of cytotoxic phytochemicals, which induces apoptosis via translocation of phosphatidyl serine to the external surface of cell membrane and loss of mitochondrial potential. These compounds included three monoterpenoids: 1, 8-cineole, camphor and α-pinene and a sesquiterpenoid: β-caryophyllene[21].

Lipolytic activity

The ricin produces the lipolytic activity by using the various substrates: (i) one analogue of triacylglycerol, BAL-TC; (ii) various chromogenic substrates such as p-NP esters of a liphatic short to medium chain acids, and (iii) monomolecular films of a pure natural diacylglycerol, DC 10 in emulsion and in a Membrane-like model. It reveals that ricin from *R. communis* act as a lipase and has the capability of hydrolyzing different lipid classes. The action of ricin on membrane phospholipids could occur through a phospholipase activity which is very often as a minor activity of lipases[41].

Antiinflammatory activity

Ilavarasan et al. reported the antiinflammatory activity of the leaves and root extract of *R. communis* in rats[42]. The 250 and 500 mg/kg dose of *R. communis* methanol leaves extract possess protective effect in the prevention of cellular events during edema formation and in all the stages of acute inflammation[43]. The antiinflammatory potential of the *R. communis* methanolic extract was due to the presence of flavonoids against carragennan-induced paw edema in rats[44].

Wound healing activity

The *R. communis* possess wound healing activity due to the active constituent of castor oil, which produces antioxidant activity by inhibiting lipid peroxidation. The study of wound healing activity of castor oil was in terms of the scar area, percentage closure of scar areas and epithelization in the excision wound model. Due to the astringent and antimicrobial property the tannins, flavonoids, triterpenoids and sesquiterpenes present in the castor oil, promote the wound healing process, which are responsible for wound contraction and increased rate of epithelialisation. The study resulted that the castor oil showed wound healing activity by reducing the scar area and also the epithelialisation time in the excision wound model[45].

Future Perespectives

R. communis is a very useful medicinal plant having no adverse effects on the body. Now a day, people are becoming more and more dependent on the herbal products rather than the chemical ones due to their residual effects on the long run[46]. The multidisciplinary use of the active constituents of the castor bean reveals that it will be possible to find out new herbal products in the field of medical science/ethno-botanical science for the better health of the human being. The contraceptive effect of the chemical constituent of the castor bean has also added a new dimension in the field of birth control might be useful in the densely populated countries even having no baleful effects on the body as the chemical birth control pills do. The antioxidant and free radical scavenging activities of phytochemical constituents isolated from this plant give us

an impression that the plant might be the future prospective target for a diversified panel of tumors and cancers. A systematic scientific approach from phytochemical either in the pure or crude form to modern drug development can provide valuable drugs from traditional medicinal plants. Development of such medicines with international safety and efficacy can give better and satisfactory treatment of various diseases. To ensure ample production of phytoconstituents within limited space and time, new approaches must be adopted. This is because the prospecting of bio-resources for economic development is emerging as a new economic venture.

CONCLUSION

R. communis or castor plant is a natural plant of India. Medicinal effect of *R. communis* plant occupied a distinct place in the life right from the primitive period to till date and provided information on the use of plants or plant products as medicine. It has various pharmacological actions, some of them are reviewed here, but still this plant has much novel potential which is yet to explore. The pharmacological activities reported in the present review confirm that the therapeutic value of *R. communis* is very high having a leading capacity for the development of a new, safe, effective and cheaper drug in future. But it needs more elaborative study, pharmacological investigations, clinical trials, more exploration and public awareness for the best utilization of its medicinal properties. Overall, all these phytochemical constituents and pharmacological activities exhibited by the *R. communis* have great potential and significance in the field of medicinal plant research. Hence, the industrial entrepreneurs also should come forward with new concepts and steps towards the best use of this potential medicinal plant.

COMPETING INTERESTS

The author declared that he has no competing interests.

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