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REVIEW ARTICLE **OPEN ACCESS**

Pharmacological activities of *Wrightia tinctoria* R.Br.

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ABSTRACT
In the traditional systems of medicine, most of the remedies were taken from plants and that were proved to be useful in various disease conditions. Noteworthy that traditional herbal medicines are efficacious, lesser side effects compared to modern drugs. The vast Ayurveda literature claims a number of plants to be useful in the treatment of diseases and disorders. The search for drugs from natural sources will assume greater importance in traditional system of medicine. Wrightia tinctoria R.Br. is widely used as a traditional medicine for the dysentery, piles, psoriasis and other skin diseases, flatulence and bilious affections, pain and inflammation, antidiabetic, antibacterial, anthelmintics. The present review summarizes the pharmacological and toxicity updates of Wrightia tinctoria R.Br.
Keywords: *Wrightia tinctoria, Lithiasis, Apocynaceae, Lupeol, Amyrin.*

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INTRODUCTION

Medicinal plants accumulate primary and secondary metabolites. The medicinal properties of plants come from the presence of bioactive chemical constituents in their extracts. The most important constituents like steroids, alkaloids, flavonoids, tannins, volatile oil, mineral and vitamins possess medicinal properties and played as significant role in providing primary health care services to all living organism and various ancient traditional system of medication[1]. Ayurvedic literatures described many plants used in the various types of diseases and disorders. *Wrightia tinctoria* R.Br. is widely used as a traditional medicine for the dysentery, piles, psoriasis and other skin diseases, flatulence and bilious affections, pain and inflammation, anthelmintics[2,3]. The bark extracts have been used in the treatment of dysentery, piles and skin diseases. The bark and seeds extracts are effective against psoriasis and other skin problems and non-specific dermatitis. The bark and seeds are used as antidysenteric, astringents, anti-inflammatory, anthelmintics, flatulence and bilious affections[2]. It has anti-inflammatory and anti-dandruff properties and hence is used in hair oil preparations. The leaves are used as Astringent, aphrodisiac and in the treatment of palpitation of heart & chronic cough[4]. The leaves are applied as a poultice for mumps and herpes and sometimes, chewed to relieve toothache[5]. The leaves extract of *Wrightia tinctoria* R.Br. exhibited anti-diabetic activity in alloxan induced diabetic rats. Decoction of leaves and bark is used as stomachic, tonic and febrifuge. The flowers exhibited significant anti-inflammatory activity in carrageenan induced hind paw oedema. The root preparations are documented in improving fertility in women. In folk medicine, the dried and powdered roots of *W. tinctoria* R.Br. is orally administered to women for improving fertility. Charaka prescribed Madana (*Catunaregam spinosa)* with Pippali (*Piper longum*) and Indrajava (*W. tinctoria* R.Br. seeds) with warm water and for inducing emesis during fevers. A decoction of Patola (*Trichosanthes dioica Roxb.*), Indrajava (*W. tinctoria*) and Dhaanyaka (*Coriandrum sativum*), cooled and added with sugar and honey was prescribed for checking vomiting, diarrhoea, acid gastritis[6].

PLANT PROFILE

The plant *W. tinctoria* R.Br. belonging to family Apocynaceae is the sweet variety of kutaja. It is a deciduous tree with milky juice and has white jasmine-like white flowers with a fragrant odour. The bark scaly smooth, young parts glabrous or puberulous much branched and variable leaves. The fruits have two distinct pendulous follicles, cylindric, deep green in colour, slightly tapering to both ends. The fruits have cohering at first and at the tip of ends only. The Seeds consist with a tuff of hairs at the base[7]. It is found in Central India, Western peninsula, Coromandel coast, Coimbatore and Godavari districts[4]. It is distributed

in the areas of Madhya Pradesh, Rajasthan and Tamilnadu. According to Charaka Samhita, Kutaja is of two varieties: male and female. The male variety has bigger fruits, white flowers and long leaves. Its bark is extremely red and thick. The female variety gives small fruits, flowers are round in shape and greyish red in colour and bark of white colour. A few scholars equate the male variety with Holarrhena and the female variety with Wrightia. *W. tinctoria* R.Br. has been extensively studied by various researchers for its biological activities and therapeutic potentials such as Antidysenteric activity, Antibacterial, Antimicrobial, Antifungal, Anti-inflammatory, Analgesic, Anthelmintics, Anti-psoriasis, Antidiabetic, Hepatoprotective and also possess Wound healing activity. *W. tinctoria* R.Br. pods contain alpha-amyrin, beta-sitosterol, ursolic acid and oleanolic acid. The stem bark contains beta-amyrin, beta-sitosterol and lupeol[6]. The leaves contain beta-amyrin. The properties of *W. tinctoria* are the same as those of *Holarrhena antidysenterica*. The present review summarizes the pharmacological, and toxicity updates of *W. tinctoria* R.Br.

Vernacular name:

Sanskrit	- Asita-kutanja; (seeds: Indrayavam). Stri kutaja, Shveta Kutaja, Punkutaja.
English	- Sweet Indrajao.
Hindi	- Mitha Indrajava, Dudhi, Indrajau, Kala kuda, Karayaja, Kuda
Gujarati	- Mita Indrajawatunjhad, Indarjou, Dudhalo Kalikari
Konkani	- Kalakudo, Kalakuddo,
Marathi	- Godaindrajav, Bhurevadi, Kalakuda, Kalakudi, Kalakura
Kannada	- Ajamara
Bengali	- Indrajav, Indrajau, Indarjou
Malayalam	- Ayyapala, Kotakappala, Bhanthappaala, Kampippaala, Nilappaala, Irumpala
Tamil	- Veppalai, Vetpalai, Vetpalarisi, Nilapaalai, Irumbalai, Kumbambalai
Telegu	- Ankudu, Ankid-kodisha, Tedlapala, Tondambalai, Ankuduchettu.
Uriya	- Dudhokrya, Krya.

Classification:

Kingdom	- Plantae
Phylum	- Tracheophyta
Class	- Magnoliopsida
Order	- Gentianales
Family	- Apocynaceae
Genus	- Wrightia R.Br.
Species	- tinctoria

PHARMACOLOGICAL ACTIVITIES

Antibacterial activities

Khyade M. S., *et. al.* investigated the comparative phytochemical and antibacterial activities of bark of *W. tinctoria* R.Br. and *Wrightia arborea*. The successive extracts of bark in petroleum ether, chloroform, acetone and methanol were prepared and it has shown the presence of alkaloids, phenolics, saponins and tannins in both the species. The antibacterial activities of extracts of *W. tinctoria* and *W. arborea* in successive different solvent were tested against gram-positive and gram-negative organisms. The chloroform extracts of *W. arborea* showed the broader spectrum of antibacterial activity when compared with *W. tinctoria*. However, it can be used as a good antibacterial agent[8]. Vedhanarayanan P. *et. al.* investigated, antibacterial activity of different extracts (Chloroform, ethanol and methanol) of *W. tinctoria* R.Br. against the human pathogenic bacterial strains, *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* by disc diffusion method on agar. Preliminary phytochemical analysis of *W. tinctoria* R.Br. showed the presence of alkaloids, flavonoids, phenols, saponins, steroids and tannins. Among the three solvents extract tested, ethanol extract of leaf showed higher zone of inhibition. Ethanol extract of *W. tinctoria* R.Br. exhibited maximum zone of inhibition against *E. coli* (29 mm), *B. subtilis* (24 mm) *S. aureus* (30 mm) and *P. aeruginosa* (24 mm). The findings showed potential antibacterial properties of the extracts against the organisms tested[9]. Jain P. S., *et. al.* investigated acute oral toxicity of methanolic extract of woody stems of *Abelmoschus manihot* and *W. tinctoria* R.Br. on ICR mice. No mortalities or evidence of adverse effects have been observed in ICR mice following acute oral administration at the highest dose of 2500 mg/kg crude extracts of *A. manihot* and *W. tinctoria*. The LD_{50} values of crude *A. manihot* and *W. tinctoria* R.Br. extracts were more than 2500 mg/kg. It indicated that both the species did not cause any acute toxicity, thus findings provide scientific validation on the use of the *A. manihot* and *W. tinctoria*[10]. Kannan P., *et. al.* studied the antibacterial and antifungal activity of hexane, methanol and ethanol extracts of *W. tinctoria* R.Br. leaf against the skin bacteria and dermatophytes by *in-vitro,* using agar

dilution method and broth micro dilution method. Methanol and ethanol extracts showed antibacterial activity with MIC value 0.5 mg/ml for *Bacillus subtilis* and *Staphylococcus epidermidis* and 0.25 mg/ml for *Staphylococcus aureus*. The hexane extract showed antifungal activity against *Trichophyton rubrum* and *Trichophyton tonsurans* at 2 mg/ml concentration. The studies were showed *W. tinctoria* R. Br. leaves possessed potent antimicrobial properties. The hexane extracts were showed antifungal properties against dermatophytes fungi whereas methanol and ethanol leaf extracts of *W. tinctoria* R.Br. showed antibacterial properties against dermatophytic microbes. It was suggested that active constituents may be useful in the topical treatment of superficial skin infections[11]. Moorthy K., *et. al.* Studied antimicrobial activity against fourteen microorganisms by *in-vitro* disc diffusion and broth dilution methods using methanolic and petroleum ether extracts from the leaves of *W. tinctoria*. Methanolic extract of *W. tinctoria* R.Br. leaves showed significant antimicrobial activity with MIC value 256 µg/ml for *Cryptococcus neoformans* and 512 µg/ml for *Staphylococcus aureus* and *Candida albicans*. Whereas petroleum ether extract of *W. tinctoria* R. Br. showed significant antimicrobial activity with a MIC value 512 µg/ml for *C. neoformans*, *S. aureus* and 1024 µg/ml for *S. epidermidis* and *C. albicans*. The findings revealed that methanolic and petroleum ether extracts of *W. tinctoria* R.Br. leaves possesses both antibacterial and antifungal activity[12]. Shankar S. R., *et. al.* studied antibacterial activity of hexane, methanol, chloroform, ethyl acetate and aqueous extracts of *W. tinctoria* L. leaf against plant pathogenic bacteria by *in-vitro*. The extracts were tested using disc diffusion method and minimum inhibitory concentration calculated. Ethyl acetate and methanol extracts showed significant antibacterial activity against gram negative bacteria; the MIC was 50 µg/ml for *Xanthomonas campestris* and *Erwina* sp. Study shows *W. tinctoria* L. leaves possessed potent antibacterial properties against plant pathogenic bacteria suggesting that the active constituents may be useful in the control of plant disease[13].

Antifungal activity

Anand D., *et. al*. carried out the phytochemical analysis and antifungal activity of chloroform extracts of *W. tinctoria* R.Br. leaves against seven dermatophytes fungi by agar well diffusion method. The chemical composition of Chloroform extracts from *W. tinctoria* R.Br. leaves using Gas Chromatography - Mass Spectroscopy analysis revealed the presence of eight major compounds. Chloroform extracts of *W. tinctoria* R.Br. leaves showed zone of inhibition against all test organisms at concentration of 50 µg/ml compared with standard drug Clotrimazole. The observations revealed that chloroform extracts of *W. tinctoria* R.Br. leaves possesses potential anti-dermatophytic activity[14]. Kannan P., *et. al.* investigated the *in-vitro* antifungal activity of hexane, chloroform, methanol and ethanol extracts of six different plants (*Acalypha indica*, *Cassia alata*, *Lawsonia inermis*, *Punica granatum*, *Thespesia populnea* and *W. tinctoria* R.Br.) against dermatophytes, non-dermatophytes and yeasts by spore germination test using agar dilution method and the pure compound indirubin isolated from *W. tinctoria* R.Br. The minimum inhibitory concentration (MIC) was determined using broth microdilution method. *W. tinctoria* R.Br. showed remarkable activity against dermatophytic and non-dermatophytic fungi. Chloroform extract of leaf showed activity at 0.5 mg/ml for *Trichophyton rubrum*, *Epidermophyton floccosum*, *Aspergillus niger* and *Scopulariopsis brevicaulis*. Indirubin, exhibited activity against dermatophytes with MIC = 6.25 µg/ml for *Epidermophyton floccosum,* MIC = 25 µg/ml for *T. rubrum* and *T. tonsurans*. It was also active against non-dermatophytes (*A. niger*, *C. albicans* and *Cryptococcus sp.*) within a MIC range of 0.75–25 µg/ml. The indole compound indirubin from *W. tinctoria* R.Br. showed antifungal activity and may be useful in the treatment of dermatophytosis[15].

Anthelmintic activity

Rajalakshmi G. R., *et. al*. investigated alcoholic and aqueous extracts from leaves of *W. tinctoria* R.Br. for their anthelmintic activity against *Raillietina spiralis* and *Ascaridia galli*. Three concentrations 10, 25, 50 mg/ml of each extract were used for anthelmintic activity and determine the time of paralysis and time of death of the worms compared with the standard drug piperazine citrate. The alcoholic and aqueous extract exhibited significant dose dependent anthelmintic activity. Study shows alcoholic and aqueous extract from *W. tinctoria* R.Br. leaves possessed potent anthelmintic activity [16]. Latha K. P., *et. al.* studied anthelmintic activity of crude petroleum ether and chloroform extracts from *W. tinctoria* R.Br. leaves using *Pheretima posthuma*. Three concentrations 2.5, 5.0, 7.5 mg/ml of each extract were used for anthelmintic activity and determine the time of paralysis and time of death of the worm compared with the standard drug piperazine citrate. Study shows petroleum ether and chloroform extracts from *W. tinctoria* R.Br. leaves possess anthelmintic activity and suggesting that has an alternative source of anthelmintics [17].

Anti-psoriasis activity

Dhanabal S. P., *et. al*. evaluated antipsoriatic activity of hydro alcoholic extract from *W. tinctoria* R.Br. leaves by mouse tail test in mice. Antipsoriatic activity was performed at a dose 200 mg/kg body weight in 25-30g mice and Isoretinoic acid (0.5 mg/kg) was used as standard. Degree of orthokeratosis, drug activity and the relative epidermal thicknesses were calculated and statistically analysed. The hydro alcoholic extract produced significant degree of orthokeratosis compared to control and the drug activity was found to be

70.18%, which is more potent than the standard (57.43%). It was concluded that the hydro alcoholic extract from *W. tinctoria* R.Br. leaves has potent antipsoriatic activity and can be used for treatment of psoriasis [18]. Jacob G., *et. al*. invented a pharmaceutical preparation ointment for the treatment of psoriasis, the ointment comprising the ingredients of a latex extracted from the leaves of the *W. tinctoria* R.Br. plant, urea, and polyethylene glycol. The pharmaceutical preparation is also a hydrophilic ointment that is capable of delivering the active drugs without being greasy or irritating to the skin [19].

Antidiabetic activity

Ashok R. R., *et. al*. investigated the antidiabetic and hypolipidemic activity of petroleum ether extract from *W. tinctoria* L. leaves in alloxan induced diabetic albino wistar rats. Diabetes was induced by oral administered alloxan as a single dose (120 mg/kg, body weight). Two doses (200 & 400 mg/kg body weight/day) of pet ether extracts were used for the studies to alloxan-induced diabetic rats. The fasting blood sugar levels and serum biochemical analysis in alloxan-induced diabetic rats were investigated. Oral administration of petroleum ether extract (200 & 400 mg/kg) for 14 days exhibited a significant reduction in serum glucose, total cholesterol, and triglycerides in alloxan diabetic rats. The anti-diabetic and hypolipidemic activities of the pet ether extract ware similar to those produced by glibenclamide at 2.5 mg/kg. It was concluded that the Petroleum ether extract from *W. tinctoria* L. leaves has potent antidiabetic and hypolipidemic activity and can be used for treatment of diabetes mellitus[20]. Kumar S., *et. al*. evaluated the antidiabetic activity of alcoholic extracts *W. tinctoria* and *P. quinquefolia* using an oral glucose tolerance test and blood insulin levels on Zucker diabetic rat model. Alcoholic extracts of *W. tinctoria* and *P. quinquefolia* at a dose of 250 mg/kg body weight were used throughout the study. Following a glucose tolerance test and blood insulin levels were used to determine the ability of these extracts to alter glucose levels in diabetic rat model and the glucose lowering activities of these extracts were then compared to the controls. Both tested alcoholic extracts have shown to exhibit significant antidiabetic and hypoglycaemic activity compared to the control. *W. tinctoria* and *P. quinquefolia* have an antidiabetic activity which reduced the blood glucose level in oral glucose tolerance test significantly compared with the control. These studies revealed that the herbal extract of *P. quinquefolia* has direct correlation between glucose and insulin levels. However, *W. tinctoria* significantly lowered blood glucose levels[21]. Latha K. P., *et. al*. investigated the antidiabetic effect of petroleum ether, chloroform and alcohol extracts from *W. tinctoria* leaves on alloxan induced diabetic rats of wistar strain. Petroleum ether, chloroform and alcohol extracts from *W. tinctoria* leaves at a dose 250 mg/kg body weight were used throughout the study. Blood glucose levels were determined by one touch profile method using Gluco-meter and ware compared to standard drug glibenclamide at 5 mg/kg. body weight. It was concluded that chloroform extract from *W. tinctoria* leaves showed a significant anti-diabetic activity when compared to the standard drug glibenclamide[22].

Anti-inflammatory activity

Tharkar P. R., *et. al*. investigated the anti-inflammatory activity of aqueous, pet. ether, chloroform and methanolic extract from stem bark of *W. tinctoria* R.Br. in rat by carrageenan- induced rat paw oedema and cotton pellet induced granuloma method. The aqueous, pet. ether, chloroform and methanolic extract showed inhibition of rat paw oedema and percent granuloma changes at dose of 200mg/kg when compared to control group and standard drug diclofenac sodium (13.5 mg/kg /b w, p.o) group. It was concluded that the aqueous, chloroform and methanolic extract at dose of 200 mg/kg showed significant reduction in carrageenan- induced paw oedema and Chloroform extract at dose of 200 mg/kg inhibited the cotton pellet induced granuloma. It was suggested *W. tinctoria* R.Br. stem bark can be used in the treatment of inflammation[23]. Bigoniya P., *et. al*. investigated the anti-inflammatory activity of hydro-alcoholic extract of *W. tinctoria* in mice and rats using various models. The anti-inflammatory effects of the extract were observed in three different dose levels 300, 500 & 1000 mg/kg. Carrageenan-induced paw oedema and cotton pellet induced granuloma model were employed to test anti-inflammatory activity. The hydroalcoholic extract showed inhibition of rat paw oedema and percent granuloma changes at dose of 1000 mg/kg when compared to control group and standard drug aspirin (100 mg/kg /b w, p.o) group. Study revealed anti-inflammatory activity at the 1000 mg/kg dose[24]. Jain P. S., *et. al*. investigated the anti-inflammatory activity of petroleum ether and methanol extracts of *W. tinctoria* woody stems using carrageenan- and histamine-induced rat paw oedema method. The petroleum ether and methanolic extract of air-dried, powdered woody stems were extracted in Soxhlet apparatus. The crude dried petroleum ether and methanolic extract at doses of 100, 200 and 400 mg/kg were used for the studies to anti-inflammatory activity. The results obtained from studies indicate that the petroleum extract (400 mg/kg) possessed significant anti-inflammatory activity when compared with the standard drug, diclofenac sodium (10 mg/kg). This study showed that the petroleum ether and methanol extracts of *W. tinctoria* woody stems possess potential pharmacologically active constituents capable of inhibiting inflammation[25]. Bindu A. R., *et. al*. investigated analgesic and anti-inflammatory effects of *W. tinctoria* leaf extract in rats and mice. The total ethanolic extract was fractionated with different solvents (petroleum ether, benzene, chloroform and

ethyl acetate) and aqueous extract was also prepared. All the extracts were studied for its preliminary phytochemical screening. The ethyl acetate and aqueous extract at doses of 200 and 400 mg/kg were used for the studies to anti-inflammatory activity by carrageenan induced hind paw oedema method. The percentage inhibition of paw volume in drug treated group was compared with control group and standard group (Indomethacin 10 mg/kg). Ethyl acetate fraction (400 mg/kg) showed maximum percent inhibition of paw volume. The ethyl acetate fraction was studied for its analgesic effect on acetic acid-induced writhing test and hot plate method in mice and was found to be effective. The results conclude that *W. tinctoria* leaves were active as an anti-inflammatory and analgesic agent[26].

Antinociceptive activity

Reddy Y. S. R., *et. al*. studied the antinociceptive activity of extract of *W. tinctoria* bark by acetic acid induced writhing test in Swiss male mice. The petroleum ether, chloroform, ethyl acetate, acetone and methanol extracts of *W. tinctoria* bark was studied at dose 200 mg/Kg body weight. The findings of drug treated group was compared with control group and standard group (Acetylsalicylic acid 100 mg/kg). The results showed significant antinociceptive activity and concluded that the *W. tinctoria* bark possess the antinociceptive activity[27].

Antihypertensive activity

Jamshed H., *et. al.* reported the hepatoprotective, antihypertensive, and antioxidant activities of hydro methanol (70% Methanol) extract of *Viola odorata* leaves and *W. tinctoria* R.Br. seeds. Total phenolic compounds, total flavonoids content, and proanthocyanins of the methanolic extracts were identified using HPLC. Antioxidant capacity was measured using the in vitro assays. Hydro methanol extract dose at 300 and 600 mg/kg were used for Antihypertensive and hepatoprotective studies on a high fat diet rat model. Both extracts exhibited significant antioxidant potential. The *in vivo* studies indicated a significant reduction in the high fat diet induced rise in serum uric acid, phosphorus, aspartate aminotransferase, alanine aminotransferase, and gamma-glutamyl transferase. The results showed significant antihypertensive and hepatoprotective activity and concluded that the *V. odorata* and *W. tinctoria* R.Br. can be use in the treatment of hepatic disorder and hypertension[28].

Antiviral Activity

Selvam P., *et. al.* investigated the antiviral activity and cytotoxicity of different extracts (ether, chloroform methanol ethanol and aqueous) of leaves from *W. tinctoria* and fruit powder of *Morinda citrifolia* against replication of HIV-1(IIIB) in MT-4 cells and HCV in Huh 5.2 cells. Chloroform extract of *W. tinctoria* exhibited a maximum protection of 48% against the cytopathic effect of HIV-1(IIIB) in MT-4 cells. Fruit juice of *M. citrifolia* exhibited a displayed marked cytotoxic activity in lymphocyte (MT-4) cells (CC50: 0.19 µg/ ml). The effective concentration for inhibition of HCV sub genomic replicon replication in Huh 5-2 cells by *M. citrifolia* was 0.98 µg/ml and by chloroform extract of *W. tinctoria* was 10 µg/ml. The concentration that reduced the growth of exponentially proliferating Huh 5-2 cells by 50% was greater than 50 µg/ml. It was concluded that *W. tinctoria* leaves were active as an anti-HIV and can use in the treatment of AIDS [29].

Wound healing activity

Jain P. S., *et. al.* studied wound healing potential of petroleum ether and methanol extracts of woody stems of *Abelmoschus manihot* (L.) Medik. and *W. tinctoria* R.Br. in Wistar albino rats. The rats were divided into six groups of six animals each. First group is normal wounded control, second group received standard drug (Iodine-povidone ointment) and the other four groups were extract-treated groups with two different doses. The wound healing parameters were evaluated by using incision wounds in extract-treated rats, standard and controls. The observations showed significantly increased the wound healing activity of both the doses of petroleum ether and methanol extract when compared with the control group [30]. Veerapur V. P., *et. al.* studied the wound healing activity of ethanol (95%) extract of *W. tinctoria* bark using incision, excision and dead space wound models in albino wistar rats. Preliminary phytochemical analysis of *W. tinctoria* showed the presence of triterpenoids, saponins, steroids. In resutured incision wound model, ethanol extract showed significant breaking strength compared to control. The ethanol extract promotes better wound healing by increasing the percentage wound closure and decreasing epithelization time compared to control. The observation showed that ethanol extract from *W. tinctoria* bark have significant wound healing activity. This may be attributed to the presence of triterpenoids in the *W. tinctoria* plant [31].

Hepatoprotective activity

Bigonia P., *et. al.* investigated protective effect of triterpene fraction (lupeol, β-amyrin and β-sitosterol) isolated from the stem bark of *W. tinctoria* R.Br. on carbon tetrachloride-induced hepatotoxicity in the rat. Concentration (1.5 mg/kg, i.p) of Carbon tetrachloride (CCl_4) was used as potent hepatotoxic agent which causes peroxidative degeneration of membrane lipids with the potential outcome of fatty degeneration. The hepatoprotective effect of triterpene fraction (125, 250 and 400 mg/kg, p.o.) was compared with standard drug silymarin (20 mg/kg, body weight). It was observed that the CCl_4-induced acute increase in

serum SGPT, SGOT and ALP activities and triterpene fraction suggesting the protection of liver metabolizing enzymes. Triterpene fraction afforded protection against the hepatic abnormalities due to presence of lupeol and β-amyrin. This study supports the traditional use of *W. tinctoria* bark in liver diseases [32].

Antidiarrheal activity

Bigoniya P., *et. al.* investigated the antidiarrheal activity of ethanol extract and isolated steroidal alkaloid fraction (WTSA) from *W. tinctoria* R.Br. Roxb. bark in different experimentally induced diarrhea models of rats, isolated rat ileum, and on enteric bacterium to establish the therapeutic potential. The extract at 500 and 1000 mg/kg dose, and WTSA at 50 and 100 mg/kg dose significantly inhibited the frequency and wetness of faecal droppings in castor oil-induced diarrhea. Extract and WTSA decreased propulsion of charcoal meal and also reduced prostaglandin E2-induced enteropooling. WTSA reduced amplitude, frequency, and tone of spontaneous gut movement. Alkaloid fraction also inhibited acetylcholine (Ach)-induced contraction of rat ileum. *W. tinctoria* alkaloid has antisecretory, spasmolytic, antienteropooling, antimotility, and antiperistaltic activity. These results showed good antidiarrheal activity of *W. tinctoria* against secretory, osmotic, motility related, and inflammatory diarrhea [33].

Antiulcer activity

Divakar M. C., *et. al.* evaluated the antiulcer activity of methanolic and 70% ethanolic leaves extract of leaves of *W. tinctoria* (Roxb.) R.Br. by employing aspirin plus pylorus ligation induced ulcer in albino rat model. The antiulcer activity of the extract from *W. tinctoria* R. Br. (200 mg/kg body weight) were compared with carboxy methyl cellulose (CMC), pylorus control, Aspirin and standard famotidine (20 mg/kg). Various biochemical parameters like volume of gastric juice secretion, pH, free acidity, total acidity, ulcer index and percentage inhibition were studied. The methanolic extract from *W. tinctoria* R. Br. leaves showed significant gastro protective activity (65.89%) when compared with the standard drug famotidine which showed 75.34%. It was suggested that the methanolic extract of *W. tinctoria* R.Br. leaves possesses anti-ulcer effect [34].

Anti-anaemic activity

Bigoniya P., *et. al.* studied anti-anaemic activity of flavonoid fraction of *W. tinctoria* R.Br. bark methanolic extract on phenyl hydrazine and butadiene induced anemia in albino mice. Phenyl hydrazine (40 mg/kg, i.p.) and butadione (100 mg/kg, i.p.) was used to induce anemia in albino mice. Various biochemical parameter like, Hemoglobin (Hb), total red blood cells (RBCs), white blood cells (WBCs), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), packed cell volume (PCV), iron, total iron binding capacity (TIBC), and ferritin were measured. Flavonoid fraction of *W. tinctoria* R.Br. showed significant rise in RBC, Hb, and PCV and decrease in serum iron and ferritin level significantly signifying potent anti-anaemic activity against butadione. Flavonoid fraction of *W. tinctoria* R.Br. treatment on phenyl hydrazine and butadione induced anaemic rat showed good anti-anaemic activity with rich presence of flavonoid [35][5].

Human platelet aggregation inhibitor

Barletta M. A. *et. al.* studied inhibitory effects on human platelet aggregation of chlorogenic acid isolated from *W. tinctoria* by using *in-vitro* study. A 70% ethanolic extract derived from seeds of *W. tinctoria* R. Br. was fractionated with chloroform followed by ethyl acetate. The ethyl acetate fraction was further fractionated and purified through a series of three successive column chromatographic separations. LC-MS/MS and NMR studies were performed for the structure elucidation of the active phenolic compound present in the ethyl acetate fraction of *W. tinctoria* seeds. A phenolic compound was isolated and identified as chlorogenic acid by LC-MS/MS and NMR studies. It was found that chlorogenic acid showed concentration-dependent inhibitory effect on collagen-induced platelet aggregation *in-vitro* with an IC_{50} of 0.2363 µg/µl. It was suggested that chlorogenic acid can be developed as potential antiplatelet agent in the treatment of cardiovascular diseases in diabetes mellitus [36].

Immunomodulatory activity

Nandakumar K., *et. al.* investigated the immunomodulatory activity of the bark petroleum ether, ethanol and 40% ethanol extracts of *W. tinctoria* R.Br. (Roxb.) by using delayed type hypersensitivity reaction and carbon clearance assay on albino Swiss mice. Petroleum ether and ethanolic extracts (200, 400 mg/kg, p.o each) produced a significant increase in delayed type hypersensitivity in response to sheep red blood cells. Petroleum ether extract showed better activity than ethanolic extract in delayed type hypersensitivity response. Ethanolic extracts (200 and 400 mg/kg, p.o.) in dose dependent manner have shown significantly increase in the phagocytic activity. It was concluded that ethanolic extract of *W. tinctoria* R.Br. possesses immunostimulant activity in carbon clearance assay whereas petroleum ether extract showed immunomodulatory activity in delayed type hypersensitivity model [37].

CONCLUSION

As per the Ayurvedic literature, *W. tinctoria* R.Br. is an important medicinal plant having diverse pharmacological activities such anthelmintics, antipsoriatic, antidysenteric and used in the treatment of piles, skin diseases, flatulence & bilious affections, pain & inflammation. It is also reported having cytotoxic, antidiabetic, wound healing, antiviral, antianemia and antiulcer activity. The major component isolated from this plant is lupeol, which is widely used. Lupeol and its derivatives are useful topically as an anti-inflammatory agent and in epidermal regeneration, in maintaining skin texture and integrity of the skin. The stems bark of *W. tinctoria* R.Br. has shown to contain β-amyrin, lupeol, β-sitosterol. It is essential that more clinical and pharmacological studies should be conducted to investigate the unexplored activities of the plant. As per the above finding, it was concluded that the plant species may form a good potential source in the drug development and we hope that this review will help researcher in near future to create interest towards *W. tinctoria* R.Br.

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