**World Journal of Current Research**
**www.worldcurrentjournal.com**
**Online ISSN: 3107-9636**
**Received: 25-06-2026, Accepted: 24-07-2026, Published: 11-08-2026**
**Volume 2, Issue 3, 2026, Page No. 6-13**

# Chironji *(Buchanania lanzan* Spreng.): A review of from traditional medicine to contemporary phytopharmacology

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**Abstract**
*Buchanania lanzan* Spreng. (Anacardiaceae), commonly known as Chironji or Priyala, is an economically and medicinally important deciduous tree native to the Indian subcontinent. It is extensively utilized in Ayurveda, Siddha, Unani, and traditional tribal medicine, where its seeds, bark, leaves, fruits, gum, and roots are used to treat diarrhoea, dysentery, diabetes, skin diseases, wounds, inflammatory disorders, ulcers, and other ailments. In addition to its therapeutic value, the edible kernels are highly nutritious and represent an important non-timber forest product supporting the livelihoods of tribal and rural communities. This review integrates classical knowledge with recent scientific literature to summarize the taxonomy, botanical characteristics, ethnomedicinal uses, nutritional composition, pharmacognosy, phytochemistry, pharmacological activities, toxicology, conservation, and pharmaceutical potential of *B. lanzan*. Phytochemical investigations have identified numerous bioactive constituents, including phenolic compounds, flavonoids, tannins, triterpenoids, phytosterols, fatty acids, proteins, vitamins, and minerals, which contribute to its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, gastroprotective, wound-healing, immunomodulatory, antihyperlipidaemic, and anticancer activities. Recent advances in phytochemical profiling, molecular authentication, biotechnology, and nutraceutical development have further strengthened its therapeutic potential. However, additional studies on standardized extracts, pharmacokinetics, long-term safety, and well-designed clinical trials are required before evidence-based phytopharmaceuticals can be developed. This review provides an updated scientific resource for researchers, pharmacognosists, ethnobotanists, and pharmaceutical scientists interested in the sustainable utilization and therapeutic applications of *B. lanzan*.

**Keywords:** *Buchanania Lanzan*, chironji, anacardiaceae, ethnomedicine, pharmacognosy, phytochemistry, pharmacological activities, nutraceuticals

## Introduction

Medicinal plants continue to serve as an indispensable source of healthcare, particularly in developing countries where traditional medicine remains an integral component of primary health services. According to the World Health Organization, nearly 80% of the global population relies partly on plant-based medicines for the prevention and treatment of various diseases (WHO, 2013). India, recognized as one of the world's megadiversity centres, possesses a rich heritage of medicinal plants documented in Ayurveda, Siddha, Unani, and numerous tribal healthcare systems. Among these, *Buchanania lanzan* Spreng., commonly known as Chironji or Charoli, occupies a prominent position because of its nutritional, medicinal, ecological, and socioeconomic importance (Warrier *et al*., 1993; Khare, 2007) [12, 31].

*Buchanania lanzan* is a medium-sized deciduous tree belonging to the family Anacardiaceae. It is naturally distributed throughout the tropical dry deciduous forests of India, Nepal, Bangladesh, Sri Lanka, and Myanmar, with its greatest abundance in central and peninsular India. The species is widely recognized as one of the most valuable non-timber forest products (NTFPs) because its edible kernels command a high market value and provide a substantial source of income for tribal and forest-dependent communities (Troup, 1921; Orwa *et al*., 2009) [18, 30]. The kernels are highly nutritious, containing proteins, healthy lipids, essential amino acids, vitamins, and minerals, making them an important dietary component as well as an ingredient in confectionery and traditional foods (Gopalan *et al*., 2012) [5].

In traditional medicine, almost every part of the plant—including the bark, leaves, fruits, seeds, gum, and roots—is used for the treatment of diarrhoea, dysentery, skin diseases, ulcers, wounds, fever, diabetes, rheumatism, cough, asthma, reproductive disorders, and inflammatory conditions (Kirtikar & Basu, 1935; Khare, 2007) [12, 13]. The bark is valued for its astringent and anti-inflammatory properties, while the kernels are considered nutritive, aphrodisiac, and restorative. Tribal communities also utilize the gum and leaves for wound healing and various gastrointestinal disorders (Jain, 1991) [10].

Scientific interest in *B. lanzan* has increased considerably during the past two decades because of its diverse phytochemical composition and promising pharmacological properties. Phytochemical studies have identified flavonoids, phenolic compounds, tannins, triterpenoids, sterols, glycosides, fatty acids, carbohydrates, proteins, and essential minerals, many of which exhibit significant antioxidant, antimicrobial, antidiabetic, hepatoprotective, wound-healing, immunomodulatory, and anticancer activities (Khare, 2007; Orwa *et al*., 2009) [12, 18]. Recent advances in chromatographic profiling, metabolomics, molecular biology, and plant tissue culture have further expanded opportunities for quality control, conservation, and pharmaceutical development.

Despite its extensive traditional use and growing scientific evidence, information on *Buchanania lanzan* remains scattered across ethnobotanical, phytochemical,

pharmacological, and forestry literature. Moreover, several recent investigations published between 2000 and 2025 [23] have substantially enhanced current understanding of its medicinal potential, nutritional value, biotechnology, and conservation biology. Therefore, an updated and comprehensive review is warranted to integrate historical knowledge with contemporary research.

The present review critically summarizes the available literature on the taxonomy, botanical description, distribution, ethnomedicinal uses, nutritional composition, pharmacognosy, phytochemistry, pharmacological activities, toxicology, biotechnology, pharmaceutical applications, and future research prospects of *Buchanania lanzan*. The review aims to provide a comprehensive scientific reference for researchers, pharmacognosists, botanists, pharmaceutical scientists, and healthcare professionals engaged in medicinal plant research, conservation, and evidence-based herbal drug development.

## Botanical Description and Taxonomy

### 1. Taxonomic Classification (Linnaean System)

*Buchanania lanzan* Spreng. is a member of the family Anacardiaceae, which comprises economically important genera such as *Mangifera*, *Anacardium*, *Pistacia*, *Spondias*, and *Semecarpus*. The genus *Buchanania* consists of approximately 25–30 species distributed throughout tropical Asia, Australia, and the Pacific region, of which *B. lanzan* is the most economically and medicinally important species in India. The species was first validly described by Kurt Polycarp Joachim Sprengel in 1826. It is widely recognized as the authentic source of Chironji (Charoli), whose edible kernels are extensively utilized in food, traditional medicine, and pharmaceutical preparations (Hooker, 1879; Kirtikar & Basu, 1935 [13]; POWO, 2025).

**Taxonomic Classification**

**Rank Classification**

Kingdom - Plantae
Division - Magnoliophyta
Class - Magnoliopsida
Subclass - Rosidae
Order - Sapindales
Family - Anacardiaceae
Genus - *Buchanania* Spreng.
Species - *Buchanania lanzan* Spreng.

**Accepted scientific name:** *Buchanania lanzan* Spreng.

**Common synonyms:** *Buchanania latifolia* Roxb. (misapplied); *Buchanania angustifolia* Roxb. (reported in older literature)

Recent taxonomic databases, including Plants of the World Online (POWO) and the World Flora Online (WFO), recognize *Buchanania lanzan* Spreng. as the accepted name, while several older names have been reduced to synonymy (POWO, 2025; WFO, 2025) [9].

### 2. Botanical Description

*Buchanania lanzan* is a medium-sized to large deciduous tree attaining a height of 10–20 m, occasionally reaching 25 m under favourable environmental conditions. The tree develops a straight cylindrical bole with a broad, spreading crown and thick grey to dark-brown bark exhibiting shallow longitudinal fissures in mature individuals. Young branchlets are smooth or slightly pubescent and exude a clear gummy exudate when injured (Troup, 1921; Orwa *et al*., 2009) [18, 30].

The leaves are simple, alternate, coriaceous, broadly elliptic to oblong-obovate, measuring approximately 8–20 × 5–12 cm, with entire margins, rounded or obtuse apex, and a conspicuous reticulate venation. Young leaves often exhibit a reddish or coppery coloration before becoming dark green and glabrous at maturity. The petiole is stout, measuring 1–3 cm in length (Hooker, 1879; Kirtikar & Basu, 1935) [13].

Flowering generally occurs from January to April, depending upon geographical location and climatic conditions. The small, greenish-white to creamy-white, bisexual flowers are arranged in large terminal or axillary panicles. Each flower possesses five sepals, five petals, ten stamens arranged in two whorls, and a superior unilocular ovary. The flowers are rich in nectar and are pollinated primarily by insects, especially bees and flies (Warrier *et al*., 1993) [31].

The fruit is a globose drupe, measuring 1–2 cm in diameter, initially green and turning purplish-black upon ripening. The thin fleshy mesocarp encloses a hardstony endocarp containing a single edible seed commonly known as Chironji or Charoli. The kernel is cream coloured, oily, sweet, and highly nutritious, resembling almonds in taste and culinary use. Fruiting generally occurs between April and June, although seasonal variations are common (Troup, 1921; Orwa *et al*., 2009) [18, 30].

The root system is well developed with a strong taproot and extensive lateral roots, enabling the species to survive prolonged drought conditions. Owing to its deep root system and adaptability to nutrient-poor soils, *B. lanzan* is regarded as an ecologically important species in tropical dry deciduous forests and contributes significantly to soil conservation and ecosystem stability (Luna, 1996) [15].

### 3. Vernacular Names

*Buchanania lanzan* Spreng. is known by a wide range of vernacular names throughout the Indian subcontinent, reflecting its extensive geographical distribution, cultural importance, and long-standing use in traditional medicine and nutrition. The edible kernels are commercially known as Chironji or Charoli, while the plant is referred to by different regional names in various Indian languages and tribal communities. In classical Ayurvedic literature, the species is primarily known as Priyala (also *Priyalaka*, *Chara*, and *Akola*), and its seeds are described as Brimhana (nutritive), Balya (strength-promoting), Vrishya (aphrodisiac), and Rasayana (rejuvenating), highlighting their therapeutic and nutritional significance (Chunekar & Pandey, 2010) [3]. In English, it is commonly called Chironji, Cuddapah Almond, or Almondette Tree because of its almond-like edible kernels. The species is popularly known as Chironji, Charoli, or Piyal in Hindi; Charoli, Char, or Priyal in Marathi; Charoli in Gujarati; Piyal in Bengali; Murkalu or Chara in Kannada; Saraparuppu in Tamil; Sara Pappu in Telugu; Chara in Malayalam and Odia; while several tribal communities refer to it as Achar, Piyar, or Char. The diversity of vernacular names reflects the plant's widespread utilization as an important medicinal species, nutritious food source, and valuable non-timber forest product across different regions of South Asia (Kirtikar & Basu, 1935; Warrier *et al*., 1993; Khare, 2007) [12, 13, 31].

**Distribution and Habitat**

*Buchanania lanzan* is indigenous to the Indian subcontinent and is naturally distributed throughout India, Nepal, Bangladesh, Sri Lanka, Myanmar, Thailand, and parts of Southeast Asia. India represents the principal centre of distribution and genetic diversity of the species, where it is extensively found in tropical dry deciduous and mixed deciduous forests (Orwa *et al*., 2009 [18]; POWO, 2025).

Within India, the species occurs abundantly in the states of Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Rajasthan, Odisha, Jharkhand, Uttar Pradesh, Bihar, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, and West Bengal. Large natural populations occur in the forests of the Central Indian Plateau, particularly in Madhya Pradesh and Chhattisgarh, which together contribute a major proportion of the country's commercial Chironji production. The species is also widely distributed in the Satpura and Vindhyan ranges, Eastern Ghats, Western Ghats, and Deccan Plateau (Troup, 1921; Luna, 1996) [15, 30].

*B. lanzan* thrives under tropical and subtropical climatic conditions with annual rainfall ranging from 750 to 1,500 mm and temperatures between 20 and 45°C. It grows well from sea level to about 1,200 m above mean sea level, preferring well-drained sandy loam, red, lateritic, and light black soils with good aeration. The species is highly drought tolerant and performs well under semi-arid conditions owing to its deep taproot system (Orwa *et al*., 2009) [18].

Ecologically, *B. lanzan* is an important component of dry deciduous forests and often occurs in association with Tectona grandis, Terminalia tomentosa, Terminalia arjuna, Madhuca longifolia, Boswellia serrata, Diospyros melanoxylon, Anogeissus latifolia, Butea monosperma, Acacia catechu, and Lagerstroemia parviflora. Besides its ecological significance, the species serves as a valuable non-timber forest product (NTFP), providing sustainable livelihood opportunities to tribal and forest-dependent communities through the collection and marketing of edible kernels (Warrier *et al*., 1993; Khare, 2007) [12, 31].

**Traditional and Ethnomedicinal Uses**

*Buchanania lanzan* Spreng. (Chironji/Priyala) has been extensively used in Ayurveda, Siddha, Unani, and indigenous systems of medicine for centuries owing to its nutritional and therapeutic properties. In classical Ayurvedic literature, including the *Charaka Samhita*, *Sushruta Samhita*, *Bhavaprakasha Nighantu*, *Dhanvantari Nighantu*, and *Kaiyadeva Nighantu*, the plant is referred to as Priyala and is described as Brimhana (nutritive), Balya (strength-promoting), Vrishya (aphrodisiac), Rasayana (rejuvenating), Pittahara, and Trishnanashaka (thirst-relieving). The kernels are recommended as restorative foods for improving physical strength, vitality, reproductive health, and recovery after illness, whereas the bark is valued for its astringent, anti-inflammatory, and wound-healing properties (Kirtikar & Basu, 1935; Chunekar & Pandey, 2010; Khare, 2007) [3, 12, 13].

Almost every part of the plant is utilized in traditional medicine. The stem bark is administered as a decoction for the treatment of diarrhoea, dysentery, bleeding disorders, ulcers, gastrointestinal complaints, and fever, while bark paste is applied externally to wounds and skin infections because of its astringent and antimicrobial properties. Leaf paste is traditionally used for cuts, burns, boils, eczema, and inflammatory swellings, whereas leaf decoctions are prescribed for fever, cough, and digestive disorders. The gum obtained from the trunk acts as a demulcent and is employed in the treatment of sore throat, chronic cough, ulcers, and diarrhoea. The roots are occasionally used in folk medicine for rheumatism, urinary disorders, and general debility (Warrier *et al*., 1993; Jain, 1991) [10, 31].

The edible kernels (Chironji or Charoli) constitute the most economically important part of the plant and are highly regarded as a nutritive tonic, aphrodisiac, galactagogue, and restorative food. They are consumed either raw or incorporated into milk preparations, sweets, confectionery, and traditional formulations to improve nutrition, stamina, immunity, reproductive health, and convalescence. The seed oil is also applied externally to relieve dry skin, cracked heels, minor burns, and inflammatory skin disorders (Khare, 2007; Orwa *et al*., 2009) [12, 18].

Ethnobotanical investigations have documented the widespread use of *B. lanzan* among numerous tribal communities, including the Gond, Bhil, Baiga, Kol, Korku, Santhal, Oraon, and Pawra tribes inhabiting Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Odisha, Jharkhand, Rajasthan, and Telangana. Traditional healers prescribe bark decoctions for diarrhoea, dysentery, diabetes, stomach disorders, menstrual complaints, and snakebite, while leaf and bark preparations are applied to wounds, fractures, ulcers, skin diseases, and insect bites. The kernels are also considered beneficial in managing malnutrition, weakness, infertility, and lactation, reflecting the plant's importance in tribal healthcare systems (Jain, 1991; Kala, 2005; Dhale & Patil, 2024) [4, 10, 11].

In addition to its medicinal value, *Buchanania lanzan* is one of India's most important non-timber forest products (NTFPs). Collection and marketing of Chironji kernels provide a significant source of seasonal income for rural and forest-dependent communities, particularly in central India. The species therefore possesses considerable ethnomedicinal, nutritional, socioeconomic, and cultural significance, making it an important component of sustainable livelihood programmes and biodiversity conservation initiatives (Orwa *et al*., 2009; Saha *et al*., 2020) [18, 22].

Modern pharmacological studies support many of these traditional claims by demonstrating antioxidant, antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, wound-healing, analgesic, antihyperlipidaemic, gastroprotective, and immunomodulatory activities of different plant extracts and isolated phytochemicals. Nevertheless, well-designed clinical studies are still required to validate traditional therapeutic applications and establish standardized dosage regimens for evidence-based medicinal use (Khare, 2007; Saha *et al*., 2020) [12, 22].

**Nutritional Composition**

The kernels of *Buchanania lanzan* are considered one of the most nutritious edible forest products of India and are often referred to as the "almond of the tropics" because of their pleasant taste, high lipid content, and excellent nutritional value. They are rich in proteins (approximately 18–22%), lipids (52–59%), carbohydrates (12–20%), dietary fibre, and essential amino acids, making them an important source of energy and nutrition for rural and tribal populations (Gopalan *et al*., 2012; Orwa *et al*., 2009) [5, 18].

The seed oil contains a high proportion of unsaturated fatty acids, particularly oleic, linoleic, palmitic, and stearic acids, which contribute to cardiovascular health and antioxidant activity. The kernels also provide appreciable amounts of essential amino acids, including lysine, leucine, valine, isoleucine, methionine, and phenylalanine, enhancing their nutritional quality and digestibility (Khare, 2007; Gopalan *et al*., 2012) [5, 12].

In addition to macronutrients, Chironji kernels are a valuable source of minerals, including calcium, phosphorus, potassium, magnesium, iron, zinc, copper, and manganese, which are essential for bone health, haemopoiesis, enzymatic functions, and immune regulation. They also contain vitamins such as vitamin C, thiamine, riboflavin, niacin, and tocopherols (vitamin E), together with natural antioxidants that protect against oxidative stress (Gopalan *et al*., 2012) [5].

The kernels are widely used in confectionery, dairy products, desserts, bakery items, traditional sweets, beverages, and nutraceutical formulations because of their rich flavour and high nutritive value. The press cake remaining after oil extraction is rich in protein and has potential applications as livestock feed and as an ingredient in functional foods. Owing to their balanced nutritional profile and bioactive constituents, Chironji kernels are increasingly recognized as a promising functional food and nutraceutical capable of supporting metabolic health, immunity, and overall well-being (Orwa *et al*., 2009; Saha *et al*., 2020) [18, 22].

**Pharmacognostic Characters**

Pharmacognostic evaluation of *Buchanania lanzan* Spreng. is essential for the authentication, standardization, and quality control of crude drugs and herbal formulations. Macroscopic, microscopic, physicochemical, and chromatographic characteristics collectively serve as reliable diagnostic parameters to distinguish the species from closely related members of the family Anacardiaceae and to detect adulteration (Anonymous, 2022 [2]; Kokate *et al*., 2021).

Macroscopically, *B. lanzan* is a medium-sized deciduous tree with thick grey to dark-brown bark exhibiting shallow longitudinal fissures. The leaves are simple, alternate, coriaceous, broadly elliptic to oblong-obovate, measuring approximately 8–20 cm long and possessing prominent reticulate venation. Flowers are small, greenish-white, bisexual, and arranged in terminal panicles, while the fruit is a globose drupe containing a single hard seed with an edible cream-coloured kernel commercially known as Chironji (Hooker, 1879; Kirtikar & Basu, 1935) [13].

Microscopic examination of the stem bark reveals a well-developed cork consisting of several layers of rectangular suberized cells followed by secondary cortex rich in parenchyma, scattered sclereids, stone cells, calcium oxalate crystals, and abundant starch grains. The secondary phloem contains groups of bast fibres, sieve elements, medullary rays, and tannin-containing cells. Powder microscopy of the bark shows fragments of cork cells, lignified fibres, sclereids, calcium oxalate crystals, starch grains, and brown tannin masses, which are considered important diagnostic characters (Anonymous, 2022 [2]; Kokate *et al*., 2021).

Leaf microscopy demonstrates a dorsiventral lamina with a single-layered epidermis covered by a thick cuticle. The leaves possess predominantly anomocytic stomata on the abaxial surface, multicellular covering trichomes, well-developed palisade tissue, spongy parenchyma, collateral vascular bundles, and numerous calcium oxalate crystals. The midrib contains lignified xylem vessels surrounded by parenchymatous tissues and sclerenchymatous fibres (Metcalfe & Chalk, 1950; Trease & Evans, 2009) [16, 29].

The kernels contain abundant oil globules, protein bodies, aleurone grains, and fixed oils rich in unsaturated fatty acids. Physicochemical parameters including moisture content, total ash, acid-insoluble ash, water-soluble ash, alcohol-soluble extractive, water-soluble extractive, and loss on drying have been proposed as standard quality-control indices according to WHO and Ayurvedic Pharmacopoeial guidelines (WHO, 2011; Anonymous, 2022) [2, 33].

Modern pharmacognostic authentication increasingly incorporates High-Performance Thin-Layer Chromatography (HPTLC), High-Performance Liquid Chromatography (HPLC), Gas Chromatography–Mass Spectrometry (GC–MS), Liquid Chromatography–Mass Spectrometry (LC–MS/MS), Fourier Transform Infrared Spectroscopy (FTIR), DNA barcoding, and metabolomic fingerprinting for accurate species identification and quality assurance. These analytical approaches facilitate batch-to-batch consistency and support the development of standardized herbal formulations and nutraceutical products (Kokate *et al*., 2021; Singh *et al*., 2019; Patel *et al*., 2022) [19, 27].

**Phytochemistry**

Phytochemical investigations have demonstrated that *Buchanania lanzan* is a rich source of structurally diverse primary and secondary metabolites, which collectively account for its nutritional and pharmacological properties. Different plant parts—including bark, leaves, fruits, seeds, kernels, roots, and gum—contain numerous bioactive compounds such as phenolic acids, flavonoids, tannins, triterpenoids, phytosterols, fatty acids, glycosides, carbohydrates, proteins, amino acids, vitamins, and minerals (Khare, 2007; Singh *et al*., 2019) [12, 27].

The seed kernels, the most economically important part of the plant, are particularly rich in fixed oils (approximately 52–59%), proteins (18–22%), carbohydrates, dietary fibre, and essential amino acids. The oil mainly comprises oleic, linoleic, palmitic, stearic, arachidic, and behenic acids, making it nutritionally comparable to several edible nut oils. In addition, the kernels contain tocopherols, phytosterols (β-sitosterol, stigmasterol, campesterol), phospholipids, and natural antioxidants that contribute to their nutritional and therapeutic value (Gopalan *et al*., 2012; Saha *et al*., 2020) [5, 22].

The bark and leaves are rich in polyphenolic compounds, including gallic acid, ellagic acid, chlorogenic acid, quercetin, kaempferol, catechin, rutin, and other flavonoids, together with condensed tannins responsible for the plant's antioxidant, antimicrobial, anti-inflammatory, and wound-healing activities. Several triterpenoids such as lupeol, betulinic acid, ursolic acid, oleanolic acid, and their derivatives have also been isolated from different plant parts (Khare, 2007; Kumar *et al*., 2021) [12, 14].

Phytochemical screening has further demonstrated the presence of saponins, alkaloids (in trace amounts), glycosides, carbohydrates, reducing sugars, gums, mucilage, proteins, amino acids, and volatile constituents. The bark contains appreciable quantities of tannins and phenolic

compounds, whereas the gum is composed mainly of complex polysaccharides with demulcent properties. These constituents contribute synergistically to the plant's pharmacological activities (Trease & Evans, 2009; Singh *et al*., 2023) [26, 29].

Recent investigations employing HPLC, HPTLC, GC–MS, LC–MS/MS, FTIR, Nuclear Magnetic Resonance (NMR), metabolomics, and high-resolution mass spectrometry have enabled comprehensive phytochemical profiling of *B. lanzan*. Chromatographic fingerprinting has identified several marker compounds suitable for quality control and standardization, while metabolomic studies continue to reveal novel bioactive metabolites with antioxidant, antidiabetic, hepatoprotective, anti-inflammatory, antimicrobial, and anticancer potential (Patel *et al*., 2022; Gupta *et al*., 2024; Sharma *et al*., 2025) [6, 19, 23].

Overall, the rich phytochemical composition of *Buchanania lanzan* provides a strong scientific basis for its extensive traditional use and supports its growing importance in the development of functional foods, nutraceuticals, cosmeceuticals, and phytopharmaceuticals.

**Pharmacological Activities**

Extensive pharmacological investigations have validated many of the traditional medicinal claims associated with *Buchanania lanzan* Spreng. Different extracts prepared from the bark, leaves, seeds, kernels, fruits, and roots possess a broad spectrum of biological activities, which are largely attributed to the presence of phenolic compounds, flavonoids, tannins, triterpenoids, phytosterols, and unsaturated fatty acids (Khare, 2007; Singh *et al*., 2019) [12, 27].

**1. Antioxidant Activity**

Methanolic, ethanolic, hydroalcoholic, and aqueous extracts of *B. lanzan* exhibit potent antioxidant activity by scavenging free radicals, inhibiting lipid peroxidation, and enhancing endogenous antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase. Phenolic acids and flavonoids, including gallic acid, quercetin, catechin, and ellagic acid, are considered the principal antioxidant constituents (Saha *et al*., 2020; Kumar *et al*., 2021) [14, 22].

**2. Anti-inflammatory and Analgesic Activities**

Experimental studies have demonstrated significant anti-inflammatory and analgesic effects of bark and leaf extracts through inhibition of cyclooxygenase (COX) and lipoxygenase (LOX) pathways, suppression of pro-inflammatory cytokines (TNF-α, IL-1β, and IL-6), and reduction of oxidative stress. Triterpenoids such as lupeol, ursolic acid, and oleanolic acid are believed to contribute substantially to these activities (Khare, 2007; Singh *et al*., 2023) [12, 26].

**3. Antimicrobial Activity**

Extracts of *B. lanzan* have shown broad-spectrum antimicrobial activity against several Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus, Bacillus subtilis, Escherichia coli,* and *Pseudomonas aeruginosa*, as well as pathogenic fungi such as *Candida albicans* and *Aspergillus niger*. These effects are primarily associated with tannins, flavonoids, and phenolic compounds (Singh *et al*., 2019; Patel *et al*., 2022) [19, 27].

**4. Antidiabetic and Antihyperlipidaemic Activities**

Several experimental studies indicate that bark and leaf extracts reduce fasting blood glucose levels, improve glucose tolerance, enhance insulin sensitivity, and decrease serum cholesterol and triglyceride concentrations in diabetic animal models. The hypoglycaemic activity is attributed to polyphenols and triterpenoids that improve carbohydrate metabolism and reduce oxidative stress (Kumar *et al*., 2021; Gupta *et al*., 2024) [6, 14].

**5. Wound-Healing Activity**

Traditional application of bark and leaf paste for wounds has been supported by experimental evidence demonstrating accelerated wound contraction, enhanced collagen synthesis, angiogenesis, epithelialization, and reduced microbial contamination. Antioxidant and anti-inflammatory phytochemicals appear to promote tissue regeneration and faster healing (Warrier *et al*., 1993; Singh *et al*., 2023) [26, 31].

**6. Hepatoprotective and Gastroprotective Activities**

Hydroalcoholic extracts of *B. lanzan* have shown protective effects against chemically induced liver injury by reducing serum hepatic enzymes and restoring antioxidant status. Gastroprotective studies suggest protection against gastric ulcers through enhanced mucus production, reduced gastric acidity, and inhibition of oxidative damage (Singh *et al*., 2019; Patel *et al*., 2022) [19, 27].

**7. Immunomodulatory and Anticancer Activities**

Recent investigations indicate that extracts of *B. lanzan* modulate both humoral and cellular immune responses and exhibit cytotoxic activity against selected cancer cell lines. Although the precise mechanisms remain under investigation, phenolic compounds and triterpenoids are believed to regulate inflammatory signalling pathways, apoptosis, and oxidative stress (Kumar *et al*., 2021; Sharma *et al*., 2025) [14, 23].

Overall, current pharmacological evidence supports the traditional use of *B. lanzan* as a promising source of antioxidant, antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, wound-healing, and immunomodulatory agents. Nevertheless, further mechanistic studies and well-designed clinical trials are required to confirm its therapeutic efficacy and establish standardized dosage regimens (Gupta *et al*., 2024; Sharma *et al*., 2025) [6, 23].

**Toxicology and Safety**

Available toxicological studies indicate that *Buchanania lanzan* possesses a relatively favourable safety profile when consumed in traditional dietary amounts or administered at therapeutic doses in experimental models. Acute toxicity studies on aqueous and alcoholic extracts have reported high median lethal dose ($LD_{50}$) values, with no significant mortality or behavioural abnormalities observed following oral administration. Subacute toxicity investigations likewise demonstrated no major alterations in body weight, food intake, haematological parameters, liver enzymes, kidney function markers, or histopathological architecture of vital organs at pharmacologically effective doses (Singh *et al*., 2019; Kumar *et al*., 2021) [14, 27].

The edible kernels (Chironji) have been consumed safely for centuries as a nutritious food and are considered rich sources of proteins, essential fatty acids, vitamins, and

minerals. However, as with other members of the family Anacardiaceae, occasional hypersensitivity or allergic reactions have been reported in susceptible individuals, particularly after excessive consumption of kernels or exposure to seed oil. Such reactions are uncommon but warrant consideration during pharmaceutical development (Khare, 2007; Saha *et al*., 2020) [12, 22].

Although traditional medicine employs various plant parts for prolonged use, comprehensive chronic toxicity, reproductive toxicity, teratogenicity, mutagenicity, genotoxicity, and carcinogenicity studies remain scarce. Likewise, information regarding herb–drug interactions, pharmacokinetic behaviour, and long-term safety in humans is limited. Standardization of herbal preparations, quality-control testing, and evaluation of contaminants such as pesticides, heavy metals, microbial load, and mycotoxins are therefore essential before clinical application (WHO, 2011; Anonymous, 2022) [2].

Recent pharmaceutical research recommends the development of standardized extracts supported by Good Agricultural and Collection Practices (GACP), Good Manufacturing Practices (GMP), chromatographic fingerprinting, and regulatory toxicological evaluation to ensure the safety, efficacy, and reproducibility of *B. lanzan*-based herbal medicines and nutraceuticals. Future investigations should prioritize long-term toxicity studies and randomized clinical trials to establish evidence-based safety guidelines for therapeutic use (Patel *et al*., 2022; Gupta *et al*., 2024; Sharma *et al*., 2025) [6, 19, 23].

**Pharmaceutical and Nutraceutical Applications**

The growing scientific evidence supporting the pharmacological and nutritional benefits of *Buchanania lanzan* Spreng. has stimulated considerable interest in its pharmaceutical and nutraceutical applications. Owing to its rich composition of polyphenols, flavonoids, triterpenoids, phytosterols, essential fatty acids, proteins, vitamins, and minerals, the species is increasingly recognized as a valuable source of bioactive compounds for the development of functional foods, herbal medicines, dietary supplements, and novel phytopharmaceuticals (Khare, 2007; Saha *et al*., 2020) [12, 22].

The edible kernels, commercially known as Chironji, are widely incorporated into nutraceutical formulations because of their high nutritional value. They contain approximately 18–22% protein, 52–59% fixed oil, essential amino acids, dietary fibre, tocopherols, and unsaturated fatty acids, making them suitable ingredients for functional foods, fortified beverages, health supplements, infant nutrition, sports nutrition products, and therapeutic diets. The presence of natural antioxidants further enhances their potential in preventing oxidative stress-related disorders and metabolic diseases (Gopalan *et al*., 2012; Saha *et al*., 2020) [5, 22].

Pharmaceutical research has demonstrated that extracts from the bark, leaves, and kernels possess significant antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, gastroprotective, wound-healing, immunomodulatory, and antihyperlipidaemic properties. Consequently, standardized extracts are being explored as active ingredients in herbal tablets, capsules, syrups, topical creams, gels, ointments, and wound dressings for the management of chronic inflammatory disorders, diabetes mellitus, skin diseases, liver disorders, and gastrointestinal ailments (Singh *et al*., 2019; Kumar *et al*., 2021) [14, 27].

Recent advances in pharmaceutical technology have facilitated the incorporation of *B. lanzan* phytoconstituents into nanoformulations, nanoemulsions, phytosomes, liposomes, polymeric nanoparticles, and controlled drug-delivery systems to improve solubility, stability, bioavailability, and therapeutic efficacy. Such novel delivery approaches are expected to enhance the clinical utility of its bioactive compounds while minimizing dosage-related limitations (Patel *et al*., 2022; Sharma *et al*., 2025) [19, 23].

The plant also holds promise for the development of cosmeceuticals owing to its antioxidant, emollient, antimicrobial, and skin-protective properties. Seed oil and kernel extracts have potential applications in moisturizing creams, anti-ageing formulations, sunscreens, herbal soaps, shampoos, lip balms, and wound-care products. Their natural fatty acids and antioxidant constituents contribute to improved skin hydration, barrier protection, and tissue regeneration (Khare, 2007; Gupta *et al*., 2024) [6, 12].

In addition, *B. lanzan* has attracted attention as a sustainable source of value-added forest products, supporting the development of herbal health products and nutraceutical industries while providing livelihood opportunities for tribal communities. Nevertheless, wider commercialization requires standardized cultivation practices, quality-control protocols, chromatographic fingerprinting, regulatory compliance, and well-designed clinical studies to establish safety, efficacy, and dosage recommendations (WHO, 2011; Anonymous, 2022; Sharma *et al*., 2025) [2, 23].

Overall, the integration of traditional knowledge with modern pharmaceutical sciences positions *B. lanzan* as a promising candidate for the development of evidence-based nutraceuticals, phytopharmaceuticals, and functional foods, although further clinical validation and regulatory standardization remain essential.

**Conservation Status and Sustainable Utilization**

*Buchanania lanzan* Spreng. is one of the most valuable non-timber forest product (NTFP) species of India, providing food, medicine, and livelihood to millions of tribal and rural households. Despite its ecological and economic importance, natural populations have declined in many parts of its distribution range because of overexploitation of fruits and seeds, habitat degradation, forest fragmentation, recurrent fires, excessive grazing, and poor natural regeneration. Unsustainable harvesting practices, including premature fruit collection and indiscriminate lopping of branches, adversely affect seed production and recruitment of young plants, thereby threatening long-term population stability (Orwa *et al*., 2009; Saha *et al*., 2020) [18, 22].

Although *B. lanzan* has not been globally assessed as a threatened species by the International Union for Conservation of Nature (IUCN), regional studies have identified declining populations in several forest ecosystems of central and peninsular India, highlighting the need for conservation and sustainable management (IUCN, 2025; Dhale & Patil, 2024) [4, 9]. The species is widely distributed in the dry deciduous forests of Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Rajasthan, Jharkhand, Odisha, and adjoining states, where it contributes significantly to forest biodiversity and local economies (The Wealth of India, 1988; Orwa *et al*., 2009) [18, 28].

Sustainable utilization of *B. lanzan* requires an integrated strategy involving scientific harvesting protocols, community-based forest management, domestication, agroforestry, and large-scale plantation programmes. Harvesting should be restricted to fully mature fruits while retaining a proportion of seeds in natural habitats to facilitate regeneration. Protection of mother trees, prevention of forest fires, grazing control, and enrichment planting can further improve population recovery (WHO, 2011 [33]; ICFRE, 2021).

Recent advances in propagation techniques, including seed pre-treatment, vegetative propagation, grafting, and *in vitro* micropropagation, have enhanced the prospects for large-scale multiplication and ex situ conservation. The establishment of germplasm repositories, seed banks, field gene banks, and tissue culture facilities is recommended to conserve genetically diverse populations and support future breeding programmes (Kumar *et al*., 2021; Sharma *et al*., 2025) [14, 23].

The commercialization of Chironji should also emphasize Good Agricultural and Collection Practices (GACP), Good Manufacturing Practices (GMP), traceability systems, quality assurance, and fair benefit-sharing mechanisms involving tribal communities. Value addition through processing of kernels, seed oil, and phytopharmaceutical products can substantially enhance rural income while reducing pressure on natural forests (Anonymous, 2022; Gupta *et al*., 2024) [2, 6].

Overall, effective conservation of *Buchanania lanzan* depends on integrating traditional ecological knowledge with modern conservation biology, sustainable forest management, biotechnology, and policy support. Such multidisciplinary approaches will ensure long-term availability of this economically important medicinal tree while conserving its genetic diversity and promoting sustainable livelihoods for forest-dependent communities.

## Conclusion

*Buchanania lanzan* Spreng. (Chironji/Priyala) is a highly valuable medicinal and nutritional tree species of the family Anacardiaceae, widely recognized in Ayurveda and indigenous healthcare systems for its diverse therapeutic applications. Classical knowledge, supported by contemporary scientific investigations, demonstrates that different plant parts—including the bark, leaves, fruits, kernels, gum, and roots—possess significant medicinal potential for the management of inflammatory disorders, diabetes, microbial infections, gastrointestinal diseases, skin ailments, liver disorders, and oxidative stress-related conditions (Khare, 2007; Sharma, 2001) [12, 24].

Phytochemical studies have revealed a rich diversity of bioactive constituents, including polyphenols, flavonoids, tannins, triterpenoids, phytosterols, essential fatty acids, proteins, vitamins, and minerals, which collectively account for its broad spectrum of pharmacological activities. Experimental studies have demonstrated antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, gastroprotective, wound-healing, immunomodulatory, analgesic, and antihyperlipidaemic properties, providing scientific support for many of its traditional medicinal uses (Singh *et al*., 2019; Saha *et al*., 2020; Kumar *et al*., 2021) [14, 22, 27].

Beyond its medicinal importance, *B. lanzan* is an economically significant non-timber forest product (NTFP) that contributes substantially to the livelihood and nutritional security of tribal and rural communities across India. The edible kernels (Chironji) are widely valued as nutritious functional foods, while recent advances in phytochemistry, pharmacognosy, biotechnology, and pharmaceutical sciences have expanded opportunities for developing standardized herbal medicines, nutraceuticals, cosmeceuticals, and novel phytopharmaceuticals (Patel *et al*., 2022; Gupta *et al*., 2024) [6, 19].

Despite these promising developments, important knowledge gaps remain regarding standardization of extracts, pharmacokinetics, molecular mechanisms of action, long-term toxicological evaluation, and well-designed randomized clinical trials. Moreover, sustainable harvesting, conservation of natural populations, and implementation of Good Agricultural and Collection Practices (GACP) and Good Manufacturing Practices (GMP) are essential to ensure the long-term availability and quality of this valuable medicinal resource (WHO, 2011; Anonymous, 2022) [2, 33].

Overall, *Buchanania lanzan* represents an excellent candidate for future evidence-based herbal drug development. Integrating traditional ethnomedicinal knowledge with modern multidisciplinary research-including phytochemistry, biotechnology, pharmacology, metabolomics, molecular authentication, and clinical medicine-will facilitate the development of safe, standardized, and effective plant-based therapeutics while promoting biodiversity conservation and sustainable utilization.


## Acknowledgements

The author gratefully acknowledges the Head, Department of Botany, and the Principal of SSVPS's L.K. Dr. P. R. Ghogrey Science College, Dhule, Maharashtra, India, for providing excellent library facilities, laboratory infrastructure, and a conducive academic environment that greatly facilitated the preparation of this review article.


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