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COMPARATIVE STUDY ON PHYTOCHEMICAL & PHARMACOLOGICAL ACTIVITIES OF *CROTON BONPLANDIANUM* EXTRACTS OF LEAVES, STEM, SEEDS, AERIAL PARTS & ROOT

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ABSTRACT

Croton bonplandianum, a member of the Euphorbiaceae family, is a widely distributed plant known for its diverse medicinal properties. The plant has gained scientific interest due to its rich phytochemical composition, which includes flavonoids, alkaloids, tannins, saponins, and terpenoids. This review aims to provide a comprehensive summary of the phytochemical constituents and pharmacological activities of *Croton bonplandianum*, emphasizing its antimicrobial, antioxidant, anti-inflammatory, anticancer, and hepatoprotective effects. The plant's aerial parts and roots have been found to contain a diverse array of bioactive compounds, including diterpenes, alkaloids, flavonoids, saponins, and phenolic compounds, which contribute to its therapeutic effects. The phytochemical analysis and pharmacological properties of the leaves, stem, root, seeds, and aerial parts are compared to provide a holistic understanding of the plant's therapeutic potential. The findings suggest varying concentrations of active compounds and differing bioactivities in different plant parts which may influence their medicinal application. However, the study encourage further study in pharmacological activities in root extracts as they were found to be more significance in antimicrobial and anti-inflammatory activities on comparison with leaves and aerial parts.

KEYWORDS: *Croton bonplandianum*, phytochemistry, pharmacology, medicinal plants, bioactive compounds, comparative study, leaves, stem, root, seeds, aerial parts.

INTRODUCTION

Croton bonplandianum Baill (*Croton sparsiflorus* Morong) is a shrub with a high glabrescent stem and being a weed can be seen growing abundantly in waste lands of India.[1] The vernacular names of the plant are “dog chilli” (English), Kala bhangra or ban tulasi (Hindi), galivana mokka or “kukka mirapa” (Telugu) and “relpoondu” (Tamil).[1] The taxonomy of *Croton bonplandianum* is as follows:

Classification	
Kingdom	Plantae
Sub Kingdom	Tracheobionta
InfraKingdom	Streptophyta
Sub Division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Sub class	Rosidae
Order	Malphilghiales
Family	Euphorbiaceae
Sub Family	Crotonoideae
Tribe	Crotoneae
Genus	*Croton* L.
Species	*Croton bonplandianus*

Fig. 1: Systematic Classification and image of *Croton bonplandianum* Baill.

In natives of tropical and subtropical regions, the plant has attracted scientific interest due to its promising therapeutic potential.[2,3] The plant has been traditionally used for a variety of medicinal applications, including wound healing, anti-inflammatory treatment, antimicrobial activity, and as a laxative. It has also been employed in treating skin disorders, fevers, respiratory problems, and pain relief. The diverse pharmacological properties of *C. bonplandianum* have contributed to its significant role in traditional medicine, particularly in Ayurveda and Unani medicine. In Ayurveda, *C. bonplandianum* is characterized by its Tikta (bitter) and Katu (pungent) taste, Ushna virya (hot potency), and its ability to balance Kapha-Vata doshas. It has been extensively used in Ayurvedic formulations for skin detoxification, digestive health, pain management, respiratory disorders, and fever treatments. Traditional practitioners believe in its potential for blood purification and its ability to alleviate chronic skin diseases and inflammatory conditions.[4] A comparative table on different parts used in folklore and Ayurveda are shown in the table 1.

Table 1: Comparison of the traditional and Ayurvedic uses of *Croton bonplandianum*.[4]

Use Case	Traditional Uses	Ayurvedic Uses	Parts Used
Skin Diseases & Wound Healing	Used to treat eczema, boils, and wounds.	Applied as a paste for ulcers, wounds, and skin infections.	Latex, Leaves
Digestive Disorders	Used as a purgative (mild laxative) and digestive aid.	Helps in relieving constipation and indigestion.	Leaves, Seeds
Respiratory Issues	Used in smoke therapy for clearing phlegm and treating asthma.	Decoction used for cough, bronchitis, and respiratory congestion.	Leaf Extract
Pain Relief (Analgesic & Anti-inflammatory)	Juice applied for joint pain and inflammation.	Paste used to relieve arthritis and rheumatism pain.	Paste or Juice of Plant
Anthelmintic (Worm Expeller)	Traditionally used to expel intestinal worms.	Used in Ayurveda as a remedy for intestinal parasites.	Seeds, Leaves
Liver Protection	Folk remedy for liver disorders like jaundice.	Believed to detoxify and strengthen liver function.	Whole Plant
Blood Purification & Detoxification	Used to cleanse blood and treat skin allergies.	Considered a natural blood purifier in Ayurveda.	Whole Plant
Snake & Insect Bites	Latex applied externally for snake bites and insect stings.	Used as an antidote in some Ayurvedic treatments.	Latex

Due to its widespread traditional use, the plant parts were systematically and scientifically investigated for the phytochemical and pharmacological aspects. However, there is still a need to have a comprehensive study for understanding the differential bioactive potential of these plant components which could open avenues for targeted therapeutic applications. This review aims to provide a comparative analysis of the phytochemical and pharmacological activities of different parts of the plant, including the leaves, root, seeds, and aerial parts.

METHODOLOGY

A systematic literature review was conducted from January 2025 to February 2025 using electronic databases such as PubMed, ScienceDirect, and Google Scholar. Keywords including "Croton bonplandianum," "phytochemistry," "pharmacological activities," "antimicrobial," "anticancer," and "antioxidant" were used to retrieve relevant studies. Only peer-reviewed articles, books, and conference proceedings published in English were considered. Data were extracted, analyzed, and synthesized to provide an objective and comprehensive overview of the plant's bioactive components and therapeutic potential.

Phytochemical Constituents

Croton bonplandianum is a plant known for its rich phytochemical composition, containing various bioactive compounds. Research indicates that it is a valuable source of steroids, unsaturated steroids, phenolics, and alkaloids. Additionally, the plant contains flavonols,

cardinolides, leucoanthocyanins, flavonoids along with terpenoids and glycosides.[5] The residual biomass left after extracting biocrude from *C. bonplandianum* is abundant in biopolymers like cellulose, hemicellulose, and lignin, which can be utilized for ethanol and oil production.[6] Studies suggest that methanol serves as a more effective solvent than acetone, chloroform, and petroleum ether for extracting alkaloids, flavonoids, glycosides, steroids, phenols, tannins, saponins, and resins.[7] The following is a brief description on the different bioactive compound with reported pharmacological activity isolated from *Croton bonplandianum.*

- Alkaloids**:** Bonplandine, crotonosine, and crotsparine, which exhibit cytotoxic and antimicrobial properties.[8]
- Flavonoids**:** Quercetin, kaempferol, and rutin, known for their antioxidant and anti-inflammatory effects.[9]
- Terpenoids and Diterpenes: Phorbol esters, crotonadiol, and lupeol, demonstrating antimicrobial and anticancer properties.[10]
- Essential Oils: Limonene, eugenol, and caryophyllene, with significant antimicrobial and insecticidal activities.[11]
- Phenolics and Tannins**:** Gallic acid, ellagic acid, and catechins, exhibiting strong antioxidant and hepatoprotective properties.[12]

Here is an account of the phytochemical compounds and their pharmacological activities reported to be isolated from aerial parts, leaves, seeds and roots of the plant while the bioactive compounds identified in all the plant parts are presented in table-2. The aerial parts of *C. bonplandianum* exhibited a rich diversity of bioactive compounds, including:

- Flavonoids: Flavonoids such as quercetin and kaempferol were identified, which are known for their antioxidant and anti-inflammatory properties.[13]
- Alkaloids: Alkaloids like nicotine and various indole derivatives were present, contributing to the plant's analgesic and sedative effects.[14]
- Triterpenoids: The presence of compounds like betulinic acid suggests anti-inflammatory and antitumor activity.[13]
- Saponins: These compounds are known for their antimicrobial and immune-stimulating effects.[15]

The leaves of C. bonplandianum were found to contain[18, 19, 20]:

- Flavonoids: Coumarin is potential in managing postprandial hyperglycemia.

- Alkaloids: Sparsiflorine and crotsparine shown to have weak antibacterial activity
- Steroids: Stigmasterol active compound exhibiting antimicrobial activity

The seeds of *C. bonplandianum* were found to contain:

- Flavonoids: Rutin and myricetin were identified, with strong antioxidant activities.[16]
- Phenolic compounds: Gallic acid and caffeic acid, known for their free radical scavenging abilities, were detected.[14]
- Fatty acids: Linoleic acid and oleic acid were found, which contribute to the plant's potential as a nutritional supplement.[13]

The roots showed the presence of:

- Alkaloids: The roots were rich in alkaloids such as tropane derivatives, linked to their antispasmodic properties.[14]
- Terpenoids: Sesquiterpenes and diterpenes were identified, which have demonstrated antibacterial and antifungal activities.[16]
- Saponins: The roots also contained saponins, known for their cardioprotective and hypocholesterolemic properties.[15]

Table 2: Comparative table of the phytochemical constituents and compounds identified in the leaves, stem, aerial parts, seeds, and roots of *Croton bonplandianum*.

Phytochemical Constituent	Leaves[17]	Stem[22]	Aerial Parts[23]	Seeds	Roots[19]
Flavonoids	Coumarin, Rutin [18]	+	Quercetin, Kaempferol (Antioxidant, Anti-inflammatory)[13, 16]	Rutin, Myricetin (Antioxidant)[15], [16]	+
Alkaloids	Crotsparine, Dihyroproaporphines-Crotsparinine, N-methylcrotsparine, N-O-dimethylcrotsparine, N-methylcrotsparinine Sparsiflorine, Crotoflorine[18, 19, 21]	+	Isicrotsparinine, its N-Me derivatives, (+) – tetra-hydroglazievine[24] Nicotine, Indole derivatives (Analgesic, Sedative)[14, 15]	-	Tropane derivatives (Antispasmodic)[14]
Triterpenoids	+	-	Betulinic acid (Anti-inflammatory, Antitumor)[13]	-	+
Saponins	+	-	-	-	(cardioprotective and hypocholesterolemic properties)
Phenolic Compounds	+	+	-	Gallic acid, Caffeic acid (Free radical	-

				scavengers).[15]	
Fatty Acids	-	-	-	Linoleic acid, Oleic acid (Nutritional)[13]	-
Terpenoids	Phorbol derivative (I)[20]	+		phorbol esters[25]	Sesquiterpenes, Diterpenes (Antibacterial, Antifungal)[16]
Tanins	+	+	+	-	+
Steroids	Stigmasterol (antimicrobial activity), Beta-sitosterol[19]	+	+	-	+
Glycosides	+	-	-	-	-

Note: '+' indicates presences of compound '-' absence of compound

Pharmacological Analysis Methods

The pharmacological activities of the various parts of *Croton bonplandianum* (leaves, stem, root, seeds, and aerial parts) were assessed using a series of *in-vitro* and *in-vivo* techniques to determine their toxicity, anti-inflammatory, antimicrobial, antitubercular, antidiabetic, anticancer, anesthetic, larvicidal, antioxidant, wound healing and analgesic properties. Below is a description of the eleven methods used and a comparison on the pharmacological activities of all the plant parts is shown in table-3.

Acute toxicity studies: The rats of both the sex were acclimatized to the laboratory conditions for 10 days before the commencement of the experiment. All animals were provided with a standard pellet diet and water *ad libitium*. Wister albino rats weighing between 200-250g were divided into groups of each ten with equal number of males and females. They were kept for overnight fasting. Three doses of the extract 100, 500 and 1000 mg/kg body weight, were given orally to three different groups. The animals were kept for observation for a period of fourteen days.[26]

Anti-inflammatory Activity: The potential of ethanolic extract of Croton bonplandianum Bail leaf was evaluated in Human Red Blood Cell Membrane to investigate the anti inflammatory using an *in-vitro* model. The prevention of hypotonicity induced HRBC membrane lysis was measured as a parameter using hydrocortisone as a standard.[27] Carrageenan-induced rat paw edema model was used to measure anti-inflammatory effects by evaluating paw edema after carrageenan injection.[28]

Antimicrobial Activity: Agar Well Diffusion Method: The antimicrobial properties were evaluated by measuring inhibition zones against various microorganisms.[29, 30]

Anti-tubercular activity: Anti tubercular potential of the extract is evaluated using the MABA, a method that is nontoxic and heat stable and used together with the BACTEC radiometric technique for judging the potentials of anti-mycobacterial activity.[31]

Antidiabetic Activity: The antihyperglycemic effects of *Croton bonplandianum* was performed by evaluating its enzyme inhibitory activities. The researchers found that extracts from *C. bonplandianum* exhibited significant inhibition of key enzymes involved in carbohydrate metabolism, such as α-glucosidase and α-amylase. Compounds like triterpines and coumarin were isolated from leaves and assayed for enzyme inhibition.[32, 33]

Anti-cancer activity: The anti cancer activity of *C. bonplandianum* was assessed by performing studying effect of extracts against A549 lung cancer cells by inducing apoptosis and arrest of G2/M phase. The study should demonstrate chromatin condensation and DNA fragmentation, suggesting activation of the intrinsic apoptosis pathway and accumulation of cells in the sub-G0/G1 phase, indicative of apoptosis initiation.[34, 35]

Local Anesthetic Activity: The potential of local anesthetic effects of *Croton bonplandianum* extracts was assessed using various animal models. The researchers employed multiple experimental models, including lumbar plexus anesthesia, nerve block anesthesia, frog muscle twitch assays, guinea pig infiltration anesthesia, and surface anesthesia in rabbits, to assess the efficacy of the plant extracts.[36]

Larvicidal Activity: The larvicidal activity was performed by determining the effect of extracts on *Aedes aegypti* larvae likely following standard bioassay methods for mosquito larvicidal studies.[37]

Antioxidant activity: Antioxidation activity assessed the free radical scavenging ability of *Croton bonplandianum* extracts using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay.[38,39]

Wound healing effect: The wound-healing efficacy of *C. bonplandianum* leaf extract through topical application in rats.[49,50]

Analgesic Effect: The extracts were tested for analgesic effect on experimental rats using Acetic acid-induced writhing, formalin test and hot plate test.[51,52]

Table 3: Comparative Table of Pharmacological Activities of *Croton bonplandianum*.

Pharmacological Activity	Root Extract	Stem	Aerial Parts Extract	Seed Extract	Leaf Extract	Methods Used (Reference)
Antioxidant Activity	+	+	-	-	+	DPPH assay [38, 39,40,41]
Anticancer Activity	-	+	-	-	+	MTT assay on A549 cells [42, 43]
Antibacterial Activity	+	-	+	-	limited activity	Agar well diffusion method [29,30, 44]
Antihyperglycemic Activity	+	-	-	-	+	α-Amylase and α-Glucosidase inhibition assay [45]
Local Anesthetic Activity	-	-	+	-	+	Guinea pig and frog model [46, 47]
Anti-inflammatory Activity	+		+	+	+	Carrageenan-induced paw edema model [48]
Antimicrobial Activity	+	+	+	-	+	Disc diffusion method [49, 50]
Wound Healing Effect	-	-	-	-	+	Topical application in rats[41, 52]
Analgesic activity	+	-	-	+	+	Acetic acid-induced writhing, formalin test and hot plate test[41, 53, 54]
Larvicidal Activity	-	-	-	-	+	LD50 on *Aedes aegypti* larvae[37]

Note: '+' indicates presences of activity '-' no reported study or no activity

DISCUSSION

There were no signs of toxicity up to 1000 mg/kg body weight in methanolic and chloroform extracts of *C.* bonplandianum.[26] Studies provide strong evidence for the analgesic potential of *C. bonplandianum* in various experimental models.[53,54] The methanolic and chloroformic extracts of aerial parts, leaves and roots had exhibited dose dependent antiinflamatory activity in Carrageenan-induced paw edema model.[28,46] The alkaloid extract from the leaves of *C. bonplandianum* has exhibited moderate antibacterial activity, particularly against *Pseudomonas aeruginosa*. Sparsiflorine, an isolated compound from this extract, is identified as the primary bioactive molecule responsible for this effect.[55] Patel et al. (2011) identified stigmasterol as an active component in the leaf extracts, which exhibited promising antibacterial activities against antibiotic-resistant bacteria and also studied the antibacterial activity of alkaloid extracts from the leaves, which contained crotsparine and sparsiflorine.[56] While crotsparine did not show antibacterial activity, the extract and sparsiflorine demonstrated moderate activity, particularly against *Pseudomonas aeruginosa*.[57] Additionally, Sharma et al. (2024) reported that methanol extracts from the leaves and stems possess significant antibacterial properties against *Escherichia coli*, attributed to their rich phenolic content.[58] The methanolic and chloroform root and aerial parts of the plant exhibited significant antibacterial activity against Gram positive and Gram negative bacteria including on multidrug resistant *Pseudomonas aeruginosa*.[59] Investigations into the antihyperglycemic potential of *C. bonplandianum* have revealed that chloroform fractions of

the methanolic leaf and root extract inhibit α-amylase and α-glucosidase enzymes. The studies also show that triterpenes and coumarin isolated from the leaves α-Glucosidase inhibition is comparable to standard antidiabetic drugs, indicating the plant's potential in managing postprandial hyperglycemia.[60,61,62] Experimental studies using guinea pig and frog models have shown that extracts of *C. bonplandianum* possess local anesthetic properties too. The efficacy of these extracts was found to be dose-dependent, suggesting potential applications in pain management.[36] Studies on A549 lung cancer cells revealed that the extract inhibited cell proliferation and induced apoptosis in a dose-dependent manner. Mechanistic studies indicated that the extract caused cell cycle arrest at the G2/M phase and promoted apoptosis through the intrinsic pathway, as evidenced by increased Bax/Bcl-2 ratio and activation of caspase-9 and caspase-3.[34,35] These results suggest that *C. bonplandianum* leaf extract may serve as a potential therapeutic agent against lung cancer. The study on larval susceptibility of *Aedes aegypti* to *Croton bonplandianum* methanolic leaf extracts demonstrated significant dose-dependent larvicidal efficiency. Based on these findings, a concentration of 124 ppm is recommended for effective vector control.[37] The methanolic extracts of leaves, stem and root of *C. bonplandianum* have demonstrated significant antioxidant activity, as evidenced by their free radical scavenging capabilities. Additionally, these extracts have shown cytotoxic effects against HepG2 cancer cell lines, suggesting potential anticancer properties.[63] Moreover, the anti-oxidation activity investigates the plant's potential in neutralizing free radicals and relatively high when compared to other plants, which is essential for understanding its medicinal benefits in preventing oxidative stress-related diseases.[38,39,64] Traditionally, *C. bonplandianum* has been used in wound healing, and studies support this use. Its extracts promote tissue repair and accelerate healing by stimulating collagen synthesis and cellular regeneration.[51 52]

Croton bonplandianum bioactive compounds have been isolated and characterize since 1968 and still continue to draw the interest of researches due to its potential use in various pharmacological activities. The preliminary phytochemical analysis of the leaves, stem, aerial parts and roots have shown the presence of all major constituents like alkaloids, flavonoids, glycosides, steroids, phenols, tannins, saponins, and resins whereas the seed extracts are positive for flavonoids, phenolic compounds and fatty acids.[7,17,19,22,23] The bioactive compounds like Rutin(flavonoid),[18] Crotsparine, Dihyroproaporphines - Crotsparinine, N-methylcrotsparine, N-O-dimethylcrotsparine, N-methylcrotsparinine Sparsiflorine, Crotoflorine (alkaloids),[18,19,21] Phorbol derivative (I)(terpinoid)[20] and Beta-sitosterol [19]

were reported to be isolated. Furthermore, the phytochemical constituents of the aerial parts are rich in flavonoids like quercetin and kaempferol reported to exhibit antioxidant and anti-inflammatory properties[13,16] while alkaloids (nicotine, indole derivatives) contribute to analgesic and sedative effects[14,15] and triterpenoids (betulinic acid) are known for anti-inflammatory and antitumor activities.[13] The Seeds reported to contain flavonoids (rutin, myricetin) with antioxidant activities[15,16], phenolic compounds (gallic acid, caffeic acid) which are free radical scavengers[15], and fatty acids (linoleic acid, oleic acid) for nutritional benefits.[13] The roots are rich in alkaloids (tropane derivatives), which are antispasmodic[14], saponins with cardioprotective and hypocholesterolemic effects[15,16], and terpenoids (sesquiterpenes, diterpenes) known for antibacterial and antifungal properties.[16]

The difference in phytochemical composition across the plant parts may contribute to the observed variations in pharmacological activity. For instance, the presence of alkaloids and flavonoids in the aerial parts and leaves might explain their anti-inflammatory and antioxidant activities.[61] The pharmacological findings suggest that different parts of Croton bonplandianum may be suited for different therapeutic uses. The root and seeds, with their antidiabetic and analgesic effects, may be useful in metabolic and pain management disorders, while the leaves and aerial parts show promise for inflammation and infection control.[62]

CONCLUSION

Croton bonplandianum exhibits a diverse range of pharmacological activities, including anti-inflammatory, antioxidant, anticancer, antibacterial, antitubercular, antihyperglycemic, wound healing, local anesthetic, analgesic and larvicidal effects attributing to its rich phytochemical composition. Research on the pharmacological activities of *Croton bonplandianum* has primarily focused on its leaves and aerial parts, with limited studies specifically targeting the root and seed extracts. However, specific investigations into the pharmacological properties of *C. bonplandianum* seed extracts are scarce. While these findings support the traditional medicinal uses of the plant, further research is necessary to isolate specific and understand their mechanisms of action.

CONFLICT OF INTEREST

The author has no conflicts of interest regarding this investigation**.**

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