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Nutraceutical Potential of *Bhallataka* (*Semecarpus anacardium* Linn.): A Comprehensive Review on Nutritional Composition, Bioactive Constituents, and Health-Promoting Properties

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Abstract

Bhallataka (*Semecarpus anacardium* Linn.), the marking-nut tree of family Anacardiaceae, occupies a paradoxical place in Ayurveda: classified as an *Upavisha* (sub-toxic substance) requiring rigorous purification, yet valued as a principal *Rasayana* dravya. Beyond its established pharmacology, the edible thalamus, kernel and processed nut carry a nutrient and bioactive-compound profile that positions the drug as an emerging nutraceutical and functional-food candidate. This review consolidates literature (1996–2024) on the nutritional composition (carbohydrates, proteins, lipids, minerals, vitamins), phytochemical constituents (biflavonoids, phenolic acids, bhilawanols, anacardic acid, phytosterols, tocols) and the documented antioxidant, anti-inflammatory, antidiabetic, antimicrobial, immunomodulatory, anticancer, hepatoprotective and cardioprotective activities of *S. anacardium*. It examines how classical *Shodhana* (purification) functions as an early quality-control step enabling nutraceutical use, and outlines the toxicological considerations that must guide product development. The convergence of a nutrient-dense seed matrix with diverse bioactive phytoconstituents supports *Bhallataka* as a promising, underexplored nutraceutical resource, contingent on standardized purification, dosage and long-term safety data.

Key words : *Bhallataka- Semecarpus anacardium*; nutraceutical; functional food; phytochemistry, *Rasayana*, marking nut.

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The term "nutraceutical", coined by Stephen DeFelice in 1989 for a food or food component providing health benefits beyond basic nutrition, finds a pre-modern parallel in the Ayurvedic concept of *Rasayana* — substances consumed, often in food-like form, to promote longevity, immunity and tissue vitality. *Semecarpus anacardium* Linn., known as *Bhallataka* and as the marking-nut or oriental cashew, is a deciduous Anacardiaceae tree distributed across the sub-Himalayan belt, central and peninsular India, Sri Lanka and Southeast Asia. Its ovoid, black fruit sits on a fleshy, orange-yellow thalamus, while the kernel and its oil have long been used in Ayurvedic, Siddha and folk medicine. Chemical analyses consistently report biflavonoids, phenolic compounds (bhilawanols), anacardic acid, minerals, vitamins and amino acids in the nut.[1,2] Because several of these constituents are cytotoxic and vesicant when unprocessed, classical pharmacology mandates *Shodhana* — milk-, buttermilk- or *Kshara-Kashaya*-based purification — before internal use. This dual identity, as both nutrient-rich food and a substance requiring careful processing, is precisely what nutraceutical science is equipped to characterize.

A substantial body of pharmacological literature has validated antioxidant, anti-inflammatory, antidiabetic, antimicrobial, immunomodulatory, anticancer, hepatoprotective and cardioprotective activities of *Bhallataka* extracts,[2,3] but the nutritional composition of its edible parts and its suitability as a functional-food raw material has received comparatively little systematic attention. This review therefore brings together, under a nutraceutical lens, the nutrient composition, bioactive phytochemistry and pharmacology of *S. anacardium*, along with its purification process and toxicity profile.

This narrative review draws on peer-reviewed literature indexed in PubMed, Scopus, Google Scholar, ScienceDirect and SpringerLink, retrieved using the terms '*Semecarpus anacardium*', '*Bhallataka*', 'marking nut', 'nutraceutical', 'functional food', 'phytochemistry' and '*Rasayana*', with emphasis on studies published 1996–2024. Original research, reviews and book chapters reporting nutrient composition, phytochemical profiling or pharmacological activity were included; classical descriptions of *Bhallataka* as *Rasayana* and *Upavisha* dravya were drawn from standard editions of the *Charaka Samhita*, *Sushruta Samhita* and *Ashtanga Hridaya*. Non-peer-reviewed sources and studies unrelated to the nutraceutical dimension were excluded. Data were synthesized qualitatively under botanical profile, nutritional composition, phytochemistry, pharmacological properties, purification and safety.

Botanical Profile and the Edible/Nutraceutical Parts of the Plant :

Semecarpus anacardium is a medium-to-large deciduous tree (12–15 m) with large simple leaves and greenish-yellow flowers maturing into smooth, kidney-shaped fruits borne on a swollen, orange-yellow thalamus. Field surveys across Maharashtra's Marathwada region document considerable natural variability in fruit, hypocarp, pericarp and kernel weight, confirming a genuine reservoir of compositional diversity within the species.[4] Between the outer and inner pericarp lies a caustic, phenolic-catechol-rich oily exudate, the

principal source of both the plant's vesicant potential and its pharmacologically active phenolic load — which is why the kernel, once appropriately processed rather than the raw pericarp, is most relevant to nutraceutical development.[1]

Nutritional Composition :

Phytochemical analyses of the nut consistently identify minerals, vitamins and amino acids alongside its biflavonoid and phenolic constituents, indicating a genuine nutrient load beyond the pharmacologically active fraction.[5,6] Lipid analysis shows solvent-extractable lipids account for roughly 36% of seed weight; linoleic, palmitic and oleic acids dominate the fatty-acid profile, neutral lipids are the principal lipid class, and β-sitosterol, campesterol and stigmasterol are the major phytosterols, with δ- and β-tocopherol contributing to the tocol fraction.[5] This profile — dominated by unsaturated fatty acids and plant sterols — parallels lipid profiles of other Anacardiaceae seed oils used in functional foods, such as cashew kernel oil. Root, stem and leaf tissue additionally show sulphur, calcium, magnesium, phosphorus and iron, with alkaloid, flavonoid and phenolic content varying by plant part.[6] Together, these findings indicate a nutrient matrix of the type sought in nutraceutical raw materials, independent of the phenolic fraction discussed below.

Bioactive Phytochemical Constituents :

The nutraceutical value of *Bhallataka* rests on a well-characterized set of secondary metabolites. Phytochemical screening consistently identifies biflavonoids (jeediflavanone, semecarpetin), phenolic compounds, bhilawanols (urushiol-type catechols), anacardic acid and its derivatives, minerals, vitamins and amino acids as principal bioactive constituents[1,3] alongside flavones, tannins, saponins, coumarins, alkaloids, glycosides and carotenoids reported at the fruit level.[2] A specific catechol, 3-(82 (Z),112 (Z)-pentadecadienyl) catechol, isolated from the kernel shows potent cytotoxic activity against tumour cell lines, including multidrug-resistant lines, with lower IC_{50} values than doxorubicin in some comparisons.[7] This same catechol-rich phenolic fraction, concentrated in the mesocarp, underlies both the drug's principal bioactivities and its allergenic, vesicant character — underscoring why nutraceutical translation cannot proceed without purification.

Nutraceutical and Functional Pharmacological Properties :

Antioxidant Activity :

Multiple studies demonstrate free-radical scavenging in *Bhallataka* extracts. An ethanolic bark extract showed DPPH IC50 of 72.24 µg/mL versus 17.81 µg/mL for ascorbic acid, with appreciable phenolic and flavonoid content.[8] Aqueous nut extract restored catalase, superoxide dismutase and glutathione transferase activity and reduced lactate dehydrogenase during experimentally induced lymphoma, showing that in vitro antioxidant effects translate to endogenous defence modulation in vivo.[9] Seed oil shows strong antiradical action against DPPH and galvinoxyl radicals, attributed to its tocol and phenolic content, comparable to extra-virgin olive oil.[5] These convergent findings across bark, nut and oil fractions support a nutraceutical antioxidant application.

Anti-inflammatory and Immunomodulatory Activity :

Nut milk extract shows anti-inflammatory and anti-hyperlipidaemic effects in a high-fat-diet, streptozotocin-induced diabetic rat model, alongside favourable lipid modulation.[10] A biflavonoid-rich fraction similarly attenuates hyperglycaemia by modulating carbohydrate-metabolizing enzymes,[11] and immunomodulatory activity has been documented in an aflatoxin-B1-induced hepatocellular carcinoma model.[12] These findings support the biflavonoid/phenolic fraction as the likely active principle behind the drug's traditional anti-inflammatory *Karma*.

Antidiabetic and Metabolic Activity :

In alloxan-induced diabetic rats, ethanolic bark extract produced dose-dependent reductions in total cholesterol, triglycerides and LDL cholesterol, protected liver function (SGOT/SGPT), and increased hepatic glycogen, with effects comparable to metformin.[8] The biflavonoid-mediated modulation of carbohydrate-metabolizing enzymes noted above provides a plausible mechanistic basis.[11] Together with the anti-hyperlipidaemic findings above, these data position *Bhallataka* among *Rasayana* dravyas with mechanistically grounded relevance to metabolic-syndrome nutraceutical formulation, though human dosing remains unestablished.[10]

Antimicrobial Activity :

Extracts from different parts of *S. anacardium*, including the nut, show measurable antimicrobial activity against pathogenic organisms, indicating that the phenolic-rich fraction responsible for anti-oxidant behaviour also contributes antimicrobial function.[13] This supports the traditional *Krimighna-Kushthaghna* use and is relevant to the shelf-stability and preservative potential of nutraceutical formulations.

Anticancer and Chemo-preventive Activity :

The anticancer literature on *Bhallataka* is the most extensive. Nut milk extract increases antioxidant enzyme activity and normalizes tumour-marker levels in aflatoxin-B1-induced hepatocellular carcinoma models.[14] A mini-review synthesizing cellular, animal and limited clinical evidence confirms that *Bhallataka* fruit extracts inhibit markers of cancer progression and inflammation, with anacardic acid derivatives documented against prostate and liver malignancies.[3] The isolated kernel catechol demonstrates cytotoxicity, apoptosis induction and cell-cycle arrest in tumour cell lines, with synergistic activity alongside doxorubicin and comparable efficacy against multidrug-resistant lines.[7] In a Wistar rat hepatocellular carcinoma model, an Ayurvedic milk-extract preparation produced measurable anticancer efficacy with favourable tumour-marker responses.[15] Though predominantly preclinical, this consistency across extract types and molecular endpoints represents a strong rationale for standardized *Bhallataka*-derived chemopreventive products.

Hepatoprotective and Cardioprotective Activity :

The hepatoprotective signal in the aflatoxin-B1 model is corroborated by the improved liver-enzyme and glycogen profile

in the antidiabetic bark-extract study.[8,14] The favourable modulation of cholesterol, triglycerides and LDL, together with the unsaturated-fatty-acid- and phytosterol-rich seed-oil composition, is consistent with a lipid-lowering, cardiometabolic-support role sought in functional-food lipid formulations,[5,10,11] aligning with the classical description of purified *Bhallataka* as a *Rasayana* for geriatric and metabolic decline.

Correlation with the Classical Rasayana Concept :

Classical *Nighantus* describe *Bhallataka*'s *Rasapanchaka* as *Katu-Tikta-Kashaya Rasa*, *Laghu-Teekshna-Snigdha Guna*, *Ushna Virya* and *Madhura Vipaka*, underlying its *Deepana*, *Bhedana*, *Krimighna* and *Kushthaghna* actions, with *Madhura Vipaka* linked to its *Rasayana* and *Balya* properties. Charaka describes a graded *Vardhamana* dosage protocol for *Bhallataka Rasayana* with warm milk or ghee under a defined *Pathya-Apathya* regimen,[16] and *Ashtanga Hridaya* enumerates it for *Vata-Kapha* disorders and geriatric decline.[17] Read against the pharmacological evidence above, the correspondence is direct: antioxidant/cytoprotective activity parallels the *Rasayana* designation; anti-inflammatory/immuno-modulatory activity parallels *Shothahara* and *Vata-Kapha*-balancing *Karma*; and antimicro-bial activity aligns with *Krimighna-Kushthaghna* actions — strengthening the case that *Bhallataka*'s traditional classification reflects a genuine, chemically grounded functional-food identity.

Shodhana (Purification) as a Nutraceutical Quality-Control Step :

Raw *Bhallataka* is an *Upavisha* capable of producing severe *Daha*, *Vrana* and systemic toxicity, making its use contingent on *Shodhana*. Classical methods immerse mature fruits in cow's milk, buttermilk, rice-water or *Kshara-Kashaya* solutions followed by sun-drying, neutralizing the irritant bhilawanol-rich exudate while preserving therapeutic constituents. Chromatographic and spectroscopic comparison of unpurified (*Ashodhit*) and purified (*Shodhit*) *Bhallataka* confirms that purification measurably alters the chemical profile, reducing oil content and shifting phenolic/flavonoid content.[18] *Shodhana* can thus be understood as a traditional analogue of the detoxification and standardization steps a modern manufacturer would need before formulating *Bhallataka* into a nutraceutical product — reducing the toxic catechol/urushiol load to a defined, analytically verified level.

Toxicity and Safety Considerations :

The same catechol-rich constituents responsible for antioxidant, anti-inflammatory and anticancer activity also cause allergic contact dermatitis, vesication and, on overdose or in unpurified form, gastrointestinal irritation, oliguria and renal injury. Toxicological evaluation of a Siddha milk-extract preparation (*Serankottai nei*) has examined biochemical safety parameters, underscoring the need for formal characterization of any *Bhallataka*-derived nutraceutical.[19] Classical texts prescribe specific *Agada* (antidotes) — coconut kernel, sesame seeds, fresh tamarind juice — reflecting long clinical familiarity with its toxicity.[20] Several extract-based studies nonetheless report favourable safety margins for properly processed preparations, with non-toxicity noted even at high experimental doses.[21] *Bhallataka*'s

nutraceutical potential is thus real but conditional: safe only within a defined purification and dosage envelope, requiring standardized *Shodhana* protocols and formal toxicity studies before human dosing.

Current Formulations and Prospects for Nutraceutical Development :

Bhallataka already features in classical formulations that anticipate modern nutraceutical strategies: *Bhallataka Avaleha* and *Amrita-bhallataka Rasayana* combine purified nut with milk, honey and ghee to moderate its *Ushna Virya*; *Bhallatakasava* is a fermented, self-preserving liquid preparation; and *Bhallataka Taila/Ghrita* are oil- and fat-based delivery vehicles suited to its lipophilic actives. These strategies — matrix moderation, fermentation-based preservation and lipid-based delivery — map onto techniques used in modern nutraceutical formulation to improve bioavailability, palatability and shelf-stability. Given the confirmed nutrient density of the thalamus and kernel, the characterized pharmacological activity of standardized extracts, and a traditional purification process amenable to analytical validation, *Bhallataka* is a reasonable candidate for functional oils, encapsulated purified-extract supplements or fortified formulations targeting oxidative stress, metabolic syndrome or immune support — pending dose-standardized clinical trials and regulatory characterization of residual catechol/urushiol content.

Bhallataka (*Semecarpus anacardium Linn.*) combines a nutrient-dense seed and fruit matrix — unsaturated fatty acids, phytosterols, tocols, minerals and vitamins — with a pharmacologically active phenolic and biflavonoid fraction responsible for documented antioxidant, anti-inflammatory, antidiabetic, antimicrobial, immunomodulatory, anticancer, hepatoprotective and cardioprotective activity. This dual profile mirrors, in biochemical terms, the drug's classical identity as both an *Upavisha* requiring mandatory *Shodhana* and a *Rasayana* valued for rejuvenation. The convergence between classical *Rasapanchaka* description and pharmacological findings strengthens the case for *Bhallataka* as an underexplored nutraceutical resource, while making clear that safe use is entirely conditional on standardized purification, verified residual-toxin limits and dose titration. Future research should prioritize standardized *Shodhana* protocols, dose-toxicity mapping and well-designed clinical trials to translate this preclinical promise into safe, evidence-based products.

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