



Antioxidants from Bauhinia and Future Research Gap

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Abstract

Flower buds of Bauhinia are utilized as a human means of nourishment, and the stem and leaves serve as feed for livestock across the world. This chapter highlights the medicinal importance of various parts of Bauhinia plants. Bauhinia plants' edible regions are an excellent source of phytochemicals that have notable potential as antioxidants. Various phytochemical compounds that include Saponins, glycosides (kaempferol-3-glucoside), cardiac glycosides, sterols (β -sitosterol), tannins, phenolics, alkaloids, terpenoids (Lupeol), quinones, flavanones and flavonoids reside in these plants. These plants exhibit powerful potential as antioxidants for lipid-reducing, metal-reducing, free radical scavenging activities and metal-chelating. These also demonstrate an encouraging impact on glutathione peroxidase activity, an antioxidant enzyme. Moreover, they inhibit tyrosinase activity. Moreover decreased the levels of different liver markers (ALT, AST and ALP), and antioxidant enzymes and shift them to normal levels. Among the several Bauhinia genus species that have been explored for their antioxidant potential and phytochemical constitution, Bauhinia variegata seeds, leaves and florets have superior antioxidant and phytochemical properties. Other Bauhinia genus species that are packed with antioxidants and phytochemicals include *Bauhinia vahlii*, *Bauhinia strychnifolia* Craib, *Bauhinia rufescens*, *Bauhinia racemosa* and *Bauhinia purpurea*. Moreover, many factors influence the anti-oxidant potential of medicinal plants but up to the study of the year 2023, only the impact of solvent on the Bauhinia species' antioxidant potential has been studied, it is a necessity that upcoming research must focus on the research on remaining factors for maximum yield of antioxidants from this antioxidant-rich plant. The antioxidant capacity and phytochemical composition of Bauhinia plants render them the most suitable candidates for use in therapeutics and dietary supplements.

Keywords: Antioxidants; Bauhinia; Medicinal Importance; Future Prospects

Introduction

Bauhinia variegata Linn, belongs to the family Fabaceae and 300 species of the genus *Bauhinia* are cultivated in tropical areas of the world. It is known as the Orchid tree due to its ornamental popularity and its common name in Hindi is Kachnar. The tree is medium-sized that grows to a height of 20-40 ft and the width range is 10- 20 ft mainly in the Himalayas regions of India. Leaves have a diameter of 6-16 cm with minute stipules [1]. The names of different subspecies of different species of *Bauhinia* and their common names have

been represented (Table 1). *Bauhinia variegata* is cultivated in the native areas of Pakistan, India, and southeastern Asia. They have a lavish amount of bioactive compounds such as phenanthraquinone, flavones, triterpenes and flavanol glycosides [2]. Various components of plants, such as flower buds, root bark, leaves, seeds, and stem bark are used in the treatment of skin diseases, fever, dysentery, edema and piles. These can be used as laxatives, tonics, and antidotes [3]. The taxonomical classification of *Bauhinia variegata* (Table 2).

Species	Sub-specie	Common name
<i>Bauhinia acuminata</i>	linnaei Ali	Dwarf White Orchid Tree
<i>Bauhinia corymbosa</i>	Cory. Roxb	Orchid Vine
<i>Bauhinia purpurea</i>	-	Purple Bauhinia
<i>Bauhinia vahlii</i>	Vah. Wight & Arn.	Pahur Camel's Foot Creeper
<i>Bauhinia variegata</i>	var. candida	White Orchid Tree
	<i>Phanera variegata</i> L.	Ebony tree
	var. chinensis	Camel's foot tree
<i>Bauhinia retusa</i>	Ret. Roxb	Old world Bauhinia
<i>Bauhinia racemosa</i>		Bidi leaf tree
<i>Bauhinia tomentosa</i>	tomentosa L.	Yellow bell orchid tree

Table 1: Different subspecies of different specie of *Bauhinia* and their common names.

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Genus	<i>Bauhinia</i>
Specie	<i>Variegata</i>

Table 2: *Bauhinia variegata* taxonomical classification [2].

In dry mixed deciduous forests, *Bauhinia variegata* grows at an altitude of 900 m and 1300 m. for the beauty and fragrance of flower buds of *Bauhinia variegata* cultivated along the roadsides. The maximum temperature range it grows is 32–42°C and the minimum temperature is 7-14°C. Flowers bloom during the months of January-March and fruiting occurs in the months of March-July [4]. However, there are many indigenous names for *Bauhinia variegata* (Table 3).

Language	Local names
English	Poor man's orchid, Camel's foot, Paper mulberrrt, Mountain Ebony, Poor man's orchid, Orchid tree
Spanish	Palo de orquideas, Flamboyantorquidea
Urdu	Kachnar
Hindi	Kural, Koliar, Kachnar, Gurial, Bogakatra,
Punjabi	Kolar, Kanchanal, Kovidara
Bengali	Rakta-Kanchan, Swet-Kanchan, Rakta-Kamhar
Nepali	Koiralo, Kachnar

Table 3: Indigenous names of *Bauhinia variegata* [2,5].

However, a lot of data is available in previous literature regarding the phytochemical importance of the *Bauhinia*

specie but there is no data available that highlights the medicinal importance of the *Bauhinia* specie with a special

focus on antioxidant activity. Our study aimed to emphasize the antioxidant potential of various species of *Bauhinia* and identify the future study gap regarding it.

Medicinal importance of *Bauhinia Variegata*

The plant *Bauhinia variegata* has traditional importance as a potent ethnomedicine. The different parts of the plant are used for different medicinal purposes. Its bark is utilized for cough, salivation, hematuria, sore throat, menorrhagia, enlargement of neck glands as well as tumors and hemorrhoids while barks' decoction has significance

for the treatment of ulcers and skin disorders and dried buds are used for treating worms, dysentery, diarrhoea and hemorrhoids. Leaves have significance for inflammatory disorders and diabetes. The flowers show laxative activity while kachnar roots are used for indigestion. In skin diseases, its stem is used as an anti-inflammatory. The preparation of this plant as kachnara guggula is beneficial for the intervention of ulcers, skin disorders and tumors as well as provides healthy functions of the lymphatic and thyroid system [6,7]. Bioactive compounds and medicinal properties of different parts of *Bauhinia variegata* (Table 4).

Parts of plant	Chemical constitutes	Reference	Biological activity	Reference
Leaves	Saponins, vitamin C, carbohydrates, kaempferol-3-glucoside, sterols, tannins, phenolics, quercetin, alkaloids, catechol, fats, and amides	[2,8,9]	Anti-tumor, anti-diabetic, anti-fungal and anti-microbial	[3,10,11,12]
Roots	proteins, Phenolic compounds, glycosides, carbohydrates, tannins, gums, phenanthraquinone, 7-dimethoxy-3', and 4'-methylenedioxyflavanone,	[13]	Anti-microbial, Anti-cancerous and anti-bacterial	[14,15]
Flowers	Amino acids, tannins, flavonoids, cardiac glycosides carbohydrates, and quercetin	[4,16]	Anti-tumor, anti-diabetic, anti-ulcer antioxidant and anti-hyperlipidemic	[8,16]
Stem	Lupeol, β -sitosterol, and 5,7 dimethyl ether 4 rhamnoglucoside	[17]	Antibacterial, anticancer & antifungal	[17]
Stem Bark	Kaempferol, Lupeol, Quercetin, and β -Sitosterol, octacosanol, sterols, glycosides, reducing sugars, stigmaterol 7, lignin, glycosides, saponins, and terpenoids	[18]	Anti-bacterial, Anti-diabetic, Antimicrobial, and Antioxidant	[3,19,20]
Root Bark	5,6-dihydro-1, 4-dimethoxy-2-methyl dibenzoxepin, dihydrodibenzoxepin	[21]	Anti-microbial and anti-obesity activity	[22,23]

Table 4: Bioactive compounds and medicinal properties of different parts of *Bauhinia variegata*.

Antioxidant potential

Antioxidants are those compounds that are used to stop the biomolecules from being oxidized by the reduction of oxidizing agents, and thus they are self-oxidized in the process. These compounds stop the free radical chain reactions, by using their potential to scavenge the free radicals which are formed in living and non-living systems in the oxidation-reduction reactions. By following this strategy, oxidative stress is reduced and oxidative damage is stopped to living beings and food products. Owing to their reducing and hydrogen-donating capabilities, many of these phytochemical compounds serve as antioxidants [12].

Bauhinia is a large botanical genus, predominantly obtained from tropical areas, having about 300-350 species of plants and trees [24]. The extract obtained from

the stem bark and leaves of the *Bauhinia* has many active compounds which are employed in the cure of inflammation, hyperlipidemia, diabetes, HIV, infections, pain, and wound and bacterial infections [25]. Reactive oxygen species and free radical-producing compounds destroy structural and functional proteins ultimately damaging the cell membrane components and causing serious health problems such as cancer, immune dysfunction, heart diseases and mutations in DNA [26]. Antioxidants from natural resources such as plants, vegetables and cereals can decrease the free radical damage produced by the oxygen-containing reactive species due to the manifestation of bioactive compounds present in them such as flavonoids, phenolics, terpenes and lignans [27]. *Bauhinia variegata* has a variety of polyphenols, glycosylated flavonoids and aglycone which act as antidiabetic, antioxidant and antihyperlipidemic effects [8].

Most of the species of *Bauhinia* have antioxidant potential and they have gained worldwide importance due to this property. Some of those species are *Bauhinia pulchella*, *Bauhinia purpurea* (L), *Bauhinia racemosa* Lam, *Bauhinia rufescens* Lam, *Bauhinia variegata* Linn, *Bauhinia strychnifolia*, *Bauhinia vahlii*, *Bauhinia acuminata* Linn, *Bauhinia forficata*, and *Bauhinia tomentosa* L [28-31]. The *Bauhinia* plants are renowned for having antioxidant potential because of the inclusion of specific compounds, like Flavonoids, phenolic content, carotenoids, alkaloids, tannins,

saponins, glutathione (GSH), etc. In addition to it, these plants show various effects on the activities of antioxidant enzymes as well as they show many other assays including radical scavenging assay, metal chelating activity, and antioxidant activities against DPPH, H₂O₂, and ABTS, etc., [30,32,33]. The elevated antioxidant properties and potential of *Bauhinia* plants emphasize their substantial therapeutic as well as medicinal value. The antioxidant activities of different species of *Bauhinia* plants have been represented (Table 5).

Bauhinia species	Solvent used	Part of the plant studied	Antioxidant compounds and potential	Reference
<i>Bauhinia purpurea</i>	Water	Leaf	Contains Flavonoids and phenolics. Showed metal-reducing power activity, nitric oxide scavenging activity and metal-chelating activity	[34]
	Ethanol extract	Unripe pod & bark	Showed protection against lipid peroxidation, increased activity of catalase and increased level of GSH	[35]
<i>Bauhinia racemosa</i>	Methanolic extract		Contains Flavonoids and phenolic content. Increased 2,2-diphenylpicrylhydrazyl (DPPH) radical scavenging assay activity, increased Superoxide radical scavenging assay and increased (Iron) metal chelating ability	[32]
<i>Bauhinia rufescens</i> (Lam)	methanolic extract	leaves	Showed high antioxidant activity against DPPH radical scavenging assay	[36]
<i>Bauhinia variegata</i>	methanol extracts	Flower	Rich in phenols, flavonoids, carotenoids, alkaloids, tannins, and saponins. Depicted antioxidant activities against DPPH, H ₂ O ₂ , and ABTS as well as decreased the levels of different liver markers (ALT, AST and ALP), and antioxidant enzymes and shift them to normal levels	[30]
<i>Bauhinia strychnifolia</i> Craib	Aqueous extract	Root and stem	Rich in 3,5,7,3',5'-pentahydroxyflavanonol-3-O- α -L-rhamnopyranoside and β -sitosterol. Showed moderate antioxidant activity as well as elevated GSH production in the extract-treated oxidative stressed HepG2 cell line	[33]
<i>Bauhinia vahlii</i>	methanol extract	leaves	Comprises many antioxidants and tyrosinase inhibitory compounds, including alpha amyryn, oleic acid, vitamin E, cis-vaccenic acid, β -sitosterol, n-hexadecanoic acid, and methyl salicylate. Contains more polyphenolic compounds and total antioxidant activity than other reported species of <i>Bauhinia</i>	[37]

Table 5: Antioxidant potential of different species of *Bauhinia* plant.

Bauhinia variegata Linn. is from the Caesalpiniaceae family of plants. It has been reported in much previous research that, from the *Bauhinia variegata* L. a great variety of aglycone and glycosylated flavonoids have been obtained. Many of the previous papers also stated that the antioxidant

and antidiabetic potential of the *Bauhinia* genus is owing to the presence of polyphenol and flavonoid contents [12]. The antioxidant potential of different parts of *Bauhinia variegata* has been depicted (Table 6).

Parts utilized	Antioxidant potential	References
Bark, root, stem	Aqueous and ethanolic extracts of bark, root and stem showed very strong scavenging activity in vitro against free radicals such as 1,2-diphenyl-2-picrylhydrazyl (DPPH), hydrogen peroxide, superoxide, and nitric oxide.	[38]
Leaves	Aqueous leaf extract in phenolic compounds showed antioxidant activity against the nitric oxide free radicals (258.66±4.61mg/g). Dried and fresh leaves ethanolic extract samples showed the ability to prevent the oxidation of 1,2-diphenyl-2-picrylhydrazyl (DPPH), due to its high flavonoid content.	[34,39]
Bark	Methanol extract of bark of <i>B. variegata</i> L. showed scavenging activity against H ₂ O ₂ -induced oxidative damage in DNA pBR322 and free radical-producing species such as 1,2-diphenyl-2-picrylhydrazyl (DPPH) due to high level of phenolics and flavonoids content. Both aqueous and ethanolic extracts of bark have antioxidant potential against the 1,2-diphenyl-2-picrylhydrazyl (DPPH), superoxide and nitric oxide is 29.11± 0.39 µg/ml, 435.40± 2.15 µg/ml, 368.00 ± 0.90 µg/ml respectively. <i>Bauhinia variegata</i> barks' methanolic extracts showed high amounts of scavenging activity against free radical DPPH and IC50 value (6.48±0.08 mg/mL), due to the high content of flavonoids and phenolics. Free radical scavenging activity(87.38%) was observed against 2,2-azinobis-3-ethyl-benzothiazoline-6-sulfonic acid (ABTS) radical cation due to the presence of protocatechuic acid-methyl ester (PCA-ME), kaempferol, stigmasterol and protocatechuic acid	[18,20,39,40]
Flower	Crude, ethanolic, n-hexane, and chloroform extracts of flowers of <i>B. variegata</i> showed high scavenging activity against 1,2-diphenyl-2-picrylhydrazyl (DPPH). Methanolic extracts showed high antioxidant activity than chloroform and n-hexane fractions.	[41,42]
Root	Prunin ethanolic extracts of <i>Bauhinia variegata</i> roots showed a major decrease in the reactive substance of thiobarbituric acid (TBARS) and an increase in the catalase activity.	[43]

Table 6: Antioxidant activity of different parts of *Bauhinia variegata*.

Factors affecting the antioxidant activity of *Bauhinia variegata* and future prospects

Various factors like temperature, cooking methods, solvent polarity, nutritional and environmental stress, and extraction time have been observed to contribute to affecting the antioxidant potential of medicinal plants. When plants are stressed, their primary and secondary metabolisms shift, which can have a direct impact on the qualitative as well as quantitative characteristics. It is well known that plant growth conditions, for example, light intensity, temperature, nutrient availability, and water supply substantially influence the buildup of natural substances in plants [44].

Numerous studies suggest that phytochemicals have biological activity. Due to their capacity to scavenge free radicals, provide electrons or hydrogen atoms, or bind metal cations, polyphenols exhibit antioxidant action. Their antioxidant potential is determined by the presence of electron-withdrawing and electron-donating substituents in the ring structure of phenolics along with the quantity and arrangement of the hydroxyl groups [45,46]. Numerous phenolic compounds that have been identified in previous studies also exhibit variations in potential biochemical

modification (glycosylation, acetylation, manolinylation, esterification to organic acids, etc.). Phenolic compounds' structural variations also affect how soluble they are in various polarity-differentiated solvents. Therefore, the kind of extraction solvent and the separation techniques may have a big impact on the quantity of polyphenols that can be extracted from plant material [47].

Besides this, air humidity and air temperature are significant external elements that affect the bioactive components. According to findings on Caucasian endemic *Thymus transcaucasicus*, the productivity of herbs was favorably influenced by the application of relatively high air humidity (90%) and relatively high air temperatures (25°C) whereas the yield and content of essential oils peaked at 25°C and low air humidity (50%) levels. For the best recovery of carotenoids and polyphenols, 50% air humidity and 20°C air temperature were found to be more effective, whereas the second peak of polyphenols was recorded at 90% air humidity. The relationships between environmental temperature and humidity had varying impacts on the compositions of essential oils, carotenoids, and polyphenols. Simultaneously, the antioxidant capacity was notably influenced by humidity and environmental temperature [48]. In another study, the antioxidant capacity towards

H₂O₂, ROO•, O₂, O₂•-, and OH• radicals in the two strawberry varieties' juice (Kent and Earliglow) was substantially affected by the day and night growing temperatures. Growth of strawberries under conditions of elevated temperatures greatly increased the fruit's capacity to absorb ROO•, as well as OH•, O₂•-, O₂, and H₂O₂. Plants that were grown in low temperatures through the day and night (18/12 °C) typically exhibited the least antioxidant activity [49].

High temperature, saturated steam, and high pressure exacerbate the breaking up of hydrogen bonds between the molecules and create more hydroxyl groups for release. Enhanced chain mobility, which will be resulted as the molecule's hydrogen bonds are broken, proves advantageous for generating organized molecular structures. On the other hand, the disruption of the molecular chains encourages their rearrangement [50].

In addition to that, the antioxidant capacity of plants was observed to be considerably modified by the differences in the methods used for cooking. Concerning their corresponding controls, boiling substantially boosted the antioxidant capacity of kenikir leaves (54.93%), spinach (43.15%), turi flower (53.84%), and papaya leaves (59.04%), while the yard-long bean's antioxidant capacity (70.21%) was the same as that of the control [51].

However, in previous literature, there is only the solvent's impact on the antioxidant potential of *Bauhinia variegata* that has been observed. When the solvent's impact on the antioxidant capacity of *Bauhinia variegata* was analyzed, it was observed that among water, methanol, and chloroform extract, methanol extract showed maximum phenolic (69.39 ± 1.22 mg GAE/g) and flavonoid content (44.50 ± 1.11 mg RE/g) as well as strong free radical scavenging (57%) and total antioxidant activity (117.35 ± 2.47 mg AAE/g of dry extract) [52].

However, it is recommended that the upcoming research should focus on finding out the effect of numerous factors on the antioxidant activities of various specie of *Bauhinia* plants including *Bauhinia variegata* for finding the conditions of maximum yield for antioxidants from these plants.

Conclusion

Every section of the *Bauhinia* plant abounds in phytochemical substances which possess antioxidant abilities. Flower buds have a revered role in human nutrition, whereas root, bark and leaves hold substantial therapeutic significance because of carrying a wide range of bioactive phytochemical substances. The primary phytochemicals that occur in different parts of the *Bauhinia* plant include polyphenols, phenolics, flavonoids, terpenoids, glycosides,

sterols, as well as certain water-soluble vitamins. The existence of these phytochemical substances renders *Bauhinia* a medicinal plant that displays extensive biological functions and considerable, antioxidant capacity. Owing to its tremendous potential as an antioxidant, every part of the *Bauhinia* plant can be utilized in the prevention of oxidative stress and the cure of various illnesses.

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