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Chironji (*Buchanania lanzan* spreng.): Nutritional, functional, and technological perspectives on a high-value underexploited non-timber forest nut

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Abstract
Chironji (*Buchanania lanzan* spreng.), a non-timber forest product (NTFP) of significant economic value within the Anacardiaceae family, is a nutritionally rich yet underutilized tree nut prevalent in the dry deciduous forests of India. Despite its considerable potential for supporting livelihoods and its growing market demand, there is a paucity of systematic scientific research on its processing, nutritional quality, and functional properties. This review critically compiles and synthesizes existing literature on the taxonomy, distribution, harvesting practices, mechanized decortication technologies, physical characteristics, nutritional composition, fatty acid profile, phytochemical constituents, and oil properties of Chironji kernels. The kernels are noted for their high lipid content (approximately 57-60%), primarily comprising oleic and palmitic acids, moderate protein levels (approximately 19-25%), essential minerals, and significant bioactive compounds, including phenolics and flavonoids. The reported total phenolic content ranges from 5.78 to 39.53 mg GAE/g, contingent upon the extraction and roasting conditions, underscoring the impact of thermal processing on antioxidant potential. Mechanical decortication efficiency has been reported to reach up to 96%, with moisture conditioning and process optimization significantly enhancing whole-kernel recovery and reducing breakage. However, substantial variability in compositional attributes is observed due to genotype, geographical origin, maturity stage, and post-harvest handling of the fruit. Although traditional processing methods are widely employed, they are labor-intensive and often result in kernel damage and quality loss. Emerging mechanized technologies and optimized roasting parameters demonstrate improved efficiency and enhanced functional attributes, indicating strong potential for industrial scale-up. Nonetheless, challenges remain in terms of standardization, storage stability, quality preservation, and sustainable harvesting practices, particularly as the species is classified as vulnerable in certain regions. Overall, Chironji kernels are high-value, nutrient-dense functional food ingredients with promising applications in the food, nutraceutical, and pharmaceutical sectors.

Keywords: *Buchanania lanzan* spreng, Chironji kernel, non-timber forest products (NTFPs), Decortication, Post-harvest processing, Proximate composition, Fatty acid profile, Bioactive compounds, Antioxidant activity, Underutilized tree nuts

Introduction
Non-timber forest products contribute approximately 70% of India's total forest-based export revenue, underscoring their substantial economic significance within the forestry sector. The expanding global demand for phytochemicals has further positioned NTFPs as a strategic component of emerging bioresource-based trade. However, an estimated 90% of medicinal plant species face varying degrees of threat due to unsustainable harvesting regimes, overexploitation, habitat degradation, and unscientific collection practices. Beyond their commercial value, NTFPs constitute a critical socio-economic resource base for rural and indigenous communities in developing regions, where forest-dependent households rely on them for nutritional security, primary healthcare needs, and supplementary income generation [22]. Among the diverse range of NTFPs, tree-borne oilseeds and edible nuts hold particular importance due to their high economic value and market demand. One such valuable NTFP is chironji (*Buchanania lanzan* spreng.), a tropical deciduous tree belonging to the family Anacardiaceae. The species is widely distributed across the dry deciduous forests of central and northern India and is considered an important forest resource due to its edible kernels, medicinal properties, and livelihood potential [23]. *Buchanania lanzan*, commonly

referred to as char, achar, and chironji, is a member of the Anacardiaceae family [7]. It was initially described by Francis Hamilton in 1798[11].

Taxonomy, Botanical Description

Distribution of plant: *Buchanania lanzan,* spreng commonly known as Chironji, is indigenous to the Indian subcontinent and is also present in Vietnam, Thailand, Laos, Myanmar, and Yunnan. This tree is predominantly evergreen and thrives naturally in the tropical dry deciduous forests of Northern, Western, and Central India, particularly in the states of Madhya Pradesh, Chhattisgarh, Jharkhand, Uttar Pradesh, Maharashtra, Bihar, Odisha, Andhra Pradesh, Rajasthan, and Gujarat. This species is predominantly located in the wild within the tropical deciduous forests of these regions, which are distinguished by a monsoonal climate. The distribution of Chironji in Central India is notably concentrated in areas known for Sal and teak forests, including Betul, Mandla, Balaghat, Seoni, Amarkantak, Dindori, Anuppur, Bastar, Rewa, Satna, Dantewada, Kanker, Kondagaon, Raipur, and Surguja [16]. Chironji is a significant economic oil tree species native to India and holds ecological importance globally.

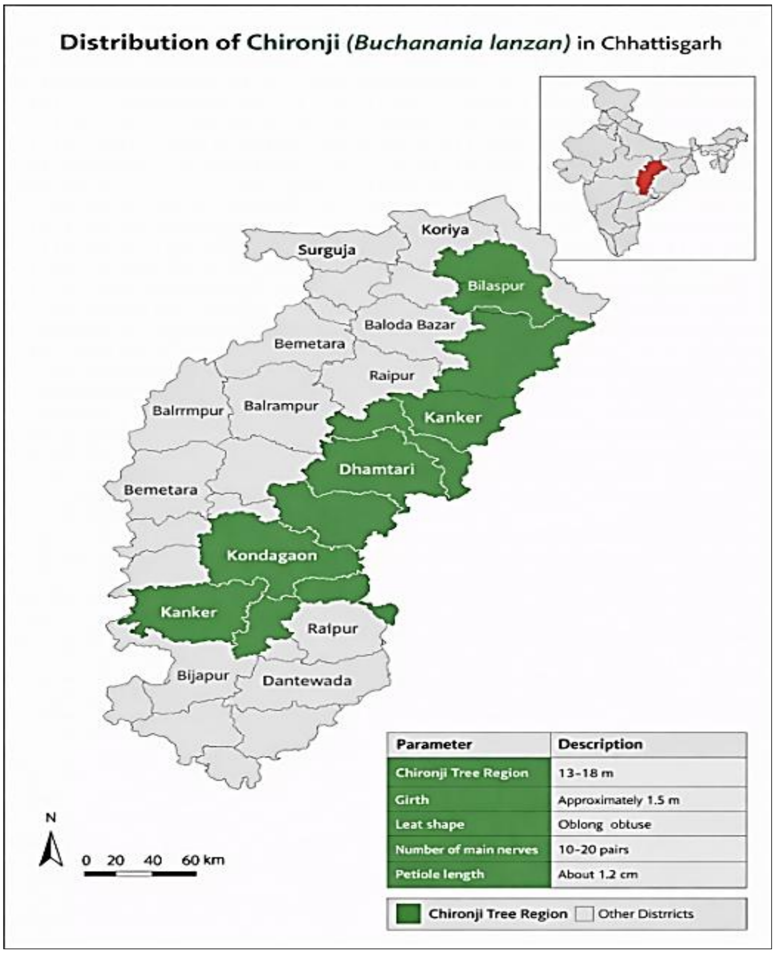

Fig 1: Map showing the distribution of chironji plants in Chhattisgarh.

Fig 2: Chironji fruits (*Buchanania lanzan* Spreng.).

Taxonomy

Approximately 20 species of chironji have been identified, with seven species documented in India. Among these, two species, *B. lanzan* (also known *as B. latifolia*) and *B. axillaries* (also known as *angustifolia*), produce edible fruits. In contrast, *B. lanceolata* is classified as an endangered species in the Kerela region whereas, *B. platyneura* are found in Andaman. Other species within this genus include *B. lucida, B. glabra*, and *B. accuminata.* The species *B. exillaris* is distinguished by its small size and the production of high-quality kernels [2]. The tree exhibits resilience and is well-suited for the restoration of arid lands and degraded soils [5]. The foliage of this tree serves as feed, while the timber is utilized in construction frameworks. Ripe fruits and harvested seed kernels possess numerous nutritional and therapeutic attributes. Whole, partially developed fruits and seeds, following the consumption of the fruit's meat, are sun-dried [9]. However, unsustainable harvesting practices and excessive exploitation pose significant threats to the species' survival, pushing it towards extinction. Contributing factors include neglect, the erosion of traditional knowledge, intense biotic and anthropogenic pressures, and overutilization by local populations, all of which significantly accelerate the species' decline. The International Union for Conservation of Nature (IUCN) has already classified Chironji as a vulnerable (VU) species on its Red Data List.[8, 15]. The plant possesses medicinal properties that serve as a source of income for the rural and tribal populations of the state, thereby contributing to the enhancement of their socio-economic status.

Table 1: Taxonomic classification and vernacular names of *Buchanania lanzan*

Category	Classification / Name
Kingdom	Plantae
Subkingdom	Viridiplantae
Superdivision	Embryophyta
Phylum / Division	Tracheophyta
Class	Magnoliopsida
Order	Sapindales
Family	Anacardiaceae
Genus	*Buchanania*
Species	*Buchanania lanzan*
Common names	Chironji, Cuddapah Almond, Calumpang Nut, Almondette
Hindi	Chironji, Piar, Char
Sanskrit	Priyala
Marathi	Charoli
Odia (Oriya)	Char
Malayalam	Priyalam, Nooramaram, Padacheru, Mungapera, Kalamavu, Mural, Nuramaram

Despite the significant potential of Chironji, its cultivation is constrained by its prolonged fruiting period [3]. The fruit requires 4-5 months to ripen, with full maturation occurring over approximately 3-4 months. Harvesting commences in mid-summer, from the end of April to the end of May [12].

Fig 3: *Buchanania lanzan* Spreng. tree

Fig 4: *Buchanania lanzan* Spreng. flowers.

Fig 5: Buchanania lanzan Spreng. seeds.

Fig 6: Buchanania lanzan Spreng. kernels.

Table 2: Morphological and phenological characteristics of *Buchanania lanzan*

Parameter	Description
Tree height	13-18 m
Girth	Approximately 1.5 m
Leaf shape	Oblong, obtuse
Number of main nerves	10-20 pairs
Petiole length	About 1.2 cm
Flower colour	Greenish-white
Flowering period	January-February
Fruit maturity stage	Green (immature), deep purple (mature)
Harvesting period	April-June

Ethnobotanical and traditional uses

Chironji fruits are among the tasty wild fruits available. Their seeds are edible and often serve as an alternative to almonds. Frequently, these seeds are ground into a powder to add flavor or act as a spice in various Indian recipes. Additionally, chironji nuts can be used to thicken sauces and stews. The kernels have a delightful, slightly tangy taste, reminiscent of both pistachios and almonds, and can be consumed either raw or roasted. In the summer, when green fodder is scarce, locals feed the leaves to their livestock, such as buffalo, goats, and sheep. The dried wood of the chironji tree is used as fuel. Its timber, which is somewhat resistant to termites, is employed in crafting furniture, boxes, crates, desks, fine furniture, matchboxes, millwork, molding, packing cases, stools, tables, and agricultural tools, and is more affordable than other types of wood. The plant holds significant value in ethno-medicine practices.

Various parts of the plant are also employed in treating ailments; for example, the leaves are used for skin diseases, wound healing, and have cardiotonic properties. The fruits are beneficial for cough and asthma treatment. Kernel oil is effective in reducing glandular swellings in the neck. Chironji paste serves as an excellent skin conditioner. In addition to the fruit, the bark is utilized in natural varnish production and tanning. The bark contains approximately 13.4% tannin. Gum exudates from the tree trunk are used in textile dressing [19] and are also helpful in treating diarrhea, intercostal, and rheumatic pains. The roots are acrid, astringent, cooling, purifying, and constipating, making them useful in diarrhea treatment as reported by the Tribal Co-operative Marketing Development Federation of India Limited, Chironji demonstrates an annual market potential of approximately 30.04 million USD within India. On average, each Chironji tree yields 40-50 kg of fresh fruits, which, after drying, reduces to 8-10 kg, ultimately producing 1-1.5 kg of finished product per tree. The dry seed of Chironji is valued at approximately 1200-1500 per kilogram. The kernel, the most valued component of the fruit, is sold at a price range of 7 to 10 USD per kilogram [10, 11].

Harvesting, processing and storage of chironji

The traditional harvesting of chironji is carried out during the peak maturity period from April to June. Physiological maturity is indicated by a distinct color transition of the fruits from green to purple, while the nuts eventually turn black upon full ripening. Ripening initiates at the proximal end of the drupe, and harvesting is generally undertaken when one or two drupes on the panicle exhibit color change, signaling overall fruit maturity. Harvesting is performed manually. In many cases, branches are shaken to dislodge the mature fruits, which are then collected from the ground. Alternatively, fruit-bearing shoots (peduncles) are cut using a sickle attached to a long bamboo pole to access higher branches. However, improper handling during cutting or shaking may injure the developing shoots and adversely affect subsequent growth and productivity of the tree. Therefore, careful harvesting practices are essential to minimize mechanical damage and ensure sustainable yield [3].

Traditional processing of chironji involves manual harvesting, storage/shade drying till it turns black, soaking, peeling by rubbing against palms or jute bags followed by washing, sun-drying for 2 to 3 days and decortications to yield kernels. Without harming the delicate inner seed, the hard shell of B. lanzan nuts breaks apart when they are decorticated. Nuts are fed between two spinning discs in a grinding stone mill in the conventional processing method. Nuts and seeds are separated using impact and abrasive forces. These disks are composed of sun-dried clay, backed clay, or stone. Usually, the top disc is manually spun while the lower disc is fastened to the bottom. The disk on the top is guided by a steel or wooden axle that protrudes from the middle of the bottom disk. The top disk is used to feed the B. lanzan nuts [8].

Mechanised processing

The evaluation of the decorticator's performance indicated that the nut moisture content, cylinder speed, and cylinder clearance significantly affected its performance metrics. The study found that chironji nuts achieved a decortication efficiency of 93.90% and a capacity of 30.15 kg-h-1. Additionally, the total kernel recovery was higher for chironji nuts soaked for 24 hours, with a moisture content of 8.57%, a cylinder speed of 286 rpm, and a cylinder clearance of 6 mm. The maximum whole-kernel recovery was observed for nuts soaked for 24 hours at a cylinder speed of 197 rpm and a clearance of 7 mm. The data further indicated that minimal kernel breakage occurred for chironji nuts soaked for 30 hours at a cylinder speed of 197 rpm and a clearance of 8 mm [20].

The application of Response Surface Methodology (RSM) in optimizing process parameters significantly reduces the number of experimental trials typically needed for the decortication of chironji nuts, while also enhancing the system's output. The independent parameters for this process, namely drying temperature, drying time, and disc clearance, were optimized using RSM. The optimal conditions identified were a drying temperature of 69.610 °C, a drying time of 163.87 minutes, and a disc clearance of 12 mm. Under these conditions, the whole kernel recovery was 27.72% (with a kernel-to-shell ratio of 30.01% to 69.99%), the decorticating efficiency reached 85.299%, unshelled nuts accounted for 11.50%, broken kernels were 3.687%, and the machine's capacity was 6.232 kg/h.

Table 3: Effect of selected nut-breaking/decortication devices on quality of chironji kernels

Decortication method / device	Operating mechanism	Key operating variables	Effect on kernel quality	Key quality indicators reported	Reference(s)
Manual stone or mallet breaking	Direct impact and compression	Applied force, nut orientation, moisture content	High kernel breakage; low whole-kernel recovery; operator-dependent results	Kernel breakage (%), whole kernel recovery (%)	[10, 21]
Hand-operated lever press decorticator	Static compressive force	Applied pressure, nut size, shell thickness	Moderate kernel damage; improved control over cracking compared to impact methods	Whole kernel recovery, shell separation efficiency	[17]
Roller-type decorticator	Compression and shear between rollers	Roller gap, roller speed, nut moisture	Improved kernel recovery at optimum moisture; excessive compression increases breakage	Kernel breakage (%), decortication efficiency (%)	[20]
Impact-type mechanical decorticator	Repeated high-energy impact	Rotor speed, feed rate, nut hardness	High kernel fragmentation due to brittle kernel and hard shell	Fines generation, kernel fracture (%)	[4]
Moisture-conditioned decortication	Pre-conditioning followed by mechanical cracking	Moisture level (6-9%), conditioning duration	Reduced kernel breakage due to shell softening and controlled fracture	Breakage reduction (%), whole kernel recovery	[14,17]
Size-graded decortication	Size-specific cracking settings	Nut size uniformity, machine adjustment	Significant improvement in kernel recovery and uniform cracking	Kernel recovery (%), cracking uniformity	[20]

Physical properties and engineering properties

The average dimensions of the small Chironji nut were 8.15 mm in length, 7.08 mm in width, and 5.63 mm in thickness, while the corresponding dimensions for the small kernels were 5.77 mm, 4.37 mm, and 3.57 mm, respectively. Similarly, the medium-sized Chironji nut exhibited dimensions of 9.67 mm in length, 8.57 mm in width, and 6.36 mm in thickness, with the medium-sized kernels measuring 6.25 mm, 4.68 mm, and 3.58 mm, respectively. For the large-sized nuts, the dimensions were 11.07 mm in length, 9.74 mm in width, and 7.01 mm in thickness, and the large-sized kernels measured 6.75 mm, 4.93 mm, and 3.81 mm, respectively [1]. The mean length, width, and thickness of the Chironji nuts were determined to be 10.19 mm, 9.12 mm, and 7.32 mm, respectively [2]. Furthermore, the shape indices suggest that the chironji nut can be modeled as an equivalent sphere, akin to the gram, for analytical predictions of its drying behavior, with a value of 0.33 g. This value is notably smaller than the 0.713 g reported for gram and the 20.2 g reported for oilbean seed. The true density, bulk density, and porosity of the nut were measured at 884.3 kg/m^3, 578.3 kg/m^3, and 33.82 percent, respectively.

Table 4: Physical properties of Chironji kernel

Property	Range	Unit	References
Length	5.40-8.25, 4.92-7.40	mm	[17, 18]
Width	4.78-5.40, 3.78-5.74	mm	
Thickness	4.10-4.66, 2.80-4.28	mm	
True density	612.30-802.50, 1030-1073	kg m^{-3}	
Bulk density	513.50-518.80, 542-556.33	kg m^{-3}	
Porosity	16.13-35.33, 43.94-44.95	%	
Volume	0.09-0.11	ml	

Nutritional composition of chironji kernels

The proximate composition of Buchanania lanzan (chironji) kernels exhibits considerable variability across different studies, which can be attributed to factors such as geographical origin, genotype or candidate-tree, maturity, and the analytical methods employed. On a dry-weight basis, the primary proximate constituents documented in the literature are: Fresh kernels typically contain low moisture; reported values for dried kernels/processed kernels range from ~3-8%. Low moisture is typical of well-dried kernels and is important for storage stability [15]. The protein content of chironji kernels varies from moderate to high, contingent upon the sample and method of analysis. Reported values range from approximately (19.0% - 21.6%) on a dry-weight basis. Certain cultivar-specific studies have reported higher protein values, reaching up to approximately 40% in specific samples. Total carbohydrates, calculated by difference, typically range from approximately 12% to 20%, while crude fiber values reported in the literature exhibit considerable variability, commonly ranging from approximately 2% to 18%. These differences can be attributed to sample selection and whether the values pertain to the whole kernel, defatted meal, or fruit. The ash content, representing mineral matter, is generally low, typically around 2% to 3%, which is consistent with other edible tree nuts and reflects the concentration of minerals in the non-lipid fraction. Due to the high lipid fraction, the energy values for chironji kernels are substantial, with many reports indicating a caloric value in the range of approximately 500 to 600 kcal per 100 grams on a dry-weight basis, depending on the precise fat and protein levels.

Table 5: Proximate composition and mineral content of Chironji kernel based on previous work

Parameter	Value	Unit	References
Proximate composition			
Moisture	3.0	%	[6, 13]
Ash	3.13	%	
Fat	59.10, 57.06	%	
Protein	19.00, 25.22	%	
Carbohydrate	12.10, 10.17	%	
Total sugar	109.07	%	
Crude fiber	3.8	%	
Calorific value	650, 598	kcal/100 g	
Mineral & vitamin composition			
Iron	8.5	mg/100 g	[6]
Phosphorus	528	mg/100 g	
Magnesium	275	mg/100 g	
Zinc	3.32	mg/100 g	
Thiamine (B_1)	0.69	mg/100 g	
Riboflavin (B_2)	0.53	mg/100 g	
Niacin (B_3)	1.5	mg/100 g	
Vitamin C	5.0	mg/100 g	

Fatty acid composition of chironji kernel

Chironji kernels have high oil content. Unsaturated fatty acids lile, oleic acid, linoleic acid, and linolenic acid, are the major components of chironji kernels, as they account for 60% of total fatty acids. The prominent fatty acid in kernel oil is oleic acid comprises of (54.38%), followed by palmitic acid (32.62%), stearic acid (5.63%),) linoleic acid (5.04%), palmitoleic acid, α-linolenic acid (Bhanu *et al.*, 2024). Similar results were achieved by [13] were kernels comprised by (53.71%) oleic acid, (4.50%) linoleic acid, (31.42%) palmitic acid and (7.47%) stearic acid.

Phytochemical properties

Chironji kernel is rich in diverse phytochemicals that contribute to its nutritional and medicinal value. These bioactive compounds include flavonoids, phenolics, alkaloids, and essential oils, which exhibit antioxidant, anti-inflammatory, and antimicrobial properties. The presence of these phytochemicals makes chironji kernel a valuable natural resource for health-promoting applications and therapeutic uses. Understanding its phytochemical profile can aid in exploring its potential benefits in food and pharmaceutical industries. Physicochemical properties of chironji kernel where the total phenolic content was measured using various extracts, including petroleum ether extract, dichloromethane extract, methanolic extract, and ethanol-water extract, yielding values of 5.78, 6.73, 10.05, and 13.42 mg GAE/g respectively. The total flavonoid content for these extracts was determined to be 13.74, 7.08, 5.21, and 11.41 mg CE/g respectively [6]. The total phenolic content (TPC) in raw chironji kernels was measured at 1150 mg GAE/100 g. This value increased by 9.39% following hot oven roasting (HOR), whereas it decreased by 9.82% after microwave roasting (MR). Pan roasting (PR) did not result in a significant change in TPC. The observed increase in TPC is likely attributable to thermal effects that release extractable phenolics and bound phenolic acids, potentially augmented by Maillard reaction products (MRPs). In contrast, the total flavonoid content (TFC) exhibited a significant reduction across all roasting methods: 41.94% and 43.40% decreases for PR and HOR, respectively, and a smaller 16.74% decrease for MR [1]. The total phenolic content (TPC) of both raw and roasted kernels (microwave roasted) was determined by [9], the TPC increased substantially with higher MW power levels and extended roasting times. The minimum TPC, measured at 10.66±0.42 mg GAE/g, was observed in the raw kernels, whereas the maximum TPC, recorded at 39.53±0.27 mg GAE/g, was found in kernels roasted at 700 W for 15 minutes, representing the highest level of MW roasting parameters.

Table 6: The bioactive compounds and oil properties values of pervious works on Chiornji kernels

Parameter	Value	Unit	References
Bioactive properties			
Total phenolic content	5.78, 7.21-15.38, 11.50	mg GAE/g	[1, 6, 13]
Total flavonoid content	13.74, 2.66-15.59	mg CE/g	
ABTS radical scavenging activity	48.20	µg Trolox/g	[1]
DPPH radical scavenging activity	0.908-3.89	µg Trolox/g	[6]
FRAP	9.65	µg Trolox/g	[1]
Oil properties			
Iodine value	59.10	g I_2/100 g oil	[6]
Saponification value	205.79	mg KOH/g oil	
Refractive index	—	—	
Acid value	18.53	mg KOH/g oil	
Free fatty acid	9.31	mg KOH/g	
Unsaponifiable matter	1.4	g/100 g	

Conclusion

Chironji seeds represent a nutritionally rich yet underutilized forest resource with significant potential for applications in food, nutraceuticals, and industry. The kernels are notable for their high lipid content, predominantly composed of unsaturated fatty acids, alongside moderate to high-quality protein, essential minerals, and bioactive phytochemicals, such as flavonoids, sterols, and triterpenoids. This compositional profile underscores their value as energy-dense functional ingredients, comparable to conventional tree nuts. In addition to their nutritional attributes, chironji seeds exhibit considerable pharmacological potential due to their antioxidant, anti-inflammatory, and antimicrobial properties. Traditional uses in indigenous medicine are increasingly corroborated by emerging scientific evidence, underscoring the therapeutic relevance of their bioactive constituents. Moreover, advancements in post-harvest processing, oil extraction, and value-added product development have broadened the scope of their commercial utilization. However, despite their promising characteristics, systematic research on their genetic variability, standardized processing protocols, storage stability, and large-scale cultivation remains limited. Variations in proximate composition and phytochemical content due to geographical origin, maturity stage, and processing conditions warrant further investigation. Future research should focus on optimizing processing technologies, enhancing shelf life through advanced packaging strategies, and exploring functional food applications. Additionally, comprehensive clinical and toxicological evaluations are necessary to substantiate health claims and facilitate wider acceptance in the global market. In summary, chironji seeds hold substantial potential as a sustainable, nutrient-dense, and functionally valuable food resource. Strategic research, value chain development, and policy support could transform this traditionally valued forest product into a commercially significant agro-based commodity.

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