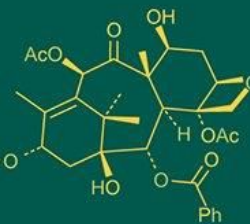


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A comprehensive review of nutritional, phytochemical and pharmacological properties of *Semecarpus anacardium* L.: A significant wild edible fruit species of central India

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Abstract

Semecarpus anacardium L., commonly known as the marking nut tree, is a significant wild edible fruit indigenous to Central India, renowned for its extensive use in traditional medicine. This review provides a comprehensive analysis of the nutritional composition, phytochemical constituents, and pharmacological properties of *Semecarpus anacardium*, emphasizing its potential health benefits and applications in modern pharmacology and nutrition. The nutritional profile of *Semecarpus anacardium* edible thalamus and kernel reveals it to be a rich source of carbohydrates, proteins, healthy fats, and essential vitamins and minerals, particularly Vitamin C, B-complex vitamins, calcium, magnesium, and potassium. These nutrients contribute to the fruit's potential as a supplementary food source in nutrient-deficient populations. Phytochemical analysis highlights the presence of various bioactive compounds, including flavonoids, tannins, alkaloids, phenolic compounds, and saponins. These compounds are known for their antioxidant, anti-inflammatory, antimicrobial, anticancer, and cardioprotective properties. The high phenolic and flavonoid content in particular underpins the fruit's strong antioxidant capabilities, which are crucial in mitigating oxidative stress and inflammation. Traditionally, *Semecarpus anacardium* has been used to treat skin diseases, digestive disorders, and joint pain. Modern research corroborates these uses, suggesting promising therapeutic potentials. In conclusion, *Semecarpus anacardium* L. is a nutritionally and pharmacologically valuable wild edible fruit with significant potential for enhancing health and wellness. This comprehensive analysis underscores the importance of further research and development to fully exploit its benefits in both traditional and modern medical practices.

Keywords: Traditional medicine, nutritional composition, phytochemicals, pharmacological activities, wild edible fruit, therapeutic potential

Introduction

Semecarpus anacardium L., commonly known as the marking nut tree, is a prominent member of the Anacardiaceae family. The genus name, *Semecarpus*, derives from the Greek "Simeion," meaning "stamping" or "following," and "carpus," meaning "nut." The species epithet, *Anacardium*, refers to the heart-shaped marking nut. Known as "Ballataka" or "Bhilwa" in local languages, the marking nut has long been recognized for its significant medicinal value (Mandal & Rahaman, 2022; Khare, 1982) [57, 44]. The term "Bhallatak" translates to "sharp like a lance," reflecting its potent properties. Historically, the marking nut has been used in various applications, including woodwork, paint, waterproofing, food, and medicine, earning titles such as Ardhavaidya in Ayurveda and the "Golden oak seed" during Galen's era in the Western world. It holds a special place in Central India's flora for its edible fruit and diverse pharmacological properties. Local people eat roasted fruit rinds (Gouthaman *et al.* 2008) [32]. The ripe fruits and petals are eaten raw (Dangol *et al.* 2017) [23].

Nutritionally, *Semecarpus anacardium* is rich in carbohydrates, proteins, fats, vitamins (particularly Vitamin C and B-complex vitamins), and minerals (such as calcium, magnesium, and potassium). These nutrients not only enhance its dietary value but also support its use as a functional food in traditional diets, attributed to its rich phytochemical

composition. The tree is predominantly found in the sub-Himalayan region and the tropical and central parts of India. Proximate and nutrient analysis of medicinal plants is crucial for evaluating their nutritional significance for both edible and medicinal purposes (Pandey *et al.*, 2006) [80]. Extensive research highlights the prominent role of *Semecarpus anacardium* in Ayurvedic and Siddha medicine. Understanding the chemical constituents of plants is essential for recognizing the actual value of traditional remedies. The therapeutic properties of medicinal plants are primarily attributed to various secondary metabolites (Karthikayan *et al.*, 2009) [42]. The fruit of *Semecarpus anacardium* is rich in bioactive compounds such as flavonoids, tannins, alkaloids, phenolic compounds, and saponins, which confer various pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, and anticancer effects. These diverse bioactivities underscore its potential as a valuable resource for developing therapeutic agents and nutraceuticals.

Despite its traditional uses and promising pharmacological profile, comprehensive studies focusing on the nutritional composition, phytochemical constituents, and pharmacological properties of *Semecarpus anacardium* from Central India remain scattered. This review aims to consolidate current knowledge, providing a thorough examination of its nutritional, phytochemical, and pharmacological attributes. By synthesizing available data, this review seeks to highlight the potential of *Semecarpus anacardium* as a source of novel bioactive compounds and therapeutic agents beyond its edible uses, while also identifying avenues for future research and development in both traditional and modern medicine contexts.

Methodology

This comprehensive review focuses on the nutritional, phytochemical, and pharmacological properties of *Semecarpus anacardium* L., a significant wild edible fruit species of Central India. The methodology involved a systematic approach to gather, analyse, and synthesize information from a wide range of scientific literature and credible sources.

Literature Search: A thorough literature search was conducted using electronic databases such as PubMed, Google Scholar, Scopus, and Web of Science. Keywords used for the search included "*Semecarpus anacardium*," "marking nut tree," "nutritional composition," "phytochemicals," "pharmacological properties," "traditional medicine," "wild edible fruit," and "therapeutic potential."

Inclusion and Exclusion Criteria: Studies included in this review were peer-reviewed articles, books, and reputable sources that provided detailed information on the nutritional, phytochemical, and pharmacological properties of *Semecarpus anacardium*. Articles that focused on other species or did not provide specific data relevant to the scope of this review were excluded.

Data Extraction: Relevant data were extracted from the selected articles, including the geographical distribution of *Semecarpus anacardium*, its traditional uses, nutritional composition, phytochemical constituents, and pharmacological properties. Special attention was given to studies that highlighted the medicinal and therapeutic

potentials of the species.

Analysis and Synthesis

The collected data were analysed to identify common themes, trends, and significant findings. This involved comparing the nutritional profiles, phytochemical compositions, and pharmacological activities reported in various studies. The synthesis aimed to provide a comprehensive understanding of the species' properties and its potential applications in traditional and modern medicine.

Presentation of Findings

The findings were organized into coherent sections covering the nutritional composition, phytochemical constituents, and pharmacological properties of *Semecarpus anacardium*. Each section includes detailed descriptions supported by data from the reviewed literature.

Identification of Research Gaps

The review also aimed to identify gaps in the current knowledge and suggest areas for future research. This involved highlighting understudied aspects of *Semecarpus anacardium* and proposing directions for further investigation.

By employing this systematic methodology, the review aims to consolidate existing knowledge on *Semecarpus anacardium* L. and provide a comprehensive resource for researchers and practitioners interested in its nutritional, phytochemical, and pharmacological properties.

Results and Discussion

Nutritional Composition: *Semecarpus anacardium* L., commonly known as the marking nut tree, exhibits a robust nutritional profile, making it a valuable addition to both traditional diets and modern nutritional paradigms. The kernels of *Semecarpus anacardium* are edible, and the fleshy, orange cup of the fruit can be consumed when ripe, although it is significantly astringent. The roasted fruit rinds are commonly eaten by local people. Additionally, it can be stored in a dried form for 4-8 months. The fruit is notably rich in carbohydrates, providing energy and dietary fiber that supports digestive health. Essential proteins found in *Semecarpus anacardium* include amino acids crucial for bodily functions, enhancing its nutritional value as a supplementary protein source. Furthermore, the presence of healthy fats, including essential fatty acids, contributes to its dietary benefits. Vitamins and minerals play pivotal roles in the nutritional composition of *Semecarpus anacardium*. It is particularly abundant in Vitamin C, known for its antioxidant properties and role in immune function. B-complex vitamins found in the fruit support metabolism and nervous system health. Additionally, minerals such as calcium, magnesium, and potassium contribute to bone health, muscle function, and overall electrolyte balance.

Nutritive Value of the Marking Nut Kernel

The nutritive value of the kernels of *Semecarpus anacardium*, which are consumed by some populations, has been extensively studied. These kernels are particularly consumed during pregnancy and lactation due to their beneficial amino acid profile. However, the vesicant nature of bhilwa juice and the manufacturing challenges associated with the kernels limit their widespread use. If the vesicant

property could be eliminated, the juice would be a valuable resource for the pharmaceutical industry (Ramasastry and

Shenolikar, 1974; Goudgaon *et al.*, 1984; Gil *et al.*, 1995^[28]; Joshi *et al.*, 2010)^[95, 41] (Table-1)

Table 1: Nutritive Value of the Marking Nut Kernel

Proximate Principles (g/100g)	Minerals and Vitamins (mg/100g)	Essential Amino acids (mg/g protein)
Moisture: 3.8	Iron: 6.1	Arginine: 9.6
Protein: 26.4	Phosphorus: 836-886	Histidine: 1.8
Fat: 36.4	Calcium: 295	Lysine: 4.1
Fiber: 1.4	Thiamine: 0.38	Leucine: 7.3
Minerals: 3.6	Riboflavin: 0.15-0.17	Isoleucine: 4.4
Carbohydrate: 28.4	Nicotinic acid: 1.06-2.74	Methionine: 1.5
Calories (kcal): 5.87		Threonine: 2.1
		Phenylalanine: 2.5
		Valine: 4.7
		Tryptophan: 1.1

Kernel oil composition: The oleic acid content in the kernels indicates their potential as a good source of salad oil. They can serve as a substitute for other oil seeds because of their high protein and fat content. The marking nut kernel contains 20-25% reddish-brown semidrying oil with a pleasant taste (Wealth of India, 1999). The seed oil is

typically mixed with food items and, for topical purposes, applied in minimal quantities or mixed with other non-toxic oils (Shastri *et al.*, 2002; Dwivedi *et al.*, 2018)^[116, 24]. Major fatty acids include linoleic, palmitic, and oleic acids, along with phytosterols (β -sitosterol, campesterol, stigmasterol) and tocopherol (δ -tocopherol, β -tocopherol). (Table-2)

Table 2: Fatty Acid Composition of Marking Nut Kernel

Fatty Acid Composition	Quantity	Reference
Palmitic Acid	16%	Jain and Sharma, 2013 ^[39]
Stearic Acid	3.8%	Jain and Sharma, 2013 ^[39]
Oleic Acid	60.6%	Jain and Sharma, 2013 ^[39]
Linoleic Acid	17.1%	Jain and Sharma, 2013 ^[39]
Anacardic acid	1.4%	Jain and Sharma, 2013 ^[39]

The oleic acid content present in the kernel indicated that it could be used as a good source of salad oil. They can replace the usage of other oil seed because of its high protein and fat content.

Nutritive Value of the Marking Edible Hypothalamus Fruit Part: the fleshy, orange cup of the fruit can be consumed when ripe, although it is significantly astringent. The roasted fruit rinds are commonly eaten by local people. Additionally, it can be stored in a dried form for 4-8 months.

Table 3: Nutritional Evaluation of Edible Fruit Part (Thalamus) of Marking Nut

Moisture Content (%)	Crude Protein (mg g ⁻¹)	Total Sugar (mg g ⁻¹)	Total Lipid (mg g ⁻¹)	Vitamin B1 (mg g ⁻¹)	Vitamin C (mg g ⁻¹)	Reference
83.6±16.3	32.20±1.11	147.30±1.25	0.016±0.003	0.0024±0.0003	0.35±0.02	Misra, S., & Misra, M. K. (2016) ^[62]

Semecarpus anacardium L. demonstrates a high nutritional value, supporting its role in traditional diets and its potential in modern nutritional applications. Its rich composition of macronutrients, vitamins, minerals, and bioactive compounds underscores its importance as both a dietary staple and a medicinal resource.

Phytochemical Constituents

Phytochemical analysis reveals *Semecarpus anacardium* to be rich in diverse bioactive compounds, each contributing distinct pharmacological properties. Flavonoids, such as quercetin and kaempferol derivatives, exhibit potent antioxidant effects by scavenging free radicals and reducing oxidative stress. Tannins, known for their astringent properties, contribute to wound healing and anti-inflammatory activities. Alkaloids present in the fruit have

been studied for their analgesic and anti-inflammatory properties, offering potential therapeutic benefits. The most significant components of *S. anacardium* oil are phenolic compounds, which oxidize to quinones upon exposure to air. This oxidation process can be prevented by storing the oil under nitrogen. The two main phenolic compounds and a glucoside in the oil are bhilavanol A (monoenepentadecyl catechol I), bhilavanol B (dienepentadecyl catechol II), and anacardoside (glucoside) (Goudgaon *et al.*, 1984; Gil *et al.*, 1995)^[31, 28]. The phytochemical investigation carried out by Bahir *et al.* (2013)^[10] shows the presence of alkaloids, carbohydrates, flavonoid glycosides and tannins and phenols which could be responsible for therapeutic properties of the plant or the plant parts. Details of different phytochemicals identified are mentioned in the below table.

Table 4: Phytochemical Components Identified in *Semecarpus anacardium*

Component	Plant part	Reference
1,2-dihydroxy-3-pentadec-8-enylbenzene (A) and 1,2-dihydroxy-3-pentadeca-8,11-dienylbenzene (B)	Nuts	Adhami <i>et al.</i> , 2012 ^[2]
Alkaloids, Flavonoids, Phenols, Bioflavonoids	Roots, stems, and leaves	Bondre and Nathar, 2002 ^[13] ; Rao <i>et al.</i> , 1973 ^[100]
Iron, copper, sodium, calcium, and aluminum	Nuts	Bose <i>et al.</i> , 1967 ^[14]
Comprised of 1,2-dihydroxy-3-pentadecylbenzene and its corresponding diene analogue.	Nuts	Gedam <i>et al.</i> , 1974 ^[27] ; Cordell and Shin, 1999 ^[22]
Phenolic Glucoside (Anacardoside): as -l-O-β-D-glucopyranosyl-(1→6)-β-D-glucopyranosyloxy-3-hydroxy-5-methylbenzene.	seeds	Gil <i>et al.</i> , 1995 ^[28]
Phenolic compounds, Quinones, Bhilavanol A, Bhilavanol B, Anacardoside, Biflavanoids (semecarpufavanone, jeediflavanone, gallufavanone, nallaflavanone, semecarpetin, and anacardufavanone)	Oil	Goudgaon <i>et al.</i> , 1984 ^[31]
Total ash (3.85%), acid insoluble ash (0.33%), alcohol soluble extractive (11.27%), water soluble extractive (11.84%), moisture content (12.71%), and trace elements like iron, copper, sodium, calcium, and aluminum.	Nuts	Gouthaman <i>et al.</i> , 2008 ^[32]
Mixture of cis- and trans-isomers of ursuhenol, mainly consisting of 1,2-dihydroxy-3 (pentadecadienyl 8', 11') benzene and 1,2-hydroxy-3 (pentadecadienyl 8') benzene.	Nuts	Indap <i>et al.</i> , 1983 ^[36]
Tetrahydroamentoflavone	Nuts	Ahmad <i>et al.</i> , 1981 ^[3]
Sterols, Saponins and amentoflavone, Tetrahydrorobustaflavone, Amentoflavone	Nuts, leaf	Ishatulla <i>et al.</i> , 1977 ^[37-38]
3-O-methyl quercetin and kaempferol	Stem bark	Kumar <i>et al.</i> , 2016 ^[50]
O-dimethyl Biflavanone B, O-heptamethyl Bichalcone B1, O-hexamethyl Bichalcone A, O-hexamethyl Bichalcone B2, O-tetramethyl Biflavanone A1, O-tetramethyl Biflavanone C, O-trimethyl Biflavanone A1, O-trimethyl Biflavanone A2, Tetrahydrobustaflavone	Nuts	Mulani, 2012 ^[64]
Anacardic acid, Semecarpol	Nuts	Mulani, 2012 ^[64] ; Rastogi and Mehrotra, 1991 ^[101]
Semecarpufavanone, Jeediflavanone, Gallufavanone, Anacardioflavanone, Semecarpetin	Nuts	Murthy, 1985 ^[66]
Bhilawanols: Mixture of 3-pentadec(en)yl catechols unsaturated in the lipophilic side chain; chief components are 8Z, 11Z-diene and 8Z-monoene, along with minor amounts of saturated bhilawanol.	Nuts	Nagabhushana <i>et al.</i> , 2002 ^[73]
Corrosive Juice Components: Contains catechol, fixed oil, and anacardol (C ₁₈ H ₁₃ O ₃ .COOH), including two phenolic acids (C ₁₆ H ₁₅ O ₃ .COOH and C ₁₄ H ₁₃ O ₃ .COOH).		Naidu, 1925 ^[74]
3-(8-(Z),11-(Z)-pentadecadienyl) catechol	Nuts	Nair <i>et al.</i> , 2009 ^[76]
Sugars, Flavonoids, Steroids, Saponins, Quinones, and Tannins	Oil	Rajakrishnan <i>et al.</i> , 2016 ^[94]
3-(n-pentadec-8-enyl) catechol, 1,2-dihydroxy-3-pentadecaenyl-8'-benzene, and 1,2-dihydroxy-3-(pentadecadienyl-8',11') benzene, Dimethyl ethers of 1-pentadeca-8-enyl-2,3-dihydroxybenzene and 1-pentadeca-7,10-dienyl-1,3-dihydroxybenzene, Biflavonoids from Ethanol Soluble Fraction: I-4', II-3', 4', I-5, II-5, I-7-hexahydroxy [I-3, II-8] biflavanone; I-4', II-4', I-5, II-5, I-7, II-7-hexahydroxy [I-3, II-8] biflavanone (3', 8-binaringenin); I-4', II-4', I-7, II-7-tetrahexahydroxy [I-3, II-8] biflavanone.	Nuts	Rao <i>et al.</i> , 1973 ^[100]
Glycosides	Nuts	Rao <i>et al.</i> , 1973 ^[100] ; Majumdar <i>et al.</i> , 2008 ^[54]
Biflavonoids: Nallaflavanone, semecarpetin, anacardoflavanone.	Nuts	Rastogi and Mehrotra, 1999 ^[102] ; Murthy, 1988 ^[65]
Tetrahydroamentoflavone	Stem bark	Selvam and Jachak, 2004 ^[107-108]
Amentoflavone, Tetrahydroamentoflavone Anacardufavanone, Biflavonoids, Diolefin II, Gallufavanone, Jeediflavanone, Mono-olefin I, Nallaflavanone, Phenolic Compounds, Semecarpufavanone, Semicarpol, Sterols and Glycosides	Nut	Semalty <i>et al.</i> , 2010 ^[109]
Bhilavanol A (Monoenepentadecyl catechol I), Bhilavanol B (Dienepentadecyl catechol II), Anacardoside	Nut	Semalty <i>et al.</i> , 2010 ^[109] ; Goudgaon <i>et al.</i> , 1984 ^[31] ; Gil <i>et al.</i> , 1995 ^[28]
1,2-Dihydroxy-3-pentadecaenyl-8'-benzene	Seeds	Shin <i>et al.</i> , 1999 ^[117]
Acetylcholinesterase Inhibitor Activity	Stem bark	Vinutha <i>et al.</i> , 2007 ^[145]

The phytochemical richness of *Semecarpus anacardium* underscores its importance as a source of various bioactive compounds with significant therapeutic potentials. These compounds contribute to its wide range of pharmacological activities and justify its extensive use in traditional medicine and potential in modern pharmaceutical applications.

Pharmacological Activities

Phenolic compounds found in *Semecarpus anacardium* demonstrate broad-spectrum bioactivities, including

antioxidant, anti-inflammatory, and anticancer effects. These compounds are crucial in mitigating chronic diseases associated with oxidative stress and inflammation. Saponins, with their immunomodulatory and cholesterol-lowering effects, further enhance the fruit's pharmacological profile. A variety of nut extract effective against many diseases *viz.* arthritis, tumours, infections etc (Premalatha, 2000) ^[86, 87, 89, 90, 92]. Leprosy, neuritis, rheumatoid arthritis, piles, asthma, cough, and STDs (Kirthikar and Basu, 1975; Nadkarni, 1976) ^[72]. Understanding the mechanism of the

pharmacological action of *S. anacardium* can be greatly aided by the isolation of its active principle and determination of structure and function relationship. A vast number of clinical and pharmacological studies on different types of Siddha preparations and also on the different parts of *S. anacardium* have been carried out. The Siddha preparation of *S. anacardium* nut extract called Serankottai nei is being used in the treatment of various ailments. The preparation of drug Serankottai nei is as follows: *S. anacardium* nuts, cow's milk, and ghee are the main

ingredients present in the drug. The drug was prepared by boiling the nuts (200 g) with 500 ml of milk. After decanting the decoction, 500 ml of milk was added to the boiled nuts and the mixture was again boiled for some time. The decoction was recovered and repeated the process again with the milk. All the three portions of the milk nut decoction were mixed with ghee and boiled till dehydrated, filtered and stored. Olive oil was used as the vehicle for the drug, since it is insoluble in water (Narayanaswami & Uthamaroyan, 1972)^[78].

Pharmacological Activity	References
Acetylcholinesterase Inhibitory Activity	Vinutha <i>et al.</i> 2007 ^[145]
Anti-arthritis	Satyavathi <i>et al.</i> 1968 ^[105] ; Saraf <i>et al.</i> , 1989 ^[104] ; Vijayalakshmi <i>et al.</i> 1997a, 1997b ^[144] ; Nada <i>et al.</i> , 1999 ^[70]
Anti-atherogenic	Sharma <i>et al.</i> , 1995 ^[113] ; Mary <i>et al.</i> , 2003 ^[59] ; Mathivadhani <i>et al.</i> , 2007 ^[60-61] ; Gouthaman <i>et al.</i> , 2008 ^[32]
Antibacterial	Nair and Bhide 1996 ^[75] ; Bonjar <i>et al.</i> , 2004
Anticancer (Breast Cancer/ Hepatocellular Carcinoma/ Leukemia)	Gothoskar and Ranadive, 1971 ^[29] ; Gothoskar <i>et al.</i> , 1971 ^[30] ; Vad, 1973; Vad and Kulkarni, 1975 ^[139] ; Hembree <i>et al.</i> , 1978 ^[34] ; Chitinis <i>et al.</i> , 1980 ^[21] ; Cassady <i>et al.</i> , 1981 ^[15] ; Indap <i>et al.</i> , 1983 ^[36] ; Francis <i>et al.</i> , 1989 ^[26] ; Patwardan <i>et al.</i> , 1988; Premalatha and Sachdanandam, 1997a; Premalatha and Sachdanandam, 1997b; Vijayalakshmi <i>et al.</i> , 1997; Vijayalakshmi <i>et al.</i> , 1997a ^[144] ; Smit <i>et al.</i> , 1995 ^[123] ; Shin <i>et al.</i> , 1999 ^[117] ; Premalatha and Sachdanandam, 1999a; Premalatha and Sachdanandam, 1999b; Premalatha and Sachdanandam, 2000a; Premalatha and Sachdanandam, 2000b; Sujatha and Sachdanandam, 2002 ^[129] ; Selvam & Jachak, 2004 ^[107-108] ; Krishnarajua AV, <i>et al.</i> , 2005 ^[47] ; Sowmyalakshmi <i>et al.</i> , 2005 ^[125] ; Ramprasath <i>et al.</i> , 2006 ^[97] ; Veena <i>et al.</i> , 2006 ^[140] ; Arulkumaran <i>et al.</i> , 2007 ^[6] ; Mathivadhani <i>et al.</i> , 2007 ^[60-61] ; Sugapriya <i>et al.</i> , 2008 ^[128] ; Bhitre <i>et al.</i> , 2008 ^[12] ; Gouthaman <i>et al.</i> , 2008 ^[32] ; Mythilypriya, <i>et al.</i> , 2008 ^[68] ; Joseph <i>et al.</i> , 2013 ^[40] ; Mansoria <i>et al.</i> , 2013 ^[58] ;
Antifertility/Antispermatogetic; (Chakraborty <i>et al.</i> , 2004;	Narayan <i>et al.</i> , 1985 ^[77] ; Sharma <i>et al.</i> , 2003 ^[112] ; Vinutha <i>et al.</i> , 2007; ^[145]
Antifungal	Sharma <i>et al.</i> , 2002 ^[114] ; Paras <i>et al.</i> , 2014 ^[81]
Anti-Inflammatory Activity	Satyavathi <i>et al.</i> , 1969 ^[106] ; Gothoskar <i>et al.</i> , 1971 ^[30] ; Vad, 1973; Saraf <i>et al.</i> , 1989 ^[104] ; Chaurasia <i>et al.</i> , 1995 ^[20] ; Tumova, 1995 ^[136] ; Vijayalakshmi <i>et al.</i> , 1996; Vijayalakshmi <i>et al.</i> , 1997; Premalatha B, <i>et al.</i> , 2000 ^[86, 87, 89, 90, 92] ; Mary <i>et al.</i> , 2003 ^[59] ; Ramprasath <i>et al.</i> , 2004; Selvam and Jachak, 2004 ^[107-108] ; Ramaprasatha <i>et al.</i> , 2005; Singh <i>et al.</i> , 2006 ^[119] ; Ramprasath VR, <i>et al.</i> , 2006 ^[97, 99] ; Mathivadhani <i>et al.</i> , 2007 ^[60-61] ; Bhitre <i>et al.</i> , 2008 ^[12] ; Gouthaman <i>et al.</i> , 2008 ^[32] ; Mythilypriya <i>et al.</i> , 2008; Tripathi <i>et al.</i> , 2008 ^[134] ; Mansoria <i>et al.</i> , 2013 ^[58] ; Sushma, 2013 ^[131] ;
Antimicrobial Activity	Patwardhan <i>et al.</i> , 1988 ^[82-83] ; Kulkarni <i>et al.</i> , 1995 ^[49] ; Nair and Bhide, 1996 ^[75] ; Sharma <i>et al.</i> , 2002 ^[114] ; Sharma <i>et al.</i> , 2003 ^[112] ; Mohanta <i>et al.</i> , 2007 ^[63] ; Gouthaman <i>et al.</i> , 2008 ^[32] ; Sharma <i>et al.</i> , 2010 ^[115] ;
Antioxidant	Vijayalakshmi <i>et al.</i> , 1996; Vijayalakshmi <i>et al.</i> , 1997; Tripathi and Singh, 2001 ^[135] ; Mary <i>et al.</i> , 2003 ^[59] ; Ramaprasatha <i>et al.</i> , 2005; Arulkumaran <i>et al.</i> , 2006 ^[7, 111] ; Shanmugam <i>et al.</i> , 2006; Ramaprasatha <i>et al.</i> , 2006; Mythilypriya <i>et al.</i> , 2007 ^[69] ; Mohanta <i>et al.</i> , 2007 ^[63] ; Sahoo <i>et al.</i> , 2008 ^[103] ; Gouthaman <i>et al.</i> , 2008 ^[32] ; Mythilypriya <i>et al.</i> , 2008 ^[68] ; Tripathi <i>et al.</i> , 2008 ^[134] ; Verma and Vinayak, 2009 ^[141] ; Madhuri and Jadhav, 2018; Solankar <i>et al.</i> , 2018 ^[124] ;
Antistress	Shukla <i>et al.</i> , 2000 ^[118] ; Gouthaman <i>et al.</i> , 2008 ^[32]
Cyclooxygenase Inhibitor	Selvam and Jachak 2004 ^[107-108]
Depressant and antagonistic action against histamine, barium chloride, and pitocin	Bose <i>et al.</i> 1967 ^[14]
Hypoglycemic Activity	Arul <i>et al.</i> , 2004 ^[5] ; Kothai <i>et al.</i> , 2005 ^[45] ; Mansoria <i>et al.</i> , 2013 ^[58] ; Veena <i>et al.</i> , 2006 ^[140] ; Aseervatham & Panchanadham, 2011 ^[9]
Hypolipidemic	Tripathi and Pandey, 2004 ^[133] ; Veena <i>et al.</i> , 2006 ^[140] ; Vinutha <i>et al.</i> , 2007 ^[145] ; Gouthaman <i>et al.</i> , 2008 ^[32] ; Joshi <i>et al.</i> , 2010 ^[41] ; Dwivedi <i>et al.</i> , 2018 ^[24] ;
Larvicidal and Ovicidal Effects	Sivaraman <i>et al.</i> , 2018 ^[121]
Neuroprotective	Charaka, 1941 ^[17] ; Farooq <i>et al.</i> , 2007 ^[25] ;
Anti-tuberculosis activity	Singh <i>et al.</i> , 2015 ^[120]
Cardioprotective effect	Asdaq and Chakraborty 2010 ^[8]
Memory enhancing effect	Vinutha <i>et al.</i> , 2007 ^[145] ; Mishra <i>et al.</i> , 2016
Contraceptive agent	Narayan <i>et al.</i> 1985 ^[77] ; Murty, 1974 ^[67] ;
Lipoxygenase inhibitory activity	Nagabhushana <i>et al.</i> , 2002 ^[73]
Aphrodisiac activity and anti-allergic activity	Chakravarthy & Ahmed 2017 ^[16] ; Gupta <i>et al.</i> , 2013 ^[33]
Analgesic activity	Lingaraju <i>et al.</i> , 2011 ^[53]
Hepatoprotective effect	Abirami <i>et al.</i> , 2007 ^[1]
Anti-tuberculosis activity	Singh <i>et al.</i> , 2015 ^[120]
ACHe Inhibitory Activity	Vinutha <i>et al.</i> 2007 ^[145]
COX Inhibition	Selvam and Jachak 2004 ^[107-108]

This comprehensive overview highlights the diverse pharmacological activities of *Semecarpus anacardium*, underscoring its potential in various therapeutic applications. The rich nutritional and phytochemical composition of *Semecarpus anacardium* underpins its traditional uses and modern therapeutic potentials. Antioxidant properties attributed to its high phenolic and flavonoid content suggest protective effects against oxidative stress-related diseases. Anti-inflammatory actions contribute to its traditional use in treating joint pain and inflammatory conditions. Moreover, antimicrobial properties provide a basis for its application in treating infections, while potential anticancer effects warrant further investigation into its chemopreventive and therapeutic roles.

Therapeutic Potentials

Seeds from *Semecarpus anacardium* have been used as healthcare products and medicines for millennia (Raut *et al.*, 2007). Extensive references to the properties and applications of Bhela are meticulously documented in Ayurvedic and Siddha classics. The authoritative Ayurvedic treatises, namely Charak, Sushrut, and Vagbhatt, delve into comprehensive details regarding the medicinal attributes of Bhela and its various formulations (Jain and Sharma, 2013)

[39]. Revered as the "HALF PHYSICIAN" in Ayurveda, Bhela is highlighted for its therapeutic potential (Poornima *et al.*, 2013) [85]. In traditional Ayurvedic practices Bhallataka is specifically indicated for hemorrhoids. After ripening, the Bhallataka fruit exhibits a sweet taste (Svadupaka Rasa), is light to digest (Laghu), and possesses astringent properties (Kashaya). It aids digestion (Pachana), is unctuous (Snigdha), piercing (Teekshna), and hot (Ushna). It induces purgation (Chedana), enhances intelligence (Medhya), promotes digestion (Vahnikara), and balances both Kapha and Vata doshas (Kaphavatahara). Additionally, it facilitates quick wound healing (Vranahara), is beneficial in ascites (Udarahara), and effective in managing skin diseases (Kushta) and piles (Arshahara). Bhallataka also addresses conditions such as malabsorption syndrome (Grahani), relieves gaseous distention of the abdomen (Gulma), alleviates inflammation (Shopha), relieves bloating (Anaha), and is useful in fever (Jwara) (Poornima *et al.*, 2013) [85]. It demonstrates efficacy against worm infestation (Krimi). The seed kernel of Bhallataka is sweet and aphrodisiac in nature, providing nutrition while balancing Vata and Pitta doshas. The bark of Bhallataka is beneficial for hair and improves digestion, enhancing its therapeutic versatility in Ayurvedic applications.

Medicinal Application	Reference
Historical Mention: Astanga Sangraha (sixth century) referenced <i>S. anacardium</i> in Sutrasthana, Chikitsasthana, Uttrasthana, and Kalpasthana. Bhallataka's false fruit properties include madhura (sweet), bhrimhana (nourishment), sheeta (cold), and atyaruchi (loss of appetite).	Bhattarai <i>et al.</i> , 2021 [11]
Fruits and oil effective against neuritis.	Charaka, 1941 [17]
Ayurveda (Charak Sanhita): Balances the three Doshas (Vata, Pitta, Kapha) and is useful in diseases like bronchitis, leprosy, eczema, and piles.	Shastri, 2002 [116]
Action against helminthic infection.	Chattopadhyaya & Khare, 1969 a&b [18-19]
Antitumor effects against various cancers.	Gothoskar <i>et al.</i> , 1971 [30]; Vad, 1973; Indap <i>et al.</i> , 1983 [36]; Vad & Kulkarni, 1975 [138]
IC50-value against Eagles 9 KB nasopharynx carcinoma cells.	Hembree <i>et al.</i> , 1978 [34]
It is applied to the cut end of newborns' umbilical cords and administered to animals to treat stomach disorders. Additionally, the oil treats skin infections in both humans and animals, while the bark's gum resin is utilized for conditions like leprosy, venereal infections, and nervous debility. The nut's oil is further employed in human medicine to treat esophageal and laryngeal cancers, and it is also used traditionally to promote hair growth and as a dyeing agent.	Jain & Sharma, 2013 [39]
Extracted oil has shown effectiveness against arthritis, tumors, and infections.	Joshi <i>et al.</i> , 2010 [41]
Clinical trials have demonstrated its efficacy in managing conditions such as arthritis, spondylitis, sciatica, and knee joint arthritis; formulations like <i>Anacardium forte</i> showing relief in cancer patients.	Joshi <i>et al.</i> , 2010 [41]; Krantikumar & Atul, 2015 [46]
Fruit Oil claimed to be useful in treating leprosy, neuritis, rheumatoid arthritis, piles, asthma, cough, sexually transmitted diseases like syphilis and gonorrhea, venereal disorder, nematocidal, etc.	Kirthikar & Basu, 1975; Nadkarni, 1976 [72]
Studies suggest that Bhilawa nuts and seeds, in specific proportions, offer benefits for cancer patients.	Krantikumar & Atul, 2015 [46]
The seeds of this plant are crushed and applied to wounds to staunch bleeding, while its oil is used to treat cracks in animal tails and hooves. Bhilawa fruits cooked in mustard oil are applied to sores to eliminate maggots, showcasing their medicinal use. The nut's milk extract, as per Ayurvedic tradition, displays anti-inflammatory properties that alleviate acute primary inflammation in arthritis. Historically, this plant has been employed to treat a wide range of ailments including beriberi, cough, constipation, liver disorders, scrofula, and venereal diseases. Additionally, the gum extracted from its bark is known for its therapeutic effects on skin conditions such as psoriasis and leucoderma.	Krithikar & Basu, 1975 [48]
Exhibits activity against tetanus-causing microorganisms.	Kulkarni <i>et al.</i> , 1995 [49]
It is effective in treating bronchitis, dysentery, fever, asthma, and hemorrhoids. The ripe fruits are considered aphrodisiacs, digestive aids, and stimulants, while a paste of its seeds with honey is used for gastric troubles. Research has explored its juice as an anticancer agent, particularly effective against human epidermoid carcinoma. In traditional medicine, it balances phlegm (Kapha dosha), enhances sexual potency, and treats conditions such as ascites, rheumatism, asthma, epilepsy, psoriasis, warts, tumors, and hypoglycemia. Its applications also include relieving rheumatic pains, treating venereal complaints when mixed with garlic, addressing ringworm and severely chapped feet with seed juice, using seed oil for skin eruptions, inducing sterility in women with root juice, and managing headaches, skin diseases, and scabies with its latex.	Manandhar, 1985, 2002 [55-56]; Siwakoti & Siwakoti, 2000 [122]; Rai, 2004 [93]
Recognized in Indian medicine for its efficacy against gout and rheumatic pain.	Nadkarni, 1954 [71]
Activity against various bacterial strains.	Nair & Bhide, 1996 [75]

Management of wound healing, diabetes, and urinary diseases.	Pandey & Chuneekar, 1967 ^[79] ; Thakur & Puri, 1978 ^[132]
Employed in treating wounds, diabetes, and urinary diseases.	Pandey & Chuneekar, 1967 ^[79]
Therapeutic properties include being acrid and anthelmintic, beneficial for conditions such as acute rheumatism, epilepsy, asthma, neuralgia, and psoriasis.	Premalatha & Sachdanandam, 2000 ^[86, 87, 89, 90, 92]
Reduction of paw edema and activity against adjuvant-induced arthritis.	Saraf <i>et al.</i> , 1989 ^[104] ; Vijayalakshmi <i>et al.</i> , 1996 ^[144]
Inhibition of acute tuberculin reaction and adjuvant arthritis.	Satyavathi <i>et al.</i> , 1968 ^[105] , 1969; Vijayalakshmi <i>et al.</i> , 1996 ^[144]
Antifungal effects against <i>Aspergillus fumigatus</i> and <i>Candida albicans</i> .	Sharma <i>et al.</i> , 2002 ^[114]
Protection against hippocampal neuron degeneration caused by stress.	Shukla <i>et al.</i> , 2000 ^[118]
Extract demonstrates a potent cytotoxic effect against human colonic cancer cells.	Smit <i>et al.</i> , 1995 ^[123]
Bhallataka rasayana, amritha bhallataka, kalpaamurathaa, brihat bhallataka lehya are marketed in India; these are supposed to possess rejuvenating properties, which increase longevity, bring glow to the face, sweetness in tone, and improvement in vision.	Sreenivasacharyulu, 1931 ^[126]
Protection against lipid peroxidation.	Tripathi & Singh, 2001 ^[135]
Clinical efficacy in treating cancers.	Vad, 1973; Vad & Kulkarni, 1975 ^[139]
Stabilization of lysosomal membranes and enhancement of detoxification enzymes.	Vijayalakshmi <i>et al.</i> , 1997; Premalatha & Sachdanandam, 2000a, 2000b

Other uses: *Semecarpus anacardium* serves multiple industrial purposes beyond its medicinal uses.

Application/Use	Reference
This plant, <i>Semecarpus anacardium</i> , serves multiple industrial purposes: it hosts lac insects, aiding lac production, while its nuts are valuable for tanning and its pericarp yields Bhilawan Shell Liquid (BSL), historically used in linen marking. It plays a pivotal role in manufacturing varnishes, lacquers, enamels, paints, and waterproofing materials. The kernels produce a semi-drying oil useful for wood preservation and lubrication. Additionally, its black resin marks clothes and contributes to the plastics industry. Various plant parts, including nuts and seeds, are integral to varnish, lacquer, and insecticide production. Despite its acrid juice, the wood finds use in charcoal production and crafting lightweight furniture and packing materials. Varnish made from the acrid and adhesive juice produced from the stem by tapping.	Anonymous, 1999 ^[4]
Oil's physicochemical values indicate its potential as a biopesticide for managing insect pests and fungi.	Srinivasan <i>et al.</i> , 2016 ^[127]
Peel surrounding the seed furnishes a sort of permanent ink.	Howes, 1948 ^[35]
Black dye obtained from the pedicels.	Manandhar, 2002 ^[56]
Wood contains an acrid juice, rendering it dangerous to those who work upon it.	Lindley, 1838 ^[52]
Seed oil used for various industrial purposes such as floor dressing; as an additive substance to lacquers, dyes, and insulating material; in the plastics industry; for regenerating rubber materials; and to protect wood from white ants. Juice of the pedicels, mixed with limewater, is used as a black marking ink to write on cloth.	Uphof, 1959 ^[137]
Nut yields a strong and bitter substance used as a substitute for indelible ink for garments, referred to as Dhobi Nut. Provides a black color to cotton materials, mixed with water as a fixator before application.	Kawale, 2020 ^[43]
Kernel oil used as a lubricant and wood preservative against termites.	Gouthaman <i>et al.</i> , 2008 ^[32]

Conclusion

Semecarpus anacardium has a long history of traditional use in Indian medicine systems, where it is employed to treat various ailments including skin disorders, digestive issues, and inflammatory conditions. Modern scientific research continues to validate these traditional uses and explore new therapeutic avenues, including cardiovascular health and neuroprotective effects. The fruit's multifaceted pharmacological properties position it as a promising candidate for developing novel pharmaceuticals and nutraceuticals aimed at improving human health and wellness. *Semecarpus anacardium* L. emerges as a versatile and valuable botanical resource, characterized by its rich nutritional composition, diverse phytochemical constituents, and significant pharmacological activities. The integration of traditional knowledge with modern scientific approaches highlights its potential in addressing contemporary health challenges. Future research directions should focus on elucidating its mechanisms of action, conducting clinical

trials to validate its efficacy and safety, and developing sustainable harvesting practices to ensure its conservation and availability. By harnessing the therapeutic potentials of *Semecarpus anacardium*, we can unlock new avenues for improving health outcomes and promoting well-being globally. Further research into its nutritional properties and elimination of its vesicant nature could enhance its utility in both food and pharmaceutical industries.

Conflict of interest

The authors declare no conflicts of interest.

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