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MINI REVIEW

The Potential Uses of *Indigofera* L. in India

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Abstract

Indigofera is an important genus of arid, semi-arid and temperate regions of India. Its species are significant as forage, particularly in hot arid regions and temperate zones, as they provide good grazing alongside native grasses. *I. oblongifolia* Forssk. and *I. cordifolia* B. Heyne ex Roth are important fodder species for sheep, goats, camels and cattle in hot arid regions. The seed of *I. cordifolia* is the source of food during times of scarcity and famine. The species *I. atropurpurea* Buch.-Ham. ex Hornem., *I. gerrardiana* Harv., *I. heterantha* Wall. ex Brandis and *I. pulchella* Roxb. are sources of good quality fodder and rich in protein in the Himalayan region. The research on the exploitation of *Indigofera* has been considerably less compared to other pasture legumes. Therefore, the present paper highlights the habits and potentials of *Indigofera* species for its forage, food, medicinal and other ethnobotanical information, and emphasizes its sustainable utilization and future prospects.

Keywords: Desert, Forage, *Indigofera*, Legume, Medicinal

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Introduction

The genus *Indigofera* Linn. belongs to the Leguminosae family, which is the third-largest genus encompassing approximately 700 - 750 species of annual and perennial herbs and shrubs found in warm regions (Schrire, 2005; Schrire *et al*., 2009). It is distributed in tropical and subtropical regions of the world with the major centers of diversity in Africa, Madagascar, Australia, the Sino-Himalayan region and the New World (Clark *et al*., 2015; Wilson and Rowe, 2015). In India, *Indigofera* is one of the five dominant genera, holding the fourth position in the tribe Indigofereae. It is also the second most prevalent endemic legume genera in India, with 21 endemic species (Rao and Chaudhary, 2002). This genus thrives in diverse forms across various niches in both tropical and temperate regions of India and represents 64 species (e-checklist, BSI). After that, two new species of *Indigofera* i.e. *Indigofera jaisalmerica* C.S. Purohit & Kulloli (Purohit and Kulloli, 2021; POWO, 2024) and *Indigofera jodhpurensis* Bhellum, Dhar & Magotra (Bhellum *et al*., 2023) reported from India. Despite their importance, the species of *Indigofera* have received limited attention in hot arid areas (Singh and Beniwal, 2005). Rajasthan state is home to a total of 29 reported species of *Indigofera* (Shetty and Singh, 1987). However, in western Rajasthan, the genus is well-represented, with 12 species occurring in different habitats (Bhandari, 1990; Purohit and Kulloli, 2021; Bhellum *et al*., 2023). These species exhibit remarkable resilience to harsh environmental conditions, such as extreme temperatures and drought in the Thar desert, and can withstand overgrazing

(Singh *et al*., 2023). These species thrive on a variety of soils and rainfall levels, adapting to a broad temperature range. *I. argentea* Burm.f. a typical dune pioneer legume, is primarily found on sand dunes in western Rajasthan. It possesses strong, long woody tap roots that descend deeply in search of water. *I. linifolia* (L.f.) Retz., grows prostrate on sand but becomes erect when grazed (Bhandari, 1993). *I. cordifolia* B.Heyne ex Roth, the most common annual species, emerges after the first rains on both open rocky slopes and sandy to gravelly ground. It is known to be an effective soil binder. *I. hochstetteri* Baker and *I. linnaei* Ali thrive on stable sandy soils. *I. oblongifolia* Forssk, an erect arid shrub, occupies open dry areas with stable sandy soils in the arid region.

The genus *Indigofera* thrives across a wide range of habitats, even in areas with low rainfall and it is also known for its rich nutrient content (Singh *et al*., 2006b). *Indigofera* species serve as crucial fodder sources in arid, temperate, and subtropical Himalayan regions. Most *Indigofera* species exist in the wild and are grazed by animals, particularly sheep and goats. They are also harvested as cut-and-carry fodder. Due to heavy grazing pressure, many species and their ecotypes are on the verge of extinction, especially in the Thar desert of western Rajasthan. During times of scarcity and famine, the seeds of some species serve as food sources. Chatterji and Baxi (1964) studied the germination behavior of seeds from five *Indigofera* species. The genus *Indigofera* has garnered attention previously in the realm of chemotaxonomy (Bhalla and Dakwale, 1978; Mishra *et al*., 1981) as well as for anatomical studies (Kumar, 1983). Subudhi and Mitra (1999) explored *Indigofera* as an underexploited forage legume. In arid regions, some species exhibit high seed yields even in poor soil conditions. Nataraja *et al*. (2002) observed abundant seed production in *I. cordifolia* with a significant portion of the seeds returning to the soil, contributing to its dominance in seed composition. Many of these seeds persist in the soil seed bank, demonstrating dormancy as a natural mechanism for ecological maintenance and long-term persistence. However, little research has been conducted on its potential as a fodder, medicinal and other ethnobotanical utilization. This paper presents the current state of knowledge on the economic importance of *Indigofera*, highlights key species with potential, and identifies future research needs, particularly for hot arid and temperate regions.

Table 1: Traditional food usage of *Indigofera* species in India

Species	*Habit*	*Food*
I. atropurpurea Buch.-Ham. ex Hornem.	Erect shrub	Gujjars in Uttarakhand cook the flowers as a vegetable (Prakash and Singh, 2002).
I. cassioides Rottler ex DC.	Under shrub	Flowers and flower buds are used as vegetables by tribal people in Maharashtra, Madhya Pradesh and Odisha (Datt, 1996; Snehalatha *et al*., 2022). Pods are also utilized as vegetables in Haryana and sold in local markets (Jain, 1984). Snehalatha *et al*. (2022) reported this plant as wild medico food plant. Its roots are used as a tonic by the tribal women after delivery. Tender leaves are used to cure cough by the Bhuian tribe. The decoction of flowers and stems is used as a tonic by tribal communities of Sundargarh and Mayurbhanj areas of Odisha.
I. cordifolia B. Heyne ex Roth	Annual herb	Seeds are mixed with sorghum (jowar) and pearl millet (bajra) to make bread in arid regions. This bread is palatable and poses no harmful effects on health (Gupta and Kanodia, 1968).
I. dosua Buch.-Ham. ex D.Don	Erect shrub	Utilized as a food source in the Himalayas.
I. glandulosa J.C.Wendl.	Annual herb	Tribals incorporate the seeds with other grains during periods of scarcity. The plant is harvested from the wild for local uses as a nutritive tonic. In times of need the plant is harvested from the Wild for its seeds which are an emergency source of food. The seed flour was used to prepare roti during extreme. (Mhaske and Kulkarni, 2022).
I. hebepetala Benth. ex Baker	Erect shrub	Sour flowers are used with vegetables in Bihar (Sen *et al*., 1986) and immature seed pods are cooked as a vegetable or are pickled (Tyagi *et al*., 2019).
I. heterantha Wall ex Brand. var. *gerardiana*	Erect shrub	Flowers are boiled and pickled and consumed in the Himalayas (Tyagi *et al*., 2019).
I. hochstetteri Baker	Annual herb	During times of scarcity, seeds are combined with other grains. They are ground and mixed with flour from other grains for consumption (Bhandari, 1990).
I. linifolia (L.f.) Retz.	Annual herb	The seeds, such as Italian millet, are threshed and ground into flour to make bread during periods of scarcity in arid regions (Gupta and Kanodia, 1968).
I. linnaei Ali	Annual herb	Tribal in Rajasthan consume the fruits raw (Katewa, 2003).
I. suffruticosa Mill.	Shrub	Utilized as a vegetable (Sen *et al*., 1986).
I. arrecta Hochst. ex A.Rich.	perennial herb	Young leaves are cooked and eaten as a vegetable (Tyagi *et al*., 2019).

Utilization Potential of Indigofera

The species of *Indigofera* genus has much potential as food, fodder, medicine, dye, green manure, fuel wood and others. The detailed species-wise utilization potential and traditional uses are described as under.

Food

Indigofera species have traditionally been used as food in India, especially during periods of scarcity (Table 1). The seeds of some *Indigofera* species are mixed with other food grains to make bread during times of famine. The seeds of *I. glandulosa* J.C.Wendl. are rich in valuable food ingredients like proteins, carbohydrates, essential amino acids and vitamins (Ghane *et al*., 2010). According to Mankad (2002), its nutritive seeds contain approximately three times more protein than wheat. Seeds of *I. cordifolia* are also used in arid regions. Additionally, the flowers and flower buds of *I. cassioides* Rottler ex DC. are consumed as vegetables and its pods are sold in local markets in Haryana (Jain, 1984).

Fodder

Several species of *Indigofera* are utilized as fodder in various regions of India, particularly in temperate and arid areas (Table 2). In western Rajasthan, *Indigofera* species hold significant importance in grazing lands, especially for sheep and goats. Farmers have been collecting and storing them as hay for an extended period. In this region, most of the herbaceous species of *Indigofera* are referred to generically as Bekaria, such as Bekaria (*I. cordifolia*), Sidio bakerio (*I. linnaei*), Aadio bekario (*I. hochstetteri*), Lambio bekario (*I. linifolia*) among others. *I. cordifolia,* locally known as Bekaria, plays a crucial role in the natural grasslands and pastures of western Rajasthan, often forming dominant colonies after the onset of monsoon rains. Sheep, goats and cattle in this region prefer it as forage. It is harvested, dried and stacked for stall-feeding during lean periods in Rajasthan, sometimes mixed with other feeds (Mertia, 1992; Kulhari and Joshi, 1992). Pigeons and ants also show a special preference for the pods of *I. cordifolia* (Chatterji and Baxi, 1964). In Rajasthan, *I. linnaei*

Table 2: Fodder usage of *Indigofera* species in India

Species	*Habit*	*Animal preference in descending order*
I. argentea Burm.f.	Perennial herb	Grazed by various animals and believed to enhance milk production (Singh *et al*., 2006b).
I. astragalina DC.	Annual herb	Grazed by goats and sheep.
I. atropurpurea Buch.-Ham. ex Hornem.	Erect shrub	Given to milking cattle in Garhwal (Rana *et al*., 2002).
I. caerulea Roxb. var. *caerulea*	Perennial herb/ under shrub	Used as fodder in western India and Bihar
I. cassioides Rottler ex DC.	Under shrub	Given to milking cattle and goats in Garhwal (Rana *et al*., 2002).
I. cordifolia B.Heyne ex Roth.	Annual herb	Considered good fodder for sheep, goats and cattle. Stored for stall feeding (Singh *et al*., 2006b).
I. cylindracea Graham ex Baker	Erect shrub	Browsed by animals in the Himalayas.
I. dosua Buch.-Ham. ex D. Don	Erect shrub	Eaten by buffaloes, sheep, and goats in Himalayas.
I. glandulosa J.C.Wendl.	Annual herb	Preferred by cattle in the green stage.
I. hebepetala Benth. ex Baker	Erect Shrub	Given to milking cattle in Garhwal (Rana *et al.,* 2002).
I. heterantha Wall. ex Brandis var. *heterantha*	Erect shrub	Eaten by sheep, goats, and horses in the temperate and subtropical Himalayas
I. heterantha Wall. ex Brandis	Erect shrub	Believed to be good fodder for sheep and goats in Garhwal (Negi *et al.,* 1993).
I. hirsuta L.	Annual herb	Grazed by all animals and also used as hay.
I. linifolia (L.f.) Retz.	Annual herb	Grazed by all animals.
I. linnaei Ali	Annual herb	Eaten by sheep, goat and cattle across India
I. oblongofolia Forssk.	Erect shrub	Browsed by sheep, goats and camels in Rajasthan (Singh *et al*., 2023).
I. sessiliflora DC.	Annual herb	Grazed by animals in western Rajasthan (Singh and Beniwal, 2005), believed to enhance milk yield and fat content in goats, sheep and, camels (Singh *et al*., 2006b).
I. spicata Forssk.	Perennial herb	Grazed by cattle
I. suffruticosa Mill.	Erect shrub	Utilized as fodder
I. uniflora Buch.-Ham. ex Roxb.	Perennial herb	Preferred by cattle
I. jaisalmerica C.S. Purohit & Kulloli	Prostrate herb	Local people used as a fodder for cattle in Jaisalmer area of Rajasthan (Purohit and Kulloli, 2021).

is highly favored by sheep, leading shepherds to refer to it as *Bhed-ka-chara*; infect, sheep often graze on it instead of many other good grasses (Paul, 1966). The substantial presence of phytochemicals such as total phenolic, total flavonoids, and total antioxidant capacity in the leaves of *I. oblongifolia* promotes it as a valuable browse species in the rangelands of the Indian hot arid region, particularly in western Rajasthan (Singh *et al*., 2023).

Equally significant are the temperate and subtropical species of *Indigofera*, such as *I. atropurpurea* Buch.-Ham. ex Hornem., *I. gerrardiana* Harv.*, I. heterantha* Wall. ex Brandis*, I. pulchella* Roxb., collectively referred to as *Sakina* in Uttrakhand. These species serve as good quality fodder, rich in protein. Notably, *I. hirsuta* L. is a self-seeding erect annual species widely distributed across India. It is grazed by various animals and is particularly valued for semi-arid

Table 3: Medicinal value of *Indigofera* species

Species	*Habit*	*Ethno-medicine*
I. argentea L.	Herb	The roots and leaves are bitter and tonic. The seeds are considered anthelmintic and are used to expel the taenia (Caius, 1989).
I. aspalathoides Vahl ex DC.	Erect undershrub	A decoction made from tender shoots, leaves and flowers is used for treating leprosy and cancerous conditions. The root is chewed to alleviate toothache, while the leaves are applied to abscesses (Caius, 1989).
I. cordifolia Heyne ex Roth.	Annual herb	It is reported to be useful for lung and kidney diseases in Pakistan (Rahim, 1988).
I. glabra L.	Annual Herb	The leaves are bitter, tonic, and febrifuge, and they are also applied externally as an emollient (Caius, 1989).
I. glandulosa J.C. Wendl.	Annual herb	The seeds are used as a nutritive tonic (Caius, 1989; Ghane *et al*., 2010).
I. heterantha Wall. ex Brandis var. *gerardiana* Ali	Erect shrub	Caius (1989) mentioned that the roots are anthelmintic. Leaves possess irritant and purging properties and are administered for inflammation of the liver.
I. hirsuta L.	Annual herb	The leaf decoction is employed in Gold Coast as a lotion for yaws, while the fruit is utilized in treating eye disease in Senegal (Caius, 1989).
I. linifolia (L.f.) Retz.	Annual herb	Used as a remedy for the eyes in combination with other drugs in Madhya Pradesh (Sen *et al.,* 1986). Root given for bowel complaints in West Bengal (Sen *et al.,* 1986). The whole plant is used in post-delivery fever and spermatorrhoea by the Kols of Uttar Pradesh. Plant juice is employed as an alternative and diuretic, and is considered an alternative in old venereal affections. Santhals use the plant in amenorrhoea along with *Euphorbia thymifolia* (Caius, 1989).
I. linnaei Ali	Annual herb	Root decoction is given for antifertility; plant decoction is used for diarrhea, dysentery, and stomachache in Andhra Pradesh (Venkata Raju, 2002). Leaf juice is used for the reddening and inflammation of eyes by the Kols of Uttar Pradesh. The decoction of the whole plant is used in epilepsy. The plant juice is a diuretic, alterative and it is also used to treat chronic venereal diseases. Leaf juice is used as eye drops to alleviate migraines. Seed powder with milk is taken as a tonic for general health (Kumar *et al*., 2005).
I. oblongofolia Forssk.	Erect shrub	It is considered an antidote to all kinds of poison. The root is used as a purgative, and the stem decoction is used as a gargle in mercurial salivation (Caius, 1989). It is also used for toothbrushes and to alleviate stomachache in Rajasthan (Bhandari, 1990).
I. pulchella Roxb.	Shrub	The Santhals used root decoction to cure cough, and root powder used to cure chest pains (Caius, 1989). The root is also used to cure cough in Manipur (Sinha, 1987).
I. tinctoria L.	Erect shrub	The root is used for liver inflammation in South India and is considered a valuable nervine tonic. Leaf juice is employed as a remedy for hydrophobia, administered both internally and externally. A leaf ointment is applied to inflamed or itchy parts in Indo-China. Plant extract is given for epilepsy and nervous disorders and is also used in bronchitis, as well as an ointment for sores, old ulcers, and hemorrhoids. The root, pounded and macerated in water, is taken for urinary complaints by the Mundas of Chota Nagpur (Caius, 1989). Leaves are used for epilepsy in Arunachal Pradesh (Sharma *et al.,* 2002). Root decoction is used for fever in Andhra Pradesh (Venkata Raju, 2002). Root juice, mixed with *Eclipta prostrata* in coconut oil, is applied as a hair tonic in Andhra Pradesh (Venkata Raju, 2002). Plant paste is applied on warts (Singh, 2002). The root is used for wounds, and foul ulcers in Arunachal Pradesh (Saklani and Rao, 2002). Root powder is given for blood dysentery (Sen *et al.,* 1986).
I. trifoliata L.	Annual herb	The seeds are prescribed along with other mucilaginous drugs as a restorative (Caius, 1989). They are also used as an aphrodisiac in Arunachal Pradesh (Sharma *et al.,* 2002).
I. trita L.f.	Herb/shrub	The seeds are used as a nutritive tonic (Caius, 1989).
I. wightii Graham ex Wight & Arn.	Erect shrub	The leaves are used in treating dysentery in the Western Ghats (Henry *et al*., 1996).

grasslands. Similarly, *I. glabra* L., *I. trifoliata* L. and *I. prostrate* Willd. are important forage species and can be used for the improvement of grasslands/rangelands in Orissa and other parts of India (Subudhi and Dikshit, 2000).

Indigofera species exhibit toxic effects when consumed by animals, which is a limiting factor for their utilization as a forage resource. For instance, *I. hirsuta* has been reported to be toxic to cattle, leading to swollen legs that become scabby, cracked and may even bleed (Singh and Pandey, 1998). *I. linnaaei* has been associated with causing 'Birdsville disease' in horses in Australia (Henty, 1980), while *I. stricta* L.f. has been documented to induce abortion in cows. Animals feeding on *I. spicata* Forssk. have also displayed various disorders, resulting in weight loss and abortion (Henty, 1980).

Medicinal Value

Several species of *Indigofera* have traditionally been used to treat a variety of diseases and ailments (Table 3). *I. oblongifolia*, known as Raktpala in Ayurveda, is an important medicinal species in arid regions. *I. tinctoria* is also utilized for its medicinal properties. Various species of *Indigofera* exhibit confirmed biological activities. *I. cassioides* has antiviral properties, *I. mysorensis* Rottler ex DC. is anticancer, and *I. trita* L.f. ssp. *subulata* is hypotensive (Ved Prakash and Rajendran, 2002). *I. aspalathoides* Vahl ex DC. , known as the South Indian detergent, has plant ash that is used to remove dandruff and is a key ingredient in specific oils for treating syphilis and other skin diseases (Caius, 1989). Singh *et al*. (2023) provided an in-depth exploration of the medicinal aspect of *I. oblongifoilia*. Indigo is a natural substance that can be used as dyestuff, it is extracted from *Indigofera* species and can be used for the treatment of various diseases, such as epilepsy, bronchitis, liver disease and psychiatric illness (Anand *et al*., 1979).

Dye

Indigofera species have long been renowned in India for dye preparation, dating back to ancient times. Certain species such as *I. tinctoria* were historically the main sources of Indian indigo, crucial for blue dye production. Additional species like *I. caerulea* and *I. dosua* were also utilized for this purpose. Moreover, *I. oblongifolia* is employed as a dye plant in Mali and Zimbabwe (Mansfeld, 2001). The species like *I. atropurpurea* and *I. heteantha* are important floral dye-yielding plants in the Himalayan region (Gaur, 2008).

Green Manure

Indigofera species are traditionally used for green manure in India. *I. oblongifolia* is widely employed for this purpose. *I. teysmanni* Miq. is grown on field bunds to provide green manure on-site. *I. tinctoria* was once used as green manure for cotton and maize crops in Punjab and was also cultivated in rotation with tobacco and sugarcane.

Basket

Species such as *I. atropurpurea* and *I. hebepetala* are used for making baskets in Garhwal (Rana *et al*., 2002). Additionally, *I. caerulea* var. *caerulea* is used for both basket and rope making.

Fuel

The stem and branches of *I. cassioides* and *I. heterantha*. var. *gerardiana,* is also used as fuel in the Himalayas (Samant *et al*., 2007; Snehalatha *et al*., 2022).

Soil Conservation

Species such as *I. argentea, I. cassioides*, *I. heterantha* var. *gerardiana*, and *I. sessilioflora* DC. are effective soil binders. Additionally, *I. heterantha* var. *gerardiana* is used to provide shelter for seedlings.

Future Prospects

In India, the tropical pasture legumes currently cultivated are predominantly exotic species such as *Stylosanthes guianensis* (Aubl.) Sw., *S. hamata* (L.) Taub., *S. humilis* Kunth, *S. scabra* Vogel, *S. viscosa* (L.) Sw., *Macroptilium atropurpureum* (DC.) Urb., *M. lathyroides* (L.) Urb. etc., which are particularly suited to semi-arid conditions but may struggle in harsh arid environments (Singh and Beniwal, 2005). Hence, there is a necessity to explore and identify legume species adapted to hot arid conditions. Fortunately, the Thar Desert and Himalayan region harbor a vast array of naturally occurring wild *Indigofera,* ranging from prostrate annual herbs, to erect perennial herbs and shrubs, thriving across various landforms. *I. oblongifolia* and *I. cordifolia* are important fodder species for sheep, goats, camels and cattle in hot arid regions. The seed of *I. cordifolia* is the source of food during times of scarcity and famine. *I. oblongifolia* is one of the important traditional medicinal plant species in arid and semi-arid regions. The *Indigofera* species such as *I. tinctoria*, *I. caerulea*, and *I. dosua* are used as blue dye, but, *I. tinctoria* was once the main source of blue dye production in India. The species *I. atropurpurea*, *I. gerrardiana*, *I. heterantha* and *I. pulchella* are sources of good quality fodder, rich in protein in the Himalayan region. Therefore, attention should be given to suitable *Indigofera* species for arid and temperate regions. The comprehensive exploration and evaluation of important *Indigofera* species should receive high priority. Wild trailing species of *Indigofera* can enrich grazing land at a low cost. *Indigofera* seeds, which have high protein content, could serve as a rich source of animal feed concentrate. The genus also has potential as a source of gum. Additionally, many species have significant food, green manure, and medicinal value in rural and tribal areas, making them candidates for validation and eventual integration into farming systems for diversified agriculture. Woody perennials with medicinal value should be integrated with crop-based production systems to ensure sustained economic gains. However,

research is needed to assess their agronomic potential in both hot arid regions and the Himalayas.

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