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Research Article

Mangrove Species Diversity and Its Use as Medicinal Plant by Coastal Communities of Lampung Timur Indonesia

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Abstract
Coastal communities have empirically utilized and proven the medicinal properties of mangrove plants. The objective of the study was to determine the species diversity of mangrove plants and their use as herbal medicine on the coast of Lampung Timur, Sumatra, Indonesia. Mangrove plant diversity was obtained through vegetation analysis and diversity index calculation. The use of mangroves as medicine was obtained through interviews and descriptive comparative analysis. The study revealed that the mangrove forest located on Lampung Timur Coastal comprises 22 species from 12 families. Out of these 22 species, 12 are true mangroves, and the remaining 10 are mangrove associates. Among the 12 true mangroves, the majority (10 species) are major mangroves, while the other two are minor. The diversity index of the Lampung Timur mangrove forest is categorized as moderate (H'= 1.9580). The use of mangrove plants as herbal medicine persists in the Lampung Timur Coastal community. Among the users of mangrove herbal medicine, the majority (55.71%) are from the older generation. Additionally, 64% of users are male, 57.37% are categorized as low-income, and 60.12% identify as Javanese based on ethnicity. The community uses various plant species for medicinal purposes. *Avicennia marina* is used as an antiseptic, anti-histamine, and source of vitamins. *Acanthus ilicifolius* is used as an anti-rheumatism and muscle ache medicine/analgesic. *Rhizophora apiculata* is used as an antipyretic, *R. mucronata* is used to increase stamina/vitality, and *Soneratia caseolaris* is used as an anti-cholesterol and anti-oxidant.

Keywords: bioactive compound, ethnobotany, herbal medical, mangrove, medical properties

1. INTRODUCTION

Biodiversity provides numerous benefits for human well-being. Humans directly benefit from biodiversity in terms of food, clothing, shelter, energy sources, medicines, raw materials for industry, and other resources [1]. In the medical field, various species of flora and fauna have the potential to produce drugs for managing or curing diseases that have not been cured until now, such as HIV/AIDS or cancer [2]. In the field of engineering, numerous designs and structures found in nature have served as sources of inspiration for the study and design of engineering products. A significant number of scientific and technological inventions have been inspired by natural phenomena. These facts provide valuable insights into the significance of biological resources in nature for addressing human needs and challenges.

Mangrove is one of the many types of biodiversity that attracts the attention of people. As halophyte plants, mangroves can grow under extreme environmental stress due to high salinity, water-saturated soil, intense solar radiation, and high temperatures [3]. To survive, mangrove plants develop organs as a morphological adaptation and produce secondary metabolic substances to adapt to environmental stress [4]-[6]. The diversity of mangrove species with various adaptive abilities has the potential to produce bioactive compounds as secondary metabolic substances, which have been demonstrated to be beneficial for human health.

Indonesia is home to the world's highest diversity of mangrove species, with a total area of 3,490,000 ha, representing 21% of the global total of 16,530,000 ha of mangrove forests [5]. Indonesia is home to 202 mangrove species, comprising 89 trees, 5 palms, 19 lianas, 44 epiphytes, and 1 cycad [7]. Furthermore, 43 species among the 52 true mangroves registered in Southeast Asia are found in Indonesia. However, this potential has not been scientifically explored, especially as a medicinal plant. Ironically, 90% of the total national demand

Figure 1. (a) Map showing Lampung Timur District in Lampung Province Indonesia and (b) Study site from line to coast.

for pharmaceutical products is imported, with a total value of USD 1.68 billion. The optimization of the potential of mangroves as medicinal plants represents a strategic means of economic development, through the independence of medicinal raw materials.

The optimization of the utilization of medicinal plants plays a pivotal role in supporting the government's objective of reducing the importation of medicinal raw materials by up to 20% in 2026, as outlined in the roadmap of the Indonesian Ministry of Health. Furthermore, the development of herbal medicines will facilitate the increased accessibility of medicine to low-income individuals, which represents a fundamental necessity. Currently, the low-income population in Indonesia is 26.36 million people (9.57%). As many as 14.38 million people (54.55%) live in rural areas [8]. Traditional fishermen and fishing workers have the lowest income [9]. Therefore, developing mangrove plants as herbal medicine is a strategic approach to health development, as it increases people's access to medicinal products, which are a basic need.

The initial step in developing mangroves as medicinal plants is to identify the species diversity and document the community's utilization of mangrove plants as herbal medicine. Species data collection is essential to determine the potential and condition of the mangrove ecosystem. The diversity of mangrove species measures community structure and stability [10]. The high diversity of species and the high number of individual species indicate that the ecosystem has good resilience [11]. It is also important to identify the traditional use of medicinal plants, as this can inform scientific studies and documentation. Scientific discoveries related to the bioactive content of medicinal plants are often inspired by the empirical practices of traditional communities that have been practised for generations. By identifying the species diversity and practices of using mangroves as herbal medicines, it is possible to raise public awareness of the direct benefits of mangrove forests [12]. This can lead to increased public concern for their existence. It can be reasonably assumed that increased public awareness and concern for mangrove forests will encourage community involvement in conservation efforts [13].

One of the most significant mangrove areas in Indonesia is Lampung Timur, which encompasses

2,595.2 ha of mangrove forests, representing 28.66% of the total mangrove area in Lampung Province (9,054.9 ha) [14]. The Lampung Timur Coast faces the Java Sea, which has a moderate current (0–45 cm/s). The area is the estuary of two major rivers, namely Way Sekampung (483,850.29 ha of watershed area) and Way Penet (181,702.46 ha of watershed area) [15]. The confluence of these factors renders the East Lampung Coast an optimal habitat for mangroves. Furthermore, nine coastal villages with diverse ethnicities are situated within the district [14]. The potential of mangroves and ethnic diversity will facilitate cultural acculturation in harmony with nature, thereby fostering local wisdom, particularly in the utilization of mangroves as herbal medicine. The study's objectives were to identify mangrove species diversity and the traditional use of these plants as herbal medicines by coastal communities.

2. MATERIALS AND METHODS

2.1. Site of Study

The study was conducted in the Sub-District of Labuhan Maringgai and Pasir Sakti Lampung Timur District. Geographically, the study area is located at 105°50' East Longitude – 105°48' East Longitude and 5°15' South Latitude – 5°32' South Latitude (Figure 1). The study comprised two data types: the diversity of mangrove species and the utilization of mangrove plants as herbal medicine traditionally by the community. The mangrove plant diversity was analyzed using vegetation analysis. The utilization of mangrove plants as herbal medicine was identified through direct observation and interviews.

2.2. Research Procedure

2.2.1. Vegetation Analysis

A cluster sampling method was employed for vegetation analysis. This method was selected due to the observed variations in the Lampung Timur Coastal area concerning fresh water supply, substrate, and current sea status. These three factors are closely related to plant species in mangrove forests. The initial study identified three clusters within the mangrove population: (1) high freshwater input, high mud sediment, high sea current (around the estuarine zone); (2) low freshwater input, low mud sediment, high sea current; and (3) low freshwater input, mud sediment, and sea current (Figure 2).

At each cluster, an observation station was established as a checkered line. The length of the lane was equal to the thickness of the mangrove at that station. The lane was initiated at the outermost point of the mangrove vegetation closest to the open sea. A track line was created perpendicular from the starting point to the shoreline, to reach the

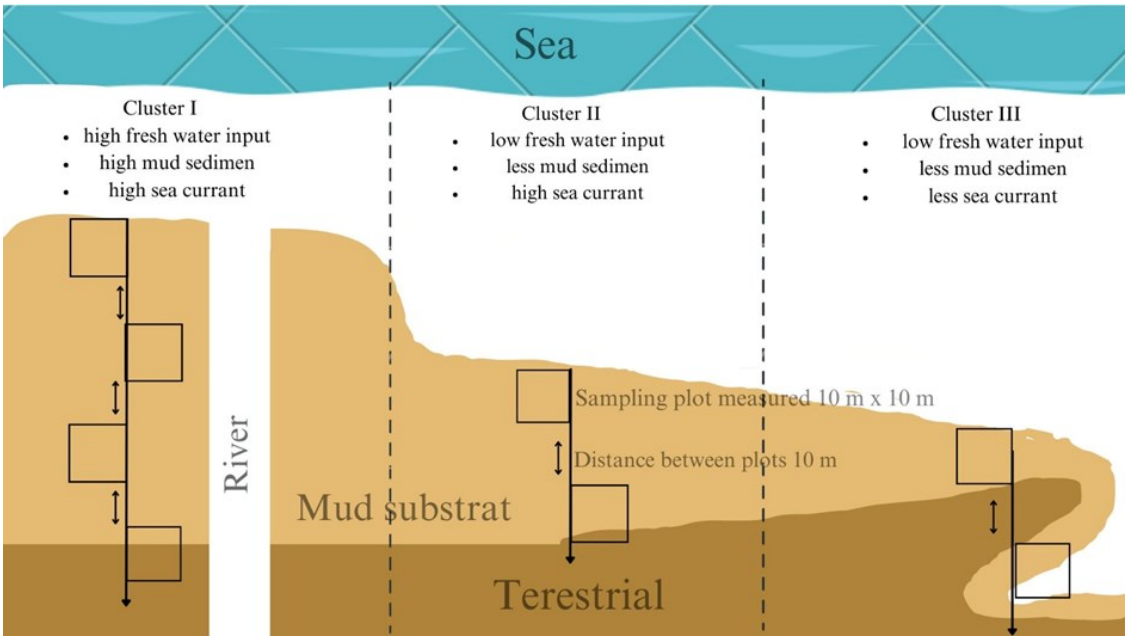

Figure 2. Population clustering in the mangrove forest of Lampung Timur.

Table 1. Species composition of lampung timur mangrove forest vegetation.

No	Species	Family	Life Form	IUCN Status	True/ Associates	Major/ minor
1	*Acanthus ilicifolius*	Acanthaceae	Shrub	LC	true mangrove	minor
2	*Avicennia marina*	Avicenniaceae	Tree	LC	true mangrove	major
3	*Acostricum sp*	Pteridaceae	Fern	DD	true mangrove	minor
4	*Bruguiera gymnorrhiza*	Rhizophoraceae	Tree	LC	true mangrove	major
5	*Excoecaria agallocha*	Euphorbiaceae	Tree	LC	true mangrove	major
6	*Lumnitzera littorea*	Combretaceae	Shrub	LC	true mangrove	major
7	*Nypa frutican*	Arecaceae	Palm	LC	true mangrove	major
8	*Rhizopora apiculata*	Rhizophoraceae	Tree	LC	true mangrove	major
9	*Rhizopora mucronata*	Rhizophoraceae	Tree	LC	true mangrove	major
10	*Rhizopora stylosa*	Rhizophoraceae	Tree	LC	true mangrove	major
11	*Sonneratia alba*	Sonneratiaceae	Tree	LC	true mangrove	major
12	*Xylocarpus rumphii*	Meliaceae	Tree	LC	true mangrove	minor
13	*Deris trilofia*	Leguminoceae	Shrub	DD	mangrove associates	-
14	*Erythrina variegata*	Leguminoceae	Tree	LC	mangrove associates	-
15	*Hibiscus tiliaceus*	Malvaceae	Tree	LC	mangrove associates	-
16	*Ipomoea pes-caprae*	Convolvulaceae	Shrub	LC	mangrove associates	-
17	*Melanthera biflora*	Asteraceae	Shrub	LC	mangrove associates	-
18	*Morinda citrifolia*	Rubiaceae	Tree	LC	mangrove associates	-
19	*Pluchea indica*	Asteraceae	Shrub	DD	mangrove associates	-
20	*Terminalia catappa*	Combretaceae	Tree	LC	mangrove associates	-
21	*Thespenia populnea*	Malvaceae	Tree	LC	mangrove associates	-
22	*Wedelia biflora*	Asteraceae	Shrub	LC	mangrove associates	-

Note: LC is the Least Concern and DD is data-deficient

nearshore area (land) (Figure 2). The observation plots, measuring 10 m × 10 m, were placed alternately on the left and right at each lane, with a distance of 10 m between plots. The objective was to observe the diversity of mangrove species along an elongated path and to gain insight into the profile of mangrove vegetation based on the existing zones (Figure 2). In a 10 m × 10 m observation plot, data on tree-phase vegetation was collected. In each observation plot, subplots measuring 5 m × 5 m were established for the observation of pole-phase vegetation data; 2 m × 2 m subplots were created for the observation of sapling vegetation data, and 1 m × 1 m subplots were established for the observation of seedling phase vegetation data. All plant species present in the sample plots were identified using the morphological characteristics described in the book 'Mangrove guidebook for Southeast Asia' [16]. All vegetation in the plots was measured for total height, after which the diameter at breast height was measured for the tree, pole, and sapling phases.

2.2.2. Respondent and Data Collection

The study was conducted in November — December 2022. A snowball sampling method was employed to identify respondents from the community who utilize mangrove plants as herbal medicine. This method was selected due to the low prevalence of mangrove plant utilization as herbal medicine within the community. Only among the older demographic is there a retained knowledge and skill set in utilizing mangroves as herbal

medicine. Consequently, probability sampling was deemed an ineffective approach to capturing comprehensive information about the utilization of mangroves as herbal medicine. A key informant, known by the community to have used mangroves as a medicinal plant, must be selected as the appropriate respondent. The data regarding the utilization of mangrove plants as medicine by the community was collected through in-depth interviews using a questionnaire. These data include (1). identity of the respondent; (2) mangrove plant species that are known by the community; (3) Species of mangrove plants utilized by the community as herbal medicinal; (4) Plant parts (tissues) of mangrove plants utilized as herbal medicinal; and (5) efficacy trusted (kind of diseases can be cured or prevented) by mangrove.

2.3. Data Analysis

A descriptive-analytic method was employed to analyze the composition of mangrove vegetation species. The mangrove species were grouped according to the families, categories (true mangroves/mangroves associated), and conservation status based on the International Union for Conservation of Nature (IUCN) category. The diversity of plant species was analyzed using the Shannon-Wiener diversity index (Shannon's index) [17], with the following formula (1);

$$H' = -\sum_{i=1}^{s}(p_i ln\, p_i) \quad (1)$$

where p is the proportion (n/N) of individuals of a particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the number of calculations, and s is the number of species.

A descriptive comparative method was employed to ascertain information on the socio-economic status of the people using mangroves as herbal medicines, species of plants, and the efficacy trusted by the community. Comparisons were made between the practices carried out by the Coastal Lampung Timur community and those carried out by people in other areas using mangroves as herbal medicine. Comparative analyses were also carried out to compare traditional community practices with scientific studies regarding the potential of a mangrove species in curing and preventing disease.

3. RESULTS AND DISCUSSIONS

3.1. Mangrove Species Diversity

The mangrove forest of Lampung Timur comprises 22 species from 12 families (Table 1). Of the 22 species, 12 are true mangroves, while 10 are mangrove associates. Of the 12 true mangroves, the majority (10 species) are major mangroves, while the other two are minor mangroves.

The mangrove vegetation in Lampung Timur has moderate species diversity, with a diversity index value of 1.9580. The diversity tends to be higher than in the three other mangrove centers area in Lampung province, as well as in Pulau Rambut Wildlife Reserve, Kepulauan Seribu, Jakarta (9 species, H' = 1.23) [18][19]. A comparison of the number of species and diversity index of mangroves in different areas of the Mangrove Centre is presented in Table 2. The diversity of species in the Lampung Timur Coastal tends to be higher than other regions in Lampung Province due to two main factors: site status and anthropogenic factors. The

Table 2. Comparison of the Number of Species, and Diversity Index of Mangroves in Different Areas of the Mangrove Centre [18][19].

Region	Number of species	Mangrove diversity index (H')
Lampung Timur	22	1.9580
Pesawaran	21	1.9318
Lampung Selatan	11	0.9003
Tulang Bawang	12	1.2402
Kepulauan Seribu, Jakarta	9	1.2300

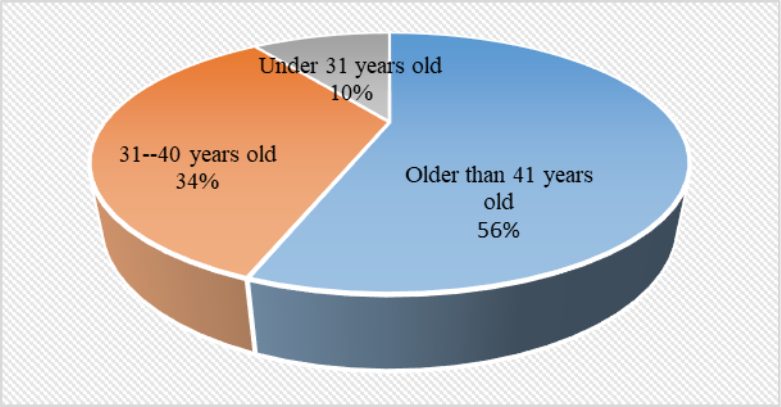

Figure 3. The user of mangrove plants as herbal medicine based on age categories.

condition of mangrove forests is closely related to habitat factors (soil, tidal inundation, salinity, erosion, addition of sandy land, and river conditions) and human activities [20].

The Lampung Timur Coast is situated on the eastern coast of Lampung, adjacent to the Java Sea. The average monthly current in this area is moderate, with a range of 0–45 cm/s. The Lampung Timur Coast is the estuary of two significant rivers, namely Way Sekampung (with a watershed area of 483,850.29 ha) and Way Penet (with a watershed area of 181,702.46 ha) [21]. The two principal river mouths in Lampung Timur discharge a considerable quantity of silt and sedimentary matter, as well as freshwater, from extensive catchment areas. The East Coastal Region of Lampung is characterized by a sloping beach due to the presence of suspended solids carried by the river, which settle and sedimentate, forming the seabed. Some of the major rivers that empty into the East Coast of Lampung are the Way Sekampung (discharge 52 m^3/s, total suspended solids (TSS) 22 mg/L, and total sediment of 81,993.60 tons/year), Tulang Bawang (discharge 195 m^3/s, TSS 28.7 mg/L, and total sediment of 1,227,381. The rivers Mesuji (discharge 320 m^3/s, TSS 60.5 ml/L, and total sediment 634,662 tons/year), Way Penet (discharge 20 m^3/s, TSS 48 mg/L and total sediment of 30,274.56 ton/year), and Way Seputih (discharge 50 m^3/s, TSS 13 mL/L, and total sediment of 20,416.40 ton/year) [22][23] contribute 12 tons/year, 320 m^3/s, 60.5 mL/L, and 634,662 tons/year, respectively, to the total sediment load of the East Coast of Lampung. The East Coast of Lampung is an appropriate location for mangrove growth, given its site factor status. The confluence of a substantial volume of freshwater, sediment influx, and moderate ocean currents represents an optimal environment for mangrove growth. Mangroves are an ecological system of coastal and estuary areas that receive nutrients and sediment from the terrestrial environment [24].

The favorable site factor on the east coast of Lampung should have the potential for high diversity. However, the H' value in the region is only categorized as moderate. This is comparable to the Pesawaran Coastal Area, which has no large estuary. It is thought to be related to the second factor influencing the mangroves' status, namely anthropogenic factors. As previously stated in the Lampung Coastal Area Resource Atlas [25], the majority of the coastal area along the coast of East Lampung (not included in the Way Kambas National Park) has been converted from swamps and mangrove forests to rice fields and shrimp ponds. This is in accordance with the opinion of Romañach et al. [26], who posit that the conversion of mangrove habitats for agriculture and fisheries is the primary factor contributing to mangrove loss. A reduction in mangrove forest land cover of 88.73% was observed in the Margasari Village, Lampung Timur, between 1973 and 1994, while a reduction of 92.08% was observed in the Pasir Sakti Village, Lampung Timur, between 1983 and 2004 [27]. The loss of the majority of the mangrove forest area has resulted in the loss of a considerable amount of biodiversity.

Deforestation and anthropogenic pollution were identified as the two primary causes of mangrove loss on the East Coast of Lampung [28]. Mangrove deforestation is a consequence of land conversion for housing, industry, and aquaculture [29]. Changes in land use have resulted in the loss of

numerous mangrove species. Deforestation has contributed to the decline in species diversity and populations, as well as the impairment of environmental services [30]. Over the past three decades, the aquaculture industry has emerged as the primary driver of mangrove deforestation in Southeast Asia. At least 60,000 ha of mangrove forests in Indonesia have been lost due to the expansion of the shrimp farming industry [28].

3.2. Medical Uses of Mangrove Plants

Mangrove plants continue to be utilized by the coastal community of Lampung Timur as a source of herbal medicine, thereby demonstrating that the practice of employing mangroves as a medicinal plant persists within the community. However, the majority of mangrove users are from the older generation (over 41 years old), some are from the middle adult generation (31–40 years old), and only a few are from the younger generation (under 31 years old) (Figure 3). The limited portion of the younger generation still using mangroves for herbal medicine indicates that mangrove herbal medicines in Lampung Timur are becoming unpopular among this demographic. The loss of this cultural knowledge within society is evidenced by the fact that the younger generation no longer practices the cultural heritage that has been passed down through the generations. This phenomenon is observed globally, with indigenous peoples and rural communities losing their knowledge of medicinal plants [31]. Lawrence et al. [32] also noted that in the Central Ugandan region, the younger generation is less interested in using medicinal plants, a trend that dispels the older generation. A similar phenomenon was observed in Wakaroni, Ecuador, where the older generation generally possesses superior knowledge regarding herbal medicine, which is not being passed down to the younger generation [33].

A majority of the 64% of individuals who utilize mangroves as a medicinal resource are male. This phenomenon is believed to be associated with male interaction and the acquisition of knowledge about mangroves. Communities with a high level of interaction and knowledge about mangroves are those whose members engage in fishing or whose livelihoods are dependent on the sea. The majority of fishermen in Lampung Timur are male. This is believed to be the cause of men's superior knowledge about mangroves as medicinal herbs compared to women. The findings of this study align with those of Hanazaki et al. [34], as evidenced by the results obtained in several communities in the Brazilian Atlantic rainforest. It can be observed that men tend to possess a greater understanding of medicinal plants than women. This apparent discrepancy in knowledge is likely because men in these communities tend to have more frequent interactions with the surrounding forest. However, the results of this study diverge from those reported by Voeks and Leony [35] and Quinlan and Quinlan [36], which indicated that women possess a more comprehensive understanding of medicinal plants than men. In various communities, social construction has placed women as the primary responsibility for health within the family, which has resulted in their knowledge regarding medicinal plants being superior to that of men. Furthermore, Camou-

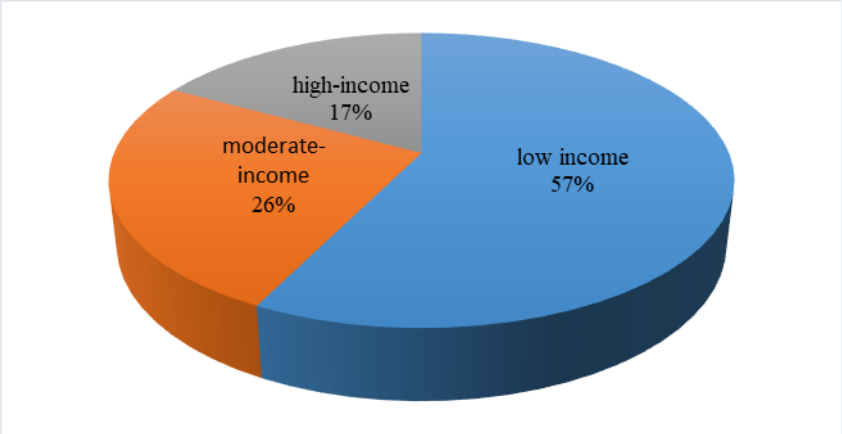

Figure 4. The use of mangrove plants as herbal medicine based on economic class categories.

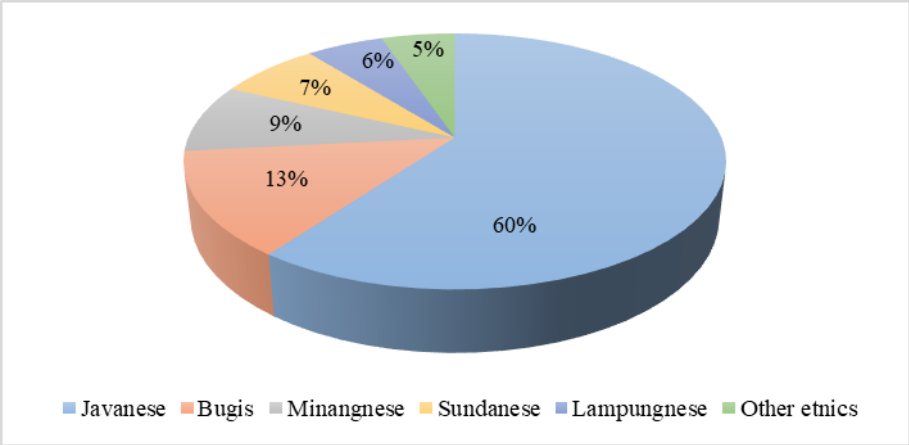

Figure 5. The use of mangrove plants as herbal medicine based on ethnicity.

Guerrero et al. [37] argued that many women's activities carried out in the yard made them directly related to plants, which would indirectly increase their knowledge regarding medicinal plants.

The Central Bureau of Statistics Indonesia's criteria indicates that the majority of users of mangrove plants as herbal medicine in Lampung Timur are categorized as low-income (100–167 USD/month), with a smaller proportion classified as moderate-income (168–233 USD/month) and only a small number identified as high-income (more than 233 USD/month) (Figure 4). The utilization of mangroves as herbal medicine by low-income individuals is related to their purchasing power. Low-income individuals generally have low purchasing power capacity, which precludes them from affording high-priced manufactured medicines. To overcome health problems, this group of people utilize resources that can be obtained free of charge or at low prices. In addition to being low-cost, mangroves as medicinal plants are also easier to reach because they are found around the settlement. The preference for herbal medicines among communities is influenced by four essential factors: low cost, ease of access, cultural acceptance, and limited access to medical services [38]. Conversely, for middle and high-income individuals, the efficacy and lower side effects of herbal medicines are believed to be the primary reasons for their preference for these products. Galabuzi et al. [39] posit that the preference for herbal medicines is not solely driven by their low prices, but also by the belief in their superior efficacy or lower side effects.

Based on ethnicity, the majority of users of mangrove plants as herbal medicine are Javanese, followed by the Bugis, Minangnese, Sundanese, Lampungnese, and other ethnic groups, respectively (Figure 5). There are two main reasons why the Javanese become the most significant users of mangrove herbal medicinal products. The first reason is because the Javanese are the largest ethnic group in Lampung Province. According to data from Statistics Indonesia [40], the Javanese are the largest ethnic group in Lampung Province, followed by the Lampungnese, Sundanese, Malay, and Balinese, with respective percentages of 64.17%, 13.56%, 11.88%, 5.64%, and 1.38%. The second reason for the prevalence of Javanese culture in Lampung Province is the long-standing tradition of using plants for healing, health care, beauty treatments, tonics, and health drinks. This practice has been passed down from generation to generation, with the Javanese people using herbal concoctions, known as "jamu," to prevent and cure various diseases [41].

A noteworthy finding of the study is the high prevalence of Bugis individuals who utilize mangroves as herbal medicine. Despite their relatively low representation in the top five ethnic groups in Lampung Province, Bugis individuals have emerged as the second largest proportion of users of mangroves as medicinal herbs. This phenomenon is believed to be associated with the cultural and traditional practices of the Bugis, an ethnic group whose cultural heritage is closely tied to the sea. The Bugis ethnic group has a more nuanced and nimbler interaction with marine resources, including mangroves, than other ethnic

groups. The Bugis are renowned for their dependable skills as fishermen and sea explorers. In accordance with Patji's [42] assertion, the Bugis have developed superior abilities in catching fish and utilizing other marine resources.

3.3. Bioactivity of Mangrove Plants

Mangrove species used as herbal medicine by the Lampung Timur Coastal community are *A. marina, A. ilicifolius, R. apiculate, R. mucronata,* and *S. caseolaris*. Of the five species, *A. marina* is the most popular and widely used species (Table 3). The mangrove species most commonly utilized by coastal communities as herbal medicine is *A. marina*. Two factors are believed to have contributed to the popularity of *A. marina* as a herbal medicine on the Lampung Timur Coast. The first factor is that the species has the widest distribution and is the most dominant species in the region. Ramadhan et al. [43] reported that *A. marina* is a dominant species in the Margasari Village, Lampung Timur, with an IVI of 194%. The second factor is the community's empirical experience of the efficacy of *A. marina*, in line with various scientific studies that have proven that *A. marina* contains many bioactive compounds. Rodiani et al. [18] reported that 49 bioactive compounds have been identified in various tissues of *A. marina*. This indicates that the species has a wide range of medicinal benefits. Jacoeb et al. [44] reported that *A. marina* leaves contain various bioactive components, namely flavonoids, steroids, and reducing sugars, which are useful in pharmaceuticals and health.

The medical properties of mangrove plants ascribed to the coastal communities of Lampung Timur differ from several ethnopharmacological reports on the use of mangroves in other regions. The inhabitants of Lampung Timur utilize *R. apiculata* as an antipyretic, whereas the same species is employed as a wound medicine and antiseptic by the coastal community of Pesawaran [45]. The Lampung Timur Coastal community utilizes *A. marina* as a wound medicine (antiseptic), source of vitamins, and anti-allergy (anti-histamine). These properties differ slightly from the reports of Chandrakala and Rajeswari [46] and Bandranayake [47], which indicate that the community in India has empirically used *A. marina* for the treatment of rheumatism, ulcers, smallpox, and skin diseases. Empirical evidence from various community groups has demonstrated outcomes that diverge from the findings of scientific studies on the bioactive potential of *A. marina*. A review by Genilar et al. [48] indicates that *A. marina* contains glycosides that are efficacious as analgesics, antivirals, and antifungals. The diverse medicinal properties of *A. marina*, as evidenced by the disparate findings in this area, suggest that the species offers a wide range of benefits as an herbal medicine. Empirical evidence indicates that there are regional variations in the perceived medicinal properties of *A. marina*. These variations are also observed in scientific studies. However, the bioactive content of *A. marina* allows for the scientific validation of the empirical findings.

A. ilicifolius contains several bioactive compounds, including alkaloids, benzoxazinoids, phenylethanoids, lignans, flavonoids, megastigmanes, fatty acids, and aliphatic alcohol glycosides [49]. The Lampung Timur Coastal community utilizes the species for the treatment of rheumatism and muscle pain. These medical properties align with the findings of Patel et al.

Table 3. The use of mangrove species as medicinal plants in Lampung Timur Coast.

No	Species	Part (tissue)	Efficacy
1	*marina*	leaf	wound medicine/antiseptic and source of vitamin
2	*A. marina*	fruit	anti-allergy/antihistamines
3	*A. ilicifolius*	leaf	anti-rheumatism and muscle aches medicine/analgesic
4	*R. apiculata*	leaf	antipyretic
5	*R. mucronata*	root	to increase stamina / vitality
6	*S. caseolaris*	fruit	anti-cholesterol anti-oxidant

[49]. *A. ilicifolius* has been demonstrated to possess anti-rheumatic properties. Additionally, the species is efficacious as a pain reliever and purifying agent of the blood [50]. However, the use of the species by the Lampung Timur Coastal Community differs from several empirical practices observed in other regions. These include the use as a medicine for asthma, diabetes, hepatitis, skin diseases, neuralgia, poisoned arrow wounds, alopecia, leucorrhoea, paralysis and asthma, snake bites, colds, dermatitis, astringent, expectorant and stimulant. From a scientific perspective, the species exhibits antiviral and antidiabetic properties, attributed to the presence of alkaloids and saponins [48].

R. apiculata contains various bioactive compounds, including alkaloids (Wagner, Mayer, dragendorff), steroids, saponins, tannins, phenols, and flavonoids [51]. Empirically, the Lampung Timur Coastal community uses the species as an antipyretic agent. The medical properties are different from what has been practised empirically by people in various parts of the world, namely as anti-elephantiasis, ulcers, hematoma, hepatitis, and febrifuge [48]; slimming, anti-diarrheal, and anti-vomiting agents [52]. Scientifically, the species is indicated to be anti-inflammatory, antitumor, anti-viral, and antibacterial thanks to the content of flavonoids, 4-pyrrolidinyl, ketone, and pyrazole derivatives [48], antifungal, antiseptic, anti-inflammatory, anti-ulcer, and wound healing agents [52].

R. mucronata contains various bioactive compounds, including alkaloids (Wagner, Mayer, dragendorff), steroids, saponins, tannins, phenols, and flavonoids [51]. Traditionally, the coastal communities of Lampung Timur use the species to increase stamina/vitality. The medical properties are different from what has been practised empirically by people in various parts of the world, namely as an antipyretic, anti-malarial, and cholera drug [48]; elephantiasis, hematoma, hepatitis, ulcers, and as a fever [47]. Scientifically, the species has the medical properties potential as an anti-viral thanks to the content of flavonoids, alkaloids, sulfate polysaccharides [48]; antifungal [52]; and hematuria [53].

S. caseolaris contains various bioactive compounds, namely phenolics, flavonoids, tannins, alkaloids, and saponins [54]. The species is believed to have anti-cholesterol and anti-oxidant properties by the Lampung Timur Coastal community. In contrast to coastal communities in other areas, which utilize the bark and leaves of *S. caesolaris*, the Lampung Timur Coastal community believes that the fruit contains more nutritious bioactive compounds. The use of fruit as a medicinal material is in line with the report by Ahmed et al. [55] the fruit of *S. caesolaris* contains steroid, terpenoid, and flavonoid phytochemicals. Phytochemical compounds such as flavanoids are anti-oxidants that neutralize free radicals, which can potentially cause cancer, heart attacks, and premature aging. Scientifically, the bioactive components in *S. caesolaris* are effective as anti-analgesic, anti-inflammatory [54], anti-oxidant, cytotoxic, and antibacterial [56].

The study revealed that the practice of utilizing mangroves as herbal medicine exists and develops within the lives of the East Lampug Coastal community. This finding has several significant implications, both in terms of scientific, economic, cultural, and public health, as well as environmental preservation. The existence of ethnopharmacological practices can facilitate the discovery of new active compounds with the potential to be developed into modern medicine. A significant proportion of contemporary pharmaceuticals are derived from natural compounds that were initially identified through ethnopharmacological studies [57]. Furthermore, the recognition and documentation of ethnopharmacological practices play a social and cultural role in helping to preserve traditional knowledge that is often endangered [58]. From an economic perspective, the discovery of new medicinal compounds from plants can stimulate the growth of the pharmaceutical industry, creating new investment and employment opportunities [57]. From a health perspective, the promotion of ethnopharmacological practices can facilitate greater access to affordable and culturally appropriate health solutions [59]. The utilization of medicinal plants can facilitate the conservation of natural habitats and biodiversity, as they are recognized for their economic and scientific value [31].

The study conducted in this research is still limited to the use of plant species, parts of the plant,

and the properties believed by the community. This research has not yet documented comprehensively the ethnopharmacological practices related to mangroves. This includes examining how the plants are processed and prepared before use, how they are administered and dosed, the expected effects or properties, healing rituals or ceremonies, treatment taboos, and the relationship between ethnicity and ethnopharmacological practices. Consequently, a comprehensive study of mangrove-related ethnopharmacology on the Coast of East Lampung is required to comprehensively document ethnopharmacological practices, thus establishing a holistic traditional treatment method. Ethnopharmacological information on phytochemical content and medicinal properties through the profiling of bioactive compounds is important. This advanced study is crucial for the elucidation of the chemical composition and the discovery of the spectrum of bioactive compounds that contribute to the medicinal properties of the subject matter. It is therefore essential to gain an understanding of the profile of these compounds to validate the efficacy and safety of herbal remedies and provide a scientific basis for their traditional use.

4. CONCLUSIONS

The mangrove forest on Lampung Timur Coastal comprises 22 species from 12 families, i.e., 12 are true mangroves (10 major mangroves and 2 minor mangroves), and the remaining 10 are mangrove associates. The diversity index of the Lampung Timur mangrove forest is categorized as moderate (H' = 1.9580). The community uses various plant species for medicinal purposes. Among the users of mangrove herbal medicine, the majority (55.71%) are from the older generation. Additionally, 64% of users are male, 57.37% are categorized as low-income, and 60.12% identify as Javanese based on ethnicity. *A. marina* is used as an antiseptic, anti-histamine, and source of vitamins. *A. ilicifolius* is used as an anti-rheumatism and muscle ache medicine/analgesic. *R. apiculata* is used as an antipyretic, *R. mucronata* is used to increase stamina/vitality, and Soneratia caseolaris is used as an anti-cholesterol and anti-oxidant.

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Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] V. H. Heywood. (2011). "Ethnopharmacology, food production, nutrition and biodiversity conservation: towards a sustainable future for indigenous peoples". *Journal of Ethnopharmacology.* **137** (1): 1-15. 10.1016/j.jep.2011.05.027.

[2] D. K. Attuaquayefio and J. N. Folib. (2009). "An overview of biodiversity conservation in Ghana: Challenges and prospects". *West African Journal of Applied Ecology.* **7** (1). 10.4314/wajae.v7i1.45621.

[3] M. Chai, R. Li, B. Li, H. Wu, and L. Yu. (2023). "Responses of mangrove (Kandelia obovata) growth, photosynthesis, and rhizosphere soil properties to microplastic pollution". *Marine Pollution Bulletin.* **189** : 114827. 10.1016/j.marpolbul.2023.114827.

[4] K. Sak. (2023). "Role of Flavonoids as Potential Plant Fungicides in Preventing Human Carcinogenesis: A Short Communication". *Bioactivities.* **1** (2): 39-42. 10.47352/bioactivities.2963-654X.187.

[5] Y. S. Kurniawan, T. Indriani, H. Amrulloh, L. C. Adi, A. C. Imawan, K. T. A. Priyangga, and E. Yudha. (2023). "Journey of Natural Products: From Isolation Stage to Drug's Approval in Clinical Trials". *Bioactivities.* **1** (2): 43-60. 10.47352/bioactivities.2963-654X.190.

[6] R. Ranganathan, S. Kumaravel, and R. Vinoth. (2019). "Therapeutic and Traditional Uses of Mangrove Plants". *Journal of Drug Delivery and Therapeutics.* **9** (4-s): 849-854. 10.22270/jddt.v9i4-s.3457.

[7] M. Basyuni, S. D. Sasmito, K. Analuddin, T. Z. Ulqodry, M. F. Saragi-Sasmito, S. Eddy, and N. Milantara. (2022). In: "Mangroves: Biodiversity, Livelihoods and Conservation, ch. Chapter 16". 397-445. 10.1007/978-981-19-0519-3_16.

[8] Tarlani and T. Sirajuddin. (2020). "Rural development strategies in Indonesia: Managing villages to achieve sustainable development". *IOP Conference Series: Earth and Environmental Science.* **447** (1). 10.1088/1755-1315/447/1/012066.

[9] R. P. Mamengko and E. D. Kuntari. (2021). "Pengelolaan Pariwisata Bahari berbasis Community-Based Tourism dalam Peningkatan Ekonomi Masyarakat Pesisir". *Media Wisata.* **18** (1): 1-20. 10.36276/mws.v18i1.72.

[10] H. Hardiansyah and N. Noorhidayati. (2020). "Keanekaragaman Jenis Pohon pada Vegetasi Mangrove di Pesisir Desa Aluh-Aluh Besar Kabupaten Banjar". *Wahana-Bio: Jurnal Biologi dan Pembelajarannya.* **12** (2). 10.20527/wb.v12i2.9540.

[11] A. S. Downing, E. H. van Nes, W. M. Mooij, and M. Scheffer. (2012). "The resilience and resistance of an ecosystem to a collapse of diversity". *PLoS One.* **7** (9): e46135. 10.1371/journal.pone.0046135.

[12] R. Badola, S. Barthwal, and S. A. Hussain. (2012). "Attitudes of local communities towards conservation of mangrove forests: A case study from the east coast of India". *Estuarine, Coastal and Shelf Science.* **96** : 188-196. 10.1016/j.ecss.2011.11.016.

[13] E. Oprasmani, T. Amelia, and E. Muhartati. (2020). "Membangun Masyarakat Peduli Lingkungan Pesisir Melalui Edukasi Kepada Masyarakat Kota Tanjungpinang Terkait Pelestarian Daerah Pesisir". *To Maega : Jurnal Pengabdian Masyarakat.* **3** (2). 10.35914/

tomaega.v3i2.372.

[14] D. Damsir, A. Ansyori, Y. Yanto, S. Erwanda, and B. Purwanto. (2023). "Pemetaan Areal Mangrove Di Provinsi Lampung Menggunakan Citra Sentinel 2-a Dan Citra Satelit Google Earth". *Jurnal Pengabdian Kolaborasi dan Inovasi IPTEKS.* **1** (3): 207-216. 10.59407/jpki2.v1i3.37.

[15] H. Kaskoyo, A. Mohammed, and M. Inoue. (2017). "Impact of community forest program in protection forest on livelihood outcomes: A case study of Lampung Province, Indonesia". *Journal of Sustainable Forestry.* **36** (3): 250-263. 10.1080/10549811.2017.1296774.

[16] W. Giesen, S. Wulffraat, M. Zieren, and L. Scholten.(2007)." Mangrove guidebook for Southeast Asia". FAO Regional Office for Asia and the Pacific.

[17] W. L. Strong. (2016). "Biased richness and evenness relationships within Shannon–Wiener index values". *Ecological Indicators.* **67** : 703-713. 10.1016/j.ecolind.2016.03.043.

[18] Rodiani, Duryat, T. Maryono, and D. A. Ramdini. (2023). "Avicennia Marina: A Natural Resource for Male Anti-Fertility in Family Planning". *International Journal of Design & Nature and Ecodynamics.* **18** (5): 1077-1085. 10.18280/ijdne.180508.

[19] C. Kusmana and N. A. Azizah. (2022). "Species composition and Vegetation Structure of Mangrove Forest in Pulau Rambut Wildlife Reserve, Kepulauan Seribu, DKI Jakarta". *IOP Conference Series: Earth and Environmental Science.* **950** (1). 10.1088/1755-1315/950/1/012020.

[20] C. P. Ghosh S. (2015). "A Review of Threats and Vulnerabilities to Mangrove Habitats: With Special Emphasis on East Coast of India". *Journal of Earth Science & Climatic Change.* **06** (04). 10.4172/2157-7617.1000270.

[21] M. Purba and I. Jaya. (2004). "Analisis perubahan garis pantai dan penutupan lahan antara Way Penet dan Way Sekampung, Kabupaten Lampung Timur". *Jurnal Ilmu-Ilmu Perairan dan Perikanan Indonesia.* **11** (2): 109-121.

[22] D. R. Romlah, S. B. Yuwono, R. Hilmanto, and I. S. Banuwa. (2018). "Pengaruh Perubahan Tutupan Hutan Terhadap Debit Way Seputih Hulu". *Jurnal Hutan Tropis.* **6** (2). 10.20527/jht.v6i2.5408.

[23] Y. Yulma, E. M. Adiwilaga, and Y. Wardiatno. (2013). "Contribution of organic material from white mangrove (Avicennia marina) to evaluate mangrove ecosystem management: Case Study of Labuhan Maringgai, East Lampung". *International Journal of Bonorowo Wetlands.* **3** (1): 12-29. 10.13057/bonorowo/w030102.

[24] P. Bunting, A. Rosenqvist, R. M. Lucas, L.-M. Rebelo, L. Hilarides, N. Thomas, A. Hardy, T. Itoh, M. Shimada, and C. M. Finlayson. (2018). "The Global Mangrove Watch—A New 2010 Global Baseline of Mangrove Extent". *Remote Sensing.* **10** (10). 10.3390/rs10101669.

[25] N. Simarmata, N. Nurisman, and T. Tarigan. (2019). "Identification of Coastal Problem along the East Coast of Lampung Indonesia". the Proceedings of the 7th International Seminar on Ocean and Coastal Engineering, Environmental and Natural Disaster Management.

[26] S. S. Romañach, D. L. DeAngelis, H. L. Koh, Y. Li, S. Y. Teh, R. S. Raja Barizan, and L. Zhai. (2018). "Conservation and restoration of mangroves: Global status, perspectives, and prognosis". *Ocean & Coastal Management.* **154** : 72-82. 10.1016/j.ocecoaman.2018.01.009.

[27] Yuliasamaya, A. Darmawan, and R. Hilmanto. (2014). "Perubahan Tutupan Hutan Mangrove Di Pesisir Kabupaten Lampung Timur". *Jurnal Sylva Lestari.* **2** (3). 10.23960/jsl32111-124.

[28] M. Ilman, P. Dargusch, P. Dart, and Onrizal. (2016). "A historical analysis of the drivers of loss and degradation of Indonesia's mangroves". *Land Use Policy.* **54** : 448-459. 10.1016/j.landusepol.2016.03.010.

[29] J. H. Primavera. (2005). "Global voices of science: Mangroves, fishponds, and the quest for sustainability". *Science.* **310** (5745): 57-

9. 10.1126/science.1115179.
[30] I. Nordhaus, M. Toben, and A. Fauziyah. (2019). "Impact of deforestation on mangrove tree diversity, biomass and community dynamics in the Segara Anakan lagoon, Java, Indonesia: A ten-year perspective". *Estuarine, Coastal and Shelf Science.* **227**. 10.1016/j.ecss.2019.106300.
[31] A. C. Hamilton. (2004). "Medicinal plants, conservation and livelihoods". *Biodiversity and Conservation.* **13** (8): 1477-1517. 10.1023/b:Bioc.0000021333.23413.42.
[32] D. Lawrence, H. Smith, E. Magala, and M. Cooper. (2014). "Young people's opinions about herbal medicines in a suburban district of Central Uganda". *International Health.* **6** (4): 337-8. 10.1093/inthealth/ihu036.
[33] H. Weckmüller, C. Barriocanal, R. Maneja, and M. Boada. (2019). "Factors Affecting Traditional Medicinal Plant Knowledge of the Waorani, Ecuador". *Sustainability.* **11** (16). 10.3390/su11164460.
[34] N. Hanazaki, J. Y. Tamashiro, H. F. Leitão-Filho, and A. Begossi. (2000). "Diversity of plant uses in two Caiçara communities from the Atlantic Forest coast, Brazil". *Biodiversity and Conservation.* **9** (5): 597-615. 10.1023/a:1008920301824.
[35] R. A. Voeks and A. Leony. (2004). "Forgetting the Forest: Assessing Medicinal Plant Erosion in Eastern Brazil". *Economic Botany.* **58** (sp1): S294-S306. 10.1663/0013-0001(2004)58[s294:Ftfamp]2.0.Co;2.
[36] R. J. Quinlan and M. B. Quinlan. (2016). "Evolutionary Ecology of Human Pair-Bonds". *Cross-Cultural Research.* **41** (2): 149-169. 10.1177/1069397106298893.
[37] A. Camou-Guerrero, V. Reyes-García, M. Martínez-Ramos, and A. Casas. (2007). "Knowledge and Use Value of Plant Species in a Rarámuri Community: A Gender Perspective for Conservation". *Human Ecology.* **36** (2): 259-272. 10.1007/s10745-007-9152-3.
[38] E. Rutebemberwa, M. Lubega, S. K. Katureebe, A. Oundo, F. Kiweewa, and D. Mukanga. (2013). "Use of traditional medicine for the treatment of diabetes in Eastern Uganda: a qualitative exploration of reasons for choice". *BMC International Health and Human Rights.* **13** : 1. 10.1186/1472-698X-13-1.
[39] C. Galabuzi, J. G. Agea, B. L. Fungo, and R. M. Kamoga. (2009). "Traditional medicine as an alternative form of health care system: a preliminary case study of Nangabo sub-county, central Uganda". *African Journal of Traditional, Complementary and Alternative Medicines.* **7** (1): 11-6. 10.4314/ajtcam.v7i1.57224.
[40] A. Q. Zaelani, F. Faisal, M. S. Fajar, and A. Hanif. (2023). "An Implementation of the Joint Inheritance Division of Ethnic Groups in Lampung, Indonesia". *Samarah: Jurnal Hukum Keluarga dan Hukum Islam.* **7** (3). 10.22373/sjhk.v7i3.9125.
[41] S. Yoshimi, H. Triana, and R. Katrin. (2023). "Relationship between Customers and Jamu Gendong in Central Java, Indonesia: Focusing on the Use of Herbal Beverages in Daily Life". *People and Culture in Oceania.* **38** : 51-67. 10.32174/jsos.38.0_51.
[42] A. R. Patji. (2009). "Makassar Nama Kolektif: Masyarakat Migran Sulawesi Selatan di Alor Kecil, Kabupaten Alor, Nusa Tenggara Timur". *Jurnal Masyarakat dan Budaya.* **11** (2): 151-175.
[43] M. F. Ramadhan, D. Duryat, A. Darmawan, A. Bintoro, and R. Qurniati. (2020). "Struktur Vegetasi Hutan mangrove di Desa Sidodadi Kecamatan Teluk Pandan Kabupaten Pesawaran Provinsi Lampung". *Proceeding of Seminar Nasional Konservasi.*
[44] A. M. Jacoeb, S. Purwaningsih, and R. Rinto. (2011). "Anatomi, Komponen Bioaktif Dan Aktivitas Antioksidan Daun Mangrove Api-Api (Avicennia marina)". *Jurnal Pengolahan Hasil Perikanan Indonesia.* **14** (2): 143-152. 10.17844/jphpi.v14i2.5323.
[45] Duryat, Rodiani, and T. Maryono. (2023). "Mangroves species diversity and their use as medicinal plants by coastal communities of Pesawaran Lampung". *IOP Conference Series: Earth and Environmental Science.* **1255** (1). 10.1088/1755-1315/1255/1/012027.

[46] N. Chandrakala and S. Rajeswari. (2017). "Medicinal potentials and bioactive compounds from mangroves-A Review". *International Journal Of Current Innovation Research.* **3** (2): 572-576.

[47] W. M. Bandaranayake. (2002). "Bioactivities, bioactive compounds and chemical constituents of mangrove plants". *Wetlands Ecology and Management.* **10** (6): 421-452. 10.1023/a:1021397624349.

[48] L. A. Genilar, E. Kurniawaty, R. A. Mohd-Mokhtar, and K. A. Audah. (2021). "Mangroves and Their Medicinal Benefit: A Mini Review". *Annals of the Romanian Society for Cell Biology.* **25** (4): 695-709.

[49] R. Patel, N. Patel, K. Patel, M. Patel, K. Patel, P. Verma, and M. Shah. (2022). "Acanthus ilicifolius: A True Mangrove with Biomedical Potential World". *Journal of Pharmacy and Pharmaceutical Science.* **9** (11): 472-489.

[50] P. Lalitha, V. Sachithanandam, N. S. Swarnakumar, and R. Sridhar. (2019). "Review on Anti-inflammatory Properties of Mangrove plants". *Asian Journal of Pharmaceutical Research.* **9** (4). 10.5958/2231-5691.2019.00045.5.

[51] S. Egra, H. Kuspradini, I. W. Kusuma, I. Batubara, I. Imra, N. Nurjannah, E. Wahyuni, K. Yamauchi, and T. Mitsunaga. (2023). "Potential of prospective medicinal plants of Rhizophoraceae from North Kalimantan, Indonesia". *Biodiversitas Journal of Biological Diversity.* **24** (3). 10.13057/biodiv/d240303.

[52] M. A. Wardina, S. Mustofa, and A. N. T. A. Malarangeng. (2023). "Review Article: Potential of Rhizophora apiculata As Phytopharmaca". *Medula.* **13** (2): 137-146. 10.53089/medula.v13i2.620.

[53] T. Warningsih, D. Efizon, N. Aulia, and D. Deviasari. (2022). "Economic value of carbon in mangrove ecosystem of Cawan Island, Indragiri Regency, Riau, Indonesia". *IOP Conference Series: Earth and Environmental Science.* **1118** (1). 10.1088/1755-1315/1118/1/012080.

[54] P. Kundu, S. L. Debnath, H. S. Devnath, L. Saha, and S. K. Sadhu. (2022). "Analgesic, Anti-inflammatory, Antipyretic, and In Silico Measurements of Sonneratia caseolaris (L.) Fruits from Sundarbans, Bangladesh". *BioMed Research International.* **2022** 1405821. 10.1155/2022/1405821.

[55] R. Ahmed, S. J. Moustami, H. Ahmed, M. Ali, W. M. Haq, R. Jahan, and M. Rahmatullah. (2010). "Serum glucose and lipid profiles in rats following administration of Sonneratia caseolaris (L.) Engl. (Sonneratiaceae) leaf powder in diet". *Journal Advance in Natural and Applied Science.* **4** (2): 171-173.

[56] B. Bokshi. (2020). "Bioactivities of Sonneratia Caseolaris (Linn) Leaf and Stem Using Different Solvent Systems". *Biomedical Journal of Scientific & Technical Research.* **31** (5). 10.26717/bjstr.2020.31.005175.

[57] M. Yadav, S. Chatterji, S. K. Gupta, and G. Watal. (2014). "Preliminary phytochemical screening of six medicinal plants used in traditional medicine". *International Journal of Pharmacy and Pharmaceutical Sciences.* **6** (5): 539-42.

[58] N. Singh, R. Srivastava, T. Kanda, S. Yadav, R. Prajapati, S. Yadav, K. N. Tiwari, and N. Atri. (2023). "Essential Oils: A "Potential Green" Alternative in Pharmaceutical, Nutritional and Agricultural Sectors". *Bioactivities.* **2** (1): 1-23. 10.47352/bioactivities.2963-654X.197.

[59] R. R. Alves and I. M. Rosa. (2007). "Biodiversity, traditional medicine and public health: where do they meet?". *Journal of Ethnobiology and Ethnomedicine.* **3** : 14. 10.1186/1746-4269-3-14.