



(REVIEW ARTICLE)



An updated phytochemical and pharmacological review on Malabar Spinach (*Basella alba* or *Basella rubra*)

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Abstract

Cancer, autoimmune diseases, microbial infections and oxidative stress are becoming unavoidable threats in recent times. Despite advances in conventional treatments such as surgery, radiotherapy and chemotherapy, problems related to these therapies such as side effects, opportunistic infections and the development of drug resistance remained unsolved. Therefore, the need of the hour is to develop novel treatment modalities using plant derivatives which act as effective therapeutic agents and have minimal side effects. *Basella alba* is one such plant which contains various phytochemicals viz. flavonoids, alkaloids, phytosterols, tannins and triterpenoids etc., which helps in curing various diseases. The main aim of the present review is to highlight the phytochemical and pharmacological investigation carried out on the plant so that the more pharmacological studies could be conducted to investigate the untapped potential. Based on the published evidences on various databases, findings suggest that various parts of *B. alba* are used as antioxidant, anticancer, antibacterial, anti-inflammatory, antiulcer and many other diseases. Finally, it can be concluded that *B. alba* may be appealed as a good source of pharmacologically active compounds to develop new drugs.

Keywords: *Basella alba*; Phytochemicals; GC-MS analysis; Antioxidant; Immunomodulator

1. Introduction

Medicinal plants have been a good source of therapeutic agents since ancient times to treat human diseases. Despite the major advances in the modern medicine, the development of new medicines from natural products is still has its importance due to the wide spread belief that natural medicine is healthier than synthetic drug. Since 1980, World Health Organization (WHO) has been encouraging many countries to develop traditional medicine and phytotherapy. The main Indian traditional system of medicine namely Ayurveda and Siddha, are primarily plant-based system. As per WHO, about 80% of the population in the world relays on the traditional medicine for the treatment of various diseases. Therefore, the development of traditional medicine is essential.

In this regard, *Basella alba* is one such plant which is a good source of many phytochemicals responsible for cure of various diseases. It is a fast-growing plant reaching 10 m in length. It is a leafy vegetable. The leaves are thick, heart shaped which have mild flavor and mucilaginous texture. The size of the leaves varies from 3 to 9 cm in length and 4 to 8 cm in width. The flowers are inconspicuous, bisexual white flowers borne on axillary spikes or branching peduncles. Its fruits are fleshy and stalk less, ovoid or spherical in shape, 5 to 6 mm, and purple when mature.[1]

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It is native of southern Asia and popularly known as Malabar spinach, Indian spinach. The stem of the cultivar *Basella rubra* is reddish purple. In eastern and southern parts of India, the leaves and stems of the plant are used in cooking. It is widely distributed in the tropics and often cultivated in warm temperature areas of both the eastern and western hemisphere. It is cultivated in almost whole of India, especially in lower Bengal and Assam, it is an important part of diet-stated by Watt. It is considered as food plant in the Philippine, and boiled and eaten like spinach. The leaves are used to poultice sore in both Malaya and India. [3] Nowadays, it is widely grown for its nutritive value.

1.1. Taxonomy

- Kingdom: Plantae
- Order: Caryophyllales
- Family: Basellaceae
- Genus: Basella
- Species: *Basella alba* Linn. [1]



Figure 1 Malabar spinach with red stem

The various synonyms of the plant *Basella alba* are *Basella cordifolia* Linn, *Basella lucida* Linn, Pothaki, Upodika, Maalava, Turangi, Kantaki. The common names of the plant are Malabar spinach, Indian spinach, Ceylon spinach, Vine spinach. The various vernacular names are Hindi: Poi ki Bhaji, Telugu: Bachhali, Tamil: Kodip pasali, Kannada: Basale soppu, Marathi: Mayalu, Bengali: Pui shak, Oriya: Poi saga, English: Malabar spinach, Indian spinach, Ceylon spinach.

1.2. Traditional uses

The plant has been known to be a demulcent, a diuretic and an emollient action. The entire plant is used in Chinese medicine where it is claimed to reduce fever and neutralize poison. The pulped or bruised leaves are used as a poultice for ulcers and to hasten the maturation of abscesses. The decoction of the leaves is believed to have laxative properties, and is used to treat constipation in pregnant women and children. The juice of the plant is used as a dye for official seals, as a rouge on the facial skin and food coloring. [1] Especially the ones with red stem shows anti-inflammatory and anti-ulcer effects. [2] *Basella* plant species contain betacyanin, carotenoids, bioflavonoids, β -sitosterol and lupeol which are reported to have anti-oxidant, anti-proliferative, anti-microbial and anti-inflammatory effects etc., and help in curing various diseases, namely anti-cancer, anti-viral, anti-ulcer, anti-cholesterol, hypoglycemic, wound healing and androgenic from the ancient times. Leaf juice is used to treat catarrh. [7] The ayurveda treatment in India has been used *B. alba* leaves and stem for anti-cancer such as melanoma, leukemia and oral cancer. [8]

2. Phytochemicals reported in the plant

Hema Arya et al., 2021 reported that preliminary qualitative analysis is one of the useful methods to detect various bioactive compounds which is responsible for various pharmacological activities like antioxidant value depends on presence of flavonoid and phenolic compounds, further contributed to cure cancer etc., [4]. They analyzed total phenolic

content and total flavonoid content of *Basella alba* leaves extract and reported that the alcoholic, ethyl acetate and methanolic extracts of plant contains good phenolic and flavonoid contents. The methanolic extract showed high values as 533.28 ± 0.16 and 446.02 ± 0.1 total phenolic content and total flavonoid content respectively. These phenolic flavonoid compounds are capable of preventing the aging, inflammatory and cell proliferation. Malabar spinach was found to be rich in kaempferol at a concentration of 1.4 mg/100g which is a flavonoid protective against cardiovascular diseases and cancer. Kumar et al., (2021) performed isolation, identification and characterization of flavonoids from *B. alba* L. using TLC and IR and confirmed by GC-MS analysis. This study reported that 49 compounds were found in GC-MS analysis and 1-Methyl-4-isopropylcyclohexyl 2-hydroperfluorobutanoate was found in highest amount. [29] *Basella alba* contains carotenoids, betacyanins, triterpene oligoglycosides, organic acids, basellasaponins A, B, C and D. The leaf extract contains vitamin A, C, E, B1, B2, B3, B9, folic acid, protein, fat and minerals such as magnesium, calcium and iron. The preliminary phytochemical screening of various leaf extracts of the plant exhibited high levels of flavonoids, poly phenols, moderate levels of alkaloids, tannins, glycosides, carbohydrates, vitamins, minerals and low levels of saponins.

Table 1 Phytocomponents identified in GC-MS analysis of various extracts of *Basella alba* leaves and their reported biological activities

S. No.	Compound name	Compound nature	Type of extract	Biological activities
1	Pentadecanoic acid	Saturated fatty acid	Ethanol	Anti-inflammatory, anti-anaemic, dyslipidemic [31] and antibiofilm [32].
2	n- Hexadecenoic acid	Saturated fatty acid	Ethanol	Cytotoxic [33] and anti-inflammatory [34].
3	Cis-13-Octadecanoic acid	Monounsaturated fatty acid	Ethanol	Antioxidant [35] and anti-inflammatory [36].
4	Cis-vaccenic acid	Monounsaturated fatty acid	Ethanol	Anti-atherosclerotic [37].
5	Oleic acid	Monounsaturated fatty acid	Ethanol	Anti-inflammatory, immunomodulator [38] and antitumor [39].
6	Octadecanoic acid	Saturated fatty acid	Ethanol	Antioxidant [40].
7	Linoleic acid	Polyunsaturated fatty acid	n-Hexane	Antioxidant [40], anti-inflammatory, anticancer [45], hepatoprotective and antiarthritic [46].
8	Caryophyllene	Sesquiterpenoid	n-Hexane	Neuroprotective, cardioprotective, nephroprotective, gastroprotective, immunomodulator and anticancer [41].
9	Phytol	Terpene	n-Hexane	Antinociceptive and antioxidant [42].
10	Cyclotetracosane	Hydrocarbon	n-Hexane	Antimicrobial, cytotoxic and antioxidant [43].
11	2,4-Decadienal	Polyunsaturated fatty aldehyde	n-Hexane	Nematicide [44].
12	Phenol, 2,6-bis(1,1-dimethylethyl)-	Aromatic and phenolic compound	Methanol	Anti-inflammatory and anti-atherosclerotic [19].
13	l-Heptatriacotanol	Alcoholic compound	Methanol	Antioxidant, anticancer and antimicrobial [45].
14	l-(+)-Ascorbic acid 2,6-dihexadecanoate	Vitamin	Methanol	Antioxidant and lowers triglyceride level [19], antimutagenic, anti-inflammatory, antinociceptive and wound healing [46].
15	α - Tocopherol, O-methyl-	Vitamin	Methanol	Lowers total cholesterol and LDL cholesterol [19], antioxidant and anticancer [47].

[5] *B. alba* contains better phenolic and flavonoid contents compared to *B. rubra*. The fruit fraction of *B. alba* contains the highest total phenolic content (5.07 mg/ml), total flavonoid content (9.87 mg/g), saponin content, tannin content

(5.9 mg/g) and carotenoid content (0.28mg/g) compared to other parts. The terpenoid content and alkaloid content are higher in leaves fraction of *B. alba* which are 0.89mg/g and 1.61mg/g respectively. [reported by Gabriel Olaniran Adegoke et al., 2017] - [6]. This plant has also antioxidant compounds. The stem, leaves and flowers of this plant have a natural color pigment Anthocyanin. [2]

3. Reported pharmacological activities of *Basella alba*

3.1. Cytotoxic and anticancer activity

Aliya sheik et al., (2023) evaluated the anticancer activity of methanolic extract of *B. alba* against HT-29 and HCT-116 colorectal cancer cell lines using XTT. The results showed that the extract had the highest cytotoxicity against HT-29 at a concentration of 50g/ml, inhibiting cell growth by 78.9% in 72h. At 48h, it was discovered that extract in HCT-116 and HT-29 had IC₅₀ values of 51µg/ml and 22µg/ml, respectively with 70% cell growth inhibition. These findings suggested that the extract consisted of a wide-ranging amount of both flavonoid and phenolic compounds which exhibited substantial antioxidant activity. Both colon cancer cell lines experienced a cell cycle arrest at the G₀/G₁ phase after receiving treatment with this extract. [9]

Md. Shihabul Islam et al., (2018) evaluated *In Vivo* anticancer activity of *B. alba* leaf and seed extracts against Ehrlich's Ascites Carcinoma (EAC) cell line. In haemocytometric observation, the leaf and seed extracts exhibited about 62.54±2.41% and 53.96±2.34% cell growth inhibition, respectively, whereas standard drug Bleomycin showed 79.43±1.92% growth inhibition. Morphological alteration under fluorescence microscope showed nuclear condensation and fragmentation which is the sign of apoptosis. [10]

Krishnendu Pal (2016) this study evaluated the cytotoxic activity of methanolic extract of *B. alba* whole plant on human leukemic cell lines U937 and murine macrophage cell line RAW 264.7 cells using MTT assay. The results showed that the extract has selectivity for leukemic cells and exerts no effect on the RAW 264.7 cells. The extract at concentrations of 10µg to 200µg significantly inhibited the growth of U937 cells in a concentration and time dependent manner. The IC₅₀ value was found to be 24.54µg/ml. DNA laddering assay by gel electrophoresis showed its apoptotic activity. [11]

Rathee Sushila et al., (2010) this study evaluated the cytotoxic effect of methanolic extract of *Basella alba* whole plant on Jurkat and lung cancer (A549) cell lines. The results showed that the extract exhibited cytotoxic effect against both cell lines but the activity was very much significant against Jurkat cell lines. At 100µg/ml concentration, the percentage cell viability in Jurkat and A549 cells was found to be 41.78±1.25 and 57.12±1.11, respectively. The TLC fingerprinting revealed the presence of β-Sitosterol and lupeol in the extract. [12]

3.2. Antioxidant activity

Aliya sheik et al., (2023) this study evaluated and confirmed that the plant *Basella alba* has good antioxidant activity by observing DPPH, Superoxide, Hydroxyl radical scavenging activities and phosphomolybdate assay. This study showed the DPPH radical scavenging potential of methanolic extract of the plant ranging from 28.24% to 94.81% at different concentrations (20 to 100µg/ml). The IC₅₀ values of the extract in DPPH assay, Superoxide radical scavenging activity, phosphomolybdate assay and hydroxyl radical scavenging activity were found to be 46.6±0.0, 47.2±1.2, 918.5±0.1 and 380.3±0.9, respectively. [9]

Omowumi O. Adewale et al., (2022) reported that the ethanol extract of *B. alba* Linn modulates acrylamide induced oxidative stress in Wistar rats. The liver and kidney tissues were processed for the analyses of antioxidant activities. Serum was analyzed for hepatic and renal function biomarkers in the treated animals. The treatment with 100 and 250mg/kg body weight significantly reduced the elevated renal and hepatic biomarkers. These findings in this study suggested that the plant is a potential chemoprotective agent against acrylamide induced oxidative stress in wistar rats. [25]

Bamidele O et al., (2020) reported that the methanol extracts of *B. alba* leaves alleviate stress in rats. In stressed rats, there were substantial increases in fasting blood glucose and white blood cell count while there were substantial decreases in superoxide dismutase activity and glutathione concentration. In extract treated rats, there were significant decreases in blood glucose and white blood cell count and significant increases in superoxide dismutase and glutathione concentrations. The results from this study suggested that the plant alleviates hyperglycemia, chronic activation of immune system and generation of free radicals due to stress in wistar rats. [26]

Dennis Seyi Arokoyo et al., (2018) evaluated the antioxidant activity of *B. alba* aqueous leaf extract in blood, pancreas, and gonadal tissues of diabetic male wistar rats. The extract significantly lowered fasting blood sugar in rats. The results showed that the plant extract exerts antioxidant effects in the gonads by enhancing antioxidant parameters in circulating blood, but not necessarily in the gonadal tissues. [13]

3.3. Hepatoprotective activity

Mathew Folaranmi Olaniyan (2017) tested hepatoprotective activity of ethanolic and aqueous extracts of Malabar spinach in rabbits overdosed with paracetamol. The results showed lower AST (aspartate aminotransferase), ALT (alanine transaminase), TBA (total bile acid) and LDH (lactate dehydrogenase) values than paracetamol alone treated rabbits, which indicates that the plant has good hepatoprotective activity. [14]

Saibal das et al., (2014) evaluated the hepatoprotective activity of aqueous extracts of leaves of *B. alba* in albino rats. Hepatoprotective effect was evaluated by comparing serum bilirubin, serum glutamic oxaloacetic transaminase, serum glutamic pyruvic transaminase, proteins, alkaline phosphatase and liver histology. The results were well comparable and even in some respects superior to standard drug silymarin. The plant extract at a concentration of 100mg/kg/day orally had significant hepatoprotective effect in paracetamol induced hepatotoxicity in albino rats. [15]

3.4. Anti-inflammatory activity

Narapusetty Naidu et al., (2017) evaluated the anti-inflammatory activity of ethanolic extract of *B. alba* in acute and sub-acute model using egg albumin, turpentine oil and formaldehyde as phlogistic agents. The extract showed significant anti-inflammatory activity in a dose dependent manner. The animals were treated with doses 250mg/g and 500mg/kg of extract and Diclofenac sodium at a dose of 10mg/kg was used as a standard drug. The extract (500mg/kg) exhibited maximum anti-inflammatory activity i.e., 46.25%, 44.30%, 46.40% like standard drug Diclofenac 47.02%, 46.50%, 48.57% in egg albumin, turpentine oil and formaldehyde induced methods respectively. [16]

Vijender Kumar et al., (2011) tested *in-vitro* anti-inflammatory activity of methanolic and aqueous leaf extracts of *Basella alba* Linn var alba by human red blood cell membrane stabilization method (HRBC). The aqueous extract showed the most significant membrane stabilizing action. The methanolic extract showed 68.38±1.18 percentage protection at a concentration of 400µg/ml. The maximum percentage protection is 71.89±1.22 at 400µg/ml concentration of aqueous extract. Based on the results they concluded that the plant has a significant anti-inflammatory activity. [17]

3.5. Antiulcer activity

P. Venkatalakshmi et al., (2012) tested anti-ulcer effect of *B. alba* leaf extract in aspirin induced albino rats and revealed that the plant has been endowed with gastro protective potential. In this study, *B. alba* leaf extract was found to alter the observed ulcer parameters like ulcer index, percentage of ulcer inhibition, gastric PH, pepsin content, glutathione reductase (GSH), vitamin C and E. The animals co treated with ethanolic leaf extract of *Basella alba* (200mg/kg body weight) and aspirin (150mg/kg) for 21 days showed 8.59±0.19 ulcer index and 66% ulcer inhibition. Whereas animals treated with ethanolic leaf extract of the plant alone (200mg/kg) for 21 days showed 0.4±0.03 ulcer index and 99% ulcer inhibition. The pH of gastric juice was found to be increased in plant extract treated animals (4.2±0.3) compared to aspirin treated animals (2.17±0.12). The pepsin content was reduced in plant extract treated animals (2.4±0.05) compared to aspirin alone treated animals (4.3±0.1). [18]

3.6. Hypocholesterolemia effect

Baskaran et al., (2015) reported that the plant *Basella alba* reduces hypercholesterolemia in rabbits induced with hypercholesterolemia. The treatment with *B. alba* extract significantly lowered the levels of total cholesterol, LDL, and triglycerides and increased HDL and antioxidant enzymes levels. The administration of *B. alba* at 100 and 200 mg/kg decreased TC level by 49 and 54.3%, respectively, LDL level by 45 and 50.1%, respectively, and TG level by 34.9 and 39.7%, respectively. *B. alba* extract (200mg/kg) reduces TC, LDL and TG levels as effectively as simvastatin. The histopathological examination of aorta showed that *B. alba* treated rabbits had a significant reduction in aortic plaque and intimal thickening.[19]

3.7. Antimicrobial activity

H. T. Nguyen et al., (2022) reported antiadhesive activity of polysaccharides from *B. alba* against *Helicobacter pylori* using flow cytometric analysis. Raw polysaccharides were isolated and 9% of them were identified as AGP (arabinogalactan-protein). Functional assays indicated that fresh extract of the plant inhibited the bacterial adhesion of *H. pylori* to AGS cells in a dose dependent manner. Best anti-adhesive effect of 67% was observed at 2mg/ml. [27]

Biswajit dash et al., (2017) evaluated *in-vitro* antimicrobial activity of ethanolic extract of stem of *B. alba* using disc diffusion method and results showed that the extract had significant activity against both gram-positive and gram-negative bacteria and the fungi strains of *Candida albicans* and *Trichophyton rubrum*. The maximum antibacterial effect was observed at 100mg/ml i.e., 15.65 and 17.67mm zone of inhibition against *Staphylococcus aureus* and *Escherichia coli* respectively. Whereas the standard drug gentamycin showed 29 and 23mm Zone of inhibition respectively at 20mg/ml. The maximum antifungal activity was also observed at 100mg/ml concentration i.e., 20.2 and 15.25mm zone of inhibition and standard drug fluconazole at concentration of 20mg/ml showed 24 and 22mm zone of inhibition against *Candida albicans* and *Trichophyton rubrum* respectively. [20]

S. K. Reshmi et al., (2012) evaluated antimicrobial activity of *B. alba* fruit using agar well diffusion method against eight species of microorganisms. The extract showed significant action against *Lactobacillus* and *Aspergillus fumigatus*, no activity was found against *Klebsiella* and moderate activity was found against other tested organisms. The minimum inhibitory concentration of the extract against bacterial strains was found to be 25mg/ml for *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Lactobacillus*, *Escherichia coli*, *Aspergillus niger* and *Aspergillus fumigates* and 50mg/ml for *Klebsiella pneumonia*. [21]

3.8. Nephroprotective activity

Saleh et al., (2011) in this study, the ethanolic extract of *B. alba* on gentamycin induced nephrotoxic wistar albino rats was found to exert nephroprotective effect. It reverses increased serum and urine creatinine, urea, uric acid, protein, gamma-glutamyl transferase (GGT) and malonaldehyde levels and decreased total proteins and free-SH in kidney tissue, which are indicators of oxidative stress of kidney. The experimental results suggested that *B. alba* extract protected gentamycin induced nephrotoxicity, possibly by enhancing renal antioxidant system. [22]

3.9. CNS depressant activity

Ananda Rajagopal et al (2011) tested and observed that the methanolic and aqueous extracts of dried aerial parts of *B. alba* (100 and 200 mg/kg) exerted CNS depressant activity in experimental animals. It is evaluated by pentobarbitone induced sleeping time test, open field test and hole cross test in mice. The maximum activity was observed at 120 min in methanolic extract treated animals followed by petroleum ether extract treated animals with 0 number of movements similar to standard drug diazepam. [23]

3.10. Wound healing activity

Mohammed et al., (2012) tested wound healing capacity of different gel formulations of aqueous extract of *B. alba* on male albino rats. In this study, it was observed that 20 days treatment with *B. alba* leaf extract showed a maximum wound healing capacity. *B. alba* treated animals were found to epithelize in 23 days while the solvent control and untreated rats epithelize within 35 days and 39 days respectively. So, it was concluded that aqueous extract of *B. alba* shows significant improvement in burn wound contraction. [24]

3.11. Antiviral activity

Cai-Xia Dong et al., (2011) isolated four acidic polysaccharides from aerial parts of *B. rubra* which exhibited antiviral activity against herpes simplex virus type 2 (HSV-2) by interfering with absorption and penetration of virus to host cells. The most abundant component BRP-4, showed a high therapeutic efficacy in the mouse model infected intravaginally with HSV-2. Orally administered BRP-4 resulted in moderate therapeutic efficacy in the mice infected intranasally with influenza A virus. [30]

4. Discussion

B. alba contains the terpenoid Caryophyllene which has remarkable nephroprotective, cardioprotective, neuroprotective, gastroprotective and immunomodulatory properties. The various fatty acids present in the plant showed anti anemic, dyslipidemic, antitumor, anti-atherosclerotic, anti-inflammatory and antioxidant effects. The alcoholic, phenolic and aromatic compounds present in this plant suppresses total cholesterol, triglyceride level and fat accumulation which makes them to show anti-atherosclerotic effect. The vitamins and minerals present in this plant are good hematinics. *B. alba* is apparent to keep antioxidant, anti-inflammatory and cytotoxic properties which makes it good for the development of anticancer therapies. Due to the presence of antioxidant and immunomodulatory effects, this plant helps in treating various stress related and auto immune disorders like diabetes, neurodegenerative diseases and cancer etc.,

5. Conclusion

In summary, this review suggests that *B. alba* is a great source of valuable phytochemicals such as flavonoids, terpenoids, fatty acids, polyphenols, vitamins, proteins and minerals. According to the scientific reports on various databases, *B. alba* and its extracts are used to treat many diseases in various countries. This plant owns many pharmacological activities. Among them, anticancer, antimicrobial, anti-inflammatory, antioxidant, nephroprotective, antidiabetic, antiulcer, wound healing, CNS depressant and androgenic properties are significant. Therefore, *B. alba* may be one of the great sources of traditional medicines.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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