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Parkia timoriana (DC.) Merr. (Bean Tree) in Northeast India: A review of its phenology, Phytochemistry, Biology, and Pharmacology

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Abstract
The utilization of botanical remedies for therapeutic purposes is prevalent in the rural communities of Nagaland, India. *Parkia timoriana*, a member of the Fabaceae family, represents an example of an underutilized and relatively obscure tree species with untapped potential for multiple purposes. This tree species is widely distributed in the southern hemisphere, particularly in countries such as Indonesia, Taiwan, Australia, Singapore, Vietnam, and upper Srilanka in South Asia. It is recognized as a prominent multifunctional tree form. The majority of the components of the tree, such as the bark, leaves, pods, tender shoots, and flowers, have been historically employed for medicinal purposes to address diverse health conditions. The utilization of pods for diverse medicinal applications was prevalent. The objective of this current review is to assess the ethnobotanical applications, phenological behaviours, phytochemical constituents, and pharmacological efficacy. *Parkia timoriana* have the potential to significantly contribute to the improvement of global food security.

Keywords: *Parkia timoriana*, medicinal plants, phenology, pharmacology, Nagaland, Parkia

Introduction
Plant-based foods are known to contain bioactive compounds that are beneficial for preventing various health conditions and providing essential nutrients [1]. The field of ethnobotany is a significant area of study that focuses on the utilization of plants for medicinal purposes and the application of various plant components in the management of diverse ailments and conditions. This is based on indigenous pharmacopoeia, folklore, and herbal charms, as noted by Weiner [2]. Prior to the development of synthetic drugs and antibiotics, humans primarily depended on naturally occurring active compounds derived from plants, animals, and microbes [3]**.** The Naga society has traditionally relied heavily on nature for sustenance, including shelter, food, and medicine, due to its cultural significance and ethnobotanical values. However, the influence of modern cultures has had a significant impact on these practices in contemporary Naga society. According to Moa *et al*. [4], the northeastern states of India, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, possess a highly diverse collection of plant species, characterized by a wide range of vegetation. The Naga tribes are classified under the Mongolian ethnic group and utilize the Tibeto-Burmese language. Additionally, they exhibit socio-cultural similarities with Southeast Asia [5]. The regions inhabited by the Naga tribal community in the north-eastern part of the country are widely recognized as one of the most bio-diverse areas within the biodiversity hotspot region. Due to the significant presence of various tribes in this region, it presents a substantial opportunity for the exploration of medicinal plants [6].
Parkia timoriana (DC.) Merr which is commonly referred to as tree bean, is a member of the Fabaceae family and is extensively distributed among the Parkia species. This species is versatile in nature and can be found in the Indo-Pacific region, with a global distribution that includes the northeastern region of India [7, 9]. P. *timoriana* holds significant ethnobotanical importance among the diverse ethnic groups residing in the Northeastern states [10]. Plant species possess significant commercial value due to their subsistence products and beneficial attributes that support the livelihood of society [11]. According to Hopkins [9], P. *timoriana* exhibits elevation distribution within its natural habitats, ranging up to 1300 m above sea level. The tree is found in various agro-climatic regions and is frequently cultivated in domestic gardens, residential backyards, Jhums, and forests across northeastern India with minimal

maintenance due to its high adaptability [8, 12]. The utilization of various parts of the tree, including the barks, leaves, pods, tender shoots, and flowers, has been a customary practice for addressing diverse health concerns. The pods have been extensively utilized for medicinal purposes and are considered a delicacy among the inhabitants of northeast India. They are a rich source of protein, fats, fibre, and minerals [13, 14], as well as antioxidants [15]. The culinary preparations derived from the pod and seed of this particular species hold significant prominence among the array of dishes served during diverse rituals and events. In addition to its primary applications, this particular species has been found to possess anti-diabetic and antioxidant properties, as well as being utilised for pulpwood and firewood purposes [16]. The utilization of seed, bark, and pod components has been reported as an efficacious medicinal treatment for diverse maladies [17, 19]. The stem and branches are utilized as a source of firewood [20]. There is a positive correlation between the annual growth of human population and the increasing need for P. *timoriana* pods and seeds [8].

Profile of the plant

P. *timoriana* is a significant multipurpose tree species that is utilized for its ethnomedicinal attributes. This taxonomic classification (Table 1) denotes that it pertains to the Parkia genus and the Fabaceae family. The genus Parkia encompasses six additional species that are distributed across various regions of the globe. These species include *P. roxburghii* G. Don, *Inga timoriana* DC., *Acacia niopo* Litv, *P. calcarata* Lecomte, *Mimosa peregrine* Blanco, and *P. grandis* Hassk. The aforementioned tree species is indigenous to Thailand, Indonesia, Malaysia, as well as the Northeast region of India, Myanmar, Bangladesh, and New Guinea. It has also been introduced to other countries such as the Philippines, Sri Lanka, and Taiwan. Vernacular names of P. *timoriana* in different languages of India and some other countries is given in table 2. *P. biglobosa*, commonly known as the African locust bean plant, is a notable member of the genus Parkia, which comprises 34 known species [21]. It is indigenous to South Africa. *P. roxburghii* is believed to be a probable precursor for the production of activated carbon [22]. According to Masae [23], Parkia pods are a source of polyphenolic, betalain dye, and chlorophyll content. These compounds have been found to be useful for coloring silk fabrics, exhibiting a distinctive dyeing technique with high colour fastness, and providing protection against UV radiation. *P. timoriana* is a sizable arboreal species that exhibits expansive boughs and features a bark that ranges in colour from white to brown or light grey, with white spots. This species is known to thrive in regions with colder hilly terrain as well as hotter plains, and can be found in lowland rainforests and along streams. Its habitat encompasses a diverse altitudinal range, spanning from 40-820 m [24]. The plant is frequently found in its natural state in the Jhums, woodlands, and residential gardens across Northeast India, requiring only minimal attention. The mature height exhibits a range of approximately 15-25 metres. The leaves exhibit a compound bipinnate morphology, measuring across 18-45 cm in length and bearing 40-80 pairs of diminutive leaflets. The morphology of the leaflets is characterized by an S-shape, an off-center mid-vein, and a slightly pointed apex. One to two glands that are round or oval in shape are generated on the leaf stalk. Hopkins [9] stated that, the ovary exhibits marginal placentation and is characterized by the presence of a solitary stigma. The corolla lobes of the flowers are typically glabrous on the exterior and emerge during the months of September through October. These lobes ultimately mature into a fruit with a strap-shaped morphology and a less distinct linear seed pod. The maturation of the fruits occurs between the months of February and March, with harvesting typically taking place in March or April. An adult tree has the capacity to produce an estimated range of 10,000 to 15,000 pods.

a)

b)

Fig 1: (a) Fruit and **(b)** Tree of *Parkia timoriana*

Table 1: Taxonomic arrangements of *P. timoriana*

Kingdom	**Plantae - plants**
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Sperrmatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida - Dicotyledons
Subclass	Rosidae
Order	Fabales
Family	Fabaceae
Genus	Parkia R. Br. - parkia
Species	*Parkia timoriana* (DC.) Merr
Binomial name	*Parkia timoriana*
Common name	Bean tree

Table 2: Vernacular names of P. *timoriana* in different languages of India and some other countries

Languages (in India)	Vernacular names
Assamese	Manipur- urohi, Khorial
Bengali	Manipuri seem
Garo	Aoelgap
Hindi	Supota, Kharial
Kachari	Bire- phang
Kannada	Shivalingadamara
Manipuri	Yonchak
Marathi	Unkampinching
Mikir	Themuk- arang
Mizo	Zongto
Nagamese	Unkamn- Pinching
Naga (Lotha)	Yenchak

Languages (in other countries)	Vernacular names
Alia, Alei(Indonesian)	Sumatra
Amarang	Palawan
Buah Batar (Kelabit)	Sarawak
Cupang/ Kupang (Taf, Tagalog, Visayan)	Luzon
Kedawong, Keda-ong, Petai Kerayong, Gudayong, kuayong, Neneting, Tayur Kedawung, Peundeuj, Dawang, Petir	Maalay Peninsula
W Java	Java
Koepang (Bandji)	Kalimantan
Kopang (Indonesian)	Sumbawa
Mai- Karien (Shan)	Burma
Olimbopo (Toalaki)	Sulawesi
Riang, Karieng & Spelling Variants (Thai)	Thailand

Evaluation of ethnobotanical uses

The tree bean, scientifically known as *Parkia timoriana*, holds significant ethnobotanical value and is widely utilised by local and indigenous communities in Northeast India. It is regarded as one of the most expensive vegetables in Nagaland, and the wider Northeast region, due to its cultural and traditional importance. The utilization of raw or cooked pods, leaves, and other plant parts has been found to be effective in the treatment of various ailments. The various ethnic groups have reported utilizing multiple components of the tree bean for various ethnobotanical objectives. The pod is utilized as a vegetable and incorporated into various preparations such as salads and chutneys [14]. On the other hand, Thangjam and Sahoo [25], note that the wood is commonly utilized as firewood or timber.

Table 3: Parts used and its benefits of *Parkia timoriana*

S. No.	Parts	Benefits	References
1	Bark	The bark is used in treatment of fever, toothache, wound, and ulcer, skin diseases, intestinal disorder, piles, dysentery, diarrhoea, diabetes are used as plaster to treat eczema.	[26, 27, 19]
2	Pods	The pods is used in treatment of diabetes, kidney disorder, urinary tract infection, hypertension, headache, stomach, liver, piles, dysentery, diarrhoea, constipation and intestinal disorder, Leprosy, digestive problem, diabetes and high blood pressure.	[13, 17, 18, 28]
3	Fruits	The fruits are used in treatment of leprosy, hypertension, wounds, scabies, diarrhoea, dysentery and relief from food poisoning.	[29-30]
4	Leaves and roots	The leaves are used in treatment of skin diseases, ulcer and decoction obtained from leaves and roots produce lotion to cure sore eyes.	[31-33]

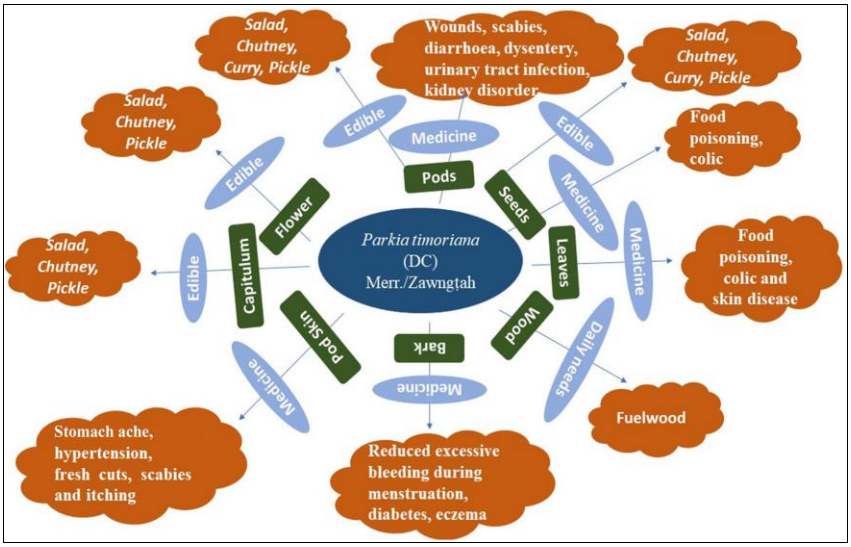

Fig 2: Diagrammatic representation of ethnobotanical uses of *P. timoriana* [34].

Phenology of vegetative and reproductive stages in *P. timoriana*

The bean tree is known to have a maximum lifespan of 80-90 years or beyond. On average, a single P. *timoriana* tree has the capacity to yield approximately 5 kg of seeds. Parkia pods are seasonally accessible in the market during the period spanning from December to March annually. Consumption of the produce commences at the stage of tender light green pods, which typically measure approximately 30 cm in length, and continues until the point of maturity. This particular food item serves as a supplementary source of sustenance and is typically consumed in its fresh, raw, or sun-dried form during periods of the year when it is not readily available. According to Salam *et al*. [14], the cultivation of multifunctional crops can offer improved food and livestock, while also serving as a reliable source of primary income for both growers and users. The farmers employed multiple methods to gather the seeds. In cases where the fruit fails to be of high density, the harvesting process entails collecting the fruit that has naturally detached from the tree. In cases where the fruit is compact, the act of harvesting is accomplished through the implementation of stakes that enable the individual to ascend the tree. The community's utilization of *P. timoriana* involved a process of drying and pulverizing the plant material, which was subsequently combined with honey or other substances, such as ginger, for the treatment of colic and colds [35]. The flowering period of the plant occurs between September and October. Following this, the flowers develop into a strap-shaped fruit within a span of four months from anthesis. The fruit is typically available for harvesting between January and March [7]. The observed phenomenon may be attributed to the influence of climate-related and geographic variables on the temporal progression of flowering and harvesting. Clusters of 10-15 pods are suspended on elongated heads that measure 25-40 cm in length and 2-4 cm in breadth. According to the report, the wood density of the species was recorded as 0.39 g cm^{-3}, classifying it as a light hardwood species. According to a study conducted by Devi *et al*. [36], the density of trees in the Meitei home gardens of Northeast India can vary between 6 to 8 individuals per hectare. The leaves exhibit a compound bipinnate configuration and are arranged in a spiral or alternate fashion. A single leaf is capable of bearing approximately 500 to 3500 leaflets. The inflorescence exhibits a terminal racemose pattern. The floral structure is situated apically on a peduncle that can reach a maximum length of 45 cm. The flora in question displays a phenological cycle that occurs on a yearly basis, characterized by a brief period of leaflessness succeeded by the emergence of fresh, light green, lustrous leaves. The flowers themselves are approximately 1 cm in length and exhibit a coloration that is predominantly white with yellow accents. The commencement of vegetative growth in P. *timoriana* was triggered by the temperature observed during the February to March period. This finding contrasts with the reports of Mishra *et al*. [37] and Das and Das [38] from Orissa and the home gardens of Assam, respectively, which were based on observations from moist tropical deciduous forests. The onset of leaf flushing is observed towards the conclusion of the dry season or the commencement of the rainy season [39]. This phenomenon is attributed to the combined influence of rising day length and temperature [40]. The overall biomass of P. *timoriana* was 2.24 Mg ha^{-1} and the potential for carbon sequestration was estimated to be 0.23 Mg ha^{-1} $year^{-1}$ [36]. Propagation can be achieved through the utilization of semi-hard stem cuttings (measuring 3-4 cm in diameter and 2-2.5 cm in length, treated with 200 ppm indole 3-butyric acid for a duration of 2 hours) and air layering (measuring 2-3 cm in diameter and subjected to the same treatment as that of stem propagation) [41]. According to Ningthoujam *et al*. [8], the highest occurrence of leaf flushing takes place between the months of April and June. The leaf initiation in Parkia was found to be significantly impacted by rainfall ($p< 0.001$), whereas the impact of temperature was not found to be significant. Table 2 indicates that there was a negligible negative correlation between the leaf fall and the temperature as well as rainfall period. Hence, it is comprehended that the joint impact of both precipitation and temperature plays a significant role in triggering leaf emergence, as opposed to their independent effects. The amount of leaf fall exhibited an increase during the months of November through January, which corresponds with the period of dry weather. The utilization of biotechnological tools has facilitated the identification of superior genotypes, mass propagation, and genetic enhancement of this versatile tree legume. The Barak valley of Northeast India, the commencement of leaf fall occurs during the pre-winter and winter seasons. Additionally, the peak of leaf fall during the dry season is a significant adaptation strategy for forests in subtropical regions that undergo at least 2-3 months of dry weather [42].

Table 4: Correlation coefficients between P. *timoriana* phenophases and environmental factors [8].

Environmental factors	Phenophases			
	Leaf flush	Leaf fall	Flowering	Fruiting
Rainfall	0.828**	− 0.435ns	− 0.502ns	− 0.646*
Temperature	0.564ns	− 0.297ns	− 0.357ns	− 0.769**

The conventional method of categorizing the different types was founded on their morphological and gustatory characteristics. Trees that produce narrow and uniform pods with a light green hue are deemed to have a superior flavour compared to other trees. 13 cultivars were identified to possess this desirable trait [43]. The extent and structure of genetic variation within plant species are influenced by various factors such as past evolution features, population density, mating system, and mechanisms that regulate gene flow [44]. Janzen [45], claimed that the time of flowering has been beneficial for plants in various climates during both the reproductive and vegetative phases, as it allows for efficient resource partitioning. Tree specimens propagated through vegetative means exhibit a shorter time frame for flowering, with an onset of less than five years post-planting. Conversely, those propagated through seeds typically require a longer period of five to seven years before flowering commences. The onset of flowering typically occurs in the beginning of September and persists until early December, with some individual trees exhibiting flowering activity until early January. The flowering phenophases exhibit a temporal span of 60-90 days. The *Parkia timoriana* fruit exhibits softness and tenderness, and displays a green hue during its early developmental stages. Upon maturation, the pods undergo a colour transformation to black, with multiple black entities embedded within. The period of fruit maturation can last for a duration of up to five months, commencing from the month of January and concluding in May. The number of fruit pods produced per tree is subject to variation, ranging from 53 to 402, and is contingent upon the girth size of the tree. The duration of fruiting and ripening is contingent upon both temperature and photo-periods. This phenomenon is typically observed during the dry season, which spans from the months

of November to March [46]. While every hermaphrodite flower has the potential to yield a singular pod, only a limited number of them actually undergo this development. An urgent need exists to conduct a comprehensive study on pollination in order to gain a better understanding of the role played by pollinators belonging to the genus [47]. Therefore, it is imperative to provide community-level education regarding the importance of bats for the preservation and conservation of ecologically and economically significant food crops, in order to ensure their sustained yield. The regulation of flowering synchronization during a particular season of the annual cycle seems to be influenced by prevailing climatic conditions [48]. According to Rodrigues *et al.* [49], seed germination occurs during favorable monsoon environmental conditions. While morphological characters and agronomic traits are both conventionally employed for characterizing diversity levels and patterns, they only account for a fraction of the plant genome and are subject to environmental influences. Consequently, their usefulness in describing intricate genetic structures that may exist within and between taxa is limited [50]. The successful attainment of *in vitro* regeneration and genetic transformation through the utilization of cotyledonary node explants [51].

Phytochemistry

The popularity of P. *timoriana* has led to studies on the identification of phytochemicals, highlighting its potential value for consumption and therapeutic benefits [52]. Salam *et al.* [14], have reported the presence of various phytochemicals such as tannins, flavonoids, saponins, anthocyanins, and leuco-anthocyanins in these seeds. The existence of saponins, glycosides, alkaloids, ursolic acid, and β-sitosterol compounds within Parkia species has been previously documented in scholarly literature [53, 55]. The investigation of phytochemicals through the screening of Captitulum, Flower, Pod and Seed has showed a potential activity of alkaloids, flavonoids, saponins, tannins and terpenoids as given in table 5 [34]. Similar outcome from the seed extracts of P. *javanica* that has indicated the existence of various compounds such as flavonoids, saponins, alkaloids, terpenoids, anthraquinones, steroids, reducing sugar and glycosides, as reported by Khangembam *et al.* [52]. The existence of anti-nutritional components, complete free phenols, tannins, and lectins was documented [56]. The identification of the amino acid of Thioprolin, a cyclic sulphur compound, has been reported in seeds and has been attributed to the characteristic pungent odour [57]. The aforementioned substance is characterized by significant levels of phytochemicals, which are known to exert antibacterial, anti-aging, and anticancer effects [58]. The commonly employed high-temperature cooking method for legumes results in a considerable reduction in their oligosaccharide, phenolic, mineral, tannin, and phytic acid content [59]. The seeds of P. *timoriana* contain a high concentration of antioxidants [60]. The process of germination can be utilized as a viable approach to enhance the antioxidant activity of legumes [61]. The isolation of two biomolecules, namely hyperin and epigallocatechin gallate, from ethyl acetate was reported [62]. Parkia has acquired the moniker "smell bean" due to its potent and distinctive aroma. Its primary constituent is campesterol [22]. Research has demonstrated that flavonoids are a well-researched group of phytochemicals that are known for their diverse range of biological activities exhibit various beneficial properties such as antioxidant, antibacterial, anti-inflammatory, and anti-allergic activity. The potential of the substance to exhibit anti-diabetic, antihypertensive, antiulcer, antimicrobial, and antitumor properties [63].

Table 5: Qualitative screening of extracted plant parts of P. *timoriana*. '+' represents 'positive' [34].

Sl. No.	Plant Parts	Alkaloids	Flavonoids	Saponins	Tannins	Terpenoids
1	Captitulum	+	+	+	+	+
2	Flower	+	+	+	+	+
3	Pod	+	+	+	+	+
4	Seed	+	+	+	+	+

Table 6: Quantitative screening of extracted plant parts P. *timoriana* [34].

Sl. No.	Plant Parts	Total flavonoid content (mg/g)	Total phenol content (mg/g)
1	Captitulum	36.69±0.002	24.17±0.11
2	Flower	28.95±0.004	18.7±0.16
3	Pod	58.38±0.001	38.21±0.13
4	Seeds	35.15±0.002	32.04±0.12

The inflorescences of Parkia are highly compact and take the form of a captitulum that serves as a singular unit of pollination. These structures are frequented by a variety of pollinators, including bees, moths, and other similar organisms. However, some of these inflorescences have evolved to be exclusively adapted for pollination by bats [64, 66]. The Quantitative screening of extracted plant parts *P. timoriana* by Laldinfeli *et al.*, [34], the pods exhibited highest flavonoid content of about 58.38±0.001 and phenol content of about 38.21 ± 0.13 (Table 6). The tree bean is utilized as a supplemental food source that offers high-quality nourishment for both humans and livestock. These consumption practices are believed to contribute to the plant's health benefits. It is considered a versatile vegetable that offers a reliable and valuable source of income for farmers in Northeast India. P. *timoriana* pulp (in dry pods) was found to contain approximately 10% moisture, 5.49% ash, 5.04% protein, 0.77% fat, and 27.86% total dietary fibres. The study also revealed that the pulp could induce gel formation with limewater, indicating its potential as a source of pectic polysaccharides for the production of flavored jellies [67]. Hidayati *et al.* [68], conducted a study which revealed that the chemical composition of P. *timoriana* seeds primarily consisted of saponins. The chemical analysis of the mature kernel indicates that it exhibits a maximum percentages of moisture (10.0%), protein (28.8%), fat (33.5%), energy (505 kcal), iron (13.3 mg 100g − l), manganese (2.9 mg 100 g − 1), zinc (5.6 mg 100 g − l), and chromium (7.9 µg 100 gm. − l) in comparison to a tender, immature, and mature pod. The tender pod, in contrast, exhibits a greater proportion of carbohydrates and fibre (71.15%) in its composition. The mineral composition of the pods was observed to follow the sequence

of pulp > testa > cotyledon. The proximate composition of P. *timoriana* was determined to include the following constituents: water percentage (2.33%), protein percentage (28.68%), ash percentage (3.27%), content of carbohydrates (44.49%), and fat content (21.23%). The predominant fatty acids present in the sample were palmitic acid (34.74±1.51), oleic acid (22.72±0.37), and linoleic acid (9.13±0.10). In addition, the triglyceride composition was found to be comprised of UUU (triunsaturated) (2.82%), SUU (saturated-unsaturated-unsaturated) (17.57%), SUS (saturated-unsaturated-unsaturated) (37.33%), SSS (trisaturated) (32.22%), and a category of triglycerides that could not be identified (7.56%) (Salam *et al*., 2009). Seeds possess phytochemical compounds that render them suitable for human consumption as food ingredients, as well as a source of food oils or fats [68]. The observed antioxidant activity can be attributed to the inhibition of the free radicals DPPH and ABTS [69].

Pharmacological potential of *P. timoriana*

The seeds of *P. timoriana* are commonly used in traditional medicine to alleviate symptoms of colic, cholera, menstrual spasms, and to improve stomach function [70]. Individuals in Malaysia have been known to utilize their pods as a form of treatment for various ailments such as kidney disorders, urinary tract infections, hypertension, and headaches. The community employs it as a medicinal remedy for the alleviation of various stomach ailments, including but not limited to bloating, cholera, intestinal inflammation, intestinal worms, and chickenpox. The substance in question encompasses a range of bioactive constituents that have been identified as potential remedies for a variety of ailments, including but not limited to renal maladies, diabetes, high blood pressure, cephalalgia, Hansen's disease, open sores, and gastrointestinal distress. Organically extracted extracts and aqueous solutions derived from P. *timoriana* have demonstrated a range of biological activities, including antibacterial, insecticidal, antioxidant, haemagglutinating and anticancer properties [16].

Antibacterial activity

The aforementioned species has the potential to contribute to the preservation of ecological equilibrium by enhancing and ameliorating soil quality [16]. The presence of various advantageous bacterial communities such as *Pseudomonas fluorescens*, *P. hibiscicola*, *P. putida*, *P. aeruginosa*, *Bacillus subtilis*, *B. brubrevis*, *B. cereus*, *Agrobacterium fabrum*, and *Serratia marcescens* have been observed to inhabit the rhizospheric region of the plant. The utilization of this particular bacterial population has the potential to facilitate the production of indigenous bacterial bio-inoculants. These bio-inoculants may subsequently aid in the establishment and growth of nascent plantlets, as well as enhance the quality of deteriorated jhum fallows in the area [71]. Certain components of *P. timoriana* possess the ability to impede the proliferation of *Streptococcus faecalis* and *Bacillus cercus* [72]. The efficacy of the extracts and their fractions was evaluated against standard gram-positive and gram-negative microorganisms as well as the parasite *Leishmania donovani* [73]. The leaf extract exhibited significant efficacy towards *Escherichia coli*, *Vibrio cholera*, *Staphylococcus aureus*, and *B. cereus* [74]. The exceptional properties found in *E. coli* seed extract have demonstrated efficacy contrary to all pathogenic bacteria. The results indicate that the fraction comprising chloroform, ethyl acetate, n-butanol, methanol, and aqueous components exhibits the most effective antibacterial activity against *N. gonorrhoeae* [75]. The antibacterial activity of methanol extracts derived from the seeds of *P. timoriana* has been observed against *Bacillus pumilus*, *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas aeruginosa* [69].

Anticancer activity

The utilization of *P. timoriana* bark as a topical application has been reported for the treatment of cancer and skin ailments [16]. Khangembam *et al*. [52], discovered that the seed extracts demonstrated inhibitory effects on HepG2 cells in a dose-dependent manner. Additionally, the extracts were observed to hinder the antiproliferation of human cancer cells and cancerous macrophage cell lines, including P38DI and J774 [76].

Antidiabetic activity

The anti-hyperglycemic and hepato-protective properties of hyperin and epigallocatechin gallate enriched ethyl acetate sub fraction found in the pods of *p. timoriana* have been observed [16]. The extract obtained from the pods exhibited inhibitory activity against α-glucosidase and α-amylase, with IC^{50} values of 7.39±0.04 and 9.11±0.815 mg mL^{-1}, respectively. According to a study conducted by Sheikh *et al*. [62], the IC^{50} value of the ethyl acetate fraction of pods was found to be 0.39±0.06 mg mL^{-1}, indicating a significant inhibition of α-glucosidase.

Insecticidal and haemagglutinating activities

The seed oil extract of P. *timoriana* has been found to effectively control a range of insect pests. The insecticidal properties of the substance in question Salam *et al*., [77], may account for its observed effects, while the raw seeds have been found to exhibit haemagglunating activity that lacks specificity towards the human ABO system, a characteristic that is attributed to the presence of albumins and globulins [56]. The utilization of a multipurpose tree bean in conjunction with native bio inoculants has the potential to greatly improve plant growth and survivability, enhance soil nutrient status, and ultimately promote regional biodiversity [71]. Certain types of Parkia species exhibit self-incompatibility in their natural environment, resulting in limited usefulness [78]. On the contrary, the complete utilization and consumption of this particular species of tree has yet to be thoroughly investigated in other regions of India. This phenomenon could potentially be attributed to the emission of a highly odorous fruit, which is known to contain Thiazolidine-4-carboxylic acid, a sulphur-containing amino acid. The utilization of tissue culture techniques for the large-scale production of high-quality planting materials and genetic modification through the incorporation of gene(s) that encode for insect resistance or proteinase inhibitors is imperative in the field of biotechnology. To enhance the genetics of a given plant species, it is imperative to establish a proficient protocol for transformation and regeneration, which will enable the successful transfer of the desired gene. Therefore, it is imperative to commence additional research initiatives in these areas to effectively utilize the ethnobotanical properties for a wider populace and to acquire further knowledge with significant potential in the development of pharmaceutical products, thereby attaining therapeutic and nutritional safety [79].

Conclusion

Numerous plant species that are rich in nutrients and well-

suited for low input agriculture have been overlooked and underutilized. The ethnic population residing in the north-eastern region of India and some other regions have a customary practice of cultivating and consuming *P. timoriana*, either in its raw form or as a pickled delicacy. The present review study has ascertained that *P. timoriana* harbors various phytochemical and biologically active compounds, including flavonoids, saponins, alkaloids, terpenoids, anthraquinones, and others. Further investigation is required to ascertain and isolate the efficacious antimicrobial constituents. As of yet, no *in vivo* toxicity assessment has been conducted on this botanical specimen, thus human-based research is warranted to evaluate its potential toxicity. Further evaluation is required through the utilization of appropriate models in order to extensively investigate the bioactive compounds for their potential health benefits, with the aim of discovering safer and more affordable pharmaceuticals. Insufficient attention has been given to researching, educating, improving, multiplying seeds, and utilizing this particular tree. Hence, it is necessary to suggest that the training of an exclusive circle of agricultural experts in the areas of assessment, agronomy, and cultivation and utilization of underutilized legume trees may lead to an increase in knowledge and evidence-based practises, which can guide policy and promote good practises.

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