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REVIEW ARTICLE

Ethnobotany of coconut: A review on its traditional, cultural and economic significance

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Abstract

Cocos nucifera L. (2n = 2x = 32), the only species within the genus *Cocos*, is a diploid perennial oilseed plant belonging to the Arecaceae family, earning its title as "Kalpavriksha" or "Tree of Heaven". Despite its widespread cultural, traditional and economic importance, ethnobotanical research remains limited and cultivation faces increasing threats from urbanization. Originating from the land fragments of the ancient Gondwana landmass, coconut has undergone wide geographic dispersal and ecological adaptation, thriving particularly along the coastal areas of the Pacific and Indian Ocean regions. In India, coconut is deeply integrated into indigenous health systems, used for its ethnomedicinal properties including analgesic, anti-inflammatory, cardioprotective, antidiabetic, antioxidant, antibacterial and immunomodulatory activities. It is rich in fatty acids such as caprylic, capric, caproic and myristic acids, enhancing its potential in nutritional therapy and functional food development. This review integrates phytochemical, pharmacological and ethnobotanical evidence, emphasizing coconut's potential in food, medicine and sustainable development.

Keywords: coconut; ethnobotany; ethnomedicine; origin; traditional knowledge

Introduction

Coconut palm (*Cocos nucifera* L.) is the only species in the genus *Cocos* and it belongs to the Arecaceae family. The coconut palm is found in all intertropical regions with the highest genetic diversity in Southeast Asia. From Southeast Asia, coconut initially spread to India, then to East and West Africa and finally to the entire intertropical zone by human migration and travel (1). Unlike many other crops, coconut palm can tolerate high salinity and is easily grown on sandy soils in areas with little rainfall and is widely adapted to different kinds of biotic and abiotic stresses (2). Major products include coconut meat, water, milk and oil. Its dietary and medicinal qualities are linked to its metabolites, including polyphenols, amino acids, organic acids and electrolytes, along with essential vitamins. The principal components are soluble carbohydrates, proteins, salts, minerals and vitamins (3). The coconut palm is one of the nature's most adaptable and culturally important plants that exist across the world. It is universally recognized as the "tree of life," and has serves the human population for thousands of years by providing food, shelter, medicine and spiritual significance across diverse cultures (4, 5).

Ethnobotanical studies reveals the profound relationships between humans and plants that encompass profound cultural, religious and economic value (6). The remarkable versatility and cultural importance of coconuts in tropical regions highlight their significance in ethnobotanical research. Every part of the coconut, including the nutrient rich meat, water, fiber, shell and wood, serves multiple purposes, making it a valuable resource within traditional knowledge systems (7). The cultural significance of coconut extends far beyond their usefulness. Coconut is considered sacred in many cultures, particularly in Hindu religion and it is widely used in ceremonies and rituals (8, 9). Coconut offers valuable insights into community-based resource management strategies, sustainable farming practices and traditional medicinal systems (10). The primary aim of this review is to provide a comprehensive documentation and analysis of coconut ethnobotany, focusing on its ethnomedicinal uses, cultural and religious significance and economic importance. By integrating traditional knowledge with modern scientific evidence, this study highlights the diversity of ethnobotanical practices and explores potential applications in food, medicine and sustainable development.

Taxonomy

The genus *Cocos* is considered mono-specific, meaning it contains only *Cocos nucifera* L., with no extant close botanical relatives in its lineage. In contrast, related palm genera such as *Lodoicea* (double coconut), *Borassus* (palmyra palm) and *Syagrus* (queen palm) include multiple species within their lineages, with *Syagrus* containing dozens of species. Although the 'double coconut' (coco de mer or 'coconut of the sea') resembles the coconut to a modest extent, it is significantly larger and differs in morphology and phenology. With 27 genera and 600 species, the coconut belongs to the Arecaceae family (previously Palmaceae) and its subfamily, Cocoideae (11). Coconut has 32 chromosomes (n = 16) and is classified into two groups: tall and dwarf. Tall plants are generally allogamous because the pollen is released before the female flowers are receptive. Within the dwarf group, there are further divisions between variants with robust or fragile trunks. Release of pollen from male flowers coincides with the receptivity of female flowers and thereby dwarfs palms are primarily autogamous (12).

Origin, distribution and domestication of coconut

Phylogenetic origin and evolution

The phylogenetic origin and evolution of the coconut (*Cocos nucifera*) have been influenced by both natural and human-induced factors, resulting in its widespread distribution and genetic diversity across the tropics. Recent genetic and genomic studies have clarified its evolutionary relationships, domestication sites and adaptation. Phylogenetic studies suggest that it evolved in the Indo-Pacific region, with its closest relatives found in the tropical regions of Southeast Asia. (Fig. 1) illustrates the phylogenetic relationships of *Cocos nucifera* with its closest relatives in Southeast Asia, highlighting the Indo-Pacific as its evolutionary origin (13). The fruit's ability to float on the water to new places and the lack of distinctly wild populations, in addition to its pantropical range, make it difficult to pinpoint the origin and domestication region of the coconut palm (14). Genetic analyses of over 1300 coconut samples have identified two important and distinct subpopulations of coconuts: one in the Pacific and another in the Indo-Atlantic regions (15). This indicates that coconut cultivation developed independently on the island of Southeast Asia and the southern Indian subcontinent and its genetic makeup continues to evolve and therefore adapt to diverse coastal environments and thrive in sandy soils and tropical cyclones (15). The wild coconut likely had large, thick-husked, slow-germinating fruit adapted for oceanic dispersal, as these traits enhanced buoyancy, protected the embryo during long sea voyages and delayed germination until the seed reached a suitable shoreline. Selection and cultivation resulted in spherical, thin-husked, rapidly germinating varieties with more endosperm that were suitable for transportation and human consumption.

Ecological adaptation

The long evolutionary history of coconut has enabled it to persist across a wide range of coastal environments, extending from East Africa to eastern Polynesia. Studies indicate that specific coconut populations, having survived in distinct ecological niches for thousands of generations, exhibit notable resilience and adaptability to lethal phytoplasmas, non-lethal viruses and herbivorous insect pests (16). There is also evidence of ecological adaptation to climatic extremes with coconuts showing tolerance to high temperatures, drought and salinity, allowing them to thrive in tropical coastal environments and withstand challenging growing conditions. Compared to the typical palm of South Pacific origin, the West Coast Tall of India exhibits the remarkable capacity to tolerate severe water scarcity. On Hainan Island, the tall population can tolerate yearly brief annual drops in daily mean temperature below 10 °C, while transplanted genotypes experienced fruit fall. Since coconut generations have occupied a particular place for a considerable amount of time, it is evident that natural selection has been at work for millions of years. Natural selection favors adaptable mutations in the environment.

Geographic distribution and dispersal

Fossil evidence indicates the palm family originated on the Gondwana landmass approximately 100 million years ago. After Gondwana tectonic rifting approximately 85 million years ago, numerous smaller island fragments drifted apart. The palm family underwent diversification (17). Evidence suggests that the modern coconut species originated from land fragments of the

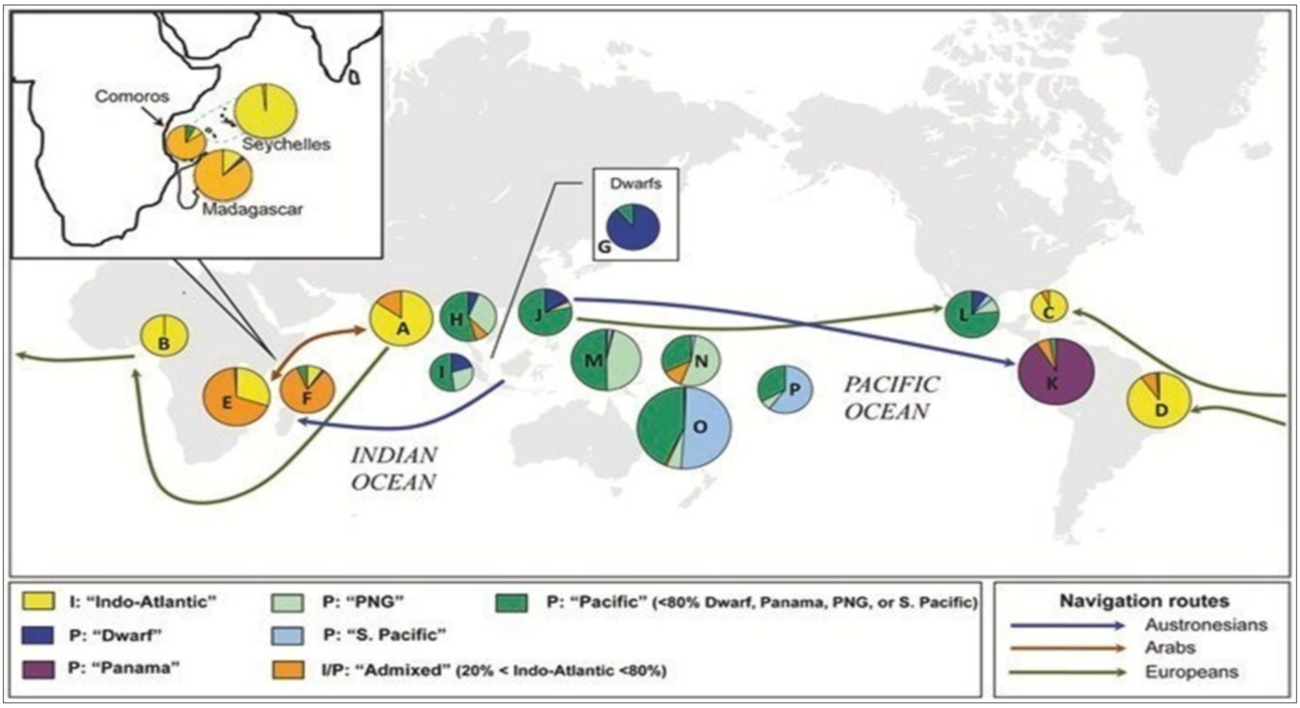

Fig. 1. Geographical distributions of coconut in Indo-Atlantic and Pacific regions (15).

This map displays the worldwide distribution of coconut genetic subpopulations based on structure analyses at K=5 with ≥80 % membership threshold, revealing distinct Indo-Atlantic (I) and Pacific (P) lineages established through K=2 population assignments. Pie charts (A-P) represent genetic composition across different geographic regions with corresponding sample sizes from multiple countries, ranging from Indian Ocean locations to Pacific islands.

East African continent that drifted across the Tethys Sea. This led to the development of a buoyant, sea dispersible fruit capable of colonizing a wide range of habitats, including both atolls and larger landmasses (18). The precise onset of the current phase of coconut population evolution driven by human selection remains uncertain. However, it is likely to have begun over 100000 years ago during the initial colonization of tropical coastal regions by hominins and early humans (19). The strong association between human settlements and cultivated coconut stands was further intensified during the 1830s, when global demand for coconut oil expanded beyond tropical regions. The need for edible coconut oil arose to supplement animal fats, which could not meet the demands of growing industrial populations. Within a few decades, this demand expanded significantly. Industrialists' investments in plantations spread throughout the tropical world, particularly in Southeast Asia, South Pacific, Central America, the Caribbean and East Africa, due to the high market value that was then placed on coconut oil (20).

Ethnomedicinal values of coconut in India

The coconut palm provides a wide range of products like coconut water, coconut oil, copra, kernel, shell and coir, which are used in daily use. The coconut palm is valued for its many uses, especially for its nutritional and medicinal benefits. Coconut has antiviral, antifungal, antibacterial, antioxidant and immune stimulating properties. It is rich in essential nutrients like nitrogen (N), phosphorus (P), potassium (K), boron (B), manganese (Mn) and magnesium (Mg) and micronutrients *viz*., sulphur (S), iron (Fe), zinc (Zn), calcium (Ca) and copper (Cu), which are vital to human health (21, 22) and has numerous therapeutic benefits. In Indian traditional medicine particularly Ayurveda, the coconut palm and its fruits are used to prepare various natural remedies for treating a wide range of ailments (8). Several extracts, fractions and isolated compounds from different parts of the coconut fruit have been evaluated and shown to exhibit a wide range of biological activities, such as analgesic, anti-oxidant, cardioprotective, anti-bacterial, immunomodulation and antidiabetic properties (Table 1) (23).

Analgesic activity

Ethanol extract of coconut husk fiber has significant analgesic activity, as evidenced by reduction in the number of writhes and stretches induced by 1.2 % acetic acid in mice. The analgesic response was compared in animals treated with morphine sulfate (1.15 mg), paracetamol (68 mg) and aspirin (68 mg). Administration of the ethanol extract with either morphine or pethidine enhanced the analgesic effect of both drugs (24). These findings suggest that coconut husk fiber has a strong analgesic effect, indicating its possible application in development of new, affordable medications for a wide range of illnesses and could offer a very cheap source of novel analgesic medications (25).

Antioxidant activity

Coconut water is primarily composed of water (94 %) and sugars (5 %), including aldohexose, fructose and disaccharides, along with minor quantities of proteins (0.02 %) and lipids (0.01 %). It serves as a significant source of minerals such as calcium, magnesium and manganese, while other metallic elements are found only in trace amounts. Tender coconut water contains bioactive compounds like L-arginine (30 mg/dL) and vitamin C (15 mg/100 mL), which reduces the production of free radicals (26) and significantly decreases lipid peroxidation respectively. Dietary supplementation with virgin coconut oil has been reported to increase the activity of antioxidant enzymes in rats (27). The presence of micronutrients, including essential vitamins and inorganic ions, highlights the potential of coconut water in supporting body's antioxidant defense system (27, 28).

Cardioprotective activity

Coconut contains various fatty acids, including lauric acid (49 %), myristic acid (18 %), caprylic acid (8 %), palmitic acid (8 %), oleic acid (6 %), stearic acid (2 %) and linoleic acid (2 %) (29). A high proportion of these are medium chain saturated fatty acids (MCFAs), accounting for approximately 65 % of the total fatty acids. MCFAs are rapidly absorbed in the intestine and transported directly to the liver, where they undergo rapid metabolism to generate energy. Due to this metabolic pathway, MCFAs are not involved in cholesterol biosynthesis or transport and MCFAs reduces the bad cholesterol LDL (low density lipoprotein) but increases the good cholesterol HDL (hight density lipoprotein). Coconut water exhibits cardioprotective function in cases of myocardial infarction (30) and tender coconut water has been shown to lower serum levels of triglycerides, low density lipoprotein, very low-density lipoprotein and total cholesterol levels (31).

Antibacterial activity

The antibacterial properties of coconut oil have been investigated in numerous studies. Fatty acid analysis revealed that coconut oil contains 42 % lauric acid, a functional MCFA which has antiviral and antibacterial properties (32). In gram positive bacteria, MCFAs exhibit membrane disruptive activity, which inhibits bacterial growth and causes cell lysis (33). Coconut oil exhibited antibacterial activity against gram negative gut bacteria but was ineffective against Lactobacillus species and gram positive Bifidobacterium. It inhibited *Enterococcus cecorum* at 1.13–2.25 mg/mL and *Staphylococcus aureus* at 0.56 mg/mL (33). Additionally, diethyl ether extracts of coconut mesocarp inhibited a harmful bacterium, *Salmonella typhi*, while benzene extracts showed greater antibacterial activity against *Escherichia coli* (34).

Table 1. Ethnomedicinal value of coconut (8)

Plant parts	Ailment treated	Traditional belief/use
Root	Gingivitis	Boiled with potash alum for mouthwash.
Stem bark	Gastritis	Ash mixed with water relieves pain.
Tender coconut water	Multiple (e.g., urinary issues, headache, diarrhoea)	Used for hydration, digestion, urinary relief, headaches and hair health.
Coconut shell	Fractures	Paste with turmeric and mango bark used as bandage.
Shell oil	Toothache	Oil from burned shell used topically.
Kernel	Rheumatoid arthritis	Warm herbal paste applied to joints.
Coconut milk	Poisoning, obesity	Used as detox remedy and appetite suppressant.
Coconut oil	Dermatitis	Applied with saltwater and herbal juice for skin relief.
Whole tree (multiple parts)	Snake bites	Decoction with millet and ghee consumed.
Inflorescence	Vaginal bleeding, fractures, diarrhoea	Boiled with herbs for gynaecological issues; used in paste for fractures; juice with nutmeg seeds treats diarrhoea.

Immunomodulation

The immunomodulatory properties of coconut protein have been studied in Swiss albino mice, which had immunological suppression induced by cyclophosphamide (CP). CP is a commonly used anti-cancer drug that contains harmful reactive metabolites such as acrolein and phosphoramide. This study revealed that coconut protein has a significant immunomodulatory effect (35) and virgin coconut oil inhibits *Staphylococcus aureus* growth by enhancing phagocytic activity of immune cells which have the capacity to break down bacterial cell walls. This suggests that virgin coconut oil could serve as a modulator of the cellular immune system, offering a potential alternative to antibiotics (36).

Antidiabetic activity

The antidiabetic potential of purified coconut kernel protein (CPK) was evaluated in diabetic rats. These rats were maintained on a semi -synthetic diet supplemented with CPK extracted from dried coconut kernels. Compared to healthy control rats, the liver's glycogen levels and the serum carbohydrate-metabolizing enzyme activity were restored to normal in diabetic rats. Histopathological analysis revealed that CPK supplementation reduced pancreatic damage associated with diabetes. These effects are likely mediated through arginine-induced regeneration of pancreatic β-cells (37). Overall, coconut kernel protein exhibits strong antidiabetic properties by normalizing glycogen levels, restoring carbohydrate-metabolizing enzyme activities and repairing pancreatic tissue via arginine-mediated β-cell regeneration (21).

Phytochemical validation of ethnomedicine

Phytochemical analysis of coconut fiber (mesocarp) by ethanolic extract revealed the presence of phenols, tannins, leucoanthocyanidins, flavonoids, triterpenes, steroids and alkaloids, whereas the butanol extract contains triterpenes, saponins and condensed tannins (38). Lyophilized extracts, fractions and ethyl acetate extracts of coconuts are rich in polyphenols, flavonoids, epicatechins, catechins and tannins (39). The liquid albumen of coconut contains various bioactive components, including vitamins such as B-complex (nicotinic acid B3, 0.64 µg/mL; pantothenic acid B5, 0.52 µg/mL; biotin, 0.02 µg/mL; riboflavin B2, <0.01 µg/mL; folic acid, 0.003 µg/mL) and trace amounts of thiamine (B1), pyridoxine (B6) and vitamin C. It also contains amino acids such as L-arginine, plant hormones (auxin, 1,3-diphenylurea, cytokinin), enzymes (acid phosphatase, catalase, dehydrogenase, diastase, peroxidase, RNA polymerases) and other growth promoting factors (40). Alpha tocopherol and lauric acid are the primary constituents of oil extracted from the solid albumen. Phenolic compounds identified in the roots include flavonoids and saponins (41). The high concentrations of polyphenols (581.33 mg per 100 g), flavonoids (10 to 25.9 mg per 100 g), alkaloids (2.5 to 8.6 g per 100 g) and tannins (35 to 50 mg per 100 g) indicate the pharmacological relevance of coconut- derived compounds (42). Coconut phytochemicals exhibit diverse biological activities: phenols, flavonoids and tannins act as antioxidants; alkaloids provide analgesic and anti-inflammatory effects; medium-chain fatty acids show antimicrobial action; triterpenes and steroids aid immune modulation and tissue repair; and saponins regulate glucose and cholesterol metabolism.

Cocos nucifera is a nutritionally and medicinally important plant with proteins contributing to antimicrobial, anti-inflammatory, antidiabetic and insecticidal activities. Makapuno, a jelly-like coconut mutant, has higher dietary fiber, medium-chain fatty acids, antioxidant and DNA-protective properties ((43, 44). Various parts, including cotyledon, mesocarp, spadix and roots, show antioxidant, antibacterial and antimicrobial activities. Methanolic cold cotyledon extracts exhibit strong antioxidant potential (45). Coconut root extract possesses antibacterial, antioxidant activities and antimicrobial effects against *Klebsiella pneumoniae*, *Bacillus subtilis*, *Staphylococcus aureus* and *Candida albicans*. Phytochemical analysis confirmed the presence of key antioxidant compounds, while GC-MS analysis identified 21 bioactive constituents. The results provide scientific validation for the traditional use of coconut root in ethnomedicine for its antimicrobial and antioxidant potential (Table 2) (46).

Cultural significance of coconut

In Sanskrit, the coconut is referred to as "Sriphala," which means "The fruit of God" (8). It has been documented in post-Vedic literature such as the Puranas, the ancient epics of the Mahabharata, Ramayana and in Buddhist Jataka stories, with the epics traditionally dated several millennia ago. Before the sixth century AD, coconuts were used in India for ceremonies, regarded as a sacred offering to deities and presented as a gift for guests on auspicious occasions like festivals, marriages and other ceremonies (47). In Tamil Nadu, the festival Aadi Perukku (celebrating the life-giving nature of water) involves a unique ritual of breaking coconuts on devotees' heads. In Daman and Diu and coastal Maharashtra, Narali Purnima marks the start of the fishing season. During this festival, fishermen offer coconuts to the sea god Varuna for a safe journey and abundant catches and celebrations include music, dance and traditional coconut-based dishes. In Kerala, coconuts are first offered to calm the sea before fishing commences and then distributed to devotees for blessings and prosperity (8).

The coconut holds a crucial role in various rites, rituals and ceremonies across many cultures, symbolizing fertility, folklore and deep-rooted cultural beliefs. In many tropical and subtropical regions, coconuts hold great cultural and economic significance, often being more important than other customary foods in local rituals and traditions. In regions such as Gujarat, Kanara and Mysore, the coconut is worshiped as a household deity. Although its ritualistic use was not widely recognized in India before the 6th century AD, it gained a vital role in religious practices during the period of Agni and Brahma Puranas (800-900 AD) (48).

Table 2. Phytochemical compound in various parts of coconut

Parts used	compound	Reference
Coconut shell	Dodecanoic acid, Tetradecanoic acid, n-hexadecanoic acid, 9-octadecenoic acid, Squalene	(66)
endosperm (kernel)	alkaloids, steroids and terpenoids	(67)
Coconut roots	n-decane, 3,7-dimethylundecane, 1,1-diethoxyhexane, 2,3,3-Ttrimethyloctane, n-tridecane, 3,8-dimethylundecane, Ethyl linoleolate, Ethyl n-heptadecanoate, Ethyl linoleolate	(46)
Coconut water	Saponins, Flavonoids, Flavonoids, Glycosides	(68)
Coconut copra	Alkaloids, Flavonoids, Glycosides, Saponins, Tannins, Steroid, Terpenoids	(69)
Coconut husk	Flavonoids, alkaloids, resins, glycosides, saponins and tannin	(70)
Coconut neera	Phenolics acid (vanillic acid, syringic acid, transcinnamic acid and p-hydroxybenzoic acid) and flavonoids (catechin, hesperidin and myricetin)	(71)

In South India, planting a coconut palm in household is considered as punyakarma (good deed), often performed on the first and last days of the Ratha Yatra (Chariot Festival). In Hindu worship, coconuts are frequently offered to deities along with incense sticks and flowers. The Purnakumbha, a "full pitcher" filled with mango leaves and topped with a coconut, is an essential element in many religious ceremonies (2). At the beginning of new endeavors, like the inauguration of buildings, the launching of ships, or the start of the use of new vehicles, bridges and similar structures, where breaking of coconut is traditional habit (49). The coconut is regarded as a symbol of wealth, purity and good beginnings. The unbroken fruit represents wholeness and spiritual integrity until it is ceremoniously broken. This symbolizes surrendering one's ego and inner purity to the divine; the white kernel represents spiritual essence and the hard shell represents ego. The three eyes on the coconut are frequently compared to the Hindu trinity of Brahma, Vishnu and Shiva. In Hindu weddings, coconuts are placed atop on sacred vessel (kalash) to bless the couple with fertility, wellness and divine energy (8). Coconut palms possess deep cultural importance across Southeast Asia, the Pacific Islands and Africa, where they play vital roles in religious, social and economic life. In Vanuatu, colonial influence altered the coconut's cultural role, leading locals to refer to it as "the tree of the Whites," highlighting its shift from a traditional resource to a key commodity in the copra industry (50). In Bali and Nusa Penida, coconut products are absolutely crucial for religious participation, with no ritual possible without coconut fruit or leaves (51). Throughout the Pacific, over thousand years of traditional Polynesian knowledge and the cultivation of diverse coconut landraces are increasingly at risk due to globalization and shifting cultural practices (52).

Value added products from coconut

The coconut palm holds immense ornamental and practical value, with every part contributing significant economic benefits. Edible products derived from coconut include coconut milk, desiccated coconut, coconut oil, coconut water, coconut flour, vinegar and jaggery. Its non-edible parts are also widely utilized *viz* leaves for baskets and fans, coir for ropes and mats, shell for utensils and the trunk for construction purposes (8). In 2022, the global coconut products market was valued at $ 6.9 billion, with projections to reach $14.0 billion by 2030, growing at a CAGR of 9.3 %. In India, the Coconut Development Board reported that domestic consumption of packaged coconut water grew by 22 % annually between 2020 and 2023, indicating a significant rise in demand for value-added coconut products.

Kernel based products

Coconut oil is an edible oil widely used in India and many other countries. In India, most coconuts are processed for oil extraction, with approximately 40 % used for edible purposes, 46 % for toiletries and 14 % for industrial applications (53). Coconut oil is currently ranked as the world's second most valued edible oil after olive oil. It is extensively used in southern Indian states such as Tamil Nadu, Kerala and Karnataka. Chocolates, ice cream, cookies and other confections, as well as medications and paints, are the primary products made from refined coconut oil. Demand for coconut oil increases by 15-20 % during festive season (8). A study revealed that crude coconut oil is more stable than refined oil because it has high tocopherol content (54). Virgin coconut oil (VCO) has high polyphenolic content which is responsible for anti-inflammatory and antioxidant properties, which contribute to the prevention of cardio vascular disease by slowing the progression of atherosclerosis. In addition to these advantages, VCO has anti-inflammatory activity and improve antithrombotic actions linked to platelet coagulation inhibition (55).

Desiccated coconut

Desiccated coconut is widely used in chocolate, sweets and other confectioneries, as well as in the preparation of curries, chutney and various dishes. India produces approximately 4000 tonnes of desiccated coconuts annually (56). The primary producers of desiccated coconut are Kerala, Tamil Nadu andhra Pradesh, Karnataka, Odisha and Maharashtra. These companies not only manufacture valuable products but also create numerous job opportunities due to the labour-intensive nature of the industry (57). In Assam, the festival of Magh Bihu, also known as Bhogali Bihu, celebrated at the end of harvest season and the coconut desserts like Laru and Narikel Pitha are traditionally prepared. In Bengal, Narikel Pitha is prepared during Makar Sankranti (Uttarayan), while Bhappa and Narikel Laddu remain popular throughout the winter season (57).

Coconut milk-based products

Coconut milk is a ready-to-use product that can be consumed undiluted or diluted with water to prepare various recipes. Coconut candy is made with either coconut milk or coconut cream (58). Malai Chingri, a curry that is served as a side dish with rice or bread in Bengal and Punjab, is made using coconut milk. Coconut residue that remains after the extraction of coconut milk is a by-product of the coconut milk industry. The coconut flour produced has more dietary fiber and helps in prevention of long-term health conditions like diabetes, heart disease and cancer. It is a non-starch polysaccharide that is not broken down in the small intestine but can be fermented into short-chain fatty acids (SCFA) including acetate, propionate and butyrate in colon and has dietary fiber of 1.5-2.0 kcal/g (8).

Nata-de-coco

Nata-de-coco is a chewy, translucent, jelly-like product made from fermented coconut water. It is mainly consumed in western and southern India. It is widely used in recipes, including ice cream, pickles, fruit cocktails, sweet fruit salads and drinks. Numerous fruits, including bananas, pineapples, tomatoes and other vegetables, can be used to make nata. The product is named after the medium used, for example, "Nata-de-coco" from coconut and "Nata de pina" from pineapple (59).

Products from coconut inflorescence

"Neera" is the vascular sap extracted from immature, unopened coconut inflorescence. In southern India, Sri Lanka, Africa, Malaysia, Indonesia, Thailand and Myanmar, neera is widely consumed (60).The nutrient-dense "sap" has a low glycemic index (GI 35), making it suitable for individuals with diabetics. Coconut water has a near-neutral pH and is rich in essential nutrients. For instance, it contains approximately 7.46 mg of vitamin C, 28.64 mg of potassium, 3.05 mg of calcium and 0.84 mg of magnesium per 100 mL. Neera is utilized in the production of several high-value goods, including coconut palm sugar, jaggery and coconut flower syrup (61).Toddy is a coconut sap-based alcoholic beverage. It is also known as palm toddy, Kallu in South India, or just toddy or tadi in North India. Toddy is converted to an alcoholic beverage by fermentation.

Coconut as "tree of life"

For many years, the main function of the coconut on the global market has been the extraction of copra for oil (Fig. 2). It presents the projected trends in coconut genetic resources, showing an increase from 416 to 600 varieties and from 855 to 1000 populations between 2019 and 2028. This growth is supported by regeneration, merging and introduction of new cultivars from farmers' fields. The figure highlights ongoing efforts to conserve diversity and develop improved cultivars for resilience and sustainability. Still, there are many uses at farm level in non-food purposes and for small landowners. This is particularly true when it comes to construction with the palm. The house's heavy foundation is well supported by the trunks. Additionally, the trunk can be sawed into floor boards (62). The leaves themselves are utilized for thatching and their petioles and midribs are helpful for building frameworks for buildings and roofs. The coconut palm provides a variety of household goods, with the shell of the nut commonly used to make utensils and containers. The leaves are woven into numerous products. Coir fiber is used to make mattresses. Torches are made from bundles of leaves and lamps are made from the oil (63). The coconut palm is undoubtedly more than just a resource base. It is the foundation for human survival in certain areas. In Indian households, coconut palms are an integral part of everyday life because almost every part of the tree has a useful purpose. The fruit is staple in cooking, providing coconut water as a widely consumed drink and kernels for oil production, which is utilized in traditional medicine, hair care and culinary preparation (64). Coconut coir peat, husk and coconut-based charcoal have been demonstrated as efficient and cost-effective adsorbents for the removal of heavy metals, organic pollutants and water hardness, thereby improving the efficacy of both conventional and reverse osmosis water treatment systems (65).

Conclusion

The coconut palm (*Cocos nucifera* L.), often referred to as the "tree of life," remains one of the most valued and economically significant plants in tropical regions. From architecture and rituals to food and health, its diverse uses demonstrate its profound ethnobotanical value. Ageing plantations, pest and disease outbreaks, a lack of planting material and declining genetic diversity due to inadequate germplasm conservation are some of the major issues in coconut industry. Many traditional gene banks have already been lost or neglected. In order to preserve coconut's legacy and provide its continuous contribution to livelihoods, culture and ecosystem, it is necessary to enhance conservation methods, promote sustainable utilization and bridge indigenous knowledge with modern research. To sustain the role of coconuts in supporting livelihoods, culture and ecosystems, it is crucial to enhance germplasm conservation by establishing well-documented, region-specific gene banks, advance research in molecular breeding, tissue culture and genomics to produce disease resistant and climate adapted varieties and implement integrated pest and disease management along with sustainable plantation approaches, including agroforestry and intercropping.

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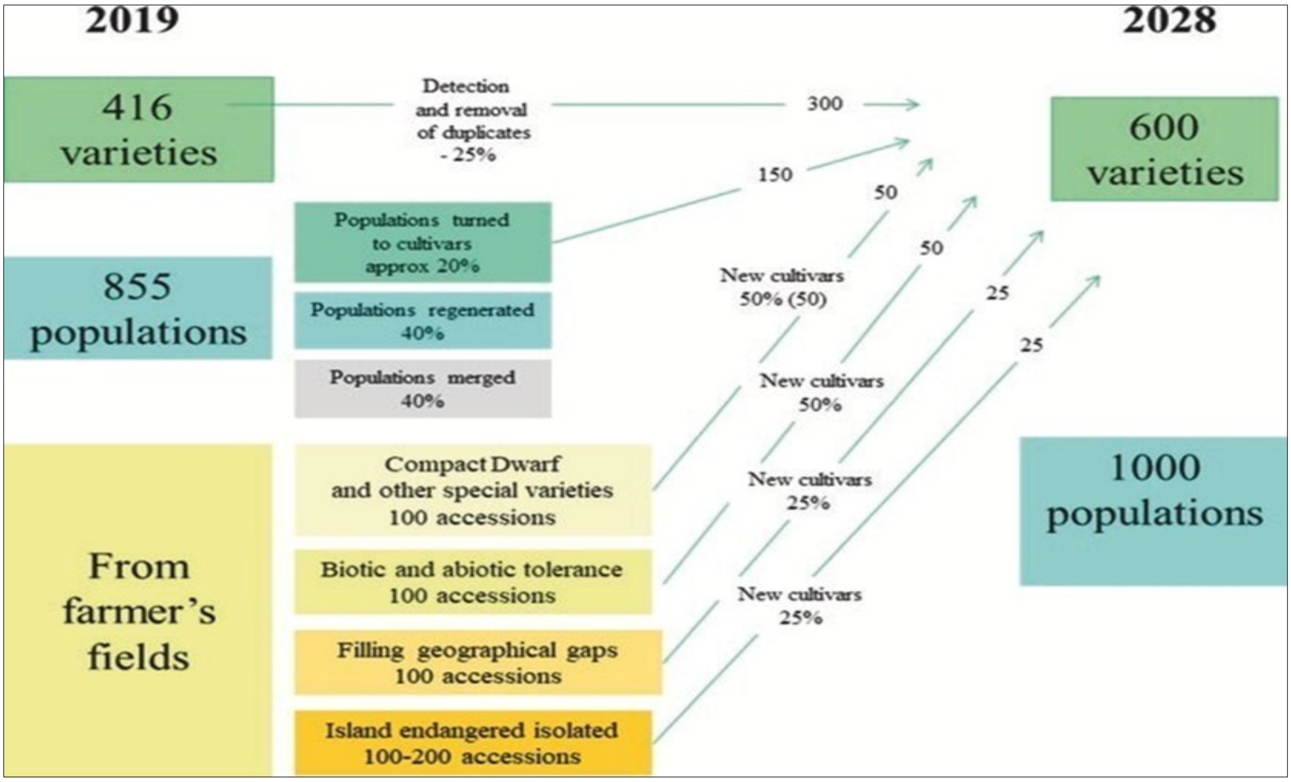

Fig. 2. Forecasts for collecting coconut varieties and populations (72).

This strategic plan highlights the targeted expansion of coconut genetic resources *via* organized collection, conservation and breeding efforts, aiming to develop stress-tolerant cultivars and safeguard endangered germplasm, thereby strengthening global coconut biodiversity and agricultural resilience.

Authors' contributions

MA has written the whole manuscript. RR and KKK guided in providing technical support to write the manuscript in a proper format and equally contributed and approved the final manuscript. MM, NT and KH guided to write the manuscript in a proper format and approved the final manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

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