

Review: Phytochemical composition, medicinal uses and other utilization of *Nypa fruticans*

**GILANG DWI NUGROHO^{1,2}, MUHAMMAD FIRDAUS WIRAATMAJA³,
PUTRI SEGI PRAMADANINGTYAS³, SARAH FEBRIYANTI³, NOR LIZA^{1,2}, DARLINA MD. NAIM⁴,
YAYA IHYA ULUMUDDIN⁵, AHMAD DWI SETYAWAN^{3,6,✉}**

¹Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia

²Biodiversity Study Club, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia.

³Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ✉email: volatileoils@gmail.com

⁴School of Biological Sciences, Universiti Sains Malaysia. 1112, Persiaran Sains, 11800 Gelugor, Pulau Pinang, Malaysia

⁵Research Center for Oceanography, Indonesian Institute of Sciences. Jl. Pasir Putih I, Ancol Timur, North Jakarta 14430, Jakarta, Indonesia

⁶Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami No. 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 21 January 2020. Revision accepted: 1 May 2021.

Abstract. Nugroho GD, Wiraatmaja MF, Pramadaningtyas PS, Febriyanti S, Liza N, Naim DM, Ulumuddin YI, Setyawan AD. 2020. Review: Phytochemical composition, medicinal uses and other utilization of *Nypa fruticans*. *Bonorowo Wetlands* 10: 51-65. *Nypa fruticans* Wurmb or “*nipa/nipah*” is a palm plant in mangrove ecosystems along tropical and subtropical river estuaries affected by tides. *Nypa* has a high abundance in the mangrove forest ecosystem. Therefore, knowledge and utilization of this *nypa* plant need to be sought and examined more deeply to optimize its utilization. This review aims to find out the phytochemical composition, medicinal uses, and other utilization of *nypa* plants. The main phytochemical composition of *nypa* is polyphenols, phenolics, alkaloids, tannins, flavonoids, and saponins. However, other chemical compounds such as ethyl acetate, chloroform, hexane, triterpenoids, phenol hydroquinone, diterpenes, and steroids are still available. The many chemical compounds in *nypa* can be used as raw materials in a product, especially in modern medicines. Based on people's beliefs in several tropical countries that *nypa* has the potential of herbal medicine to treat fever, gout, kidney stones, energy booster, aid digestion, as a cure for certain chronic diseases and metabolic syndromes such as diabetes and hypertension, treat asthma, leprosy, tuberculosis, sick throat, liver disease, snakebite, as a pain reliever, and also be used as a sedative and able to expel excess wind in the body. Then in the pharmacological aspect, *nypa* has antioxidant, antidiabetic, antimicrobial (antifungal and antibacterial), anticancer, anti-inflammatory, antinociceptive, antihyperglycemic and analgesic activities. In addition to other benefits outside of drugs, *nypa* is used as a roof for houses, cattle pens, huts in the garden, broomsticks, handicrafts, fishing gear, food and drink sources, and sources of renewable fuel.

Keywords: Mangrove plant, medicine, *Nypa fruticans*, phytochemical, utilization

INTRODUCTION

Mangroves consist of trees, shrubs, palms, or ferns found above sea level in the intertidal zone (Duke et al. 1998; Romañach et al. 2018). Mangroves dominate intertidal sedimentary habitats in the tropics and subtropics. Most mangroves are associated with soft silty sediments on sheltered tropical beaches such as bays, estuaries, and lagoons. Then, unlike other terrestrial or aquatic ecosystems, mangrove ecosystems are unique because they exist in terrestrial, freshwater, and marine environments. Also, mangrove ecosystems are regularly inundated by tides, watered by freshwater, and most of the time inundated by water (Giri et al., 2015; Xaverius et al., 2019; 2020).

Mangroves are one of the most productive ecosystems on earth. Mangroves are one of the natural resources that have various functions and benefits in terms of ecological

and economic aspects. The ecological function of mangroves can be seen from the physical, chemical, and biological aspects (Nyangon et al., 2019). Mangroves are a renewable resource that provides food, shelter, and habitat for various terrestrial and marine fauna (Okugbo et al., 2012; Irwansyah et al., 2021). In addition, various types of products derived from various flora and fauna as well as environmental services, such as effective sediment trapping, shoreline protection from erosion, seawater intrusion control, nutrient recycling, reduction of sea wave height and speed, cleaning of water pollutants, and other things that are very important to support human life (Estoque et al. 2018; Kusmana 2018). The primary productivity of mangroves can exceed tropical terrestrial forests (Alongi, 2014), and their carbon storage is greater than terrestrial forests on a per unit area basis (Donato et al., 2011; Mahli et al., 2011). Although mangrove forests account for only 0.5% of global coastal areas, they can

absorb 14% of the carbon in coastal oceans (Alongi 2014). In addition, mangrove forests also offer many necessities and goods such as food, firewood, and wood (Wulan et al. 2021) and have aesthetic, historical, and cultural values (Grasso 2000).

Mangroves are commonly found along the coasts of tropical and sub-tropical developing countries where coastal populations rely heavily on these forests for their livelihoods. According to Kusmana (2018), mangrove forests currently grow in 124 tropical and subtropical countries with around 15.2 million ha areas, of which about 36% (5.4 million ha) grow in Southeast Asian countries. Most of the mangrove forest in Southeast Asia grows in Indonesia; the area is currently around 3.2 million ha (59% of the mangrove forest in Southeast Asia, or 21% of the mangrove forest in the world). The Southeast Asia region, especially Indonesia, has extensive mangrove forests and many mangrove species.

Centuries ago, coastal communities traditionally used various species of mangrove plants for food, clothing, shelter, and traditional medicines. Several plant species in mangrove ecosystems have the potential to be utilized by humans in daily life, such as *Rhizophora mucronata*, *R. apiculata*, *R. stylosa*, *R. racemosa*, *R. harrisonii*, *R. mangle*, *Avicennia marina*, *A. alba*, *Bruguiera cylindrica*, and *Sonneratia* spp. These species also contain phytochemicals or secondary metabolites that can be used in ethnomedicine to treat various diseases and play an important role in modern medicine. Some of the phytochemicals present in mangroves are steroids, triterpenes, saponins, flavonoids, polyphenols, alkaloids, tannins, fatty acids, resins, and phenols (Mani et al. 2012; Soonthornchareonnon et al. 2012; Rengasamy et al. 2013; Subhashini et al. 2013; Yadav et al. 2014; Genilar et al. 2021). This species is very potential because the mangrove ecosystem is always under pressure, leading to the production of certain compounds for its survival (Sasidhar 2020). Then, mangrove plant species can also contain toxic substances that exhibit biological activities such as antifungal, antibacterial, and pesticide properties (Azman et al., 2015). Extracts from mangrove plants are reported to have various medicinal properties such as antibacterial, anthelmintic, antidiabetic, antioxidant, antifungal, antimicrobial, anti-inflammatory, anticancer, analgesics, and others (Neamsuvan et al. 2012; Prabhu and Guruvayoorappan 2012; Yang et al. 2015; Das et al. 2016; Reddy and Grace 2016; Sachithanandam et al. 2019).

Various diseases can be cured using plants that live in the mangrove ecosystem, such as angina, diarrhea, dysentery, hematuria, flatulence, epilepsy, smallpox, diabetes, asthma, rheumatism, and stomach pain, malaria, cholera, hepatitis, cancer, ulcers, nausea, vomiting, stop bleeding from wounds, hemostatics, AIDS, ulcers, fever, leprosy, minor injuries, plaster fractures, tuberculosis, elephantiasis, hematoma, cough, diabetes, eye infections, gastrointestinal diseases, headaches, insect stings, animal bites, liver disease, etc. (Prabhakaran et al. 2012; Shilpi et al. 2012; Arumugam et al. 2014; Revathi et al. 2014; Manilal et al. 2015; Vinoth et al. 2019; Rajani et al. 2020).

In addition to the plants mentioned above, one of the plants that also lives in the mangrove ecosystem and has the potential to contain chemical compounds to treat various diseases and other benefits is the *nipa/nipah* plant (*Nypa fruticans* Wurmb). Then, parts of nipa commonly used by the public include roots, rhizomes, leaves, leaf bones, sap, fruit, and seeds. In addition, nipa provides livelihoods for the community, such as providing food sources and building materials. Nipa plants are the only palms and the oldest globally that grow in coastal areas and along estuary flows affected by tides (Gee 1989; Badve and Sakurkar 2003; Robertson et al. 2020). Nipa plants are the dominant plant species in mangroves in many tropical and subtropical areas, covering large coastal areas with low salinity and deposition of sediments (Hossain and Islam 2015). This plant was also introduced to river mouths in West Africa and Panama (Numbere 2018).

Materials derived from nipa are used to build and produce fuels, sugar, beverages, and pharmaceuticals in Southeast Asia and Oceania (Tsuji et al., 2011; Yahaya et al., 2021). Nipa forests can serve as an effective barrier against damage from tsunamis (Hossain and Islam, 2015). Nipa plants can also contribute significantly to the carbon budget in coastal ecosystems (Ghani et al., 2017). Furthermore, significant literature on livestock and the economy supports the sustainable use of nipa resources throughout the Indo Pacific Ocean region (Carandang et al., 2009).

Although, nipa forest plantations are often used for human use, such as for commercial and industrial use (Akpakpan et al. 2012) or land clearing to support aquaculture and subsistence agriculture (Veetil et al. 2018; Arifanti et al. 2019). However, nipa continues to grow rapidly and predominantly in estuarine areas, covering tens of thousands of hectares in the lower salinity areas of major river deltas (Robertson et al. 1991). Therefore, knowledge and utilization of this nipa plant need to be sought and studied more deeply. Therefore, this review aims to find out the phytochemical composition, medicinal uses, and other utilization of nipa plants.

MANGROVE FOREST PLANT: *Nypa fruticans*

Local name

Nipa is a type of palm that has been known as a plant with various uses and benefits by people in various regions of the world, especially coastal areas of the tropics and subtropics. Therefore, this plant also has various local names that differ in each region, such as *poothada* (Andaman Islands); *rola*, *ki-bano*, *tacannapoon* (Australia); *golpata*, *nipa palm* (Bangladesh); *dani* (Myanmar); *shui ye* (China); *gabna gulag*, *nipumu* (India); *nipa* (Malaysia); *chickenatangh*, *ayangmbakara* (Nigeria); *biri -biri* (Papua New Guinea); *anipa*, *pinok*, *tata*, *pinóg*, *sasa*, *saga*, *nipa*, *lasá*, *pawid*, *pawid* (Philippines); *attap palm* (Singapore); *gim-pol* (Sri Lanka); *chaak*, *lukchaak*, *atta* (Thai); *dtra nước*, *dùa lá* (Vietnam) or commonly called nipa palm (or simply nipa) or mangrove palm (Baja-Lapis et al. 2004; Lim 2011; GRIN 2017). Meanwhile, this plant is also

known by many names in various regions, communities, tribes, or islands in Indonesia, among others, as in Sundanese it is *daon*, *daonan*; Javanese or Balinese people call it *buyuk*; *bhunyok* by the Madurese; *bobo* or *boho* by the people of Manado, Ternate and Tidore; The people of Halmahera call it *boboro*; then in the area of Seram Island, Ambon and its surroundings it is commonly called *palean*, *palenei*, *pelene*, *pulene*, *puleanu*, *pulenu*, *puleno*, *pureno*, *parinan*, *parenga*, *parena* (Heyne 1987; Crawford 2017).

Description

Nipa consists of roots, stems/rhizomes, leaves, flowers, fruits, and seeds. Unlike most palms, nipa stems grow underground and are submerged in water. Only the leaves and flower stalks grow upward above the surface so that the nipa looks trunkless. The bark of this nipa plant has a very hard green texture and will turn brown when the nipa condition is old. However, the inside remains softer like a cork. According to Tomlinson (1986), the nipa is a monoecious and pleonanthic palm. It also exhibits viviparous germination, as in many other mangrove plant species. The stature and some organs of the nipa can be seen in Figure 1.

Roots. Its fibrous roots can reach a length of 13 m. Because the nipa roots are only located in unstable soil/sand/mud, the nipa clumps can be washed away by water to the sea.

Trunks. Like the *Metroxylon* spp. tree, the nipa trunk spreads along the ground, forming a rhizome about 60 cm thick, which is submerged by a layer of mud and water and can reach a length of about half a meter.

Leaves. From the rhizome emerges compound pinnate leaves typical of palms. The leaves are erect or nearly erect, rising 7 to 10 m above the ground. The leaf blade has a stocky petiole which is round at the base, 1-1.5 m long, green, and will turn brown when the condition of the nipa plant is old. The leaflets are ribbon-shaped elongated, and tapered at the end, have a leaf bone called a stick (as in coconut leaves). Leaflets can reach 60-130 cm long and 5-8 cm wide. The old nipa leaves are green, while the young leaves are yellow (shiny on the top surface), resembling coconut leaves. The number of leaflets in each stalk reaches 25-100 strands.

Inflorescences. Compound wreaths appear in the axils of sturdy leaves, 1-2 m long, single, male and female flowers are separate with female flowers collected at the end to form a ball (round head) with a diameter of about 25-30 cm, and male flowers are arranged in panicles. Strand-like, red, orange, or yellow on the underlying branches. Each strand has 4-5 male flowers that reach 5 cm in length.

Flowers. Male nipa flowers are yellowish red, protected by a flower sheath, but the pollen-filled part is still sticking out. Then, the female nipa flowers are round. The length of the flower stalk reaches 100-170 cm. These flower bunches can be tapped to take the juice. Four to five months after the release of nipa flowers, the flower bunches can be tapped because the amount of sap produced is maximum.

Fruits. The fruit structure is similar to a coconut, with a smooth exocarp, a fibrous mesocarp, and a hard endocarp called a shell. Type of stone fruit, oval, upside down and flattened with 2-3 ribs, reddish-brown, 11 x 13 cm, collected in tight groups resembling a ball, with a diameter of about 30-45 cm. In one bunch, the fruit can reach between 30 and 50 grains. The ripe fruit falls into the water and floats with the ebb and flow of water until it gets stuck in a new growing place. Often the fruit has germinated while still being carried by the current to a new place.

Seeds. Seeds are protected by a shell, white, egg-shaped, measuring about 5 x 4 cm.

Habitat and distribution

Mangrove is an ecosystem term that refers to the diverse collection of trees and shrubs that form the dominant plant community in tidal wetlands near the seafront along sheltered tropical and subtropical coasts. Nipa is one of the mangrove plants that grow in that place with a temperature of 20-35°C and a rainfall of 1,000 mm/month, evenly distributed throughout the year. This is the only palm (Arecaceae) that is able to live and adapt in the mangrove ecosystem. The genus *Nypa* and the subfamily Nypoideae are monotypic taxa because nipa is the only members (Dowe 2010). They are common on beaches and rivers flowing into the Indian and Pacific Oceans, from India to the Pacific Islands. This plant is a native species from China (Hainan); South Asia, such as Sri Lanka and Bangladesh; Southeast Asia, such as Indonesia, Malaysia, Thailand, Myanmar, Cambodia, Singapore, Vietnam, and the Philippines; Australia (Queensland and Northern Territory); and Pacific Islands such as Solomon, Mariana, Bismarck Islands, New Guinea, and the Caroline Islands. Later, it was also reported that this species was introduced to several regions and countries, such as Cameroon, Guyana, Marianas, Nigeria, Panamá, Society Islands, and Trinidad-Tobago (POWO 2022) (Figure 2).

Nipa plants can grow in soft mud and slow-moving tides, and river water that carries the nutrients these plants need. Usually, nipa can grow by forming its stand, but it grows mixed with other mangrove tree species in some areas. Nipa is one species that is best adapted to growing in coastal mangrove areas with moderate and less extreme salt content. According to Setyawan (2005) and Theerawitaya et al. (2014), this plant will suffer if exposed to pure seawater and prefer brackish waters at river mouths. This species can live in bays, tidal plains, and creeks as long as high tides and freshwater flow. They can be found inland, as far as the tide can store the seeds of this plant. Nipa can withstand short-term drying in its environment. The rhizome that creeps horizontally along the riverbank can stabilize the soil and prevent soil erosion. Then, new leaves can emerge quickly after damage and protect from storm winds, and can be used to produce useful products for local residents.



Figure 1. Some parts of *Nypa fruticans*. A. Flower (a. Female, b. Male); B. Fruit (insert: individual fruits); C. Tree stature with roots and rhizomes submerged in water and leaves standing upright above the water (Photo by YIU)

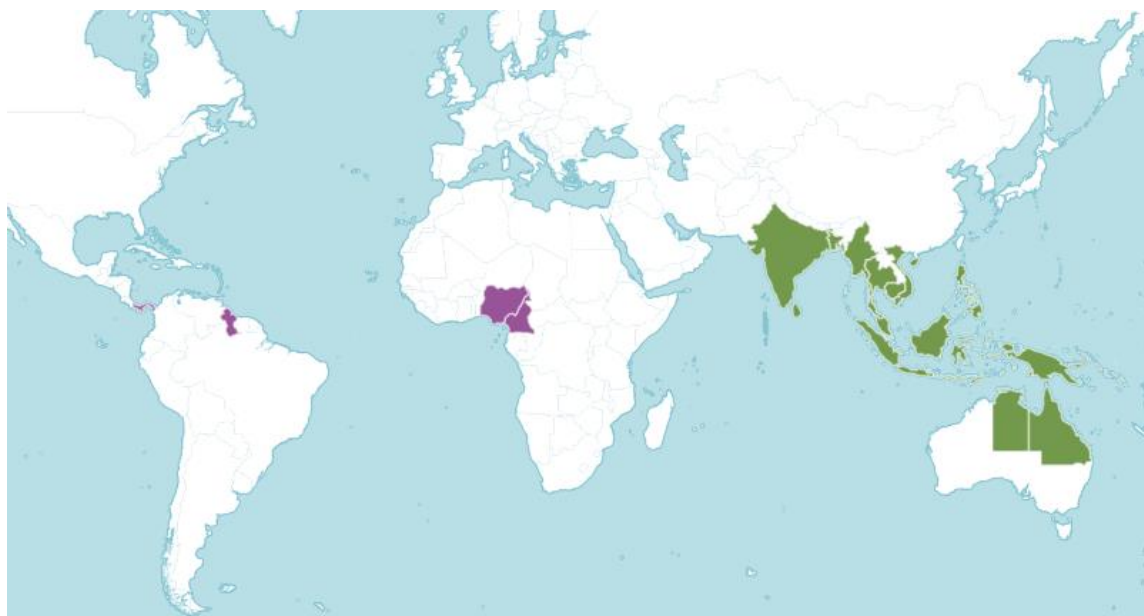


Figure 2. Distribution of *Nypa fruticans* in the world. Green borders: Natively found in China (Hainan); South Asia such as Sri Lanka, India, and Bangladesh; Southeast Asia such as Indonesia, Malaysia, Thailand, Myanmar, Cambodia, Singapore, Vietnam, and the Philippines; Australia (Queensland and Northern Territory); and Pacific Islands such as Solomon Islands, Mariana, Bismarck Islands, New Guinea, and the Carolinas. Purple borders: Introduced to Cameroon, Guyana, Marianas, Nigeria, Panamá, Society Islands, Trinidad-Tobago (Source: Plants of the World Online 2021)

PHYTOCHEMICAL COMPOSITION

The phytochemical analysis is one way to determine the presence of chemical compounds (primary and secondary metabolites) in plants (Hayne 1987). Primary metabolite products are compounds that can be used to fulfill plant life itself, either helping the plant grow, develop, or survive climate change. Meanwhile, secondary metabolite products are compounds that can protect plants from disturbances and pathogens in the vicinity to continue to grow properly. These secondary metabolite products are also often referred to as bioactive.

All plants can be found in the phytochemical analysis, including nipa. Nipa plant is a palm-shaped mangrove plant that can produce secondary metabolites with various biological properties and activities. This can be caused by the extreme conditions in which it grows. As also stated by Boopathy and Kathiresan (2010) that plants that live near the sea and around the coast contain more and more unique bioactive compounds than plants that live on land. The reason is that the environmental conditions in which they live are extremely extreme. Many external disturbances need to be faced, such as wind, waves, water currents, salinity, etc.

At least 25 chemical compounds were detected by Azuma et al. (2002) on nipa. These chemical compounds consist of fatty acid derivatives, terpenoids, carotenoid derivatives, benzenoids, and several unknown compounds. In addition, Choi et al. (2020) have shown in their research that nipa has the potential to reduce UVB-induced photoaging. Furthermore, the phytochemical analysis also found protocatechuic acid, catechin, chlorogenic acid, epicatechin, kaempferol, and penguianencins in nipa. In vivo studies by Zhao et al. (2012) and Al-Numair et al. (2015) suggest that phytonutrients such as kaempferol may be important in protecting biological systems from oxidative stress. Meanwhile, in general, the active compounds produced by nipa include phenolics, saponins, flavonoids, and tannins (Sahoo et al., 2012; Astuti et al., 2020). The many chemical compounds in nipa can be used as raw materials in a product, especially in modern medicines. Therefore, by knowing the content of chemical compounds through phytochemical analysis, the utilization of nipa can be optimized and can be a reference and innovation in the utilization of mangrove ecosystems.

Phytochemicals in roots

Nipa roots contain alkaloids, steroids, triterpenoids, phenolics, flavonoids, and tannins (Radam and Purnamasari 2017). Still, research by Radam and Purnamasari (2017), through testing nipa root solutions with various treatments, the results obtained that the presence of alkaloids in nipa roots was characterized by the formation of a white precipitate in the test solution after being reacted or added with reagents (Wagner's reagent, Meyer's reagent, and Dragendof's reagent). Then, the presence of steroid content was marked by a color change to green in the solution when tested. Then, the presence of triterpenoids was indicated by a change in color to bluish in the test solution. Meanwhile, the presence of flavonoid compounds in this test was marked by a red-orange to black color change in the test solution. This content indicates antioxidant activity as a defensive metabolite capable of fighting reactive oxygen (Lovly and Marlee 2018). Similar results were also shown in Yusoff et al.'s (2015a) study, which showed that nipa extract contained phenolic and flavonoid compounds. Furthermore, the presence of hydroxyl indicates phenolic compounds (-OH) functional groups (Park et al. 2013) and carboxylic acids (COOH) (Ha et al. 2012), which are structurally similar and are very well used as antioxidants (Zhao et al. 2014).

Phytochemicals in leaves

According to several studies, nipa leaves contain phytochemicals. To test the phytochemicals of nipa leaves, the leaves must first be extracted. Then the extract was experimented with to determine what content was contained in the nipa leaves. Based on research that has been done, nipa leaves contain ethyl acetate, chloroform, and hexane extracts (Lovly and Marlee 2018). The ethyl acetate extract of nipa leaves has a very strong antioxidant activity. Bakshi and Chaudhuri (2014) research found that methanol, ethyl acetate, and acetone in nipa leaves showed antibacterial activity against *Escherichia coli*,

Agrobacterium tumefaciens, *Streptococcus mutans*, and *Staphylococcus aureus*. Osbor et al. (2008) said that nipa leaves contain polyphenols and alkaloids. Similar results were also shown by research conducted by Lestari et al. (2017), which showed that positive nipa extract and leaf fraction contained natural phytochemical compounds. The crude extract contains polyphenols, flavonoids, triterpenoids/steroids, saponins, and alkaloids. The methanol fraction contains polyphenols, flavonoids, saponins, and alkaloids, while the ethyl acetate and n-hexane fractions contain triterpenoids/steroids.

In addition, the results of research by Ebana et al. (2015) reported that nipa leaf samples in the Niger Delta Region of Nigeria revealed the presence of alkaloids and polyphenols. Then, the proximate analysis carried out also showed that the plant was very rich in ash, lignin, cellulose, hemicellulose, moisture, and nitrogen (Ekpunobi and Onuegbu 2012). Then, from research by Gazali and Nufus (2019), it was shown that nipa leaves contain almost all bioactive compounds; antioxidants, namely flavonoids, phenolics, tannins, saponins, steroids, and triterpenoids. Then, the intensity of the phenolic test precipitate was higher than the other components. The phenolic and flavonoid compounds in the sample indicated that the sample's activity had potential as an antioxidant. This is also reinforced by Imra et al. (2016) report that nipa leaf extract contains active chemical compounds, including flavonoids, tannins, phenol hydroquinone, diterpenes, steroids, and saponins. From all the research results that have been mentioned, the main ingredients in nipa leaves are polyphenols, phenolics, alkaloids, tannins, flavonoids, and saponins. However, the nipa leaf extract contains other chemical compounds such as ethyl acetate, chloroform, hexane, triterpenoids, phenol hydroquinone, diterpenes, and steroids. Nipa leaves also have methanol extract and have been shown to have antidiabetic and analgesic effects by research by Reza et al. (2011).

Phytochemicals in fruit

Nipa contains fruit that can be tapped to produce abundant sap called nipa palm sap (NPS) (Hafizi et al., 2018). NPS is also known as a source of traditional medicine used to treat various diseases. Research by Yahaya et al. (2021) identified good antiradical activity in NPS with an IC₅₀ value of 33.36 g/mL using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) test. DPPH radical scavenging assay, FRAP assay, and CUPRAC assay were performed to determine the anti-free radical activity in nipa (Islam et al. 2020a). The NPS tested consisted of water content (72.44%), ash (1.04%), protein (7.04%), carbohydrates (19.48%), fat (0%), and energy levels (106 kcal). The large protein content in NPS shows that it can be used as a protein supplement for muscle development and maintaining the health of the human body (Wakili et al. 2015) and with a fat content of 0%, indicating that NPS is a food source with low cholesterol levels and is healthy (Olalude et al. al. 2015). In addition, maleic acid, cinnamic acid, chlorogenic acid, and kaempferol are the main compounds revealed by ultra-high-performance liquid chromatography. Overall, NPS is a potential source of

antioxidants with significant health benefits. Then according to Gordon et al. (2012), Prasad et al. (2013), Sukairi et al. (2019), and Phetrit et al. (2020), NPS showed high phenolic and flavonoid content, as well as antioxidant activity. In addition, the fruit is also rich in carbohydrates, fiber, minerals, sucrose, glucose, fructose, and vitamin A (Osabor et al., 2008; Saithong et al., 2019).

Other parts of the fruit, especially the fruit's skin, also found other biochemical compounds. The skin of nipa fruit is like coconut but has a smaller size and has fewer skin fibers than coconut. The skin of the fruit is then investigated to determine the phytochemical content. The phytochemical content in the nipa fruit peel was investigated by Herfayati et al. (2020), who obtained the results that the skin of nipa fruit contains anthocyanins. This is indicated by a change in the color of the solution from red to blue during the test. The red color is lost due to the high pH of the solution (Khoo et al., 2017), so the anthocyanins lose their red color due to the formation of quinoidal anones (Rajesh et al., 2014; Utami et al., 2016; Saptarini and Herawati 2018). In addition, nipa also contains polyphenols (Osabor et al. 2008). Polyphenols are one of the chemical compounds that are classified as natural antioxidants found in plants (Putri et al. 2015).

Besides conducting phytochemical analysis on nipa organs, nipa plants can also be tested for their phytochemical content through their product, namely flour from the fruit. The results obtained the average nutritional value of nipa flour, namely the average water content of 5.57%, ash content of 2.35%, protein 4.23, carbohydrates 52.14%, crude fiber 24.14%, fat 1.06%, the calorific value is 226.29 cal/100 g, zinc 17.13 mg/kg and iron 405.32 mg/kg (Radam et al. 2019). So, it can be said that the phytochemical content in nipa flour is very diverse. The content of compounds in nipa plants is influenced by the content of chemical compounds, heavy metals in media water, and the environment as a place to live (Nafieet al. 2019).

From the results of phytochemical studies on various nipa organs, various contents and benefits of nipa are produced to be utilized optimally; many more studies have been carried out and processed with the most appropriate method for human needs in the future.

MEDICINAL USE

Traditional medicinal use

Human awareness of health is also increasing; medicinal products with natural ingredients are preferred because they are believed to be cheaper, easier to obtain, and will not cause prolonged effects on the body in the future. Some medicines derived from nature or herbs have been passed down and passed down from generation to generation and have become the main choice of the community (Az-Zhara et al., 2021), one of which is drugs derived from nipa.

Coastal communities have realized the abundance of nipa plants. People have long used nipa to be processed into various traditional medicines. This is also supported by

Gazali and Nufus's (2019) statement, which states that mangroves, including nipa, are plants that have millions of benefits, which can be processed into various kinds of support for the life needs of coastal communities. Almost all parts of the nipa plant can be processed and used further in herbal medicines.

Young shoots, wood, roots, or nipa leaves are sometimes used for medicinal purposes (Tsuji et al., 2011). Then according to Bandaranayake (1998) and Rahmatullah et al. (2010), traditionally, the leaves, stems, and roots of nipa are used to treat asthma, leprosy, tuberculosis, sore throat, liver disease, snake bites, as a pain reliever, and can also be used as a sedative and able to expel excess wind in the body.

Vinegar from nipa, locally known as nipa palm vinegar (NPV), is a traditional preparation produced by the fermentation of sap. It is commonly consumed throughout East Asia (Päiväke et al. 1984). Added to drinking water, NPV is taken before meals and at bedtime. It has been shown that consumption of nipa vinegar reduces postprandial hyperglycemia in type 2 diabetic patients who receive a diet with a moderate glycemic index (Liatis et al. 2010). Likewise, the local community in Malaysia considers that nipa vinegar can treat diabetes, and this is scientifically justified by the research of Yusoff et al. (2015b) that vinegar exerts an anti-diabetic effect by delaying the absorption of carbohydrates from the small intestine through selective inhibition of intestinal glucose transporters, thereby suppressing postprandial hyperglycemia. Then, in the research of Yusoff et al. (2015a), chronic administration of NPV aqueous extract at a dose of 1,000 mg/kg caused a significant effect of lowering blood glucose and increasing insulin in diabetic rats.

In some countries, based on public belief from Malaysia, Philippines, Indonesia, Thailand, Sri Lanka, and India that NPS has medicinal potential to treat fever, gout, kidney stones, energy booster, helps the digestive process, and a cure for certain chronic diseases and metabolic syndromes such as diabetes and hypertension (Tamunaidu et al. 2013; Yusoff et al. 2015a; Hafizi et al. 2018; Sukairi et al. 2019; Phetit et al. 2020).

Then, there are some uses of nipa in other traditional medicine. According to Burkill (1935), Päiväke (1996), and Lim (2011), one of the traditional recipes in Malaysia to treat herpes is to drink the juice of young shoots with coconut milk. In other countries, such as Patuakhali and Barguna District of Southern Bangladesh, ash from burned nipa plants is used to treat toothaches and headaches (Islam et al. 2020b). In the Philippines, a decoction of fresh leaves of nipa is used as a lotion for boils. Fresh leaves of nipa are widely used to treat ulcers in the form of cataplasm or lotion. Nipa alcohol is used as an eyewash for inflammation of the eyelids.

Meanwhile, in Indonesia, the coastal community of Banyuasin, South Sumatra, has processed nipa as a medicine for stomach pain, diabetes, and fever-reducing medicine. The same thing can also be found in Aceh, where people use nipa leaf extract as medicine for canker sores and toothaches. Meanwhile, the people of Kalimantan use

leaf ash and nipa roots as medicine for toothaches and headaches. Other parts of nipa are also used to treat abdominal pain, diabetes mellitus, fever, and canker sores (Imra et al., 2016). The bones of nipa leaves have also been traditionally used for a long time by the coastal communities of Kakap River, West Kalimantan, as a toothache medicine. The young leaves are used as a thrush medicine (Lestari et al. 2016). Then the ashes from the leaves and roots are burned to produce salt ash called salt nipa, which is used for headaches and toothaches in Kalimantan (Lim 2011). Although the target disease is not described, nipa wood can potentially be used as medicine in Borneo (Kalimantan) (Burkill 1935).

Mineral content as medicine

Research conducted by Tamunaidu and Saka (2011) revealed that the nipa fruit contains eleven minerals that are good for use by the body. Three of the most abundantly contained minerals in nipa fruit are potassium, sodium, and magnesium. These results are also strengthened by Herman et al.'s (2011) research that the mineral content of magnesium, sodium, and potassium in nipa fruit reached 7.97 ppm, 9.35 ppm, and 3.79 ppm, respectively. Furthermore, potassium reduces the risk of cardiovascular disease and stroke and protects the body from bone loss (Weaver et al., 2018; Sun and Weaver, 2020). Meanwhile, according to Strazzullo and Leclercq (2014), sodium plays an important role in regulating cell homeostasis, body fluid, electrolyte balance, and blood pressure. Lastly, magnesium is also known to have an important role in the body. Whereas magnesium can stimulate ATPase reuptake of calcium from the sarcoplasmic reticulum and modulate insulin signal transduction and cell proliferation, it is important for cell adhesion and transmembrane transport (Jahnen-Dechent and Ketteler 2012). However, the consumption of nipa must also be in accordance with the body's daily needs. Minerals contained in nipa, if consumed too much, will produce effects that are not good for the body.

Fiber content as a cholesterol drug

Furthermore, nipa is also known to have a fairly high fiber content. Fiber is a type of carbohydrate that is resistant to digestion and absorption in the human small intestine. Instead, fiber generally undergoes partial or complete fermentation in the human large intestine (Santoso 2011). The benefit of fiber for the human body is that it can prevent hypercholesterolemia in humans who are overweight or obese (Fairudz and Nisa 2015). In addition, Santoso (2011) also revealed that fiber could be used as an agent for controlling diabetes, cancer, and cardiovascular disease. Research conducted by Dalming et al. (2018) revealed that nipa fruit contains 46.18% crude fiber, which can bind cholesterol *in vitro*. Then, cholesterol is adsorbed on the nipa fruit flour to allow cholesterol to be lowered or suppressed. Another possibility is that the fiber component of nipa fruit can stimulate the excretion of cholesterol in the body by binding to bile acids in relation to the satiety effect produced by nipa fruit (Dalming et al. (2018).

Pharmacological properties

There is still a lot of knowledge of plants or animals that can be trusted to cure diseases by indigenous peoples. The search for bioactive compounds from mangrove plants in pharmacology is still neglected, although many studies have proven that mangrove plants can be a good source of natural medicine (Das et al., 2015). Climatic conditions and rampant pollution in the world cause an increase in the risk of disease suffered by humans. Various types of diseases continue to infect humans, both old and diseases that have only emerged recently. Such conditions encourage researchers to look for mechanical and medicinal treatments from existing natural resources to grow up the world of pharmacology.

One of the natural resources that can be used as medicine for many years is the mangrove plant. This aligns with Mahmud et al.'s (2014) statement that mangrove plants have been shown to contain phytochemicals that have significant antioxidant, antinociceptive, antihyperglycemic, antimicrobial, and anticancer activities. Further research on one of the plants in the mangrove ecosystem, the phytochemical content of nipa, has also been carried out.

From studies that have been carried out in various countries, it is found that nipa is full of benefits for the human body. Some of these benefits include being an antioxidant (Sabri et al. 2018; Shin et al. 2018), antibacterial (Nopiyanti et al. 2016), anti-inflammatory (Bae and Jung 2016), a stimulator of insulin secretion (Yusoff et al. 2017), and as cytoprotective (Sari et al. 2018). Then it was also supported by the positive results of the antioxidant activity test on nipa parts, such as leaf, stem, bark, and root extracts (Abdel-Aziz et al. 2016).

The results of other studies have also been carried out, such as the results of research by Reza et al. (2011), which revealed that there were antidiabetic and analgesic activities in methanol extracts of twigs and leaves of nipa plants. Reza et al. (2011) also stated that nipa leaf extract could stimulate the residual function of pancreatic cells, produce an antihyperglycemic effect through the extrapancreatic mechanism, and increase peripheral glucose utilization. Likewise, the research of Yusoff et al. (2015b) was conducted to evaluate the effect of aqueous extract (AE) on postprandial hyperglycemia to understand the mechanism of antidiabetic action. *In vitro* intestinal glucose absorption, *in vivo* carbohydrate tolerance test, AE was tested, and spectrophotometric enzyme inhibition test. One mg/mL AE showed comparable results to phloridzin (1 mM) *in vitro*. It delayed glucose absorption through the isolated rat jejunum and was more effective than acarbose (1 mg/mL). Later, *in vivo* confirmatory tests showed AE (500 mg/kg) caused significant suppression of 30 min postprandial hyperglycemia in mice. In contrast, AE showed somewhat weak inhibitory activity against -glucosidase and -amylase compared to acarbose in the spectrophotometric enzymatic assay. These findings suggest that NPV exerts an anti-diabetic effect by delaying carbohydrate absorption from the small intestine through selective inhibition of intestinal glucose transporters, thereby suppressing postprandial hyperglycemia.

Furthermore, Bae and Jung (2016) stated that nipa fruit extract could inhibit the production of nitrite and pro-inflammatory cytokines at a dose of 200 g/mL. Then Kang and Hyun (2020) revealed research results showing that nipa leaf extract with a 500 mg/kg bodyweight concentration could reduce the expression of TRPV1, COX 2, inflammatory and pro-inflammatory expression in experimental rats. These studies are also supported by Khairi et al. (2021) research, who revealed that nipa's fruit and leaf extract showed enormous potential to be further developed into drugs or inflammatory inhibitory agents. Other pharmacological activities of nipa, such as antinociceptive and anticancer, have been revealed in various scientific studies (Yusoff et al. 2015a; Kang and Hyun 2020). Other compounds found contained in nipa in fruit, leaves, and stems were polyisoprenoid compounds. According to Sari et al. (2018) and Istiqomah et al. (2020), polyisoprenoid compounds from nipa showed anticancer activity in vitro. They could reduce cell proliferation and induce apoptosis in colon cancer cells.

Nipa exhibits a variety of pharmacological activities, including antioxidant, anti-inflammatory, antibacterial, antidiabetic, and analgesic activities. This plant's traditional herbal medicines are associated with no side effects, toxicity, and increased efficacy and safety. The following potencies are presented in more detail regarding the pharmacological activity of nipa as an antioxidant, antibacterial, and anti-inflammatory.

Antioxidant

Natural antioxidants from plants have gained considerable scientific interest due to their natural origin and lower adverse side effects (Lourenço et al., 2019). There is also increasing public consumption of exogenous antioxidants, such as ascorbic acid (i.e., Vitamin C), network tocopherols (i.e., Vitamin E), carotenoids, and polyphenols found in fruits, vegetables, cereals, beverages, and other natural food products. This is due to the belief that these products can support the antioxidant defense system (Lourenço et al., 2019). In addition, mangrove plants tend to have more compounds that can act as antioxidants than the activity of other compounds (Rahman 2018).

A study by Blanch et al. (2020) reported that the salicylic acid present in nipa could reduce the high salt stress experienced by nipa in the environment by increasing the activity of the antioxidant system. Then according to Choi et al. (2022), chemical compositions including phenolic acids and flavonoids can be found in nipa. Moreover, PCA shows the high relevance of each antioxidant potential. This finding can be used for wide commercial applications in the food and pharmaceutical industry for nipa.

Furthermore, the phenolic compounds, alkaloids, and flavonoids found in nipa have also been shown to have antioxidant properties (Gordon et al., 2012; Manojlovic et al., 2012; Soonthornchareonnon et al., 2012; Maqsood and Benjakul 2013; Sharief et al. 2014). According to Margaretta and Handayani (2011), these compounds are indeed proven to be compounds that can act as

antioxidants. Antioxidants can counteract free radicals and autoxidation reactions in lipid oxidation. In biological systems, phenolic compounds and flavonoids act as free radical scavenging agents with antioxidant activity (Lourenço et al., 2019). Therefore, the beneficial effect of the bioactive compounds present in NPS may have antioxidant activity that provides a protective element from chronic diseases.

According to Yahaya et al. (2021), ascorbic acid in nipa also showed the highest antioxidant activity with an IC_{50} value of 21.29 ± 0.74 g/mL. According to Sowndhararajan and Kang (2013), the lower the IC_{50} value, the higher the antioxidant activity. While the antioxidant properties of the sample were determined by the radical scavenging activity of DPPH and showed positive results, namely EC_{50} 112.90 mg/mL (Sukairi et al. 2018). The antioxidant compounds contained in nipa can combat free radicals in our body system and have great potential to be commercialized as healthy foods and beverages with scientific evidence and validation (Thyagarajan and Sahu 2018).

To assess the antioxidant activity of NPV, three in vitro antioxidant assays were used: 2,2-diphenyl-1-picrylhydrazyl and 2,2'-azinobis-3-ethyl benzothiazoline-6-sulphonic acid-free radical scavengers, and a reducing power assay (Yusoff et al. 2015a). Analysis of the chemical profile of the NPV aqueous extract revealed the presence of acetic acid (35.25%). Then, the ethyl acetate extract in nipa triggers a significant antioxidant effect caused by its high phenolic content. There are several reports on the antioxidant activity of plants affected by the content of their ethyl acetate extract (Nishidai et al., 2000; Kawano et al., 2010). Thus, it can also be concluded that the antioxidant component is present in the ethyl acetate extract.

Anti-inflammatory

Mangrove plant extracts have shown positive results and are important in indigenous medicinal practices. Research shows that one of the activities found can cause a very potent anti-inflammatory agent. An important aspect needed by mangrove extract to be useful as an anti-inflammatory drug is its flavonoid composition. Nipa has been used as a drug to treat inflammatory diseases because it has flavonoid compounds (Sahoo et al., 2012; Astuti et al., 2020). Flavonoids are a group of secondary metabolites widely found in plants and generally consist of 15 carbon atoms. Many flavonoids directly affect the enzymes responsible for the inflammatory process. In addition, some flavonoids can inhibit the induction of adhesion molecules such as blood neutrophils, which are required for the inflammatory process (Middleton et al. 2000).

Then, the results of the research of Bae and Jung (2016) showed that the aqueous extract of nipa alone had no cytotoxic effect at a concentration of 200/mL in 264.7 RAW cells. Nipa treatment inhibits nitrite production, and pro-inflammatory cytokines including IL-1 β , IL-6, and TNF- α are dose-dependent. In addition, nipa treatment inhibited LPS-induced activation and nuclear factor (NF)- κ B translocation. These results suggest that nipa treatment can reduce LPS-induced inflammatory response through

the inactivation of NF- κ B. This study may indicate that nipa can be a useful drug or agent to prevent inflammation (Bae and Jung 2016).

Nipa, which is used in traditional medicine, is a plant that has received attention because of its various effects. The study of Kang and Hyun (2020) investigated the anti-inflammatory effect of nipa extract by controlling the neurological function of TRPV1 in experimental mice. The validation of the TRPV1 channel as a therapeutic target for controlling pain and inflammatory conditions in various disease and injury states has prompted the development of several TRPV1 agonists and antagonists that have entered clinical trials (De Petrocellis and Moriello, 2013). Then, quantification of the sciatic nerve and spinal cord protein L4-L6 showed a decrease in the expression of TRPV1, inflammatory expression factors, COX2, and pro-inflammatory factors in the group treated with nipa extract, thus indicating that nipa extract affects inflammation by controlling TRPV1 in neuropathic sciatic pain, so that produce an anti-inflammatory effect.

Antibacterial

Antibacterial is a drug that kills bacteria, especially pathogenic bacteria that can harm humans. Drugs that can be used to eradicate microbes must have the highest possible selectivity, meaning that the drug must be highly toxic to microbes. Antibacterial can also be used as a prevention against various pathogenic bacterial infections.

Most of the natural antioxidants reported in the literature also have antibacterial activity (Lourenço et al., 2019). The antibacterial properties of nipa have been investigated by Osabor et al. (2008), Chaudhuri and Guha (2010); Prabhakaran and Kavitha (2012); Shamsuddin et al. (2013), and Bakshi and Chaudhuri (2014). Then, Ebana et al. (2015) decided to analyze the leaves of nipa plants through phytochemical tests by testing the antibacterial properties of various extracts against *E. coli*, *Klebsiella pneumoniae*, *S. aureus*, *Staphylococcus epidermidis*, and *Pseudomonas aeruginosa*. Nipa is a rich source of various biochemical compounds such as alkaloids, cardiac glycosides, polyphenols, phlorotannins, saponins, and anthranoids. The presence of polyphenols indicates excellent antibacterial activity. Aqueous and ethanolic extracts of the tested nipa sections showed good antimicrobial resistance against all test organisms. Variations in the leaf ethanol extract concentration showed that a concentration of 5% and above gave absolute inhibition of *E. coli*. Another study showed that this plant also has excellent antibacterial and antifungal activity against *Vibrio* species (Shamsuddin et al. 2013; Imra et al. 2016), *Fusarium oxysporum* (Chaudhuri and Guha 2010), *B. cereus* (Lestari et al. 2016), and *B. subtilis* (Nopiyanti et al. 2016).

Then, another study showed that the highest concentration of crude extract of nipa leaves to inhibit *Aeromonas hydrophila* and *Streptococcus agalactiae* was 60%, with inhibition zones of 15.90 mm and 16.85 mm, respectively. The MIC results of crude extract of nipa leaves against *A. hydrophila* and *S. agalactiae* were found at concentrations of 100% and 75%, respectively. The

MBC value with the lowest growth of *A. hydrophila* bacteria was $1.33a \pm 0.52$, and the highest was $4.33b \pm 0.82$. MBC with the lowest growth of *S. agalactiae* bacteria was $2.17a \pm 0.75$, and the highest was $4.67b \pm 0.52$. (Sari 2017).

OTHER UTILIZATION

Other utilization in Indonesia

nipa is a palm plant often used by coastal communities because of its many benefits. The part of nipa that can be utilized by the people of West Kalimantan, Indonesia, consists of leaves, shoots, bone leaves, fruit, and *Mayang* (flowers that have not yet bloomed) (Suparto et al., 2019). Then, nipa leaves are also used as raw materials in making roofs and walls of buildings. Nipa leaves as a roof are usually applied to houses, cattle pens, or huts in the garden (Febriadi and Saeni 2018). The roofing of nipa leaves is carried out by drying the old leaves to remove the moisture content, then the leaf's midrib is removed, and the leaf skeleton is folded to two-thirds of its length (Hamilton and Murphy 1988). Then, the prepared leaves are stitched together with vines overlappingly until they reach a length of 1-2 m. The advantages of this roof are that it can last 3-5 years before being replaced with a new one and can withstand the heat, especially in coastal areas.

In the Bawean Islands, Indonesia, woven from nipa leaves, produces a product in mats sold as souvenirs for visiting tourists (Trimanto et al. 2016). Nipa leaf stalks are quite strong and flexible and can also be used as a broomstick. In Makassar, broomsticks from nipa leaf stalks are traded for economic value. The economic benefit value from the production of the broomstick is IDR 2,055,333 or 13.57% of the total economic benefit value of nipa in Tallo District, Makassar City (Muthmainnah and Sribianti 2016). In Sumatra, the young nipa leaves (named shoots) were used as cigarette leaves in the past, namely wrapping sheets for rolling tobacco. After the thin epidermis is removed, the leaves are dried in the sun, then bleached to whiten and cut into cigarette sizes (Heyne 1987).

Besides being processed into various unique items, parts of the nipa plant also produce promising food resources. As many as 2.55 tons of nipa fruit can be produced from one hectare of vegetation (Dalming et al., 2018). People usually consume nipa fruit directly or further processed for preservation purposes. Nipa fruit tastes like coconut meat and can be processed as drinks and sweets that have economic value for people living in mangrove ecosystems. The manufacture of candied fruit nipa can be done because the method of manufacture is easy and uses simple technology (Khotimah et al. 2020). Old nipa fruit is used as flour in Kalimantan, precisely in Sangkimah Lama, Sangatta Village, East Kutai District, East Kalimantan Province. Flour made from old nipa fruit is produced by separating the fruit from the shell, cleaning the epidermis, grinding it by pounding it or blending it, drying it, and finally sieving (Subiandono et al. 2011). Further management of this nipa fruit can be a new source of economy for the community. Furthermore, food production

from processed nipa fruit can be further packaged and marketed to visiting tourists.

Furthermore, the community has widely used nipa resin and syrup for processing and have economic value in their lives. Actually, not only in Indonesia, according to research conducted by Tamunaidu et al. (2013), the sap from the nipa plant derived from its *mayang* can be used as a potential raw material for ethanol production. One nipa plant can produce 0.4-3 L of sap per day, and each stalk can be harvested continuously for 20 days. Therefore, the amount of ethanol produced per 1,000 ha of nipa is estimated at 4,550-9,100 L per hectare per year. Ethanol comes from the fermentation of raw materials containing glucose using the bacteria *S. cerevisiae* (Hadi et al., 2013).

The advantage of using nipa as the main raw material for bioethanol is that nipa is not the main food source, so it will not compete with other food needs. The part used as raw material for bioethanol is the juice so that it does not damage its ecology (Hamilton and Murphy 1988). Knowing the influencing environmental factors is necessary to produce maximum bioethanol from nipa plants. One of the environmental parameters where nipa grows to produce the best juice as raw material for producing bioethanol is salinity. The results of fermentation can be an environmentally friendly alternative fuel. This utilization has the potential to reduce dependence on fewer fossil fuels. However, the utilization of nipa sap for fermentation into bioethanol has not been widely carried out. This is motivated by the lack of knowledge and public capital in processing nipa sap into bioethanol.

Then, the syrup tapped from nipa is mostly used by the public to be processed into consumption and flavoring ingredients. The Indonesian people know the syrup produced from this tapping as sap which can be used as a sweetener for food and beverages after further processing. Nira has a clear color with a sweet taste and a distinctive fragrant aroma (Heriyanto et al. 2011). Tapping was carried out on young nipa fruit stalks. Further processing, the sap that has been collected from the tapping process is boiled for five hours to make brown sugar. Brown sugar producers in East Kalimantan, in one day, can process 50 L of sap and produce approximately 200 grams of brown sugar (Heriyanto et al. 2011). In South Kalimantan, the sap from the nipa plant is processed by crystallization to make brown sugar in the form of granules. Other Indonesians also use the sap to ferment it into a sweet alcoholic beverage. The drink is known as *tuak* in North Sumatra Province, Indonesia, and has the local name *saguer* in North Sulawesi Province (Kurniawan et al. 2018). Fermentation of nipa to be used as an alcoholic beverage is generally found in areas with a non-Muslim majority population.

Other utilization in other countries

The Southeast Asia peoples use some of the results from tapping sap from nipa to make traditional vinegar (Cheablum and Chanklap 2020). Flower bunches (inflorescences) can be tapped to produce a sweet, edible sap collected to produce a local alcoholic drink called *tuba*, *bahal*, or *tuak*. A bunch of fruit is ready to be tapped when

the unripe fruit is at its peak of sweetness. The bunches are cut from the stalks about six inches down, and mud is rubbed on the stalks to induce sap flow. The sap begins to flow immediately if the ripeness of the fruit is measured correctly. A bamboo tube or bottle is placed over the cut stems, and the sap is collected twice daily, cutting half a centimeter from the end of the stem after each harvest to prevent it from clumping. The sap flow will continue for 30 days per stalk, and the nipa will flower continuously throughout the year, providing a continuous supply of sap. In Thailand alone, vinegar production from nipa plant sap reaches 12% of the total use of sap to manufacture other products. Khanap Nak is one of the places where there is a vinegar producer from nipa. Every day, farmers can produce as much as 7.5-200 liters of vinegar, depending on the number of workers. The valuation of vinegar production in Thailand's coastal communities reaches 40-66.7 USD per day. The vinegar produced can also be used for household purposes as a condiment for various local dishes.

Before World War II, Malaysia was dealing with the manufacture of alcohol from nipa, which was used as a vehicle fuel (Baja-Lapis et al. 2004). Two factories produced alcohol from nipa in Sarawak, Malaysia (Chai and Lai 1984) until the 1980s. Simultaneously, similar studies were conducted in the Philippines (Halos 1981) and Papua New Guinea (Newcombe et al. 1980). The manufacture of industrial alcohol from nipa was also an important industry in the Philippines in the early decades of the 20th century (Whitmore 1973). However, the industry was short-lived due to political problems, and competitive gasoline prices prevailed during that period (Fong 1984; Whitmore 1973). Nevertheless, the use and study of alcohol in nipa continued into the middle of the 20th century.

In the Philippines and Malaysia, *tuba*/alcohol can be stored in a *tapayan* (earthly balloon vase) for several weeks to make a type of vinegar known as *sukang paombong* in the Philippines and nipa vinegar in Malaysia. *Tuba* can also be distilled to make *arak*, locally known as *lambanog* in Filipino. Young shoots are also edible; The flower petals can be infused to make an aromatic tea. In Cambodia, the leaves are used to wrap cakes (such as *num katâm*), and the flowers are sometimes used to make sugar, vinegar, and alcohol (Phon et al., 2000).

Then, nipa leaves are flexible, making them easy to shape and use for handicrafts. For example, in Nigeria, the leaves are woven to form the hats known locally as "*ikpoto*" (Udofia and Udo 2005). The hats are sold as souvenirs for beach visitors and used by local people to accompany them in activities such as selling fish. The people of Nigeria also use nipa as bio-ethanol (Okugbo et al., 2012).

According to Hossain and Islam (2015), in Bangladesh, nipa leaves are part of people's lives that can be used as cigarette wrappers as we know that some people habits are smoking. Smoking is a medium to relieve stress or socialize with neighbors and is mostly done in rural and urban communities. Therefore, nipa leaves also have social value in their utilization. The leaf stalk can be used as a

float for fishing nets that have been spread, the main stalk is used as a net framework, and the middle bone is used as a rope to pull the net. Nipa, locally called '*Golpata*,' is used for multipurpose such as thatched roofs, partitions, food, and as a source of firewood. The newly developed shoots will be used as a vermicide. Dried leaves, petioles, woody stems, fruit residues, and other parts are used as fuel. In fishing, nipa rhizomes are widely used to make it easier for fishing nets to float on the water surface. The sweet sap from the inflorescence stems is used as a source of syrup (cane molasses), amorphous sugar, vinegar, and alcohol. Nipa plant sap is an important factor in producing sap/sugar. The growth properties of nipa fruit stems and their water content have affected sap production (Matsui et al., 2014).

In conclusion, the active compounds produced by nipa include phenolics, saponins, flavonoids, and tannins. The many chemical compounds in nipa can be used as raw materials in a product, especially in modern medicines. In some tropical countries, based on people's beliefs that nipa has the potential of herbal medicine to treat fever, gout, kidney stones, energy booster, aiding the digestive process, as a cure for certain chronic diseases and metabolic syndromes such as diabetes and hypertension, treat asthma, leprosy, tuberculosis, sick throat, liver disease, snakebite, as a pain reliever, and can also be used as a sedative and able to expel excess wind in the body. Then, it was also proven that nipa could act as an antioxidant, antidiabetic, antimicrobial (antifungal and antibacterial), anticancer, anti-inflammatory, antinociceptive, antihyperglycemic and analgesic. Nipa plants other than medicine are used as a roof for houses, cattle pens, or huts in the garden, broomsticks, handicrafts, fishing tools, as a source of food and drink, to a source of renewable energy fuel. Further research is needed to find out more about the actual potential of the drug and educate the public about the importance of the benefits of nipa as a renewable resource for the future of human life.

REFERENCES

- Abdel-Aziz SM, Foukia E, Mouafi M, Yomna A, Moustafa M, Nayera A, Abdelwahed M. 2016. Medicinal Importance of Mangrove Plants: Microbes in Food and Health. Springer, Switzerland. DOI: 10.1007/978-3-319-25277-3_5.
- Akpakpan AE, Akpabio UD, Obot IB. 2012. Evaluation of physicochemical properties and soda pulping of *Nypa fruticans* frond and petiole. *Elixir Appl Chem* 45: 7664-7668.
- Al-Numair KS, Chandramohan G, Veeramani C, Alsaif MA. 2015. Ameliorative effect of kaempferol, a flavonoid, on oxidative stress in streptozotocin-induced diabetic rats. *Redox Rep* 20 (5): 198-209. DOI: 10.1179/1351000214Y.0000000117.
- Alongi DM. 2014. Carbon cycling and storage in mangrove forests. *Ann Rev Mar Sci* 6: 195-219. DOI: 10.1146/annurev-marine-010213-135020.
- Arifanti VB, Kauffman JB, Hadriyanto D, Murdiyarto D, Diana R. 2019. Carbon dynamics and land use carbon footprints in mangrove-converted aquaculture: The case of the Mahakam Delta, Indonesia. *For Ecol Manag* 432: 17-29. DOI: 10.1016/j.foreco.2018.08.047.
- Arumugam S, Palanisamy D, Sambandam RT. 2014. Identification of bioactive compounds of *Rhizophora mucronata* Poir. leaves using supercritical fluid extraction and GC-MS. *World J Pharm Pharm Sci* 3 (10): 1621-1631.
- Astuti MD, Nisa K, Mustikasari K. 2020. Identification of chemical compounds from nipah (*Nypa fruticans* Wurm.) endosperm. *BIO Web Conipah* 20: 03002. DOI: 10.1051/bioconf/20202003002.
- Az-Zahra FR, Sari NLW, Saputry R, Nugroho GD, Pribadi T, Sunarto S, Setyawan AD. 2021. Traditional knowledge of the Dayak Tribes (Borneo) in the use of medicinal plants. *Biodiversitas* 22 (10): 4633-4647. DOI: 10.13057/biodiv/d221057.
- Azman A-S, Othman I, Velu S, Chan K-G, Lee L-H. 2015. Mangrove rare actinobacteria: Taxonomy, natural compound, and discovery of bioactivity. *Front Microbiol* 6: 856. DOI: 10.3389/fmicb.2015.00856.
- Azuma H, Toyota M, Asakawa Y, Takaso T, Tobe H. 2002. Floral scent chemistry of mangrove plants. *J Plant Res* 115: 47-53. DOI: 10.1007/s102650200007.
- Badve RM, Sakurkar CV. 2003. On the disappearance of palm genus *Nypa* from the west coast with its present status in the Indian subcontinent. *Curr Sci* 85: 1407-1409.
- Bae GS, Jung WS. 2016. The anti-inflammatory effect of *Nypa fruticans* Wurm., fruit on lipopolysaccharide-induced inflammatory response on RAW 264.7 cells. *Kor J Herbol* 31 (5): 79-84. DOI: 10.6116/kjh.2016.31.5.79.
- Baja-Lapis AC, David ME, Reyes CG, Audije BS. 2004. ASEAN's 100 Most Precious Plants. The European Commission & Philippine Govt., Manila.
- Bakshi M, Chaudhuri P. 2014. Antimicrobial potential of leaf extracts of ten mangrove species from Indian Sundarban. *Intl J Pharm and Biosci* 5 (1): 294-304.
- Bandaranayake WM. 1998. Traditional and medicinal uses of mangroves. *Mangroves Salt Marshes* 2 (3): 133-148. DOI: 10.1023/A:1009988607044.
- Blanch GP, Gomez-Jimenez MC, Del Castillo MLR. 2020. Exogenous salicylic acid improves phenolic content and antioxidant activity in table grapes. *Plant Foods Hum Nutr* 75: 177-183. DOI: 10.1007/s11130-019-00793-z.
- Boopathy NS, Kathiresan K. 2010. Anticancer drugs from marine flora: An overview. *J Oncol* 2010: 214186. DOI: 10.1155/2010/214186.
- Burkill IH. 1935. Nipa. In *A Dictionary of the Economic Products of the Malay Peninsula*, vol. II. Crown Agents for the Colonies, London.
- Carandang MG, Camacho LD, Carandang AP, Camacho SC, Gevaa DT, Rebugio LL, Youn YC. 2009. Sustainable thatching materials production from nipa (*Nypa fruticans*) in Bohol, Philippines. *For Sci Tech* 5: 17-22. DOI: 10.1080/21580103.2008.9656343.
- Chai PK, Lai KK. 1984. Management and utilization of the mangrove forests of Sarawak. In: Soepadmo E (eds). *Proc. Asian Symposium on Mangrove Environment: Research and Management*. August 1980, Univ. Malaya, Kuala Lumpur.
- Chaudhuri P, Guha S. 2010. Potentiality of mangrove plant extracts for biocontrol of a pathogenic fungi- *Fusarium oxysporum*. *Sci Cult* 76 (7-8): 271-274.
- Cheablum A, Chanklap B. 2020. Sustainable nipa palm (*Nypa fruticans* Wurm.) product utilization in Thailand. *Hindawi Sci* 2020: 1-10. DOI: 10.1155/2020/3856203.
- Cheablum A, Chanklap B. 2020. Sustainable nipa palm (*Nypa fruticans* Wurm.) product utilization in Thailand. *Scientifica (Cairo)* 2020: 3856203. DOI: 10.1155/2020/3856203.
- Choi HJ, Alam MB, Baek ME, Kwon YG, Lim JY, Lee SH. 2020. Protection against UVB-Induced photoaging by *Nypa fruticans* via inhibition of MAPK/AP-1/MMP-1 signaling. *Oxid Med Cell Longev* 2020: 2905362. DOI: 10.1155/2020/2905362.
- Choi HJ, Naznin M, Alam MB, Javed A, Alshammari FH, Kim S, Lee SH. 2022. Optimization of the extraction conditions of *Nypa fruticans* Wurm. using response surface methodology and artificial neural network. *Food Chem* 381: 132086. DOI: 10.1016/j.foodchem.2022.132086.
- Crawford J. 2017. Sejarah Kepulauan Nusantara: Kajian Budaya, Agama, Politik, Hukum dan Ekonomi. 1. Diterjemahkan oleh Zara, Muhammad Yuanda. Penerbit Ombak, Yogyakarta. [Indonesian]
- Dalming T, Aliyah A, Mufidah M, Margareth V, Asmawati A. 2018. Kandungan serat buah nipah (*Nypa fruticans* wurmb) dan potensinya dalam mengikat kolesterol secara in vitro. *Media Farmasi* 14 (1): 140-145. DOI: 10.32382/mf.v14i1.149. [Indonesian]
- Das G, Gouda S, Mohanta YK, Patra JK. 2015. Mangrove plants: A potential source for anti-cancer drugs. *Indian J Geo-Mar Sci* 44 (5): 666-672.
- Das SK, Samantaray D, Patra JK, Samanta L, Thatoi H. 2016. Antidiabetic potential of mangrove plants: A review. *Front Life Sci* 9 (1): 75-88. DOI: 10.1080/21553769.2015.1091386.

- De Petrocellis L, Moriello AS. 2013. Modulation of the TRPV1 channel: Current clinical trials and recent patents with focus on neurological conditions. *Recent Pat CNS Drug Discov* 8: 180-204. DOI: 10.2174/1574889808666131209124012.
- Donato DC, Kauffman JB, Murdiyarso D, Kurnianto S, Stidham M, Kanninen M. 2011. Mangroves among the most carbon-rich forests in the tropics. *Nat Geosci* 4: 293-297. DOI: 10.1038/ngeo1123.
- Dowe JL. 2010. Australian Palms: Biogeography, Ecology, and Systematics. CSIRO Publishing, Australian. DOI: 10.1071/9780643098022.
- Duke NC, Ball MC, Ellison JC. 1998. Factors influencing biodiversity and distributional gradients in mangroves. *Glob Ecol Biogeogr* 7 (1): 24e47. DOI: 10.2307/2997695.
- Ebana RUB, Etok CA, Edet UO. 2015. Phytochemical screening and antimicrobial activity of *Nypa fruticans* harvested from Oporo River in the Niger Delta Region of Nigeria. *Intl J Innov Appl Stud* 10 (4): 1120-1124.
- Ekpunobi EU, Onuegbu TU. 2012. Thermal degradation effect on the proximate analysis of nipa palm fibre. *Intl J Chem Res* 3 (1): 1-2.
- Estoque RC, Myint SW, Wang C, Ishtiaque A, Aung TT, Emerton L, Ooba M, Hijjoka Y, Mon MS, Wang Z, Fan C. 2018. Assessing environmental impacts and change in Myanmar's mangrove ecosystem service value due to deforestation (2000-2014). *Glob Change Biol* 24: 5391-5410. DOI: 10.1111/gcb.14409.
- Fairudz A, Nisa K. 2015. Pengaruh serat pangan terhadap kadar kolesterol penderita over.weight. *Majority* 4 (8): 121-126. [Indonesian]
- Febriadi I, Saeni F. 2018. Inventarisasi dan pemanfaatan nipah (*Nypa fruticans* (Thunb.) Wurmb) oleh masyarakat pada hutan mangrove Kampung Mariat Pantai Distrik Aimas Kabupaten Sorong. *Median* 10 (3): 23-30. DOI: 10.33506/md.v10i3.176. [Indonesian]
- Fong FW. 1984. Nipa swamps-a neglected mangrove resource. In: Soepadmo E (eds). *Proc. Asian Symposium on Mangrove Environment: Research and Management*. August 1980, Univ. Malaya, Kuala Lumpur.
- Gazali M, Nufus H. 2019. The phytochemical screening of fresh leaves of *Nypa fruticans* Wurmb from the coast of West Aceh. *J Perikanan Tropis* 6 (1): 25-32. DOI: 10.35308/jpt.v6i1.1094. [Indonesian]
- Gee CT. 1989. On the fossil occurrences of the mangrove palm *Nypa*. Paper presented at the symposium; Paleofloristic and Paleoclimatic Changes in the Cretaceous and Tertiary. Prague.
- Genilar LA, Kurniawaty E, Mokhtar RAM, Audah KA. 2021. Mangroves and their medicinal benefit: A mini review. *Ann Romanian Soc Cell Biol* 25 (4): 695-709.
- Germplasm Resources Information Network (GRIN). 2017. *Nypa fruticans*. Agricultural Research Service (ARS), United States Department of Agriculture (USDA). Retrieved 9 January 2017.
- Ghani NA, Yusuf NYM, Isahak WNRW, Masdar S. 2017. Modification of activated carbon from biomass *Nypa* and amine functional groups as carbon dioxide adsorbent. *J Phys Sci* 28(Supp. 1): 227-240. DOI: 10.21315/jps2017.28.s1.15.
- Giri C, Long J, Abbas S, Murali RM, Qamer FM, Pengra B, Thau D. 2015. Distribution and dynamics of mangrove forests of South Asia. *J Environ Manag* 148: 101-111. DOI: 10.1016/j.jenvman.2014.01.020.
- Gordon A, Cruz APG, Cabral LMC. 2012. Chemical characterization and evaluation of antioxidant properties of Acai fruits (*Euterpe oleracea* Mart.) during ripening. *Food Chem* 13 (3): 256-263. DOI: 10.1016/j.foodchem.2011.11.150.
- Grasso M. 2000. Understanding, Modeling, and Valuing the Linkages between Local Communities and the Mangroves of the Caete' River Bay, PA, Brazil. [PhD Thesis]. Faculty of the Graduate School of the University of Maryland, College Park, Maryland.
- Ha YM, Park YJ, Kim JA, Park D, Park JY, Lee HJ, Lee JY, Moon HR, Chung HY. 2012. Design and synthesis of 5-(substituted benzylidene) thiazolidine-2,4-dione derivatives as novel tyrosinase inhibitors. *Eur J Med Chem* 49: 245-252. DOI: 10.1016/j.ejmech.2012.01.019.
- Hadi S, Thamrin, Moersidik SS, Bahry S. 2013. Karakteristik dan potensi bioetanol dari nira nipah (*Nypa fruticans*) untuk penerapan skala teknologi tepat guna. *J Ilmu Lingkungan* 7 (2): 223-240. [Indonesian]
- Hafizi SA, Razip AM, Aliana WS, Tarmizi WY. 2018. Crystallization and biological studies of *Nypa fruticans* Wurmb Sap. *Indones J Pharmac Sci Technol* 1 (1): 37-42. DOI: 10.24198/ijpst.v1i1.16122.
- Halos SC. 1981. Nipa for algos production. *Canopy* 7: 15.
- Hamilton LS, Murphy DH. 1988. Use and management of nipa palm (*Nypa fruticans*, Arecaceae): A review. *Econ Bot* 42 (2): 206-213. DOI: 10.1007/BF02858921.
- Herfayati P, Pandia S, Nasution H. 2020. Karakteristik antosianin dari kulit buah nipah (*Nypa fruticans*) sebagai pewarna alami dengan metode soxhletasi. *J Teknik Kimia USU* 9 (1): 26-33. DOI: 10.32734/jtk.v9i1.2831.
- Heriyanto NM, Endro S, Endang K. 2011. Potensi dan sebaran nipah (*Nypa Fruticans* (Thunb.) Wurmb) sebagai sumber daya pangan. *J Penelitian Hutan dan Konservasi Alam* 4 (8): 327-335. DOI: 10.20886/jphka.2011.8.4.327-335. [Indonesian]
- Herman RR, Ilimu E, Hamid R, Haeruddin. 2011. Analisis kadar mineral dalam abu buah nipa (*Nypa fruticans*) Kaliwanggu Teluk Kendari Sulawesi Tenggara. *J Trop Pharm Chem* 1 (2): 100-110. DOI: 10.25026/jtpc.v1i2.17. [Indonesian]
- Heyne K. 1987. *Tumbuhan Berguna Indonesia*, Jil. 1. Yay. Sarana Wana Jaya, Jakarta. [Indonesian]
- Hossain MDF, Islam MDA. 2015. Utilization of mangrove forest plant: Nipa palm (*Nypa fruticans* Wurmb.). *Am J Agric For* 3 (4): 156-160. DOI: 10.11648/j.ajaf.20150304.16.
- Imra I, Tarman K, Desniar D. 2016. Aktivitas antioksidan dan antibakteri ekstrak nipah (*Nypa fruticans*) terhadap *Vibrio* sp. isolat kepingit bakau (*Scylla* sp.). *JPHPI* 19 (3): 241-250. DOI: 10.17844/jphpi.v19i3.14530. [Indonesian]
- Irwansyah RM, Azzahra SIN, Darmastuti SA, Ramadhandi AR, Firdaus O, Daeni F, Safitri N, Fajri OPA, Nugroho GN, Naim DM, Setyawan AD. 2021. Crab diversity and crab potential as support ecotourism in Teleng Ria, Grindulu and Siwil Beach, Pacitan, East Java, Indonesia. *Intl J Bonorowo Wetlands* 11: 75-83. DOI: 10.13057/bonorowo/w110204.
- Islam S, Alam MB, Ahmed A, Lee S, Lee SH, Kim S. 2020a. Identification of secondary metabolites in *Averrhoa carambola* L. bark by high-resolution mass spectrometry and evaluation for α -glucosidase, tyrosinase, elastase, and antioxidant potential. *Food Chem* 332: 127377. DOI: 10.1016/j.foodchem.2020.127377.
- Islam ATMR, Hasan M, Islam T, Rahman A, Mitra S, Das SK. 2020b. Ethnobotany of medicinal plants used by Rakhine Indigenous Communities in Patuakhali and Barguna District of Southern Bangladesh. *Evid-Based Integr Med* 25: 1-27. DOI: 10.1177/2515690X20971586.
- Istiqomah MA, Hasibuan PAZ, Sumaiyah S, Yusraini E, Oku H, Basyuni M. 2020. Anticancer effects of polyisoprenoid from *Nypa fruticans* leaves by controlling expression of p53, EGFR, PI3K, AKT1, and mTOR genes in colon cancer (WiDr) cells. *Nat Prod Commun* 15 (4): 1-8. DOI: 10.1177/1934578X20918412.
- Jahnen-Dechent W, Ketteler M. 2012. Magnesium basics. *Clin Kidney J* 5 (Suppl 1): 3-14. DOI: 10.1093/ndtplus/sfr163.
- Kang MS, Hyun KY. 2020. Antinociceptive and anti-inflammatory effects of *Nypa fruticans* Wurmb by suppressing TRPV1 in the sciatic neuropathies. *Nutrients* 12 (1): 135-145. DOI: 10.3390/nu12010135.
- Kawano K, Morimura S, Mori E, Matsushita H, Ohta H, Kida K. 2010. Isolation and identification by cytoprotection assay of antioxidative compound contained in vinegar produced from sweet potato-shochu post-distillation slurry. *Food Sci Tech Res* 16 (4): 327-332. DOI: 10.3136/fstr.16.327.
- Khairi I, Bahri S, Ukhty N, Rozi A, Nasution MA. 2021. Potensi pemanfaatan nipah (*Nypa Fruticans*) sebagai pangan fungsional dan farmasetika. *J Kelautan* 2 (2): 119-128. DOI: 10.35308/jlaot.v2i2.3146. [Indonesian]
- Khooh HE, Azlan A, Tang ST, Lim SM. 2017. Anthocyanidins and anthocyanins: Colored Pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food Nutr Res* 61 (1): 1-21. DOI: 10.1080/16546628.2017.1361779.
- Khotimah K, Lisnawati A, Ardan M. 2020. Studi pengolahan manisan kering buah nipah (*Nypa fruticans*). *Buletin Loupe* 16 (1): 35-45. DOI: 10.51967/buletinloupe.v16i01.74. [Indonesian]
- Kurniawan T, Jayanudin, Kustiningsih I, Firdaus MA. 2018. Palm sap sources, characteristics, and utilization in Indonesia. *J Food Nutr Res* 6 (9): 590-596. DOI: 10.12691/jfnr-6-9-8.
- Kusmana C. 2018. Mangrove plant utilization by local coastal community in Indonesia. *IOP Conipah Ser Earth Environ Sci* 196: 012028. DOI: 10.1088/1755-1315/196/1/012028.
- Lestari Y, Ardinarsih P, Nurlina. 2016. Aktivitas antibakteri Gram positif dan Negatif dari ekstrak dan fraksi daun nipah (*Nypa fruticans* Wurmb.) Asal Pesisir Sungai Kakap Kalimantan Barat. *JKK* 5 (4): 1-8. [Indonesian]
- Liatis S, Grammatikou S, Poulia KA, Perrea D, Perrea D, Makrilakis K, Diakoumopoulou E, Katsilambros N. 2010. Vinegar reduces postprandial hyperglycaemia in patients with type II diabetes when

- added to a high, but not to a low, glycaemic index meal. *Eur J Clin Nutr* 64: 727-732. DOI: 10.1038/ejcn.2010.89.
- Lim TK. 2011. *Nypa fruticans*. Edible Medicinal and Non-Medicinal Plants 1: 402-406. DOI: 10.1007/978-90-481-8661-7_50.
- Lourenço SC, Moldão-Martins M, Alves VD. 2019. Antioxidants of natural plant origins: From sources to food industry applications. *Molecules* 24 (22): 4132. DOI: 10.3390/molecules24224132.
- Lovly MS, Marlee TMV. 2018. Phytochemical analysis and antimicrobial properties of *Nypa fruticans* Wurmb. from Kerala. *J Pharmacog Phytochem* 7 (4): 688-693.
- Mahli Y, Doughty C, Galbraith D. 2011. The allocation of ecosystem net primary productivity in tropical forests. *Philos Trans Biol Sci* 366: 3225-3245. DOI: 10.1098/rstb.2011.0062.
- Mahmud I, Islam MdK, Saha S, Barman AK, Rahman MdMr, Anisuzzaman Md, Rahman T, Al-Nahain A, Jahan R, Rahmatullah M. 2014. Review Article: Pharmacological and ethnomedicinal overview of *Heritiera fomes*: Future prospects. *Intl Sch Res Notices* 2014: 12. DOI: 10.1155/2014/938543.
- Mani AE, Bharathi V, Patterson J. 2012. Antibacterial activity and preliminary phytochemical analysis of seagrass *Cymodocea rotundata*. *IJMR* 2 (2): 99-103.
- Manilal A, Merdekios B, Idhayadhulla A, Muthukumar C, Melkie M. 2015. An in vitro antagonistic efficacy validation of *Rhizophora mucronata*. *Asian Pac J Trop Dis* 5: 28-32. DOI: 10.1016/S2222-1808(14)60622-8.
- Manojlovic TN, Vasiljevic PJ, Maskovic PZ, Juskovic M, Bogdanovic-Dusanovic G. 2012. Chemical composition, antioxidant, and antimicrobial activities of Lichen *Umbilicaria cylindrica* (L.) Delise (Umbilicariaceae). *Evid-Based Complement Altern Med* 8 (2012): 1-8. DOI: 10.1155/2012/452431.
- Maqsood S, Benjakul S. 2013. Effect of kiam (*Cotylelobium lanceolatum* Craib) wood extract on the haemoglobin-mediated lipid oxidation of washed Asian sea bass mince. *Food Bioproc Tech* 6 (1): 61-72. DOI: 10.1007/s11947-011-0530-x.
- Margaretta S, Handayani SD. 2011. Ekstraksi senyawa fenolik *Pandanus amaryllifolius* ROXB sebagai antioksidan alami. *J Widya Teknik* 10: 21-30. [Indonesian]
- Matsui N, Okimori Y, Takahashi F, Matsumura K, Bamroongruga N. 2014. Nipa (*Nypa fruticans* Wurmb) sap Collection in Southern Thailand I. Biomass and soil properties. *Environ Nat Resour Res* 4 (4): 75-88. DOI: 10.5539/enr.v4n4p75.
- Middleton E, Kandaswami C, Theoharides TC. 2000. The effects of plant flavonoids on mammalian cells: Implications for inflammation, heart disease, and cancer. *Pharmacol Rev* 52 (4): 673-751.
- Muthmainnah, Sribianti I. 2016. Nilai manfaat ekonomi tanaman nipah (*Nypa fruticans*) Desa Lakkang Kecamatan Tallo Kota Makassar. *J Hujan Tropis* 4 (2): 140-144. [Indonesian]
- Nafie NL, Liang S, Arifin RR. 2019. Fitoakumulasi logam Ni Dan Zn dalam tumbuhan nipah (*Nypa Fruticans*) di Sungai Tallo Makassar. *Indones J Chem Res* 7 (1): 92-100. DOI: 10.30598/ijcr.2019.5-nur. [Indonesian]
- Neamsuvan, Singdam P, Yingcharoen K, Sengnon N. 2012. A survey of medicinal plants in mangrove and beach forests from sating Phra Peninsula, Songkhla Province, Thailand. *J Med Plants Res* 6 (12): 2421-2437. DOI: 10.5897/JMPR11.1395.
- Nishidai S, Nakamura Y, Torikai K, Yamamoto M, Ishihara N, Mori H, et al. 2000. Kurosu, a traditional vinegar produced from unpolished rice, suppresses lipid peroxidation in vitro and in mouse skin. *Biosci Biotechnol Biochem* 64 (9): 1909-1914. DOI: 10.1271/bbb.64.1909.
- Nopiayanti HT, Agustriani F, Isnaini, Melki. 2016. Skrining *Nypa fruticans* sebagai antibakteri *Bacillus subtilis*, *Escherichia coli* dan *Staphylococcus aureus*. *Maspari J* 8 (2): 83-90.
- Number AO. 2018. The impact of oil and gas exploration: Invasive Nypa Palm species and urbanization on mangroves in the Niger River Delta, Nigeria. In: Makowski, Christopher, Finkl, Charles W (Eds.). *Threats to Mangrove Forests*. Springer International Publishing. DOI: 10.1007/978-3-319-73016-5_12.
- Nyangon L, Zainal ANS, Pazi AMM, Gandaseca S. 2019. Heavy metals in mangrove sediments along the Selangor River, Malaysia. *For Soc* 3 (2): 278-288. DOI: 10.24259/fs.v3i2.6345.
- Okugbo OT, Usunobun U, Esan A, Adegbeji JA, Oyedeji JO, Okiemien CO. 2012. A review of nipa palm as a renewable energy source in Nigeria. *Res J Appl Sci Eng Technol* 4: 2367-2371.
- Olalude CB, Oyedeji FO, Adegboyega AM. 2015. Physicochemical analysis of *Daucus carota* (carrot) juice for possible industrial applications. *J Appl Chem* 8 (8): 110-113. DOI: 10.9790/5736-0882110113.
- Osabor VN, Egbung GE, Okafor PC. 2008. Chemical profile of *Nypa fruticans* from Cross River Estuary, South Eastern Nigeria. *Pak J Nutr* 7 (1): 146-150. DOI: 10.3923/pjn.2008.146.150.
- Päiväke A, Adams MR, Twiddy DR. 1984. Nipa palm vinegar in Papua-New-Guinea. *Process Biochem* 19: 84-87.
- Päiväke AEA. 1996. Plant yielding non-seed carbohydrates. In: Flach M, Rumawas (eds). *Plant Resource of South-East Asia No. 9*. Prosea Foundation, Bogor. [Indonesian]
- Park YM, Chun SP, Byun YJ, Moon HR, Chung HY. 2013. De novotyrosinase inhibitor: 4-(6,7-Dihydro-5H-indeno[5,6-d] thiazol-2-yl)benzene-1,3-diol (MHY1556). *Bioorg MedChem Lett* 23: 4172-4176. DOI: 10.1016/j.bmcl.2013.05.029.
- Phetrit R, Chaijan M, Sorapukdee S, Panpipat W. 2020. Characterization of Nipa Palm's (*Nypa fruticans* Wurmb.) sap and syrup as functional food ingredients. *Sugar Tech* 22 (1): 191-201. DOI: 10.1007/s12355-019-00756-3.
- Plants of The World Online (POWO). 2022. *Nypa frutican*. <https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:668507-1>. [Accessed 2022]
- Prabhakaran J, Kavitha D. 2012. Ethnomedicinal importance of mangrove species of Pitchavaram. *Intl J Res Pharm Biomed Sci* 3 (2): 611-614.
- Prabhu VV, Guruvayoorappan C. 2012. Anti-inflammatory and anti-tumor activity of the marine mangrove *Rhizophora apiculata*. *J Immunotoxicol* 9 (4): 341-352. DOI: 10.3109/1547691X.2012.660997.
- Prasad N, Yang B, Kong KW, Khoo HE, Sun J, Azlan A, Ismail A, Romli ZB. 2013. Phytochemicals and antioxidant capacity from *Nypa fruticans* Wurmb. fruit. *Evid-Based Complement Alternat Med* 2013: 9. DOI: 10.1155/2013/154606.
- Putri IJMM. 2013. Aktivitas antioksidan daun dan biji buah nipah (*Nypa Fruticans*) Asal Pesisir Banyuasin Sumatera Selatan dengan metode DPPH. 5 (1): 16-21. [Indonesian]
- Radam RR, Purnamasari E. 2016. Uji fitokimia senyawa kimia aktif akar nipah (*Nypa fruticans* Wurmb) sebagai tumbuhan obat di Kalimantan Selatan. *J Hutan Tropis* 4 (1): 28-34. DOI: 10.20527/jht.v4i1.2879. [Indonesian]
- Radam RR, Sari NM, Lusyani. 2019. Kajian nilai gizi tepung buah nipah (*Nypa fruticans* WURMB) sebagai tepung substitusi. *J Hutan Tropis* 7 (3): 293-301. [Indonesian]
- Rahman M. 2018. Antifungal and Antibacterial Activity of Actinomycetes Isolated from the Sundarbans Mangrove Forest Soil and Water From Bay of Bengal. [Thesis]. Department of Pharmacy, BRAC University. [Bangladesh]
- Rahmatullah M, Sadeak SMI, Bachar SC, Hossain MT, Al-Mamun A, Montaha, Jahan N, Chowdhury MH, Jahan R, Nasrin D, Rahman M, Rahman S. 2010. Brine shrimp toxicity study of different Bangladeshi medicinal plants. *Adv Nat Appl Sci* 4: 163-173.
- Rajani KP, Prasanna KYASJ, Vijaya KC. 2020. In-vitro pharmacological evaluation of leaf extracts of a medicinal mangrove plant *Bruguiera gymnorhiza* L. *Res J Pharm Technol* 13 (4): 1867-1872. DOI: 10.5958/0974-360X.2020.00336.4.
- Rajesh KD, Vasantha S, Rajesh NV, Panneerselvam A. 2014. Qualitative and quantitative phytochemical analysis in four pteridophytes. *Intl J Pharm Sci* 73 (27): 408-412.
- Reddy ARK, Grace JR. 2016. Anticancer activity of methanolic extracts of selected mangrove plants. *Intl J Pharm Sci Res* 7 (9): 3852. DOI: 10.4172/2167-0412.1000250.
- Rengasamy RRR, Radjasagarin A, Perumal A. 2013. Seagrasses as potential source of medicinal food ingredients: Nutritional analysis and multivariate approach. *Biomed Prev Nutr* 3: 375-380. DOI: 10.1016/j.bionut.2013.06.011.
- Revathi P, Peyaseelan ST, Thirumalaikolundusubramanian P, Prabhu N. 2014. An overview of antidiabetic profile of mangrove plants. *Intl J Pharm Pharm Sci* 6 (3): 1-5.
- Reza H, Haq VM, Das AK, Rahman S, Jahan R, Rahmatullah M. 2011. Anti-hyperglycemic and antinociceptive activity of methanol leaf and stem extract of *Nypa fruticans* Wurmb. *Pak J Pharm Sci* 24: 485-488.
- Robertson AI, Daniel PA, Dixon P. 1991. Mangrove forest structure and productivity in the Fly River estuary, Papua New Guinea. *Mar Biol* 111: 147-155. DOI: 10.1007/BF01986356.
- Robertson AI, Dixon P, Daniela PA, Zagorskis I. 2020. Primary production in forests of the mangrove palm *Nypa fruticans*. *Aquat Bot* 167 (2020): 103288. DOI: 10.1016/j.aquabot.2020.103288.

- Romañach SS, De Angelis DL, Koh HL, Li Y, Teh SY, Barizan RSR, et al. Conservation and restoration of mangroves: Global status, perspectives, and prognosis. *Ocean Coast Manag* 154: 72-82. DOI: 10.1016/j.ocecoaman.2018.01.009.
- Sabri WMAW, Asaruddin MRAR, Sukairi AH, Yusop SATW. 2018. Antioxidant and cytotoxicity studies of *Nypa fruticans* (Nypa Palm Sugar) extract. *Indones J Pharm Sci Tech* 1 (1): 65-69.
- Sachithanandam V, Lalitha P, Parthiban A, Mageswaran T, Manmadhan K, Sridhar R. 2019. A review on antidiabetic properties of Indian mangrove plants with reference to island ecosystem. *Evidence-Based Complement Altern Med* 2019: 2019. DOI: 10.1155/2019/4305148.
- Sahoo G, Mulla NSS, Ansari ZA, Mohandas C. 2012. Antibacterial activity of mangrove leaf extracts against human pathogen. *Indian J Pharm Sci* 74 (4): 349-351. DOI: 10.4103/0250-474X.107068.
- Saithong P, Nitipan S, Permpool J. 2019. Optimization of vinegar production from nipa (*Nypa fruticans* Wurm.) sap using surface culture fermentation process. *Appl Food Biotechnol* 6 (3): 193-200.
- Santoso A. 2011. Serat pangan (dietary fiber) dan manfaatnya bagi kesehatan. *Magistra* 75: 35-40. [Indonesian]
- Saptarini NM, Herawati IE. 2018. Extraction methods and varieties affect total anthocyanins content in acidified extract of papery skin of onion (*Allium cepa* L.). *Drug Invent Today* 4 (10): 471-474.
- Sari DP, Basyuni M, Hasibuan PAZ, Sumardi S, Nuryawan A, Wati R. 2018. Cytotoxic and antiproliferative activity of polyisoprenoids in seventeen mangrove species against WiDr colon cancer cells. *Asian Pac J Cancer Prev* 19 (12): 3393-3400. DOI: 10.31557/APJCP.2018.19.12.3393.
- Sari TADR. 2017. Uji Aktivitas Antibakteri Ekstrak Kasar Daun Nipah (*Nypa fruticans*) terhadap Bakteri *Aeromonas hydrophila* dan *Streptococcus agalactiae*. [Thesis]. Universitas Brawijaya, Malang. [Indonesian]
- Sasidhar K. 2020. Mangrove medicinal plants and its chemistry: A review. *Intl J Multidisciplinary Educ Res* 10: 16-21.
- Setyawan AD. 2005. Keaneekaragaman Tumbuhan Mangrove di Pantai Utara dan Selatan Jawa Tengah. [Thesis]. Universitas Sebelas Maret, Surakarta. [Indonesian]
- Shamsuddin AA, Najiah M, Suvik A, Azariyah MN, Kamaruzzaman BY, Effendy AW, John BA. 2013. Antibacterial properties of selected mangrove plants against *Vibrio* species and its cytotoxicity against *Artemia salina*. *World Appl Sci J* 25 (2): 333-340.
- Sharief NMD, Rao UMV. 2014. Antibacterial and antioxidant activity of *Avicennia marina* leaf. *J Chem Pharmaceu Res* 10: 252-256.
- Shilpi JA, Islam ME, Billah M, Islam KMD, Sabrin F, Uddin SJ, Nahar L, Sarker SD. 2012. Antinociceptive, anti-inflammatory, and antipyretic activity of mangrove plants: A mini review. *Adv Pharmacol Sci* 2012: 1-7. DOI: 10.1155/2012/576086.
- Shin HS, Lee YJ, Kim JW, Song BR, Lee SL, Park SN. 2018. Evaluation of antioxidant, cytoprotective, and antimicrobial activities of the extract and fractions obtained from young shoots of *Nypa fruticans* Wurm. *Korean J Pharmacog* 49 (2): 155-164.
- Soonthornchareonnon N, Wiwat C, Chuakul W. 2012. Biological activities of medicinal plants from mangrove and beach forests. *Mahidol Univ J Pharm Sci* 39 (1): 9-18.
- Sowndhararajan K, Kang SC. 2013. Free radical scavenging activity from different extracts of leaves of *Bauhinia vahlii* Wight and Arn. *Saudi J Biol Sci* 20 (4): 319-325. DOI: 10.1016/j.sjbs.2012.12.005.
- Strazzullo P, Leclercq C. 2014. Sodium. *Adv Nutr* 5 (2): 188-190. DOI: 10.3945/an.113.005215.
- Subhashini P, Dilipan E, Thangaradjou T, Papenbrock J. 2013. Bioactive natural products from marine angiosperms: Abundance and functions. *Nat Prod Bioprospect* 3:129-136. DOI: 10.1007/s13659-013-0043-6.
- Subiandono E, Heriyanto NM, Karlina E. 2011. Potensi nipah (*Nypa fruticans* (Thunb.) Wurm.) sebagai sumber pangan dari hutan mangrove. *Buletin Plasma Nutfah* 17 (1): 54-60. DOI: 10.21082/blpn.v17n1.2011.p54-60. [Indonesian]
- Sukairi AH, Asaruddin MR, Sabri WMAW, Yusop SATW. 2018. Crystallization and biological studies of *Nypa fruticans* Wurm sap. *Indones J Pharm Sci Technol* 1 (1): 37-42.
- Sun H, Weaver CM. 2020. Rise in potassium deficiency in the us population linked to agriculture practices and dietary potassium deficits. *J Agric Food Chem* 68 (40): 11121-11127. DOI: 10.1021/acs.jafc.0c05139.
- Suparto, Oramahi AH, Sisilia L. 2019. Pemanfaatan nipah (*Nypa fruticans* Wurm) di Dusun Suk Maju Desa Sungai Sepeti Kecamatan Seponti Kabupaten Kayong Utara. *J Hutan Lestari* 7 (1) : 229-236. DOI: 10.26418/jhl.v7i1.31422. [Indonesian]
- Tamunaidu P, Matsui N, Okimori Y, Saka S. 2013. Nipa (*Nypa fruticans*) sap as a potential feedstock for ethanol production. *Biomass Bioenergy* 52: 96-102. DOI: 10.1016/j.biombioe.2013.03.005.
- Tamunaidu P, Saka S. 2011. Chemical characterization of various parts of nipa palm (*Nypa fruticans*). *Ind Crops Prod* 34: 1423-1428. DOI: 10.1016/j.indcrop.2011.04.020.
- Theerawitaya C, Samphumphang T, Cha-um S, Nana Yamada N, Takabe T. 2014. Responses of Nipa palm (*Nypa fruticans*) seedlings, a mangrove species, to salt stress in pot culture. *Flora - Morphology, Distribution and Functional Ecology of Plants* 209 (10): 597-603. DOI: 10.1016/j.flora.2014.08.004.
- Thyagarajan A, Sahu RP. 2018. Potential contributions of antioxidants to cancer therapy: Immunomodulation and radiosensitization. *Integr Cancer Ther* 17 (2): 210-216. DOI: 10.1177/1534735416681639.
- Tomlinson PS. 1986. *The Botany of Mangroves*. Cambridge University Press, New York.
- Trimanto, Danarto SA, Nurfadlan S. 2016. Bawean Island: The potential for ecotourism and local knowledge on plant diversity-supporting ecosystem. *J Indones Tour Dev Stud* 4 (3): 97-106. DOI: 10.21776/ub.jitode.2016.004.03.02.
- Tsuji K, Ghazalli MNF, Ariffin Z, Nordin MS, Khaidizar MI, Dulloo ME, Sebastian LS. 2011. Biological and ethnobotanical characteristics of Nipa palm (*Nypa fruticans* Wurm.): A review. *Sains Malay* 40: 1407-1412.
- Udofia SI, Udo ES. 2005. Local knowledge of nipa palm (*Nypa fruticans* Wurm) in the Coastal Areas of Akwa Ibom State, Nigeria. *Glob J Agric Sci* 4 (1): 33-40. DOI: 10.4314/gjass.v4i1.2252.
- Utami YP, Umar AH, Ernawati. 2016. Analysis of total anthocyanin content on ethanol extract of purple sweet potato (*Ipomoea batatas* L.) and purple yam (*Dioscorea alata* L.) with differential pH method. *J Pharm Med Sci* 2 (1): 44-47.
- Veetil BK, Pereira SFR, Quang NX. 2018. Rapidly diminishing mangrove forests in Myanmar (Burma): A review. *Hydrobiologia* 822: 19-35. DOI: 10.1007/s10750-018-3673-1.
- Vinoth R, Kumaravel S, Ranganathan R. 2019. Therapeutic and traditional uses of mangrove plants. *J Drug Deliv Ther* 9 (4-s): 849-854. DOI: 10.22270/jddt.v9i4-s.3457.
- Wakili A, Abdullahi MB, Madara MS. 2015. Proximate composition of five commonly used horticultural products in northern Nigeria. *Intl J Curr Microbiol Appl Sciences* 4 (7): 924-928.
- Weaver CM, Stone MS, Lobene AJ, Cladis DP, Hodges JK. 2018. What is the evidence base for a potassium requirement?. *Nutr Today* 53 (5): 184-195. DOI: 10.1097/NT.0000000000000298.
- Whitmore TC. 1973. *Palms of Malaysia*. Oxford University Press, London.
- Wulan DPA, Arifudin A, Nurwijayanti, Hidayat SH. 2021. Optimization of mangrove forest utilization: Similarities to improve the society economy of Kampung Onggaya Papua. *Review of International Geographical Education (RIGEO)* 11 (5): 322-331. DOI: 10.48047/rigeo.11.05.33.
- Xaverius F, Jayawardana H, Zubaedah R, Iswoyo H. 2019. Geographic information system change forest mangrove primary at Districts Merauke. *IOP Conipah Ser Earth Environ Sci* 343 (1): 012205. DOI: 10.1088/1755-1315/343/1/012205.
- Xaverius F, Loppies SHD, Siregar K, Vincēviča-Gaile Z, Adinurani PG. 2020. Geographic Information system of primary carbon deposit of mangrove forest in Merauke District, Indonesia. *E3S Web Conipah* 190 (011): 1-10. DOI: 10.1051/e3sconf/202019000011.
- Yadav M, Chatterji S, Gupta SK, Watal G. 2014. Preliminary phytochemical screening of six medicinal plants used in traditional medicine. *Intl J Pharm Pharm Sci* 6 (5): 539-542.
- Yahaya SFR, Samsuddin N, Mamat S, Hod R, Abdullah NZ, Rahman NAA, So'ad SZM. 2021. Determination of antioxidant compounds, proximate compositions, and assessment of free radical scavenging activities of *Nypa fruticans* Wurm. sap. *Pertanika J Sci Technol* 29 (3): 2061-2071. DOI: 10.47836/pjst.29.3.30.
- Yang Y, Zhang Y, Liu D, Li-Weber M, Shao B, Lin W. 2015. Dolabrane-type diterpenes from the mangrove plant *Ceriops tagal* with antitumor activities. *Fitoterapia* 103: 277-282. DOI: 10.1016/j.fitote.2015.04.016.
- Yusoff NA, Yam MF, Beh HK, Razak KNA, Widyawati T, Mahmud R, Ahmad M, Asmawi MZ. 2015a. Antidiabetic and antioxidant activities of *Nypa fruticans* Wurm. vinegar sample from Malaysia. *Asian Pac J Trop Med* 8 (8): 595-605. DOI: 10.1016/j.apjtm.2015.07.015.

- Yusoff NA, Ahmad M, Al Hindi B, Widyawati T, Yam MF, Mahmud R, Razak KNA, Asmawi MZ. 2015b. Aqueous extract of *Nypa fruticans* Wurmb. vinegar alleviates postprandial hyperglycemia in normoglycemic rats. *Nutrients* 7 (8): 7012-7026. DOI: 10.3390/nu7085320.
- Yusoff NA, Lim V, Al-Hindi B, Razak KNA, Widyawati T, Anggraini DR, Ahmad M, Asmawi MZ. 2017. *Nypa fruticans* Wurmb. vinegar's aqueous extract stimulates insulin secretion and exerts hepatoprotective effect on STZ induced diabetic rats. *Nutrients* 9 (9): 1-12. DOI: 10.3390/nu9090925.
- Zhao HX, Zhang HS, Yang SF. 2014. Phenolic compounds and its antioxidant activities in ethanolic extracts from seven cultivars of Chinese Jujube. *Food Sci Human Wellness* 3: 183-190. DOI: 10.1016/j.fshw.2014.12.005.
- Zhao Y, Wang J, Balleve O, Luo H, Zhang W. 2012. Antihypertensive effects and mechanisms of chlorogenic acids. *Hypertens Res* 35 (4): 370-374. DOI: 10.1038/hr.2011.19.