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Priyala (*Buchanania lanzan* Spreng.): A Comprehensive Review of its Ayurvedic Significance, Pharmacological Potential, and Therapeutic Applications

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ABSTRACT :

Buchanania lanzan Spreng., a multipurpose tree native to the Indian subcontinent and Southeast Asia, holds a position of significant socio-economic and medicinal importance. Known commercially for its edible kernels, 'Chironji' or 'Charoli', it provides a vital source of livelihood for forest-dwelling communities. In traditional medicine, particularly Ayurveda, the plant is revered as *Priyala* and is utilized for a wide spectrum of therapeutic purposes. This review synthesizes the extensive body of traditional knowledge with the growing corpus of modern scientific research to provide a holistic understanding of its potential. Every part of the plant, including the bark, leaves, seeds, roots, and gum, is rich in a diverse array of phytochemicals, such as flavonoids, tannins, saponins, sterols, and fatty acids, which form the basis of its medicinal activity. Pharmacological studies have validated many of its traditional claims, demonstrating potent antioxidant, anti-inflammatory, antimicrobial, wound-healing, antidiabetic, antihyperlipidemic, cardioprotective, and neuroprotective properties. A central theme emerging from this research is the plant's powerful antioxidant capacity, which appears to be the unifying mechanism underpinning its diverse, pleiotropic effects. However, the high demand for its kernels and medicinal parts has led to unsustainable harvesting, placing the species under significant threat and listing it in the IUCN Red Data Book. While preclinical evidence is robust and corroborates its traditional use, a notable gap exists in clinical research. This review consolidates the botanical, Ayurvedic, phytochemical, and pharmacological profiles of *B. lanzan*, highlighting its therapeutic promise while underscoring the urgent need for clinical trials and integrated conservation strategies to ensure its sustainable utilization for future generations.

1. Introduction

Buchanania lanzan Spreng., a member of the Anacardiaceae family, is a deciduous tree of immense value, deeply embedded in the cultural, economic, and medicinal fabric of the Indian subcontinent and parts of Southeast Asia.[1] Commonly known as Chironji, Charoli, or Almondette, the tree is celebrated for its dual utility. Commercially, its kernels are highly prized as a culinary nut, used extensively in Indian cuisine for their delicate, almond-pistachio-like flavour, and serve as a cornerstone of the rural and tribal economy.[1] Medicinally, it is a veritable panacea in traditional healing systems, including Ayurveda, Unani, and Siddha, where nearly every part of the plant—from its roots to its gum—is employed to treat a wide range of ailments[1].

The central thesis of this review is to bridge the ancient wisdom surrounding *B. lanzan*, known in Ayurveda as *Priyala*, with contemporary scientific validation. It aims to create a comprehensive synthesis of its ethnobotanical background, traditional Ayurvedic profile, detailed phytochemical composition, and the extensive pharmacological research that has begun to unravel the mechanisms behind its therapeutic efficacy. By juxtaposing traditional claims with modern evidence, this review seeks to provide a holistic perspective on the plant's potential as a source for novel phytomedicines and nutraceuticals.

This exploration is framed by a critical paradox: the plant's immense value is also the source of its greatest threat. The high market demand for Chironji kernels has driven indiscriminate and premature harvesting, which, compounded by poor natural regeneration and habitat degradation, has pushed the species to a vulnerable status[2]. Its inclusion in the International Union for Conservation of Nature (IUCN) Red Data Book as a threatened species casts a sense of urgency over the need for its systematic study, conservation, and the development of sustainable cultivation practices[8]. This conflict between commerce and conservation underscores the importance of a thorough scientific appraisal, not only to unlock its full therapeutic potential but also to inform strategies that can secure its future.

2. Botanical Profile and Ethnobotany

A clear understanding of the plant's botanical characteristics, distribution, and ecological niche is fundamental to appreciating its medicinal and economic significance.

2.1. Taxonomy, Nomenclature, and Morphology

B. lanzan is classified within the plant kingdom as follows:

- **Kingdom:** Plantae
- **Clade:** Tracheophytes, Angiosperms, Eudicots, Rosids
- **Order:** Sapindales
- **Family:** Anacardiaceae
- **Genus:** *Buchanania*
- **Species:** *B. lanzan* [1]

The genus *Buchanania*, named in honour of the Scottish botanist Francis Buchanan-Hamilton, is considered a relatively primitive member of the Anacardiaceae family[1].

A significant point of confusion exists in its nomenclature. While *Buchanania lanzan* Spreng. is the widely used binomial name in much of the literature, many authoritative botanical databases, including The Plant List, treat it as a synonym of *Buchanania cochinchinensis* (Lour.) M.R. Almeida[5]. Other common synonyms encountered in historical and regional texts include *Buchanania latifolia* Roxb...[12] For clarity and consistency, this review will primarily use the name *Buchanania lanzan*, while acknowledging its synonymous relationship with *B. cochinchinensis*. Morphologically, *B. lanzan* is a medium-sized, sub-deciduous to evergreen tree that typically reaches a height of 15-20 meters with a straight, cylindrical trunk[1]. Its most distinctive features include:

- **Bark:** The bark is thick (10-12 mm), rough, and dark grey to black. It is characteristically fissured into prominent squares, giving it a tessellated appearance often described as resembling crocodile hide[3]. The blaze, or the inner bark, is reddish[7].
- **Leaves:** The leaves are large, simple, alternate, and thickly leathery (coriaceous). They are broadly oblong, measuring 10-25 cm in length and 5-12 cm in width, with a rounded base and an obtuse or slightly indented (emarginate) apex. A key identifying feature is the presence of 10-20 pairs of straight, prominent, parallel veins that are pubescent beneath[1].
- **Flowers:** The flowers are small (3-4 mm in diameter), bisexual, pentamerous (five-petaled), and greenish-white in color. They are arranged in dense, pyramidal terminal and axillary panicles that appear from January to March[1].
- **Fruit and Seed:** The fruit is a small, sub globose, single-seeded drupe, about 1 cm in diameter[1]. It is green when immature, turning reddish-purple to black upon ripening between April and June[1]. The fruit contains a hard, two-valved stone, inside which lies the edible kernel—the prized Chironji nut. The kernel is lentil-sized, slightly flattened, and has a flavor reminiscent of almonds or pistachios[1].

2.2. Geographical Distribution, Habitat, and Conservation Status

B. lanzan is native to a wide swath of Asia, including the Indian subcontinent (India, Nepal, Bangladesh), Southeast Asia (Cambodia, Laos, Myanmar, Thailand, Vietnam), and south-central China[1]. Within India, it is a characteristic species of tropical dry deciduous forests, found extensively in the central, northern, and western states. Its distribution is particularly concentrated in the Sal (*Shorea robusta*) and teak-growing regions of Chhattisgarh, Madhya Pradesh, Jharkhand, Uttar Pradesh, Maharashtra, Gujarat, and Rajasthan, at elevations up to 1,300 meters[2]. The tree is well-adapted to harsh environmental conditions. It thrives in dry tropical and subtropical climates, tolerating a wide temperature range from 5°C to 48°C and annual precipitation between 750 mm and 2,200 mm[5]. It grows on a variety of poor soils, including dry, clayey, and lateritic types, but it avoids waterlogged areas[5].

Despite its resilience, the conservation status of *B. lanzan* is precarious. The species is officially listed in the IUCN Red Data Book and is widely considered a threatened or vulnerable species[2]. This alarming status is a direct consequence of the immense anthropogenic pressure it faces. The high commercial value of its kernels leads to destructive harvesting practices, such as lopping of branches for quick collection and premature plucking of unripe fruits[7]. These practices severely hamper its natural regeneration, which is already poor due to low seed viability and susceptibility to fungal pathogens[7]. The convergence of over-exploitation, habitat degradation, and poor regeneration has led to a significant decline in its wild populations, making it a priority species for conservation. Urgent interventions, including the development of agroforestry systems, establishment of *in-situ* conservation plots and *ex-situ* field gene banks, and refinement of *in-vitro* propagation protocols like somatic embryogenesis, are critical to ensure its survival and sustainable use[11].

3. Significance in Ayurveda: The Profile of *Priyala*

In the classical science of Ayurveda, *B. lanzan* is identified as *Priyala*, a name that reflects its cherished status. Its properties and uses are meticulously documented in foundational texts like the *Charaka Samhita* and *Sushruta Samhita*.

3.1. Ayurvedic Identity and Energetics

Priyala is recognized for its profound therapeutic effects, categorized in classical treatises under specific functional groups (*ganas*). Charaka classified it as *Udarda Prashamana* (alleviating allergic rashes and urticaria) and *Shramhara* (relieving fatigue and exhaustion), while Sushruta included it in the *Nyagrodhadi gana*[18]. These classifications provide an initial glimpse into its primary actions as being soothing, nourishing, and restorative.

The therapeutic action of any substance in Ayurveda is understood through its energetic profile, defined by its taste, qualities, potency, and post-digestive effect. The Ayurvedic energetics of *Priyala* are as follows:

- **Rasa (Taste):** Predominantly *Madhura* (Sweet). The nut is also described as having a subtle *Amla* (Sour) taste[18].
- **Guna (Qualities):** Primarily *Guru* (Heavy for digestion) and *Snigdha* (Unctuous, Oily) [19].
- **Virya (Potency):** *Sheeta* (Cooling) [18].
- **Vipaka (Post-digestive Effect):** *Madhura* (Sweet) [19].
- **Dosha Karma (Action on Doshas):** Due to its sweet taste, heavy and unctuous qualities, and cooling potency, *Priyala* is an excellent pacifier of

aggravated *Vata* and *Pitta* doshas. Its properties may, however, increase *Kapha* dosha if consumed in excess or by individuals with a *Kapha* constitution[18].

An interesting nuance appears in the description of its qualities (*Guna*). While some texts describe the nut as *Sara* (promoting mobility, laxative), others describe the kernel marrow as *Vishtambhi* (causing constipation) and *Atidurjara* (very difficult to digest) [19]. This apparent contradiction is not an error but likely reflects a sophisticated understanding of the plant's dose- and part-dependent effects. The whole fruit, with its pulp and fiber, may indeed have a laxative (*Sara*) effect. In contrast, the isolated kernel, being dense, heavy (*Guru*), and oily (*Snigdha*), could be difficult to digest for an individual with weak digestive fire (*Agni*), thereby slowing gut motility and leading to constipation (*Vishtambhi*). This highlights the precision of Ayurvedic pharmacology and points to a need for modern comparative studies on the gastrointestinal effects of the different parts of the *B. lanzan* fruit.

3.2. Traditional Therapeutic Uses and Formulations

The Ayurvedic properties of *Priyala* translate into a wide range of therapeutic applications. Every part of the tree is utilized.

- **Kernel/Seed (*Majjā*):** This is the most valued part. It is considered a premier *Brumhana* (nourishing) and *Balya* (strength-promoting) tonic, used to combat *Daurbalya* (general debility) and emaciation[19]. Its cooling potency makes it effective for *Daha* (burning sensations), *Jwara* (fever), and *Trushna* (excessive thirst)[19]. It is highly regarded as a *Vrushya* (aphrodisiac) to improve vigor and treat seminal weakness[8]. In Ayurveda, it is also classified as *Hrudya*, a tonic that is congenial for the heart[19]. For skin conditions (*Kushtha*), the seed powder is used externally in a therapeutic powder massage known as *Udvartana* to treat itching and blemishes[18].
- **Bark:** The bark decoction is used to manage bleeding disorders like menorrhagia and is traditionally used to treat diarrhea, particularly when there is blood (*Raktatisara*) [1].
- **Leaves:** The leaves are used to promote wound healing and are considered to have digestive, expectorant, and purgative properties[8].
- **Gum:** The gum exuded from the bark is used to treat diarrhea and is mixed with goat's milk as an analgesic for intercostal and rheumatic pains[5].
- **Oil (*Taila*):** The oil extracted from the kernel is used topically to treat skin diseases and is applied to the hair to prevent premature graying (*Palitya*) [18].

Priyala is also an ingredient in several classical Ayurvedic formulations, including **Chandanadi Taila**, a cooling oil used for burning sensations and dizziness, and **Ashoka Ghrita**, a medicated ghee used for gynecological disorders[19].

4. Phytochemical Composition: The Chemical Basis of Activity

The diverse therapeutic effects of *B. lanzan* are attributable to its rich and complex phytochemical profile. Scientific investigations have identified a wide array of bioactive compounds in its various parts, providing a chemical basis for its traditional uses. The major constituents are summarized in Table 1, with a detailed profile of its valuable kernel oil in Table 2.

Table 1: Key Phytochemical Constituents of *Buchanania lanzan*

Plant Part	Phytochemical Class	Specific Compounds Identified	References
Leaves	Flavonoids	Quercetin, Kaempferol, Myricetin-3'-rhamnoside-3-galactoside, Kaempferol-7-o'glucoside, Quercetin-3-rahmnoglucoside	[8]
	Tannins	Gallic acid	[8]
	Triterpenoids	-	[8]
	Saponins	-	[8]
	Alkaloids	Vomicine, Celidoniol	[8]

	Other	Pinitol, Reducing sugars	[8]
Bark	Tannins	High concentration (13.4%)	[15]
	Saponins	Present	[23]
	Phenolic Compounds	Present	[23]
	Alkaloids	Present	[23]
Seeds/Kernels	Lipids/Fats	38-59% total fat content	[21]
	Proteins	19-43% protein content	[21]
	Minerals	Phosphorus, Magnesium, Iron, Calcium	[24]
	Vitamins	Vitamin C, Thiamine (B1), Riboflavin (B2), Niacin	[25]
	Phytosterols	Stigmasterol, β-Sitosterol	[24]
	Phenolics	Present in various extracts	[24]
	Flavonoids	Present in various extracts	[24]
	Alkaloids	3.5% content	[24]
	Saponins	0.59 g/100g	[24]
Gum	Flavonoids, Saponins	Present	[8]
	Amino acids/Proteins	Present	[8]
	Carbohydrates, Tannins	Present	[8]
Roots	Tannins, Saponins	Steroidal saponins present	[8]
	Flavonoids	Present	[8]

Table 2: Fatty Acid Profile of Buchanania lanzan Kernel Oil

Fatty Acid Type	Specific Fatty Acid	Percentage (%) Composition	References
Monounsaturated (MUFA)	Oleic Acid (C18:1, ω-9)	53.7 - 56.1	[21]
	Palmitoleic Acid (C16:1)	0.76	[24]
Saturated (SFA)	Palmitic Acid (C16:0)	31.3 - 33.4	[21]
	Stearic Acid (C18:0)	5.2 - 6.3	[21]
	Myristic Acid (C14:0)	0.4 - 0.6	[21]
	Arachidic Acid (C20:0)	0.45	[24]
Polyunsaturated (PUFA)	Linoleic Acid (C18:2, ω-6)	6.0 - 6.2	[21]
	Linolenic Acid (C18:3, ω-3)	0.26	[24]

The phytochemical profile, particularly the high concentration of phenolic compounds, flavonoids, and beneficial fatty acids, provides a strong scientific rationale for the plant's widespread use in traditional medicine and its potential as a modern therapeutic agent.

5. Pharmacological Validation of Traditional Claims

Modern scientific inquiry has increasingly focused on validating the ethnobotanical uses of medicinal plants. For *B. lanzan*, a significant body of preclinical research corroborates its traditional therapeutic applications, revealing the pharmacological mechanisms that underpin its efficacy. A recurrent theme across these studies is the central role of the plant's potent antioxidant activity, which serves as a foundational mechanism for many of its other protective effects.

5.1. Antioxidant and Anti-inflammatory Activity

The traditional use of *Priyala* for inflammatory skin conditions (*Kushtha*) and as a general rejuvenating tonic (*Rasayana*) is strongly supported by its scientifically proven antioxidant and anti-inflammatory properties. Oxidative stress and inflammation are key pathological drivers of many chronic diseases, and agents that can modulate these processes hold immense therapeutic promise.

In vitro studies consistently demonstrate that various extracts of *B. lanzan* possess significant antioxidant capacity. Methanolic extracts of both the kernel (BLK-ME) and bark (BLM) have shown potent free radical scavenging activity in assays such as 2,2-diphenyl-1-picrylhydrazyl (DPPH) and ferric reducing antioxidant power (FRAP) [24]. This activity is directly correlated with the high content of total phenolics and flavonoids in the extracts[24]. Further investigation using a cellular model showed that the bark extract effectively inhibits the production of reactive oxygen species (ROS) in lipopolysaccharide (LPS)-stimulated macrophage cells, confirming its antioxidant effect at a cellular level[30].

This antioxidant potential translates directly into powerful anti-inflammatory effects. The methanolic extract of the kernel (200 mg/kg) significantly reduced paw edema in rats in both acute (carrageenan-induced) and chronic (formaldehyde-induced arthritis) models of inflammation[28]. Similarly, the methanolic extract of the root demonstrated significant analgesic and anti-inflammatory activity, likely through the inhibition of prostaglandin synthesis[31]. Mechanistic studies have revealed that the bark extract exerts its anti-inflammatory action by inhibiting key pro-inflammatory enzymes, including 15-lipoxygenase (15-LOX) and cyclooxygenase-2 (COX-2), in a dose-dependent manner[29]. This multifaceted ability to both neutralize free radicals and inhibit inflammatory pathways provides a robust scientific basis for its traditional use as an anti-inflammatory agent.

5.2. Antimicrobial and Wound Healing Properties

The traditional application of *B. lanzan* leaves and roots for treating wounds (*Vrana*) and skin diseases is substantiated by modern research into its wound healing and antimicrobial activities. Effective wound healing requires control of microbial infection, reduction of inflammation, and promotion of tissue regeneration, and *B. lanzan* extracts have shown efficacy in all these areas.

In *in vivo* animal models, a 10% w/w ointment of the methanolic root extract significantly accelerated wound healing. In an incision wound model, it increased the skin's tensile strength by over 40%, indicating enhanced collagen deposition and tissue remodeling[32]. In an excision wound model, the extract promoted significant wound contraction, with effects noticeable from the ninth day of application[33].

This wound healing potential is strongly supported by the extract's broad-spectrum antimicrobial activity. The root extract has been shown to inhibit the growth of both Gram-positive bacteria, such as *Staphylococcus aureus* and *Bacillus subtilis* (MIC 0.625 mg/mL), and Gram-negative bacteria, like *Escherichia coli* and *Pseudomonas aeruginosa* (MIC 0.625-1.25 mg/mL)[32]. A particularly crucial finding is the extract's anti-biofilm properties. Bacterial biofilms are a major challenge in wound management, as they confer significant resistance to conventional antibiotics. The root extract of *B. lanzan* was found to not only reduce the formation of new biofilms but also disrupt pre-formed biofilms of pathogenic bacteria, an effect comparable to the antibiotic ciprofloxacin[32]. In contrast, gentamicin, a common antibiotic, was ineffective against Gram-negative biofilms, highlighting a key therapeutic advantage of the plant extract. Furthermore, the extract exhibited a synergistic effect when combined with gentamicin, suggesting its potential use as an adjunct therapy to enhance the efficacy of conventional antibiotics[33].

5.3. Antidiabetic and Antihyperlipidemic Potential

Ayurveda classifies *Priyala* as *Mehahara*, useful in urinary disorders, a category that includes diabetes mellitus. Modern research has provided compelling evidence for the antidiabetic and antihyperlipidemic effects of *B. lanzan*, primarily focusing on its leaf extracts.

In a key study using streptozotocin (STZ) to induce both Type I and Type II diabetes in rats, the administration of a methanol leaf extract (MEBL) at doses of 100 and 200 mg/kg for 21 days produced significant therapeutic effects[35]. The extract caused a significant reduction in fasting blood glucose levels in both diabetic models[35]. Concurrently, it demonstrated potent antihyperlipidemic activity, significantly improving the serum lipid profile by lowering elevated levels of total cholesterol, triglycerides, and low-density lipoprotein (LDL) cholesterol, while increasing high-density lipoprotein (HDL) cholesterol[35].

The mechanism underlying these effects appears to be closely linked to the plant's antioxidant properties. Diabetes is characterized by heightened oxidative stress, which contributes to pancreatic beta-cell dysfunction and insulin resistance. The study found that MEBL treatment significantly restored the levels of endogenous antioxidant enzymes—superoxide dismutase (SOD), catalase, and glutathione (GSH)—and markedly decreased lipid peroxidation (LPO) in the diabetic rats[35]. This demonstrates that *B. lanzan* combats the metabolic dysregulation of diabetes not just by lowering glucose, but by mitigating the underlying oxidative stress, a mechanism that validates its holistic role as a *Rasayana*.

5.4. Neuroprotective and Nootropic (Memory-Enhancing) Effects

The traditional use of *Priyala* as a *Medhya Rasayana*, or brain tonic, has found support in modern pharmacological studies investigating its neuroprotective and nootropic (memory-enhancing) activities. A study on scopolamine-induced amnesia in rats, a well-established model for memory impairment, demonstrated the potent nootropic effects of *B. lanzan*[38]. Oral administration of a *B. lanzan* paste at doses of 150, 300, and 600 mg/kg significantly reversed the memory deficits caused by scopolamine. This was evidenced by improved performance in behavioural tests like the elevated plus-maze and passive avoidance tasks[38]. The proposed mechanism for this memory-enhancing effect is the inhibition of the enzyme acetylcholinesterase (AChE) in the brain[26]. By reducing AChE activity, the extract increases the availability of acetylcholine, a critical neurotransmitter for learning and memory, whose decline is a hallmark of conditions like Alzheimer's disease. Furthermore, ethanolic extracts of the seeds have shown promising anxiolytic and neuroprotective effects[39]. In animal behavioural models, the extract reduced anxiety, an effect believed to be mediated through the GABAergic system[39]. Its neuroprotective benefits are attributed to its ability to reduce oxidative stress in brain tissue, which is a key factor in the pathogenesis of neurodegenerative diseases[39]. These findings collectively provide a scientific rationale for its reputation as a brain tonic.

5.5. Cardioprotective Activity

The Ayurvedic classification of *Priyala* as *Hrudya* (cardiac tonic) suggests a long-recognized benefit for heart health. This traditional claim has been substantiated by preclinical research demonstrating significant cardioprotective effects.

In a study using an isoproterenol-induced myocardial infarction model in rats, an ethanolic extract of *B. lanzan* bark (EEBL) provided remarkable protection to the heart muscle[40]. Rats pre-treated with the extract (at 250 and 500 mg/kg) before being challenged with isoproterenol showed significantly fewer signs of cardiac damage compared to the untreated group[42]. The protective effects were observed across multiple parameters:

- **Electrocardiogram (ECG):** The extract prevented the significant ST-segment elevation that is a diagnostic marker of myocardial infarction[41].
- **Cardiac Enzymes:** It significantly lowered the serum levels of cardiac injury markers, including creatine kinase-MB (CK-MB), lactate dehydrogenase (LDH), aspartate transaminase (AST), and alanine transaminase (ALT), which are released from damaged heart cells[41].
- **Antioxidant Defense:** The study concluded that the primary mechanism of cardio protection was the extract's ability to maintain and restore the heart's endogenous antioxidant defense system, which is depleted by the oxidative stress caused by isoproterenol[42]. This again highlights the central role of antioxidant action in the plant's therapeutic profile.

5.6. Other Validated Pharmacological Activities

Beyond the major areas detailed above, research has validated several other traditional uses of *B. lanzan*.

- **Anti-venom Activity:** In both *in vivo* and *in vitro* experiments, an ethanolic extract of the bark demonstrated a remarkable ability to neutralize the venom of the monocled cobra (*Naja kaouthia*). It significantly reduced the venom's lethal, myotoxic (muscle-damaging), and hemolytic (red blood cell-destroying) effects, supporting its traditional use as an anti-ophidian remedy[26].
- **Anti-anemic and Hematological Effects:** A methanolic extract of the seeds was found to have a positive impact on hematological parameters in rats. Administration of the extract led to a significant, dose-dependent increase in packed cell volume (PCV), hemoglobin (Hb), red blood cell (RBC) count, and white blood cell (WBC) count[44]. This suggests an anti-anemic effect, possibly mediated by stimulating erythropoiesis in the bone marrow, and an immunomodulatory effect, indicated by the increase in WBCs[45].
- **Hepatoprotective Activity:** Seed extracts have demonstrated protective effects against chemically induced liver damage in animal models. This hepatoprotective action is primarily attributed to the antioxidant compounds in the extract, which stabilize the membranes of hepatic cells and protect them from oxidative injury[39].

6. Toxicology and Safety Profile

The evaluation of a medicinal plant's therapeutic potential must be accompanied by a thorough assessment of its safety. For *B. lanzan*, its long history of use as a food provides strong empirical evidence of its safety. The edible kernels are widely consumed without reports of toxicity, a fact that is now being corroborated by modern scientific studies. This synergy between traditional use and scientific validation strengthens the case for its development as a safe nutraceutical.

Preclinical toxicological studies on various parts of the plant have consistently indicated a high margin of safety.

- **Acute Oral Toxicity:** An acute oral toxicity study conducted on the gum exudate of *B. lanzan* in albino mice found the median lethal dose (LD50) to be greater than 2000 mg/kg of body weight, classifying it as safe for oral consumption according to OECD guidelines[47]. Similarly, an ethanolic extract of the bark was found to be non-toxic, with no mortality or adverse symptoms observed in mice at doses up to 2 g/kg[43]. Studies on the seed extract have also reported it to be safe in animal models at doses up to 2000 mg/kg[39].
- **Dermal Toxicity:** In an acute dermal toxicity test, an ointment formulated with the root extract of *B. lanzan* did not cause any skin irritation, erythema, or edema, indicating its safety for topical application[49].
- **Hemolytic Activity:** The methanolic extract of the bark was evaluated for its effect on red blood cells and was found to have no hemolytic activity, suggesting it is non-toxic to blood components when administered systemically[29].

Collectively, these preliminary safety data align perfectly with the plant's status as a food-medicine. The lack of acute toxicity in preclinical models provides a strong foundation for its further development, although more comprehensive sub-chronic and chronic toxicity studies are warranted before it can be advanced to human clinical trials.

7. Conclusion and Future Perspectives

Buchanania lanzan Spreng. emerges from this comprehensive review as a plant of exceptional therapeutic and economic value. The deep-rooted traditional knowledge surrounding its use as *Priyala* in Ayurveda is not merely folkloric but is increasingly being validated by the rigors of modern scientific investigation. There is a remarkable congruence between its classical applications as a tonic for the heart (*Hrudya*), brain (*Medhya*), and skin, and its scientifically demonstrated cardioprotective, neuroprotective, antimicrobial, and wound-healing properties.

A central conclusion of this review is that the pleiotropic effects of *B. lanzan* are largely driven by a unifying mechanism: its potent antioxidant and anti-inflammatory activity. The rich arsenal of phytochemicals, particularly flavonoids and phenolic compounds, endows the plant with a powerful capacity to neutralize oxidative stress. This fundamental action appears to be the primary driver that branches out to manifest as diverse therapeutic outcomes, from mitigating the metabolic cascade of diabetes and protecting neurons from oxidative damage to shielding cardiomyocytes from ischemic injury. This scientific finding provides a modern interpretation of the ancient Ayurvedic concept of a *Rasayana*—a substance that promotes holistic rejuvenation and combats the systemic decline associated with aging and disease, much of which is now understood to be rooted in chronic inflammation and oxidative stress.

Despite the promising preclinical data, the journey of *B. lanzan* from a traditional remedy to an evidence-based modern therapeutic is incomplete. Several critical research gaps must be addressed:

1. **Clinical Trials:** The most significant void in the current body of research is the complete absence of human clinical trials. While animal and *in vitro* studies provide a strong proof-of-concept, rigorous, randomized, placebo-controlled clinical trials are indispensable to establish the efficacy, optimal dosage, and long-term safety of *B. lanzan* extracts in human populations[39].
2. **Bioactive Compound Isolation and Mechanistic Studies:** Future research should focus on isolating and characterizing the specific bioactive compounds responsible for each pharmacological effect. Elucidating the precise molecular mechanisms of these individual compounds would enable the standardization of extracts and could lead to the development of novel, targeted pharmaceuticals[39].
3. **Pharmacokinetics and Bioavailability:** There is a need for studies on the absorption, distribution, metabolism, and excretion (ADME) of *B. lanzan*'s active constituents to understand their bioavailability and optimize dosing regimens[39].

4. **Sustainable Development and Conservation:** The conservation-commerce conflict remains the most pressing challenge to the future of this species. Future efforts must be interdisciplinary, integrating scientific research with practical conservation strategies. This includes developing sustainable agro-cultivation protocols, improving *in-vitro* propagation techniques for mass multiplication, and creating value-added products that can provide economic incentives for conservation to the tribal communities who are the primary custodians of this natural resource[2].

In conclusion, *Buchanania lanzan* stands as a prime example of a traditional medicinal plant with immense, scientifically validated potential. It represents a rich source for the development of nutraceuticals, functional foods, and phytomedicines. However, its future hinges on a concerted and balanced effort that marries advanced scientific research with urgent and effective conservation and sustainable commercialization strategies. Only through such a holistic approach can the legacy of *Priyala* be preserved and its benefits fully realized for generations to come.

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