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Review Article

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ETHNOBOTANICAL, NUTRITIONAL, AND FUNCTIONAL PROSPECTS OF INDONESIAN MANGROVE APPLES (*Sonneratia* spp.)

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ARTICLE HIGHLIGHTS

- Comprehensive review of Indonesian mangrove apple (*Sonneratia* spp.), focusing on *S. alba, S. caseolaris,* and *S. ovata* across major coastal regions.
- Nutritional profile of Indonesian mangrove apple characterized by significant levels of vitamins, flavonoids, and organic acids with high bioactive potential.
- Documented functional properties of Indonesian mangrove apple, include antioxidant, anti-inflammatory, anti-allergic, and antidiabetic activities.
- Emphasizes the role of mangrove apple utilization in promoting supporting food security and public health, sustainable coastal ecosystem conservation and biodiversity preservation.

ABSTRACT

Mangrove apples (*Sonneratia* spp.), native to Indonesia's extensive mangrove forests, is distributed across Sumatra, Kalimantan, Sulawesi, Maluku, and Papua. This review synthesizes ethnobotanical uses, nutritional attributes, and functional potential of three main species *S. alba*, *S. caseolaris*, and *S. ovata* that hold both ecological and cultural significance. A review article search was conducted following the PRISMA 2020 framework and structured in accordance with the standard IMRaD across Scopus, PubMed, ScienceDirect, Web of Science, and Google Scholar, yielding 91 eligible studies from an initial 612 records. Ethnobotanical evidence documents diverse applications in traditional foods, including chips, stick crackers, sweets such as *dodol*, syrup, candy, ice cream, and marshmallow, reflecting deep-rooted ties between coastal communities and mangrove ecosystems. Nutritional analyses highlight rich contents of vitamins and bioactive compounds such as flavonoids, and organic acids. These constituents exhibit antioxidant, anti-inflammatory, anti-allergic, and antidiabetic properties, underscoring the species' promise as a functional food ingredient. By integrating traditional culinary heritage with scientific evidence, this review positions *Sonneratia* spp. as both a symbol of Indonesia's coastal identity and a contributor to food security, health, and biodiversity conservation.

Keywords: ethnobotanical, functional prospect, mangrove apples, nutritional composition, *Sonneratia*

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INTRODUCTION

Indonesia, the world's largest archipelagic nation, is home to 2.7 million hectares of mangroves, accounting for nearly 23% of the global coverage and distribution, with significant species records from Java, Sumatra, Kalimantan, Papua, Sulawesi, and the Maluku Islands (Kurniawansyah *et al.* 2023). These ecosystems play a crucial role in biodiversity conservation, shoreline protection, carbon sequestration, and supporting coastal livelihoods. Among the diverse mangrove flora, the mangrove apples (*Sonneratia* spp.) has ecological, nutritional, and cultural significance (Suhardi *et al.* 2024). This extensive ecosystem, representing one-fifth of the world's mangrove coverage, is the focus of conservation efforts to support multiple Sustainable Development Goals (Arifanti *et al.* 2022). Mangrove apples (*Sonneratia* spp.) are of ecological and cultural importance. Occupying tropical and subtropical coastal forests across the Indo-West Pacific biogeographic zone, *Sonneratia* has long been integrated into the culinary and medicinal traditions of Indonesian coastal communities (Dharmayasa *et al.* 2025).

Virtually every part of the mangrove apple plants is utilized; its fruits are eaten fresh or transformed into traditional dishes and beverages, whereas the leaves, bark, and roots are widely used in ethnomedicine to treat cough, inflammation, and digestive disorders (Kulkarnii & Manohar 2014). This dual role of nourishment and healing underscores the enduring significance of food in promoting community resilience (Holmes *et al.* 2025). Ethnobotanical records further highlight the incorporation of the fruit into diverse local foods in Indonesia, reflecting both cultural adaptation to coastal environments and the preservation of intangible culinary heritage (Kalor *et al.* 2025). Traditionally, the fruit is consumed fresh or processed into beverages, jams, and confections and is also used in ethnomedicine for treating cough, inflammation, and digestive disorders.

Despite their deep cultural integration, mangrove apples remain underutilized in mainstream food systems (Wati *et al.* 2025). Despite its longstanding cultural importance, *Sonneratia* remains largely overlooked in mainstream food discourse at the national and international levels (Audah 2024). In recent years, scientific inquiry has begun to explore its nutritional and functional potential. Recent studies have highlighted its rich content of vitamins, minerals, and bioactive compounds, including polyphenols and flavonoids, with demonstrated antioxidant, anti-inflammatory, and antidiabetic activities (Liu *et al.* 2023). These findings suggest that various species of mangrove apples in Indonesia such as *S. alba*, *S. caseolaris*, and *S. ovata* could transition from a heritage food rooted in local traditions to a functional ingredient of global relevance. With the increasing demand for natural health-promoting foods, *Sonneratia spp.* presents a timely opportunity to bridge traditional knowledge with contemporary nutritional science, thereby supporting the development of innovative functional food products while reinforcing the importance of conserving indigenous resources and cultural heritage.

This review integrates ethnobotanical evidence, nutritional composition, and functional prospects of these diverse species to reposition *Sonneratia* spp. as a natural food resource, reinforcing Indonesia's coastal heritage while contributing to food innovation, health, and biodiversity conservation.

REVIEW

Review Article Selection and PRISMA 2020 Outcomes

This review article employed a structured literature review following the PRISMA 2020 guidelines to ensure transparency in the literature selection process (Page *et al.* 2021). Literature searches were conducted across Scopus, PubMed, ScienceDirect, Web of Science, and Google Scholar, covering publications from 1990 to 2024. Search strings combined controlled vocabulary and free-text terms, including "*Sonneratia*" and "*Indonesia*," "*mangrove apple*" and (nutrition or functional food), and "*Sonneratia*" and (ethnobotany or traditional food or medicine). The inclusion criteria were as follows: (i) studies focusing on *Sonneratia* spp. in Indonesia, Asia, or the Indo-West Pacific; (ii) research reporting culinary uses, phytochemical composition, nutritional content, or bioactivity; and (iii) peer-reviewed articles, theses, and government/NGO reports. The exclusion criteria removed studies that (i) addressed mangrove species other than *Sonneratia*, (ii) lacked primary or review data, or (iii) were purely descriptive without methodological details. Data were extracted and categorized into three domains: cultural/culinary uses, nutritional and phytochemical composition, and functional/biomedical potential. This review article was structured in accordance with the standard IMRaD (Introduction, Methods, Results, and Discussion) framework to ensure clarity, coherence, and alignment with international journal standards.

The literature search across PubMed, ScienceDirect, Web of Science, and Google Scholar initially yielded 612 records published between 1990 and 2024. After the removal of 132 duplicates, 480 unique records were screened. Of these, 287 were excluded at the title and abstract stage because they were irrelevant to *Sonneratia* spp. or focused on other mangrove apple species. The remaining 193 full-text articles were assessed for their eligibility. Based on the inclusion criteria, 64 studies were excluded for lacking primary data or methodological clarity, and 38 were excluded for focusing solely on ecological rather than nutritional or ethnobotanical aspects. Ultimately, 91 studies met the eligibility criteria and were included in this review article. The selection process rigorously followed the PRISMA 2020 framework, ensuring transparency, reproducibility and methodological integrity. A flow diagram is presented in Figure 1.

Species Diversity of Mangrove Apples (*Sonneratia* spp.) in Indonesia

Indonesia is home to one of the world's most extensive mangrove ecosystems, offering an ideal habitat for various species of mangrove apples (Fig. 2). Taxonomically, *Sonneratia* is part of the family Lythraceae and the order Myrtales, comprising several mangrove-associated species found across the tropical and subtropical regions of Southeast Asia (Wu *et al.* 2009). In Indonesia, these species are prevalent in Sumatra, Kalimantan, Sulawesi, Maluku, and Papua, thriving in estuarine zones, tidal flats, and river mouths with diverse salinity and sediment conditions.

Sonneratia spp. have long been acknowledged as native mangrove species in the Indo-West Pacific, a global hotspot for mangrove diversity (Li *et al.* 2025). Fossil pollen and phylogenetic evidence suggest that these species have naturally inhabited the coastal and estuarine zones of the Indonesian Archipelago for millennia (Holmes *et al.* 2025). Their ability to withstand salinity, develop specialized root systems, and disperse propagules across tidal waters has enabled widespread distribution throughout the islands (Naharuddin 2021). The earliest scientific accounts of *Sonneratia* in Indonesia date back to the Dutch colonial era in the 17th – 18th centuries, when naturalists documented their abundance on Sumatra (Wahyuningsih *et al.* 2023). These observations were later compiled in the Flora of the Dutch East Indies, highlighting their ecological roles and traditional uses. Local names such as *bogem* (Java), *pedada* (Sulawesi), and *perepat* (Sumatra and Kalimantan) reflect their deep cultural integration throughout the archipelago (Raka *et al.* 2023). Indonesia is home to three main species of mangrove apples (*Sonneratia* spp.): *S. alba*, *S. caseolaris*, and *S. ovata*, all of which hold ecological and cultural significance.

Ethnobotanical Perspectives

Ethnobotanical evidence highlights the central role of mangrove apples (*Sonneratia* spp.) in the food culture of coastal community in Indonesia (Arbiastutie *et al.* 2021). Fruits of *S. alba*, *S. caseolaris*, and *S. ovata* are eaten fresh or processed

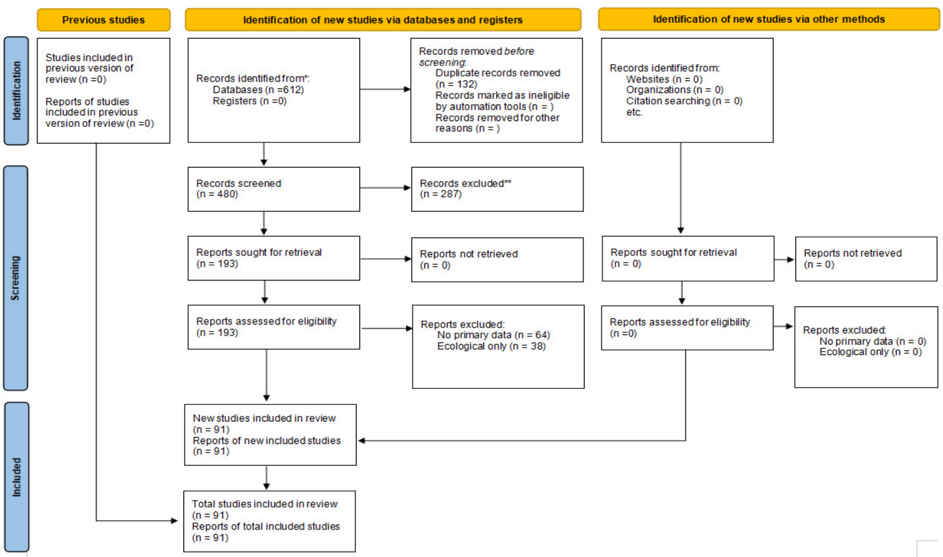

Figure 1 PRISMA 2020 flow diagram illustrating the study selection process in the updated review article of *Sonneratia* spp.

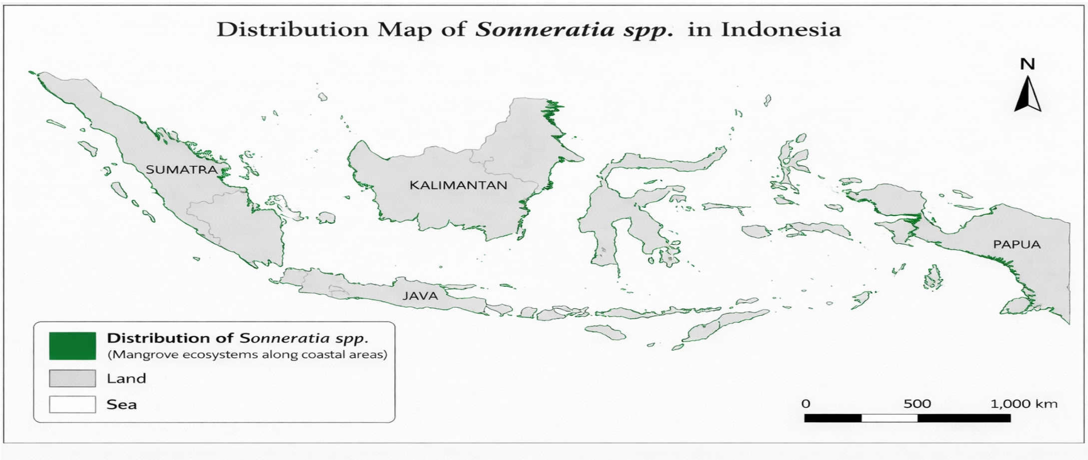

Figure 2 Distribution map of mangrove apples (*Sonneratia* spp.) along coastal regions in Indonesia

Figure 3 Food product made from mangrove apples (*Sonneratia* spp.)
Notes: A: *Dodol*; B: Syrup; C and D: Chips; E: Candy; F: Ice Cream; G: Stick Crackers; H: Marshmallow

into chips, stick crackers, sweets such as dodol, syrup, candy, ice cream, and marshmallow (Fig. 3). The culinary use of *Sonneratia* spp. in Indonesia is a unique expression of coastal ethnogastronomy, showcasing not only the ecological spread of mangrove ecosystems, but also the inventive adaptation of local communities to their natural resources (Wijaya 2019). Throughout the archipelago, species of *Sonneratia* have been utilized to create a range of food products, from staple complements to festive delicacies.

In Sumatra and Java, *Sonneratia* spp. is highly valued for its acidity and aroma, making it ideal for processing into fruit syrup, ice cream, chips, and sweet preserves commonly sold in local markets (Table 1). In some coastal communities, the fruit is also fermented into vinegar and beverages that are consumed during social gatherings (Hardoko *et al.* 2019).

Additionally, traditional confectionaries, such as candied fruits, have become popular artisanal products that preserve both flavor and heritage (Audah 2024). In Kalimantan, *S. alba* is more commonly used to produce vinegar, which is widely used in making marinades, dipping sauces, and condiments that accompany grilled or smoked fish, a dietary staple in riverine and coastal settlements (Kusmana & Sukristijiono 2016). Table 1 showed communities in Kalimantan also prepare sour relishes from *S. alba*, often mixed with chili and salt, being served as affordable yet flavorful condiment to staple meals.

In Nusa Tenggara, Bali, and Sulawesi, the softer and milder fruit pulp of *Sonneratia ovata* lends itself to a variety of preparations (Table 1). The fruit is processed into sweet products such as *dodol*, jelly candies, and marshmallows, which are

Table 1 Regional distribution and types of Indonesian ethnic food made from mangrove apples

Name of food	Regions	Types of food	Main ingredients	References
Dodol	Sumatra, Kalimantan, Java, Sulawesi	Traditional food	Coconut, brown sugar, mangrove apples	(Prastari *et al.* 2025); (Audah 2024)
Syrup	Sumatra, Kalimantan, Java, Bali, Maluku, Papua	Traditional food	Water, sugar, mangrove apples	(Audah 2024); (Kusmana 2018)
Chips	Sumatra, Kalimantan, Java	Modified Traditional food	Mangrove apples	(Lukman *et al.* 2025); (Rosulva *et al.* 2021)
Hard candy	Sumatra, Bali, Nusa Tenggara	Modified traditional food	Sugar, corn syrup, water, mangrove apples	(Sayuti *et al.* 2025)
Ice cream	Java	Contemporary creation	Milk, sugar, gelatin, mangrove apples	(Apriliani 2015); (Jariyah *et al.* 2021)
Stick crackers	Sumatra, Java, Kalimantan	Modified traditional food	Flour, salt, sugar, mangrove apples	(Audah 2024); (Lukman *et al.* 2025)
Marshmallow	Sumatra	Contemporary creation	Sugar, corn syrup, gelatin, mangrove apples	(Lestari *et al.* 2023)
Juice	Sumatra, Java	Modified traditional food	Mangrove apples	(Dari *et al.* 2022)
Instant beverage	Sumatra, Java	Contemporary creation	Sugar, mangrove apples	(Lestari *et al.* 2023)
Dry flour	Sumatra, Java, Kalimantan	Modified traditional food	Mangrove apples	(Ardiansyah *et al.* 2020)
Pudding	Sumatra, Java	Contemporary creation	Agar, sugar, mangrove apples	(Wintah & Kiswanto 2024)
Jam	Sumatra, Java, Bali, Maluku, Kalimantan	Contemporary creation	Sugar, mangrove apples	(Visakhadevi *et al.* 2024)
Jelly candy	Sumatra, Java, Kalimantan	Contemporary creation	Sugar, corn syrup, gelatin, mangrove apples	(Pujiastuti *et al.* 2025)
Vinegar	Sumatra, Kalimantan	Traditional food	Mangrove apples	(Hardoko *et al.* 2019); (Kusmana & Sukristijiono 2016)

consumed during festive occasions and are shared as part of communal traditions (Pujiastuti *et al.* 2025). *Dodol* made from *S. ovata* has a distinctive texture and aroma compared to its rice or coconut-based counterparts, signifying a regional culinary identity (Prastari *et al.* 2025). In the Maluku Islands, where sago is the main carbohydrate source, both *S. caseolaris* and *S. ovata* are incorporated into mixed preparations, including sago porridge, and mangrove apple puddings (Wintah & Kiswanto 2024). These combinations enhance the nutritional and sensory profiles of otherwise monotonous staple foods, offering a balance of sweetness, sourness, and texture. In some villages, the fruits are cooked down into chutney-like pastes, which are stored and consumed throughout the year (Lukman *et al.* 2025). In Papua, both *S. alba* and *S. ovata* have traditionally been integrated into porridges and small cakes made from local starches (Mahmud 2011).

Collectively, these practices highlight the remarkable versatility of *Sonneratia* spp. in Indonesian food production. The ability of local communities to process mangrove fruits into food products not only demonstrates culinary ingenuity, but also underscores the close interdependence between ecological resources and cultural heritage. Regional variations in the use of *S. caseolaris*, *S. alba*, and *S. ovata* reflect both ecological distribution and adaptive creativity, ensuring that mangrove fruits remain integral to the identity, nutrition, and resilience of Indonesian coastal societies.

Beyond its well documented role as a traditional food source, various parts of *Sonneratia* spp. have been utilized in ethnomedicine. The fruits are commonly consumed fresh or processed into beverages and condiments, while the leaves, bark, and roots are traditionally employed to treat ailments such as coughs, inflammation, wounds and bruises, as well as digestive disorders (Fig. 4). Culturally, *Sonneratia spp.* is embedded in local knowledge systems and practices, including traditional ecological knowledge related to mangrove management and seasonal harvesting. In some regions, the presence of mangrove species, including *Sonneratia*, is associated with customary beliefs and local wisdom that regulate resource use and conservation practices. Although less documented, its potential use in natural dyes, or cosmetics may also exist, reflecting the broader ethnobotanical significance of mangrove flora in coastal societies.

Figure 4 Traditional herbal medicine using *Sonneratia* spp. leaves to treat wounds and bruises (Source: Socfindo Conservation 2026).

Nutritional Composition

Mangrove apples (*Sonneratia* spp.) are gaining recognition as a promising and valuable source of nutrients. Phytochemical studies have shown that mangrove apples are abundant in primary metabolites, such as carbohydrates, proteins, lipids, and essential minerals, as well as in secondary metabolites, such as vitamins, (Table 2). These compounds are widely known for their protective effects against oxidative stress and chronic metabolic disorders.

Mangrove ecosystems are widely acknowledged as vital reservoirs of biodiversity, valued for their ecological services and rich phytochemical compositions. Among these ecosystems, mangrove apples (*Sonneratia* spp.) have garnered increasing scientific interest because of its diverse array of secondary metabolites and their promising therapeutic properties. Fruits from various species of *Sonneratia* have been documented to contain a wide range of bioactive compounds, each associated with specific biological activities (Table 3). To elucidate their chemical diversity and functional potential, the table summarizes the identified constituents of *S. alba*, *S. caseolaris*, and *S. ovata* categorized according to plant site and linked to their respective pharmacological prospects.

The fruits of *Sonneratia* species are among the most chemically diverse and pharmacologically significant components of the genus (Hossain *et al.* 2016). The fruits of *S. alba* are notably rich in phenolic acids, including methyl gallate, gallic acid, and vanillic acid, all of which are well documented for their potent antioxidant, antibacterial, and antitumor properties (Kulkarnii & Manohar 2014). These compounds play a crucial role in the fruit's defense against oxidative stress and microbial infection, thereby facilitating their incorporation into traditional diets and medicinal practices (Arbiastutie *et al.* 2021).

Conversely, *S. ovata* fruits are distinguished by the presence of sonneradones, a unique class of secondary metabolites, along with malate esters that serve as effective antioxidants (Astuti *et al.* 2021). This unique chemical composition not only provides robust protection against free radicals but also enhances the potential of these fruits

Table 2 Nutritional content of *Sonneratia* spp fruit from other spesies in Indonesia

Proximate Analysis	**Mangrove apples from**		
	S. alba[a]	*S. caseolaris*[b]	*S. ovata*[c]
Macronutrients			
Moisture Content (%)	30.7 ± 0.2	84.7 ± 0.1	64.2 ± 0.2
Ash Content (%)	5.6 ± 0.2	8.4 ± 0.4	5.1 ± 0.3
Protein Content (%)	3.4 ± 0.4	9.2 ± 0.3	9.3 ± 0.8
Fat Content (%)	8.5 ± 0.1	4.8 ± 0.2	1.8 ± 0.1
Carbohydrate Content (%)	52.1 ± 0.3	77.5 ± 0.2	74.9 ± 0.1
Micronutrients			
Vitamin A (IU)	219.3 ± 0.3	221.9 ± 0.1	223.2 ± 0.2
Vitamin B (mg)	4.9 ± 0.1	5.04 ± 0.2	5.1 ± 0.1
Vitamin B2 (mg)	7.8 ± 0.4	7.6 ± 0.1	7.3 ± 0.3
Vitamin C (mg)	55.2 ± 0.2	56.7 ± 0.3	54.8 ± 0.1

Source: [a]Nufus *et al.* (2023); [b]Dari *et al.* (2022); [c]Astuti *et al.* (2021).

Table 3 Phytochemical and bioactive compounds of mangrove apples (*Sonneratia* spp.)

Sonneratia species	Chemical constituents	Potential activity	References
S. alba	Methyl gallate, Syringate, Vanillic acid, 3,4-Dihydroxy-5-methoxybenzoic acid, Oleanolic acid, ursolic acid, α-, and β-amyrin cinnamate, lupeol (triterpenoids), β-sitosterol and stigmasterol (phytosterol), squalene (lipid)	Anti-oxidant, Anti-tumor, Anti-bacterial, Anti-fungal, Anti-atherosclerotic, Anti-cancer	(Kulkarnii & Manohar 2014); (Siahaya *et al.* 2017); (Nufus *et al.* 2023); (Pazla *et al.* 2025); (Liu *et al.* 2023)
S. caseolaris	Methyl gallate, Dimethyl malate, Butylethyl malates, asorbic acid, luteolin, luteolin 7-O-β-glucoside, myricetin, ellagic acid, oleanolic acid, maslinic acid	Anti-oxidant, Anti-diarrheal, Anti-inflammatory, Anti-allergic, Anti-hyperglycemic	(Wu *et al.* 2009); (Dev *et al.* 2021); (Kundu *et al.* 2023); (Audah 2024); (Liu *et al.* 2023)
S. ovata	Sonneradons A & B, Dimethyl malate, Butylethyl malates,	Anti-oxidant, Anti-microbial	(Khumaidah *et al.* 2019); (Nasution *et al.* 2025); (Liu *et al.* 2023)

as candidates for functional food development in the future. *S. caseolaris* fruits are characterized by high concentrations of gallates and malates, which bolster their antioxidant activity and are associated with antibacterial properties (Wu *et al.* 2009). Collectively, the fruits of *Sonneratia* spp. are rich sources of phenolic and derivative compounds, with predominant antioxidant activity, complemented by antibacterial and antitumor functions, highlighting their potential for nutraceutical and phytopharmaceutical applications.

Functional Prospects

In addition to their ecological function in stabilizing coastlines and supporting biodiversity, mangrove apples (*Sonneratia* spp.) present diverse opportunities that extend to human health, cultural traditions, and economic development (Kundu *et al.* 2023). Their incorporation into local diets, cultural practices, and potential for value-added products highlights their importance as a natural food source and a catalyst for sustainable development (Pugra *et al.* 2025). To comprehensively understand this potential, the functional prospects of *Sonneratia* spp. can be examined across 3 dimensions: health, social, and economic (Fig. 5).

From a health perspective, the fruits of *S. alba*, *S. caseolaris*, and *S. ovata* are abundant in essential vitamins (A, B, B2, and C) and a variety of bioactive compounds, including flavonoids, phenolic acids, and organic acids. These constituents have demonstrated significant antioxidant, anti-inflammatory, anti-allergic, and antidiabetic properties and are increasingly recognized for their role in preventing noncommunicable diseases and enhancing overall well-being (Kulkarnii & Manohar 2014). Their incorporation into functional foods, beverages, and nutraceuticals presents substantial potential for addressing contemporary dietary challenges while aligning with global consumer trends favoring natural and plant-based, health-promoting products (Audah 2024).

From a social perspective, mangrove apples hold profound cultural and ethnobotanical significance in Indonesia's coastal community (Melviani *et al.* 2024). They are traditionally transformed into a diverse array of foods, such as syrups, candies, *dodol*, jams, crackers, and even ice cream, highlighting their versatility and creativity inherent in local food heritage. This enduring culinary integration reflects a robust cultural identity, the transmission of intergenerational knowledge, and resilience in community food systems (Dharmayasa *et al.* 2025). Promoting *Sonneratia* spp. within sustainable community-based enterprises can empower local groups, particularly smallholder producers, while reinforcing the collective stewardship of mangrove ecosystems.

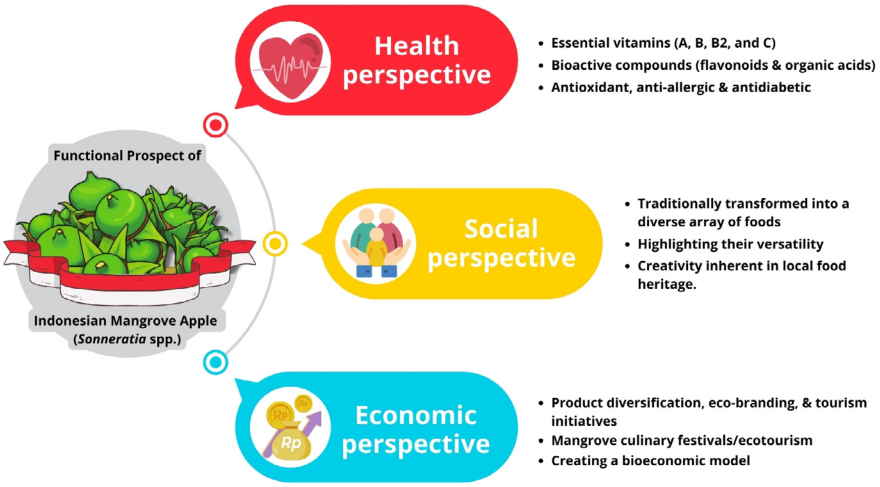

Figure 5 Functional prospect of Indonesia mangrove apples (*Sonneratia* spp.)

From an economic perspective, the sustainable utilization of *Sonneratia* spp. offers considerable opportunities to enhance livelihoods and stimulate local economies. The fruits can be developed into value-added products and increased market appeal, such as functional beverages, dietary supplements, or health-oriented snacks, catering to both domestic and international markets. Small and medium scale enterprises (SMEs) can benefit from product diversification and eco-branding, and tourism initiatives, such as mangrove culinary festivals or ecotourism packages (Kusmana 2018). Crucially, ensuring sustainable harvesting practices and integrating mangrove conservation into economic planning helps balance ecological protection with economic benefits, creating a bioeconomic model that supports both people and the environment (Arifanti *et al.* 2022). Collectively, the health, social, and economic prospects of *Sonneratia* spp. illustrate their multifaceted potential as more than just local heritage food.

From enviromental perspective, the functional prospects of *Sonneratia spp.* should be considered within a broader sustainability framework that integrates ecological conservation and responsible resource utilization (Kurniawansyah *et al.* 2023). As a key component of mangrove ecosystems, *Sonneratia* contributes to shoreline stabilization, carbon sequestration, and the maintenance of coastal biodiversity, thereby underpinning the long-term availability of its bioactive resources (Arifanti *et al.* 2022). Moreover, linking value added product development with community based conservation programs can create economic incentives that reinforce ecosystem protection (Holmes *et al.* 2025). In this context, the functional exploitation of *Sonneratia spp.* is not only a pathway for food innovation but also a strategic approach to promote mangrove ecosystem resilience and climate-adaptive livelihoods.

CONCLUSION

This review underscores the ethnobotanical, nutritional, and functional potential of the Indonesian mangrove apples (*Sonneratia* spp.) as a cultural heritage asset and promising contributor to food security and public health. Ethnobotanical evidence indicates their deep-rooted integration into traditional diets, while nutritional analyses reveal a rich composition of bioactive compounds that support functional properties such as antioxidant, anti-inflammatory, anti-allergic, and antidiabetic activities. By merging traditional knowledge with scientific validation, *Sonneratia* spp. have emerged not only as symbols of Indonesia's coastal identity but also as natural resources with significant potential for sustainable development, biodiversity conservation, and future food innovation.

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