The potential of mangrove as a food source in Riau

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Mangrove fruit has been utilized as a food by people in several regions of Indonesia, especially as traditional food. Information about the potential and benefits of mangrove fruit is still limited. There is not much information regarding the physico chemical properties of mangrove fruit as a potential food source. This study aims to gather and review various scientific information related to the potential of mangrove fruit and its use as foodstuff. This information can be used as a basis to conduct further research related to the development of mangrove-based food and functional food products. Previous research revealed that in Rokan Hilir and Bengkalis Regencies, the Mangroves were dominated by three species; Rhyzophora mucronata, Bruguiera gymnorrhiza, and Sonneratia caseolaris. These three types of mangroves have the potential for food development in the future. Advanced processing of mangrove fruit that has gone through various stages of processing such as soaking, boiling, and drying, then processed into flour into various types of food, can be declared safe for consumption because proper processing can reduce the content of anti-nutritional substances to a safe limit for consumption. When combined with other ingredients, products made from mangrove flour are safe to use as substitutes. Unlike substitute materials, further research on the use of mangroves as a main food ingredient still requires a more in-depth study, especially minimizing the risk of toxic substances contained in the mangroves, processing techniques, and the final product to determine whether its use is safe or not.

1. Introduction

Mangroves have ecological and economic functions for living things. As a renewable resource, mangroves can provide various types of direct and indirect products as well as environmental protection services such as protection against abrasion, controlling seawater intrusion, reducing strong winds, reducing wave height and speed, recreation and water purification from pollutants (Zhang, Lin, and Chen 2022).

All these benefits are provided free of charge by the mangrove ecosystem. From an economic perspective, mangrove forests hold significant value since they contribute to several sectors such as tourism, timber production, and the provision of non-wood resources including fuel wood, honey, medicinal plants, and other raw materials that can be utilized as food products (Budiyanto et al. 2022; Kusmana and Sukristijiono 2016; Salem and Mercer 2012). Mangroves can provide various types of products that are useful for supporting the needs of coastal residents and various economic activities, at local, regional, and national scales. All of these mangrove functions will continue if the existence of the mangrove ecosystem can be maintained and the utilization of its resources is based on the principles of sustainability (Arifanti et al. 2022; Titisari et al. 2022), this means that mangroves act as a renewable resource if all the ecological processes that occur in the mangrove ecosystem can take place without disturbance.

Mangrove fruit can be used as a food source because it contains relatively high energy and carbohydrates (Handayani 2018). Making flour from the mangrove fruit as a base ingredient for food products is one of the efforts made to make use of the fruit. However, because data on the physico chemical properties of mangrove flour are still limited, the potential use of this flour is also limited. Mangrove fruit contains anti-nutritional components such as cyanogenic glucosides (Ayu, Tamrin, and Hermanto 2019; Chrissanty 2012; Hardoko et al. 2015; Koeslulat and Prabawa 2019; Muryati and Nelfiyanti 2015; Sulistyawati, Wignyanto, and Kumalaningsih 2013), saponins, phytic acid, and oxalic acid (Rout et al. 2015) , tannins and alkaloid compounds (Ayu et al. 2019; Hardoko et al. 2015; Koeslulat and Prabawa 2019).

The existing area of mangroves in Riau Province in 2021 was recorded at 224,895 hectares, mangroves with dense density, a potential is 219,070 ha, medium density mangroves, with a potential is 2,537 ha, sparse density mangroves have the potential to reach 3,288 ha. Existing mangroves in Indragiri Hilir Regency cover an area of 127,144 hectares, Meranti Islands Regency 30,113 hectares, Bengkalis Regency 26,757 hectares, Rohil Regency 23,335 hectares, Pelalawan Regency 11,394 hectares, Dumai City 3,477, and Siak Regency 2,675 hectares (PPID RIAU 2022).

According to the findings of Rahadian et al., (2019) the province of Riau is positioned as the third most extensive province in Indonesia in relation to the spread of mangroves. Nevertheless, the findings of Oktorini et al., (2022) reveal a drop in the size and spatial arrangement of mangroves in Riau Province over the period spanning from the year 2000 to 2019. This decline is characterized by an annual reduction of roughly 2,493.9 hectares.

The mangrove forest ecosystem in the research site is a naturally growing community. These ecosystems are susceptible to overexploitation because they are typically found close to populated areas. Tide movements have a direct impact on mangrove ecosystems. Fishermen, farmers, and traders are some of the locals whose livelihoods are directly impacted by the presence of mangrove forests in this region. The local community makes use of the mangrove forests that are present in coastal regions close to residential areas for new settlement sites, wood, or firewood use, and building materials (Ilman et al. 2016; Miswadi, Firdaus, and Jhonnerie 2017; Rahim and Baderan 2017).

Furthermore, it is anticipated that the rate of population expansion and the demands of the economy will be influential factors in shaping alterations in land use patterns and the extent of mangrove land cover. The incomplete development of sustainable exploitation practices for mangrove ecosystems is expected to lead to a decrease in the extent of mangrove forests, hence affecting biodiversity, changing overall ecosystem functioning, and contributing to global warming (Arifanti et al. 2022; Mulyadi, Hendriyanto, and Fitriani 2010; Rahmadi et al. 2023; Widiastuti, Ruata, and Arifin 2016).

The mangrove ecosystem in Riau Province is a very productive ecosystem and provides many benefits. Mangrove ecosystem resources in Riau Province will be increasingly exploited in line with increasing population and economic pressure. Disruption of the mangrove ecosystem caused by the extraction process of the mangrove ecosystem causes the rate of damage to mangroves to be much faster than the ability of mangroves to recover themselves (Irma, Atmaja, and Marfa'i 2020; Rizaldi, Lestari, and Susiana 2020; Umayah, Gunawan, and Isda 2016). The challenges found for the sustainability of mangrove forests are weak law enforcement, conflict policies, a lack of community involvement, natural disturbances and constraints, and a lack of in-depth research and innovations (Arifanti et al. 2022; Hanifah et al. 2023). Therefore, in order to support the objectives of sustainable development, efforts must be made to strike a balance between conservation and addressing the economic needs of the community.

2. Materials and Methods

2.1 Study Area

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The research was carried out in Rokan Hilir and Bengkalis regencies, from July to December 2022. In particular, the three districts were chosen based on the amount of mangrove forest present in each district and the extent to which locals used the mangroves as a source of food.

2.2 Procedures

Data were obtained through observation, interviews, and document study. Observation (collection of data carried out by direct observation in the field, so that it can describe in a factual, accurate, and detailed manner the conditions in the field, human activities, and the context in which these activities take place). Interview (collecting data by asking written questions to respondents using a previously prepared questionnaire).

Documentation study (data collection to obtain written data through books, pictures, photographs, or the like to support the data obtained through observation and questionnaires).

Observation of the benefits of mangroves by the community is carried out through a survey method of several respondents who have been appointed or determined purposively according to the research objectives. Direct interviews were conducted using a questionnaire to 150 selected respondents to obtain information about the types of utilization of mangrove forests and their productivity. The sampling technique used to study community perceptions is purposive sampling where samples are determined or selected according to predetermined criteria, namely local communities who interact in managing mangrove forests and are actively involved in mangrove forest rehabilitation activities. Purposive sampling is employed in order to ensure that the respondents selected for the study align with the established objectives and criteria, yielding results that are both representative and pertinent to the conditions within the field. Respondents consisted of village government officials, fishermen, housewives, youth/students/students, mangrove monitoring community groups, informal leaders in villages, non-governmental organizations (NGOs), environmental services, forestry, district plantations, district tourism, youth and sports office. Types of forest function benefits are benefits derived from the existence of mangrove forests that have been recognized as having economic, physical, and biological functions as well as economic value in the form of direct benefits such as mangrove wood, fruit, leaves, and bark. Analysis of mangrove benefits is obtained from the value of direct benefits, namely income derived from the productivity of direct benefits after multiplying market prices and deducting extraction costs.

2.3 Data Analysis

The methodology employed in this study involves the utilization of descriptive analysis for data analysis purposes. The data collected from observations, questionnaires, and document studies were subsequently analysed and reported based on the gathered information. The data collected from observations were meticulously documented and subsequently presented in a manner that accurately and comprehensively depicted the on-site conditions, human activities, and the broader context of mangrove usage activities. In a similar manner, the data obtained from questionnaires underwent quantitative descriptive data analysis methods in order to elucidate perspectives. These perceptions encompassed information regarding the respondents and their utilization of mangroves.

3. Results

3.1 Basic Characteristics of Sample Households and Annual Household Income

A simple random sampling survey was conducted in the study sites with prepared questionnaires during the six-month period from July to December 2022. A total of 185 sample households were interviewed from two regencies of Rokan Hilir and Bengkalis, Riau Province. According to the results of the study, the gender distribution of the household head shows that 91.89% are male and the remaining 8.11% are female. Regarding the age distribution of respondents, only 1% of the respondents are 19 or less than 19 years old, 19% of the respondents are aged between 20 and 29 years, 27% of the respondents are aged between 30 and 39 years, 25% of the respondents are aged between 40 and 49 years and the remaining 28% of the respondents are above 49 years old.

Family size varied from 1 to 10 members with a mean value of 4.14 (standard deviation, sd = 1.65). In terms of education levels, 2% of respondents were graduates, 38% had attended high school, 42% studied at secondary school, and 18% studied up to primary school. Crop farming (mainly agriculture, rubber, and palm cultivation) is a major source of livelihood in Rokan Hilir and Bengkalis. Among the respondents, however, 68% of households owned agricultural land and the remaining households were agriculturally landless. The minimum and maximum agricultural land holding sizes of respondents were 0.5 and 10 ha, respectively, with a mean value of 2.50 ha. In the research area, 81% of households derived their income from various sources such as causal and seasonal labour in agriculture, wage labour in mangrove forest plantations, small- scale trade, shopkeeping, collection of firewood, fish proceeding, and crafts.

The sources of income in the study sites are farm activities, non-farm activities, and the collection of mangrove forest products. Among the respondents, 52% of the respondents generated their income from the collection of mangrove forest products, 24% from agricultural activities and the remaining 26% from non-farm activities. According to the results, mangrove income makes up 44% of the total household income.

It included both subsistence and cash income. Agricultural income shares 27% of the total household income and non-farm income accounts for 35% of the total household income.

3.2 Mangrove Ecosystem in Rokan Hilir and Bengkalis Regency

Area of Mangrove Ecosystem Based on measurements of the potential area of mangrove forest using Landsat 7 ETM+ imagery with RGB 453 colour combination in 2008 and based on the 2008 TGHK (Forest Utilization Concession) map, the area of mangrove forest in Rokan Hilir Regency is 23.740.00 Ha. The results of digitization and results of field verification in 2012 showed that the mangrove area was 18.934.90 Ha. This shows that there has been a decrease in the area of mangroves in downstream Rokan Regency from 2008 to 2012 of 4.805.10 Ha. Furthermore, the area of mangrove forests in Bengkalis Regency in 1997 was estimated at 69.000 ha, decreasing to 50.765.04 ha in 2002. In 2020, digitalization of mangroves was carried out in Rokan Hilir Regency and Bengkalis Regency, from these results the area documented in Rokan Hilir Regency is 21.708.00 Ha and in Bengkalis Regency is 26.757.48 Ha (Ministry of Maritime Affairs and Fisheries 2020).

Based on the land use map of Rokan Hilir Regency (figure 1), the distribution of mangroves is generally mostly spread over coastal areas and small islands such as Halang Island, Sinaboi Island, Serosa Island, Padamaran Island, Berkley Island, and Jemur Island as well as along the banks of the Rokan River, although their area is relatively large. smaller than the coastal area. Meanwhile, mangroves in Bangko District, Pasir Limau Kapas District, and Sinaboi.

The district can be said to be relatively large compared to other districts in the coastal area of Rokan Hilir Regency. With the area based on the digitized Landsat 7 ETM+ image map with the RGB 453 colour combination of 2008 and the results of field verification using the transect method, it is known that the total area of mangrove forests in the three study location districts is 16.276.80 ha with details, Bangko 10.340.40 ha, Sinaboi 3.269.40 ha, and Pasir Limau Kapas 2.667.00 ha.

Based on the results of the analysis with an importance value index (IVI) (figure 2), the dominant types of mangrove vegetation in Rokan Hilir Regency at the tree level were *Avicennia alba* 94.26%, *Sonneratia alba* 52.66%, *Bruguiera gymnorrhiza* 49.66%, *Rhizophora stylosa* 44.79%, *Sonneratia caseolaris* 43.55%, *Rhizophora mucronata* 39.61%, *Excoecaria agallocha* 13.62%, *Xylocarpus granatum* 7.28%, and *Ceriops tagal* 6.31%. The results of vegetation analysis at the sapling level of the dominant mangrove species were *Avicennia alba* 77.62%, *Rhizophora mucronata* 36.93%, *Bruguiera gymnorrhiza* 31.49%, *Rhizophora stylosa* 23.69%, *Excoecaria agallocha* 21.33%, *Sonneratia caseolaris* 19.71%, *Sonneratia alba* 16.77%, *Ceriops tagal* 13.81%, and *Xylocarpus granatum* 12.66%. While at the growth rate of seedlings, the dominant mangrove vegetation types were *Avicennia alba* 73.22%, *Rhizophora mucronata* 36.27%, *Bruguiera gymnorrhiza* 33.17%, *Rhizophora stylosa* 27.66%, *Sonneratia caseolaris* 19.33%, *Sonneratia alba* 16.17%, *Excoecaria agallocha* 15.66%, *Ceriops tagal* 13.17%, and *Xylocarpus granatum* 12.86%. Based on these values, the dominant mangrove species at the tree growth rate

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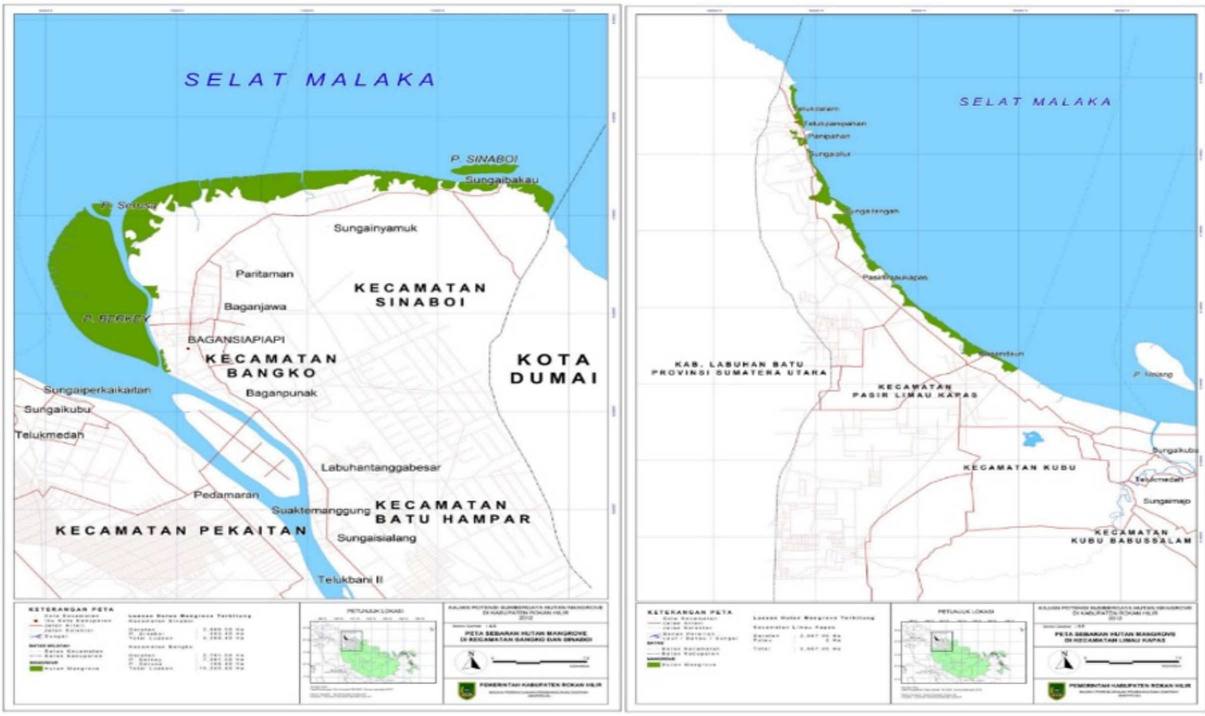

Figure 1. Mangrove distribution in Rokan Hilir Regency

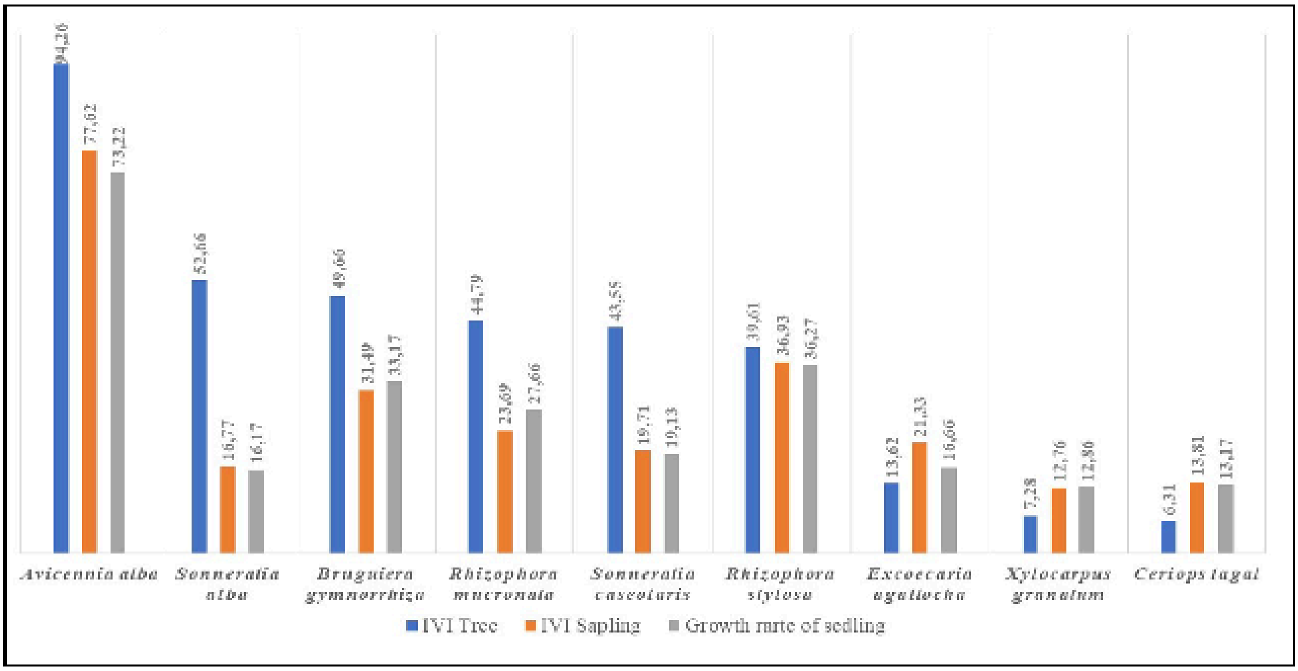

Figure 2. Importance value index tree, sapling, and growth rate of seedling mangrove in Rokan Hilir Regency

was *Avicennia alba* 94.26% and the lowest was *Ceriops tagal* 5.17%. At the growth rate of saplings and seedlings the most dominant mangrove vegetation was *Avicennia alba* at 74.79% and seedlings at 73.12%, while the lowest mangrove vegetation was *Xylocarpus granatum* for the sapling at 12.55%. and for seedlings 12.69%.

Based on the 2013 Bengkalis Regency land use maps (figure 3), the area of mangroves in Bengkalis Regency is 41.718,43 ha, from 11 sub-districts the distribution of mangroves is in 7 sub-districts, Rupat Utara 12.784,32 ha, Rupat 5.806,87 ha, Bantan 5.584,65 ha, Bengkalis 4.258,88 ha, Mandau 6.721,52 ha, Pinggir 2.215,58 ha Siak Kecil 3.452,55 ha, Bukit Batu 898,77 ha. Based on the digitization of the Landsat 7 ETM+ image map with the RGB 453 colour combination for 2020 and the results of verification of the mangrove area in Bengkalis Regency, there are only 26,757.48 ha left, meaning that from 2012 to 2020, Bengkalis Regency has lost 14,960.95 ha of mangrove area (Ministry of Maritime Affairs and Fisheries 2020).

Based on the results of the Important Value Index (IVI) analysis (figure 4), the dominant types of mangrove vegetation in Bengkalis Regency at the tree level were *Avicennia alba* 91.78%, *Sonneratia alba* 55.17%, *Bruguiera gymnorrhiza* 52.88%, *Rhizophora stylosa* 46.34%, *Sonneratia caseolaris* 44.17%, *Rhizophora mucronata* 40.42%, *Excoecaria agallocha* 19.58%, *Xylocarpus granatum* 9.73%, and *Ceriops tagal* 6.31%. Vegetation analysis results at the sapling level of the dominant mangrove species were *Avicennia alba* 79.88%, *Rhizophora mucronata* 38.77%, *Bruguiera gymnorrhiza* 37.17%, *Rhizophora stylosa* 26.19%, *Excoecaria agallocha* 23.55%, *Sonneratia caseolaris* 21.42%, *Sonneratia alba* 17, 82%, *Ceriops tagal* 15.33%, and *Xylocarpus granatum* 13.82%. Whereas in the growth rate of seedlings, the dominant mangrove vegetation types were *Avicennia alba* 76.88%, *Bruguiera gymnorrhiza* 42.88%, *Rhizophora mucronata* 36.27%, *Rhizophora stylosa* 27.84%, *Sonneratia caseolaris* 20.22%, *Sonneratia alba* 17.23%, *Excoecaria agallocha* 16 .41%, *Ceriops tagal* 14.23%, and *Xylocarpus granatum* 12.77%.

Based on these values, the dominant mangrove species for tree growth was *Avicennia alba* 92.47%, and the lowest was *Ceriops tagal* 7.88%. In the growth rate of saplings and seedlings the most dominant mangrove vegetation was *Avicennia alba* 77.23% for saplings and 75.88% for seedlings, while the lowest was for *Xylocarpus granatum* for saplings of 11.69% and for seedlings of 11.88%.

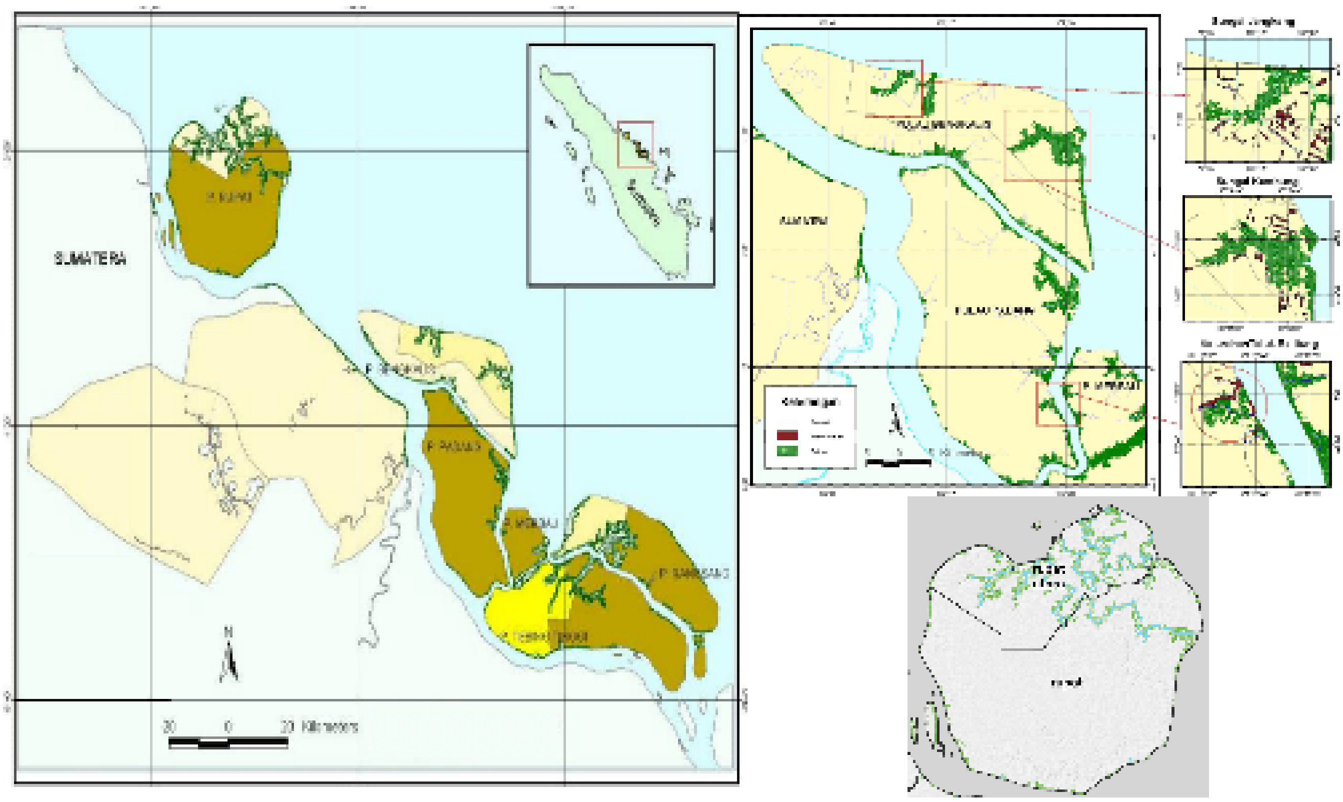

Figure 3. Mangrove distribution in Bengkalis Regency

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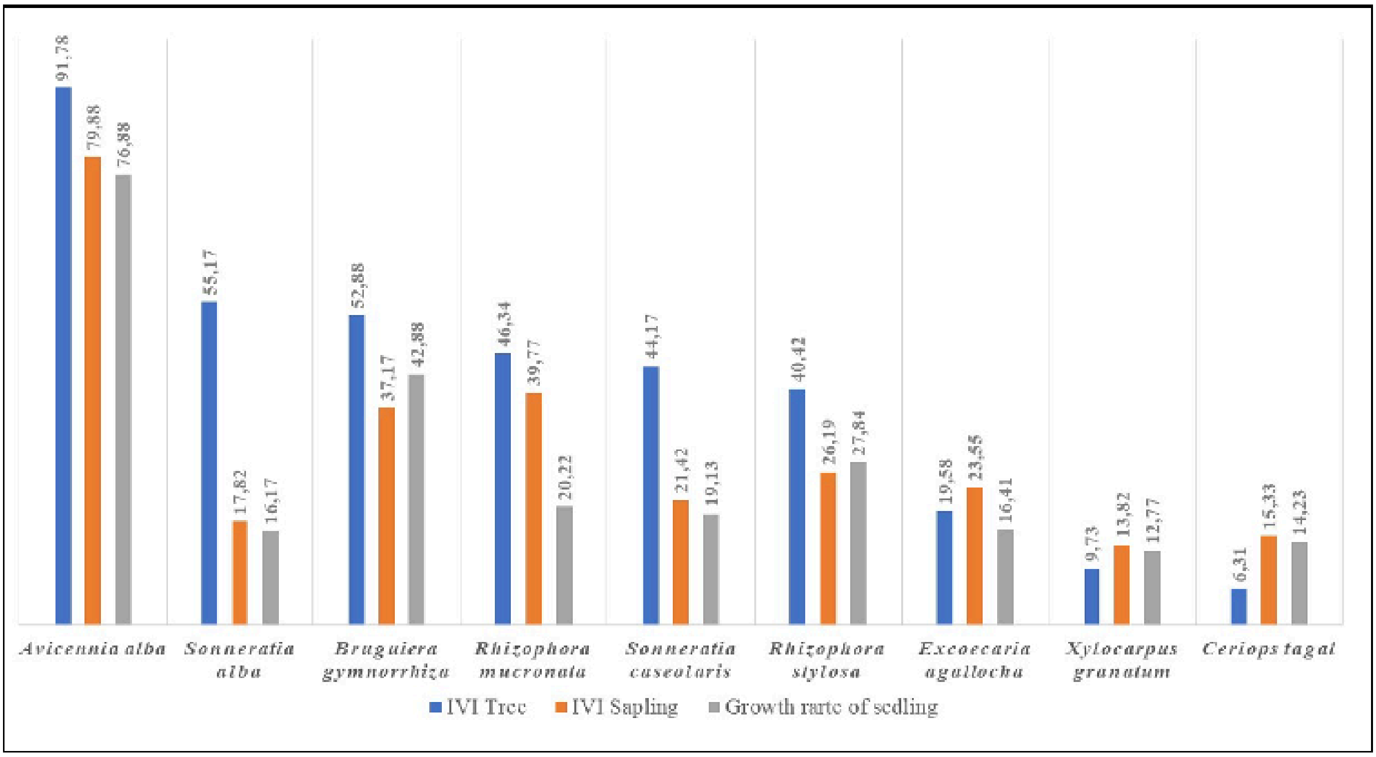

Figure 4. Importance value index tree, sapling, and growth rate of seedling mangrove in Bengkalis Regency

4. Discussion

4.1 The Potential of Mangroves as Foodstuffs in Rokan Hilir and Bengkalis Regency

According to findings from earlier research (table 1), the Rokan Hilir and Bengkalis Regencies have eight mangrove species that predominate, Avicennia marina (Forssk.) Vierh, *Avicennia alba* Blume (Brey mangrove), *Sonneratia caseolaris* (L.) Engl, Sonneratia ovata Backer (Mangrove apple), *Bruguiera gymnorrhiza* (L.) Lamk (Orange mangrove) Rhyzophora mucronata Lam (Black mangrove), Nypa fruticans (Thunb.) Wurmb and Acanthus ilicifolius Linn. These eight mangrove species have the potential for food development in the future.

Apart from these eight types of mangroves, several other types of mangroves can be processed into food, including *Avicennia alba* and Avicennia marina which are processed into flour and made for various kinds of food, especially pastries (Budiyanto et al. 2022; Mamuaja, Lumuindong, and Yapanto 2023; Rosulva et al. 2022). *Sonneratia caseolaris* and Sonneratia ovata can be made into flour and can be processed into various kinds of cakes, pastries, lunkhead, syrup, and other snacks (Asia and Wijayanti 2022; Sumartini, Harahap, and Mujiyanti 2021). As presented in Table 1, Sonneratia ovata and Rhizopora mucronate contain various nutrients, including flavonoids.

Flavonoids are bioactive compounds that can act as an antioxidant. Apart from being a source of antioxidants, flavonoids also have biological activities such as anti-bacterial, anti-cholesterol, anti-hyperlipidemia, anti-virus, anti-diabetic, anti-inflammatory and anti-cancer (Neldawati, Ratnawulan, and Gusnedi 2013) As for Rhizopora mucronata and Rhizopora apiculata, they are generally made as a variety of syrups, jams, and cake flour (Sofia, Kumalasari, and Osman 2022). *Sonneratia caseolaris* which is commonly called pedada whose fruit is like pomegranate and pineapple, is more suitable for candy because it has a sour taste (Resende and Franca 2019). Mangrove Bruguiera sp is an alternative commodity rice and sweet potato to be used if occasional crop failures. Bruguiera gymnorhiza fruit composition if compared to cassava, sweet potato, rice, and sago, then the fruit composition aibon is more like cassava, with almost the same carbohydrate content i.e., 92%. The mangrove fruit exhibits a carbohydrate content of 85.1 grams per 100 grams. In contrast to rice, the carbohydrate content

Table 1. Diversity of Mangrove Species Utilization in Rokan Hilir and Bengkalis Regencies

Species	Local name and vernacular name	Nutrient content	Various food products
Avicennia marina (Forssk.) Vierh *Avicennia alba* Blume	*Api-api putih* Grey mangrove *Api-api hitam* Grey mangrove	Api-api fruit (*Avicennia marina*) has a high nutritional content and can be used as a food source. The nutritional content in 100 grams of fruit is 10.8% protein, 21.4% carbohydrates. Vitamin B 3.74 mg vitamin C 22.24 mg (Ramli et al. 2020; Triastuti, Nashir, and Nirmala 2022). The fruit is boiled, peeled, soaked, and destroyed so it can be used as a basic ingredient for making cakes (Baderan et al. 2015; Bandaranayake 2002).	spongecake, jelly cake, cookies, round fried cakes, ketimus cake, bundt cake, porridge, bubble tea, springroll, sweet crisps, salt crisps, sheet cake, sweet sheet cake, bubble cake, pudding, avicennia balls, candy
Sonneratia caseolaris (L.) Engl *Sonneratia ovata* Backer	*Perepat/pedada merah* Mangrove apple *Kedabu/Berembang* Mangrove apple	Pedada/Berembang fruit (*Sonneratia caseolaris*) has a high nutritional content and can be used as a food source. The nutritional content in 100 grams of fruit is vitamin A 221.97 IU, vitamin B 5.04 mg, vitamin B2 7.65 mg, and vitamin C 56.74 mg. The results of the analysis in other studies show proximate levels in broiler fruit, namely: water content 84.76%, ash content 8.4%, fat content 4.82%, protein content 9.21%, and carbohydrate content 77.57%. The pedada fruit also contains phytochemicals such as steroids, tripenoids, and flavonoids (Manalu et al. 2013; Ramadani, Dari, and Aisah 2020). The fruit is peeled and crushed before being consumed for later use in the manufacture of juice, lunkhead, and shrimp crisp (Jariyah et al. 2014; Sahil and Soamole 2013).	Sweet sticky rice, cookies, dodol, sticky rice wrapped in banana leaves, compote, jalabia, diamond cake, candied fruit, bowl cake, bowl cake, dragon essence cake, bombing ball, green bulge jelly ice, candy, various syrups.
Bruguiera gymnorrhiza (L.) Lamk	*Lindur/Tancang* Orange mangrove	Lindur/Tancang fruit (*Bruguiera gymnorrhiza)* has a higher carbohydrate, and starch content than other types of mangrove fruit. The calories contained in lindur fruit are 73.756% water content, 1.246% fat, 1.128% protein, 23.528% carbohydrates and 0.342% ash content. Meanwhile, the anti-nutritional content of HCN is 6.8559 mg and tannin is 34.105 mg. It contains high carbohydrates so it has the opportunity to be explored as an alternative food ingredient that can be processed into flour (Mulyatun 2019). The fruit is consumed regularly during the harvest season by boiling, peeling, soaking, and grating before being consumed or cooked fruit with salt, dried, and consumed. The fruit is used as raw materials for cake and other traditional snacks (Baderan et al. 2015; Hidayat, Suptijah, and Nurjanah 2013; Jin et al. 2012; Priyono 2010; Sarungallo, Santoso, and Tethool 2010; Singh et al. 2005; Sudirman, Nurjanah, and Jacoeb 2014).	cookies, dodol, bubble tea, springroll, sweet crisps, salt crisps, sheet cake, sweet sheet cake, bubble cake, pudding, bombing ball, green bulge jelly ice, candy, compote, jalabia, diamond cake.

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Continue table 1. Diversity of Mangrove Species Utilization in Rokan Hilir and Bengkalis Regencies

Species	Local name and vernacular name	Nutrient content	Various food products
Rhizophora mucronata Lam	*Bakau hitam* Red mangrove	Black mangrove fruit (*Rhizophora mucronata*) based on the results of the chemical content test were: 52.38% water content; Ash content of 0.22%; Total fat content of 2.33%; protein content of 6.85% and carbohydrates 30.30% and identified bioactive compounds, namely flavonoids, saponins, tannins, tripertenoids and steroids as well as hydroquinone phenolic compounds (Hardoko et al. 2015; Mile et al. 2021; Wang'ondu et al. 2013). Fruits are boiled, peeled, soaked in ash or salt solution, dried and floured, making dry cakes or wet cakes (Priyono 2010; Sahil and Soamole 2013).	Sweet crisps, salt crisps, sweet sticky rice, cookies, dodol, sticky rice wrapped in banana leaves, compote, jalabia, diamond cake, candied fruit, bowl cake, bowl cake, dragon essence cake, bombing ball, green bulge jelly ice, candy, various syrups.
Nypa fruticans (Thunb.) Wurmb	*Nipah* Nipa palm	The nutritional content of nipa palm sugar is quite good, carbohydrates (89.61%), protein (5.95%), Ca levels (44.58 mg/kg), and calories of 3,172 cal/gr. Nipah flour contains high fibre with low fat and calorie content which has the potential to be used as food for people on a diet. Nipa fruit flour contains nine of the twelve essential amino acids, histidine, arginine, threonine, valine, methionine, iso-leucine, leucine, phenylalanine, and lysine which are needed by the human body. The nutritional content of nipa palm sugar is also quite good. This is indicated by the levels of carbohydrates (89.61%), protein (5.95%), Ca levels (44.58 mg/kg), and calories of 3,172 cal/gr (Heriyanto, Subiandono, and Karlina 2011).	Nipa flour, nipa sugar, sweets, a generous amount of sweet syrup can be made from the stems, if the flowers are picked at the right time. Used to produce alcohol and sugar. If managed properly, the resulting sugar production is better than cane sugar and has a higher sucrose content. The leaves are used to make umbrellas, hats, mats, baskets, and cigarette paper. The seeds are edible. After being processed, the leaf stalk fibre can also be made into ropes and bristles.
Acanthus ilicifolius Linn	*Jeruju* Puzzle fruit	Nutritional content of *Acanthus ilicifolius* leaf (moisture content 72.32%, ash content 5.03%, 0.58% fat content, 43.83% protein, 44.72% fibre content, 76.63 µg / ml antioxidant) (Hakim et al. 2021).	chips, spicy chips, salty chips, tea, meatball flour

of mangrove fruit is comparatively greater, surpassing that the rice 78.9 grams per 100 grams, and corn (63.6 grams per 100 grams) (Kardiman, Ridhwan, and Armi 2017).

Bruguiera gymnorhiza fruit has prospects very good to be developed into an alternative food ingredient to replace rice, especially for people living near the coast beach, as well as a provider of carbohydrates as well as industrial raw materials. One of the problems faced is if compared to other commodities for example rice or sweet potatoes, fruit processing of mangroves is quite complicated and takes a long time. As a result, society rarely uses it for food. (Helmy, Jacoeb, and Suptijah 2012; Pentury 2016; Sudirman et al. 2014).

Bruguiera gymnorhiza contains significant energy and carbohydrates, far exceeding the various types of carbohydrate sources commonly consumed by the general public, such as rice, corn, cassava, and sago.

The carbohydrate and calorie content of this mangrove fruit is higher than other staple foods. Below is a comparison of carbohydrates and calories in mangrove nuts, corn, and rice. Chemical analysis of Bruguiera gymnorhiza fruit showed a content of 73.756%, a content of 1.246%, protein of 1.128%, carbohydrate of 23.528%, and ash of 0.342%. On the other hand, HCN has 6.8559 mg of anti-nutritional content and 34.105 mg of tannin (Mamuaja et al. 2023). Mangrove fruits of Bruquiera gymnorrhiza, traditionally caked, mixed with rice, or eaten directly with coconut spice, contain significant amounts of energy and carbohydrates and are commonly consumed. Exceeds dietary sources of various types of carbohydrates rice, corn, cassava, or sago. The energy content of this mangrove fruit is 371 calories per 100 grams, higher than rice (360 calories per 100 grams) and corn (307 calories per 100 grams).

Mangroves have a carbohydrate content of 85.1 grams per 100 grams, higher than rice (78.9 grams per 100 grams) and maize (63.6 grams per 100 grams) (Hidayah and Rosyadi 2019; Ilman et al. 2016; Polnaya et al. 2021). Based on the description of many mangrove fruits that tend to be explored as new local food sources, they belong to the Bruguiera gymnorrhiza. Because this type of fruit contains a lot of carbohydrates. *Bruguiera gymnorrhiza* bears fruit all year round on hardy trees up to 35 meters high. It bears fruit when it is 2 years old. It grows in the middle layers of the genus Avicennia on the beach. Using mangrove fruit as a food ingredient is just a small part of the benefits that mangroves bring to the community.

Some researchers have reported that processed mangrove flour is a complementary ingredient to other flours. (Hidayat et al. 2013) reported on the production of similar rice from *Bruguiera gymnorrhiza* flour supplemented with sago flour and chitosan. With a fibre content of 8.16% and starch digestibility of 55.22%, 7 parts of *Bruguiera gymnorrhiza* flour and 3 parts of sago flour offer a suitable rice substitute for diabetics.

The results of Sumartini et al., (2020) study represent that the fat content of mangrove flour brownies is lower at 11.94% compared to wheat flour brownies at 30.42%. Ikasari & Hastarini (2016) Study shows that the optimal treatment was determined to be a combination of 40% Lindur fruit flour, 60% potato flour, and 3% shrimp shell powder. This formulation yielded chips with reduced hardness, elevated protein content, and a superior crispy, flavorful quality that was favored by the panelists. The reason for using mangrove meal as a supplement material and not as a whole is the fact that the physical and chemical properties of mangrove meal are not precisely known, and some researchers are still unsure about the food. Because it's not a safety issue when using whole (Polnaya et al. 2021). The availability of data on the physicochemical and functional properties of mangrove meal will facilitate research into a wider range of applications.

Mangrove fruits contain multiple tannins and alkaloid compounds (Ayu et al. 2019; Hardoko et al. 2015; Koeslulat and Prabawa 2019), anti-tropical agents (Rout et al. 2015) and hydrogen cyanide glucoside (Ayu et al. 2019; Polnaya et al. 2021 ; Rosulva et al. 2022). These nutrient-inhibiting compounds are phytochemicals that act as defense mechanisms against pests and insects. There are non-toxic and toxic nutrient- blocking compounds. Plants containing toxic compounds should be properly managed so that these non-nutritional components can be reduced to safe levels and eliminated (Emire, Jha, and Mekam 2013). Toxic anti-nutritive components are alkaloids, cyanide glucosides, and saponins, and nontoxic anti-nutritive components include tannins, protease inhibitors, lignin, silica, and cutin (Jayanegara et al. 2019).

Nutritional issues (i.e., the presence of anti-nutrient compounds) in nutrients contained in mangrove fruits used for consumption for public consumption can be eliminated through post-harvest treatment and pre-treatment (i.e., soaking and boiling) before drying and grinding into flour.

Processing mangrove fruits into raw materials for flour and processed foods is the ultimate goal of providing mangroves as an alternative food source. The availability of mangroves in flour form should be optimized to remove anti-nutritional components and other food toxins. Tanin, an anti-nutritional compound present in mangrove fruit, is responsible for imparting a bitter flavor. In addition, the excessive and continuous consumption of tannin has been found to have carcinogenic effects on the human body. Hence, it is imperative to ascertain the tannin concentration in mangrove fruit, a task that can be accomplished by the process of extraction. In a study conducted by Subandriyo and Setianingsih (2016), it was found that the most effective method for extracting mangrove

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fruit to minimize tannin content involves employing an air solvent in an extractor. The recommended volume ratio of solvent to mangrove fruit is 5:1 w/w, with a temperature of 80°C and a soaking duration of 60 minutes. Brugiella gymnorrhiza flour process yielded 0.94–1.79% w/c (Chrissanty 2012), 287.43 ppm (Muryati and Nelfiyanti 2015), 0.19% w/c (Sulistyawati et al. 2013), 47.45 ppm (Ayu et al. 2019) and 0.61% w/c (Rout et al. 2015). For Avicennia marina flour, tannins can be removed from 0.86 to 4.86% w/c (Chrissanty 2012) and 0.0995% w/c (Perdana, Soenardjo, and Supriyantini 2012). *Sonneratia caseolaris* flour contains 0.26% w/k tannins (Koeslulat and Prabawa 2019). The safe limit for tannin content in food is 560 mg/kg body weight/day (Permadi, Sedjati, and Supriyantini 2012). In mangrove flour, Rhizophora apiculata is 0.57% w/k (Rout et al. 2015), *Rhizophora stylosa* is 3.76–5.33% w/k (Chrissanty 2012), and *Rhizophora mucronata* is 0.28% w/k/k (Koeslulat and Prabawa 2019), 819 ppm, 845.68–1710.65 mg gaz/100 g (Hardoko et al. 2015).

Efforts to improve the fruit function of mangroves in food (extend shelf life, easy to apply, easy to fortify, easy to compose, easy to diversify, easy to store, and easy to pack) further processing of mangrove fruit is required into mangrove flour. Flour is a solid particle in the form of fine or very fine grains depending on the grinding and sieving process with a certain mesh size. Flour has a low water content so it can extend shelf life. Flour consists of various kinds according to the origin of the ingredients and characteristics. In the world, there are about 30 types of flour used in processed food, while in Indonesia there are about 16 types of refined flour that have different characteristics. Of these types of flour, mangrove flour is not included because it is not yet familiar to be used in processed food.

Flour has various benefits, namely to diversify and increase the power of flexibility as a processed raw material so that it is easier applied to various types of food processing, and is more flexible for composing, fortifying, shaping, and cooking accordingly needs so that it is easier to be introduced to the community.

Profit another flouring is to simplify the packaging, can expand the area marketing, and increase the added value (value added) of mangrove fruit. In addition, another advantage is that the flour can later be used as flour composites as well as in various industrial raw materials.

Mangrove flour has a low water content and is more flexible when applied to various types of food processing. The best outcome of the flouring procedure is to create food-grade mangrove flour that is suitable for consumption or incorporation into other food products. Mangrove flour derivatives are safe when combined with other ingredients as supplementary materials. In contrast to substitute materials, further investigation is needed to ascertain whether its use goes beyond the maximum threshold. There is a discovery of new food sources in the form of mangrove fruit products. The community gets new information and knowledge related to food sources other than tubers, sago, and corn in the form of fruit pulp, and siege. The function of mangrove fruit as edible properties of processed food can be diversified through proper food processing so as that produce a variety of products that have high added value.

The purpose of making mangrove flour is to extend its shelf life without reducing its nutritional value. The drying process is one of the stages very decisive because it determines the quality and sustainability of the processed product later wheat flour (Erni, Kadirman, and Fadilah 2018). The important difference in the estimated composition of mangrove fruit into mangrove flour is due to the heat absorbed by the material while drying in the drying oven. This affects the dryness level of flour. The general composition of flour varies with drying time and temperature.

The drying process is carried out at ± 65-75 °C for ± 5-7 hours. The drying process at this temperature was chosen except for the possibility of reducing the moisture content of the material can also reduce the cyanide content significantly and tannin content of mangrove flour (Muryati and Nelfiyanti 2015; Sulistyawati et al. 2013). In addition, low- temperature drying was chosen to minimize the degradation of phytochemicals and amino acids (Mardiah et al. 2015; Park et al. 2021) as well as create the best conditions for plant physiological properties of dry product (Perdana et al. 2012). Based on the physicochemical analysis of flour results, the moisture content value of *Sonneratia caseolaris* and Sonneratia ovata flours. of 9.82 ±

0.063 g/100 g (dw). This value is higher when compared to Avicennia marina and *Avicennia alba* flour (8.59 ± 0.071 g/100 g (dw), *Rhizophora mucronata* flour (8.29 ± 0.09 g/100 g (dw), and *Bruguiera gymnorrhiza* flour (4.97 ± 0.069 g/100 g (dw). Overall, the dry-base mangrove flour produced is in accordance with the flour standards, namely the Indonesian flour standard, namely the water content of less than 12% -15%, the moisture content of the mangrove flour produced in this study is within acceptable limits/ranges, namely those containing the moisture content is not more than 10% for long-term flour storage. The low moisture content of flour increases its shelf life by inhibiting the growth of moulds and other biochemical reactions (Singh et al. 2005).

The ash content of *Sonneratia caseolaris* and Sonneratia ovata flour is higher when compared to other flours which are equal to 7.38 ± 0.06 g/100 g (dw).

The ash content of Avicennia marina and *Avicennia alba* flour of 4.23 ± 0.07 g/100 g (dw), the ash content of *Bruguiera gymnorrhiza* flour was only 3.41 ± 0.06 g/100 g (dw), and the ash content of *Rhizophora mucronata* flour was 2.46 ± 0. .06 g/100 g (dw). The ash content of the research results of the mangrove flour produced is still quite high when compared to the ash content of standard Indonesian flours such as corn flour, which is less than 1.50%, rice flour is less than 1%, wheat flour is less than 0.70%, tapioca flour is less than 0.60%, and sago flour less than 0.50%. The reported ash values indicate that mangrove flour is a good source of minerals. The ash content indicates that flour samples can be a significant source of minerals (Eshun 2012).

Avicennia marina and *Avicennia alba* flour contains a relatively large amount of crude protein, 9.84 ± 0.015 g/100 g (dw), this value shows a higher yield when compared to *Sonneratia caseolaris* and Sonneratia ovata flour of 7.69 ± 0.028 g /100 g (dw), *Bruguiera gymnorrhiza* flour of 4.27 ± 0.071 g/100 g (dw), and *Rhizophora mucronata* flour of 3.12 ± 0.059 g/100 g (dw). Avicennia marina and *Avicennia alba*, *Sonneratia caseolaris* and Sonneratia ovata flours comply with Indonesian mokaf flour standards at least 7%. *Sonneratia caseolaris* and Sonneratia ovata flour contains 3.77 ± 0.91 g/100 g (dw) of fat. This value indicates a higher yield than *Bruguiera gymnorrhiza* flour of 2.87 ± 0.62 g/100 g (dw), *Rhizophora mucronata* flour of 1.74 ± 0.12 g/100 g (dw), and Avicennia marina and *Avicennia alba* flour of 1.52 ± 0.87 g/100 g (dw).

The crude fibre content in *Sonneratia caseolaris* and Sonneratia ovata flour was 16.12 ± 0.19 g/100 g (dw). This value is higher when compared to the crude fibre content of flour in *Bruguiera gymnorrhiza* of 11.27 ± 0.19 g/100 g (dw), *Rhizophora mucronata* of 9.27 ± 0.31 g/100 g (dw), and Avicennia marina and *Avicennia alba* 7.11 ± 0.14 g/100 g (dw). The carbohydrate content of *Rhizophora mucronata* flour was 93.47 ± 0.84 g/100 g (dw). This value is higher than Avicennia marina and *Avicennia alba* flour 84.77 ± 0.11 g/100 g (dw), *Bruguiera gymnorrhiza* 87.16 ± 0.08 g/100 g (dw), and *Sonneratia caseolaris* and Sonneratia ovata (82.16 ± 0.16 g/100 g (dw).

The drying and flouring processes increased the ash content, protein content, fat content, carbohydrate content significantly, and significantly reduced the moisture content and fibre content. Temperature and drying time influence the resulting water content. The higher the temperature, the more water molecules evaporate from the dried mangrove fruit, resulting in a lower water content. The higher the drying temperature, the faster evaporation occurs, so the water content in the material is lower. The longer a material is in direct contact with heat, the lower the water content (Winarno 1997). All tests of flour moisture content on a dry basis, show that the species *Sonneratia caseolaris* and Sonneratia ovata have the highest moisture content compared to other species. This shows that the water content of *Sonneratia caseolaris* and Sonneratia ovata flour is greater than that of other species so *Sonneratia caseolaris* and Sonneratia ovata flour is the flour that is the fastest to spoil and deteriorate in quality compared to flour of other species.

The specific composition of the different types of flour is important to determine the cooking properties and textural characteristics of a food (Fu 2008). Flour Mangrove is expected to be an intermediate product in the form of mixed flour (flour composite), which is a form of mixture between flour and several types of flour from another material. The purpose of making composite flour is to get material characteristics suitable for the desired processed product or to obtain certain functional properties (Mamat et al. 2020). Flour

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Composite has advantages such as having a higher nutritional value compared to only one type of flour, as well as the physical quality and more organoleptic (Masri et al. 2014). Knowing the characteristics of the flour mangrove is expected to be easier to apply and compose on other flour products to produce new food products. It is expected that thorough information related to mangrove flour can increase the value-added flour so that it can compete with other popular food sources.

Mangroves have the potential to be used as industrial raw materials form of flour and its derivative products (starch-based products). High -content amylopectin compared to amylose is responsible for the texture sticky to the starch produced, in this case, it can function as an agent thickening agent. This shows that mangrove flour has characteristics like glutinous rice flour. Mangrove flour application is suitable as a thickening agent in food (thickening agent) such as roux, beurre manie, slurry, or jayzee. The application of mangrove flour can also form a rich food that requires a sticky and chewy texture like dodol, and others. Based on differences in the characteristics of mangrove flour, produce various benefits and usefulness, namely as raw materials, and auxiliary materials in a variety of industry. Therefore, mangrove fruit and its derivative products in the form of Flour is a superior raw material for both food and non-food products.

The diverse nutritional content of mangroves with high carbohydrate levels can be developed as a renewable food source in a food diversification program to strengthen national food security because basically the implementation of this program is carried out by utilizing local food sources. In this case, local communities in Indonesia have long been using mangroves as a food ingredient. In Padang and Pariaman, coastal communities directly consume mangrove fruit from the species Ardisia littoralis, Melastoma candidum, and *Sonneratia caseolaris* (Leilani et al., 2017). Several types of mangrove fruit are used as food ingredients in the form of flour and are made into snacks such as dodol (Rosyada et al., 2018). Traditional communities in North Maluku use mangrove fruit as food for compote (Sahil and Soamole 2013; Talib et al., 2018). Even for the people of Lahanglau Village, mangrove fruit is part of the local wisdom which is used as their special food, which is called Teneh Fui and Jepa jepa (Tubay et al., 2022).

In addition to the vitamin and mineral content of processed mangrove products, the mangrove ecosystem acts as a preferred producer for small fish, shellfish, and crabs which are a source of protein for humans. Nevertheless, the broad implementation of mangroves-based food has different problems and constraints, such as the necessity to enhance technical expertise and technology proficiency in the processing and invention of mangrove fruit into diverse food products. In addition to the aforementioned point, it is imperative to enhance the vegetation cover in order to sustain the availability of mangrove fruit. It is imperative to take into account the regulations pertaining to the suitable harvesting system and the utilization of mangrove fruit as seeds. So in the utilization of mangroves, it is necessary to pay attention to the sustainability aspect, namely by implementing sustainable mangrove forest management (SMFM).

In the agenda for implementing mangrove fruit as a food source, it is necessary to involve all stakeholders, such as local communities, government, academics and researchers, NGOs, and business actors or investors. This means that this utilization must be seen from all functions of mangroves both ecologically, economically, and socially to meet the needs of the present generation without reducing the choice of uses and the needs of future generations. Therefore, the author recommends conducting research related to appropriate harvest times and innovations in developing mangrove technology as a food source, as well as stakeholder perceptions and participation in the development of mangrove-based food.

5. Conclusion

Traditional communities in Rokan Hilir and Bengkalis Regencies generally use mangroves as a food source, especially in the manufacture of pastries, lunkheads, refreshing drinks, and some even make them their main source of food. Advanced processing of mangrove fruit that has gone through various stages of processing such as soaking, boiling, and drying, then processed into flour into various types of food, can be declared safe for consumption because proper processing can reduce the content of anti-nutritional substances to a safe limit for consumption. Products

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derived from mangrove flour are safe when used as substitutes mixed with other ingredients. Unlike substitute materials, further research on the use of mangroves as a main food ingredient still requires a more in-depth study, especially minimizing the risk of toxic substances contained in the mangroves, processing techniques, and the final product to determine whether its use is safe or not. Mangroves have the potential to be used as an industrial raw material form of flour and its derivative products (starch-based products).

Based on differences in the characteristics of mangrove flour, it produces various benefits and usefulness, namely as raw materials, and auxiliary materials in a variety of industries. Therefore, mangrove fruit and its derivative products in the form of Flour is a superior raw material for both food and non-food products

Conflict of Interest

The authors agree that this research was conducted in the absence of any self-benefits, commercial, or financial conflicts and declare the absence of conflicting interests with the funders.

References

Arifanti, V. B.,Sidik, F., Mulyanto, B., Susilowati, A., Wahyuni, T., Subarno, Yulianti, Yuniarti, N., Aminah, A., Suita, E., Karlina, E., Suharti, S., Pratiwi, Turjaman, M., Hidayat, A.,Rachmat, H. H., Imanuddin, R., Yeny, I., Darwiati, W., Sari, N., Hakim, S. S., Slamet, W. Y., & Novita, N. (2022). Challenges and Strategies for Sustainable Mangrove Management in Indonesia: A Review. Forests, 13(5), 695. doi: 10.3390/f13050695.

Asia, N ., & Wijayanti, T. (2022). Analisis Nilai Tambah Buah Mangrove (Sonneratia Ovata) Sebagai Bahan Baku Pembuatan Sirup Mangrove Di Kota Bontang. Prosiding Seminar Nasional Pertanian, 2(1), 78–83 .

Ayu, M. K., Tamrin, & Hermanto. (2019). Pengaruh lama dan suhu pengeringan dalam pengolahan tepung buah mangrove jenis lindur (bruguiera gymnorrhiza) terhadap karakteristik organoleptik, kimia, dan aktivitas antioksidan. Jurnal Sains Dan Teknologi Pangan, 4(1), 1879–1891. doi: 10.33772/jstp.v4i1.5622.

Baderan, D. W. K., Hamidun, M. S., Lamangandjo, C., & Retnowati, Y. (2015). Diversifikasi Produk Olahan Buah Mangrove Sebagai Sumber Pangan Alternatif Masyarakat Pesisir Toroseaje, Kabupaten Pohuwato, Provinsi Gorontalo. Pros Sem Nas Masy Biodiv Indon, 1(2), 347–351 . doi: 10.13057/psnmbi/m010230

Bandaranayake, W. (2002). Bioactivities, Bioactive Compounds and Chemical Constituents of Mangrove Plants. Wetlands Ecology and Management, 10, 421–452. doi: 10.1023/A:1021397624349

Budiyanto, F. , Alhomaidi, E. A., Mohammed, A. E., Ghandourah, M. A., Alorfi, H. S., Bawakid, N. O., & Alarif, W. M. (2022). Exploring the Mangrove Fruit: From the Phytochemicals to Functional Food Development and the Current Progress in the Middle East. Marine Drugs, 20(5) , 303. doi: 10.3390/md20050303.

Chrissanty, P. A . (2012). Penurunan Kadar Tanin Pada Buah Mangrove Jenis Brugueira Gymnorrhiza, Rhyzophora Stylosa Dan Avicennia Marina Untuk Diolah Menjadi Tepung Mangrove. Industria: Jurnal Teknologi Dan Manajemen Agroindustri, 1(1) , 31–39.

Emire, S. A., Jha, Y. K., & Mekam, F. (2013). Role of Anti-Nutritional Factors in Food Industry. Beverage & Food World, 23–28.

Erni, N., Kadirman, & Fadilah, R. (2018). Pengaruh suhu dan lama pengeringan terhadap sifat kimia danorganoleptik tepung umbi talas (Colocasia Esculenta). Jurnal Pendidikan Teknologi Pertanian, 4(1) , 95–105. doi: 10.26858/jptp.v1i1.6223

Eshun, G. (2012). Nutrient Composition and Functional Properties of Bean Flours of Three Soya Bean Varieties from Ghana. African Journal of Food Science and Technology, 3(8), 176–181.

Fu, B. X . (2008). Asian Noodles: History, Classification, Raw Materials, and Processing. Food Research International, 41(9) , 888–902. doi: 10.1016/j.foodres.2007.11.007

Hakim, M. R. , Rahman, A., Alhabsi, F., Katili, V. R. A., & Mustasim. (2021). Pelestarian Ekosistem Mangrove Melalui Pemanfaatan Jeruju (Acanthus Ilicifolius) Sebagai Makanan Ringan Alternatif. Buletin SWIMP, 1(2), 84–89. doi: 10.15578/bs.v1i02.15

Handayani, S . (2018). Identifikasi Jenis Tanaman Mangrove Sebagai Bahan Pangan Alternatif Di Kabupaten Sidoarjo Jawa Timur. Jurnal Teknologi Pangan, 12(2), 33-46. doi: 10.33005/jtp.v12i2.1287

Hanifah, A. , Sukendi, Thamrin, & Putra, R. M. (2023). Mangrove Ecosystem Management for Sustainable Renewable Energy Production: A Multi-Dimensional Analysis. International Journal of Energy Economics and Policy, 13(5) , 585–592. doi: 10.32479/ijeep.14299

Hardoko, S. E. , Puspitasari, Y. E., & Amalia, R. (2015). Study of Ripe Rhizophora Mucronata Fruit Flour as Functional Food for Antidiabetic. International Food Research Journal, 22(3) , 953–959.

Helmy , Jacoeb, A. M., & Suptijah, P. (2012). Analysis of Plant Tissue of Bruguiera Gymnorrhiza and Its Utilization as Raw Material for Bioethanol Production. International Journal of Bonorowo Wetlands, 2(2) , 66–73. doi: 10.13057/bonorowo/w020203

Heriyanto, N. M., Subiandono, E., & Karlina, E. (2011). Potensi Dan Sebaran Nipah (Nypa Fruticans (Thunb.) Wurmb) Sebagai Sumberdaya Pangan. Jurnal Penelitian Hutan Dan Konservasi Alam, 8(4) , 327–335. doi: 10.20886/jphka.2011.8.4.327-335

Hidayah, Z., & Rosyadi, K. (2019). Regional Mapping and Community Development to Conserve Mangrove Forests on the Southern Coast of Sumenep Madura. Proceedings of The 1st Workshop Multimedia Education, Learning, Assessment and its Implementation in Game and Gamification in conjunction with COMDEV 2018, Medan Indonesia, 26th January 2019, WOMELA-GG. EAI. doi: 10.4108/eai.26-1-2019.2283321

Hidayat, T. , Suptijah, P., & Nurjanah, S. (2013). Karakterisasi Tepung Buah Lindur (Brugeira Gymnorrhiza) Sebagai Beras Analog Dengan Penambahan Sagu Dan Kitosan. Jurnal Pengolahan Hasil Perikanan Indonesia, 16(3) , 268–277. doi: 10.17844/jphpi.v16i3.8065

Ikasari, D. , & Hastarini, E. (2016). Proximate Composition, Texture Performance And Sensory Evaluation Of Lindur Fruit-Potato Simulation Chips Enriched With Shrimp (Penaeus Vannamei) Shell Powder. Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology, 11(3) , 95–105. doi: 10.15578/squalen.v11i3.212

Ilman, M., Dargusch, P., Dart, P., & Onrizal. (2016). A Historical Analysis of the Drivers of Loss and Degradation of Indonesia's Mangroves. Land Use Policy, 54 , 448–459. doi: 10.1016/j.landusepol.2016.03.010

Irma, W. , Atmaja, A. T., & Marfa'i, M. A. (2020). Biodiversitas Vegetasi Mangrove Di Kecamatan Concong Kabupaten Indragiri Hilir Provinsi Riau. Majalah Ilmiah Biologi Biosfera: A Scientific Journal, 37(2) , 85–90. doi: 10.20884/1.mib.2020.37.2.1200

Jariyah, Widjanarko, S. B., Yunianta, Estiasih, T., & Sopade, P. A. (2014). Pasting Properties Mixtures of Mangrove Fruit Flour (Sonneratia Caseolaris) and Starches. International Food Research Journal, 21(6) , 2161–2167.

Jayanegara, A. , Ridla, M., Laconi, E. B., & Nahrowi. (2019). Komponen Antinutrisi Pada Pakan. Bogor: PT Penerbit IPB Press.

Jin, L. , Zhang, Y., Yan, L., Guo, Y., & Niu, L. (2012). Phenolic Compounds and Antioxidant Activity of Bulb Extracts of Six Lilium Species Native to China. Molecules, 17(8) , 9361–9378. doi: 10.3390/molecules17089361

Kardiman, Ridhwan, M., & Armi. (2017). Buah Lindur (Bruguera Gymnorrhyza) Sebagai Makanan Masyarakat Aceh Kepulauan. Serambi Saintia: Jurnal Sains Dan Aplikasi, 5(2) , 51–55. doi: 10.32672/jss.v5i2.534

Koeslulat, E. E., & Prabawa, S. B. (2019). Kandungan Antinutrisi, Logam Berat Dan Cemaran Biologis Tepung Buah Sonneratia Spp Dan Rhizophora Mucronata Dari Kabupaten Kupang. Jurnal Pemuliaan Tanaman Hutan, 13(2) , 105–16. doi: 10.20886/jpth.2019.13.2.105-116

Kusmana, C. , & Sukristijiono. (2016). Mangrove resource uses by local community in indonesia. Journal of Natural Resources and Environmental Management, 6(2), 217–224. doi: 10.19081/jpsl.2016.6.2.217

Leilani, I. , Rizki, Sari, T. M., & Sari, D. M. (2017). Studi etnobotani pada hutan mangrove di kota padang dan kota pariaman. BioScience, 1(2) , 87–91. doi: 10.24036/bsc.v1i2.8084

Hasmadi, M., Noorfarahzilah, M. , Noraidah, H., Zainol, M. K., & Jahurul, M. H. A. (2020). Functional Properties of Composite Flour: A Review. Food Research, 4(6) , 1820–1831. doi: 10.26656/fr.2017.4(6).419

Mamuaja, C . F., Inkiriwang, D., Lamaega, J., & Yapanto, L. M. (2023). Utilization Of Various Types Of Mangrove Fruit As A High Carbohydrate Food Source. Journal of Survey in Fisheries Sciences, 10(1), 408–414. doi: 10.17762/sfs.v10i1.567

Manalu, R. D. E., Salamah, E., Retiaty, F., & Kurniawati, N. (2013). Kandungan Zat Gizi Makro Dan Vitamin Produk Buah Pedada (Sonneratia Caseolaris). Penelitian Gizi Dan Makanan, 36(2) , 135–140. doi: 10.22435/pgm.v36i2.3999.135-140

Mardiah, F. R. Z., Prangdimurti, E., & Damanik -TIP, R. (2015). Perubahan kandungan kimia sari rosela merah dan ungu (hibiscus sabdariffa l.) Hasil pengeringan menggunakancabinet dryer dan fluidized bed dryer. Jurnal Teknologi Industri Pertanian, 25(1) , 1–7.

Noorfarahzilah, M., Lee, J. S., Shaarani, M. S., Bakar, M. F. A., & Mamat, H. (2014). Applications of Composite Flour in Development of Food Products. International Food Research Journal, 21(6), 2061–2074.

Mile, L., Nursyam, H., Setijawati, D., & Sulistiyati, T. D. (2021). Studi Fitokimia Buah Mangrove (Rhizophora Mucronata) Di Desa Langge Kabupaten Gorontalo Utara. Jambura Fish Processing Journal, 3(1) , 1–8. doi: 10.37905/jfpj.v3i1.8585

Miswadi, Firdaus, R., & Jhonnerie, R. (2017). Pemanfaatan Kayu Mangrove Oleh Masyarakat Suku Asli Sungai Liong Pulau Bengkalis. Dinamika Maritim, 6(1) , 35–39.

Mulyadi, E. , Hendriyanto, O., & Fitriani, N. (2010). Konservasi Hutan Mangrove Sebagai Ekowisata. Jurnal Ilmiah Teknik Lingkungan, 2(1) , 11–18.

Mulyatun. (2019). Pemberdayaan Masyarakat Pesisir Berbasis Potensi Lokal; Alternatif Ketahanan Pangan Berupa Tepung Magrove. Dimas: Jurnal Pemikiran Agama Untuk Pemberdayaan, 18(2) , 211–38. doi: 10.21580/dms.2018.182.3260

Muryati, & Nelfiyanti. (2015). Pemisahan Tanin Dan Hcn Secara Ekstraksi Dingin Pada Pengolahan Tepung Buah Mangrove Untuk Substitusi Industri Pangan. Journal of Industrial Pollution Prevention Technology, 6(1), 9–16. doi: 10.21771/jrtppi.2015.v6.no1.p%p

Neldawati . (2013). Analisis Nilai Absorbansi Dalam Penentuan Kadar Flavonoid Untuk Berbagai Jenis Daun Tanaman Obat. Pillar of Physics, 2 , 76–83. doi: 10.24036/756171074

Oktorini, Y. , Prianto, E., Darlis, V. V., Rahmatdillah, Miswadi, & Jhonnerie, R. (2022). Mangrove Riau: Sebaran Dan Status Perubahan. Dinamika Lingkungan Indonesia, 9(1) , 50-57. doi: 10.31258/dli.9.1.p.50-57

Park, C. H. , Yeo, H. J., Park, C., Chung, Y. S., & Park, S. U. (2021). The Effect of Different Drying Methods on Primary and Secondary Metabolites in Korean Mint Flower. Agronomy, 11(4) , 698. doi: 10.3390/agronomy11040698

Pentury, M. H . (2016). Analysis of Physical and Chemical of Starch Lindur (Bruguiera Gymnorrhiza), Pedada (Sonneratia Casiolaris) and Api-Api (Avicennia Marina). Journal of Environment and Ecology, 7(2) , 42–56. doi: 10.5296/jee.v7i2.1061

Perdana, Y. S., Soenardjo, N., & Supriyantini, E. (2012). Pengaruh Kadar Abu Gosok Selama Perebusan Dan Lama Perendaman Air Terhadap Kadar Tanin Buah Dan Tepung Mangrove (Avicennia Marina). Journal of Marine Research, 1(2) , 226–234. doi: 10.14710/jmr.v1i2.2041

Permadi, Y. B., Sedjati, S., & Supriyantini, E. (2012). Pengaruh Konsentrasi Abu Gosok Dan Waktu Perendaman Air Terhadap Kandungan Nutrisi Tepung Buah Mangrove Avicenia Marina. Journal of Marine Research, 1(1) , 39–47. doi: 10.14710/jmr.v1i1.885

Polnaya, F. J., Thenu, V. J., Palijama, S., & Breemer, R. (2021) . Characteristics of Chemical Properties of

Fruit Flour of Mangrove (Bruguiera Gymnorrhiza Lamk.) with Lower Cyanide Content. IOP Conference Series: Earth and Environmental Science, 883, 012063. doi: 10.1088/1755-1315/883/1/012063

Utama, P . (2022, January 19). Eksisting Mangrove Di Riau Mencapai 224.895 Hektar. Mediacenter Riau. Retrieved from https://ppid.riau.go.id/berita/2286/eksisting-mangrove-di-riau-mencapai-224-895-hektar

Priyono, A ., Ilminingtyas, D., Mohson, Yuliani, L. S., & Hakim, T. L. (2010). Beragam Produk Olahan Berbahan Dasar Mangrove. Semarang: Kesemat.

Rahadian, A., Prasetyo, L. B., Setiawan, Y., & Wikantika, K. (2019). Tinjauan historis data dan informasi luas mangrove indonesia (A Historical Review of Data and Information of Indonesian Mangroves Area). Media Konservasi, 24(2) , 163–78. doi: 10.29243/medkon.24.2.163-178

Rahim, S., & Baderan, D. W. K. (2017). Hutan Mangrove Dan Pemanfaatannya. Yogyakarta: Deepublish.

Rahmadi, M. T., Yuniastuti, E., Suciani, A., Harefa, M. S., Persada, A. Y., & Tuhono, E. (2023). Threats to Mangrove Ecosystems and Their Impact on Coastal Biodiversity: A Study on Mangrove Management in Langsa City. Indonesian Journal of Earth Sciences, 3(2) , A627. doi: 10.52562/injoes.2023.627

Ramadani, D . T., Dari, D.W., & Aisah. (2020). Daya Terima Permen Jelly Buah Pedada (Sonneratia Caseolaris) Dengan Penambahan Karagenan. Jurnal Akademika Baiturrahim Jambi, 9(1) , 15–24. doi: 10.36565/jab.v9i1.151

Ramli, H. K., Yuniarti, T., Lita, N. P. S. N., & Sipahutar, Y. H. (2020). Uji Fitokimia Secara Kualitatif Pada Buah Dan Ekstrak Air Buah Mangrove. Jurnal Penyuluhan Perikanan Dan Kelautan, 14(1) , 1–12. doi: 10.33378/jppik.v14i1.198

Resende, L. M., & Franca, A. S. (2019). Chapter 30-Flours Based on Exotic Fruits and Their Processing Residues—Features and Potential Applications to Health and Disease Prevention. Flour and Breads and their Fortification in Health and Disease Prevention (2nd Edition). Elsevier.

Rizaldi, H. , Lestari, F., & Susiana. (2020). The Level of Damage to the Mangrove Ecosystem in the Sei Jang Estuary Area, Bukit Bestari District, Tanjungpinang City, Riau Islands, Indonesia. Akuatikisle: Jurnal Akuakultur, Pesisir Dan Pulau-Pulau Kecil, 4(2), 47–51. doi: 10.29239/j.akuatikisle.4.2.47-51

Rosulva, I. , Hariyadi, P., Budjiantno, S., & Sitanggang, A. B. (2022). Physico- Chemical Characterization of Indonesian Mangroves Fruits Species. Future of Food: Journal on Food, Agriculture and Society, 10(5) , 1–20. doi: 10.17170/kobra-202204136017

Rosyada, A. , Anwari, M. S., & Muflihati. (2018). Pemanfaatan tumbuhan mangrove oleh masyarakat desa bakau besar laut kecamatan sungai pinyuh kabupaten mempawah. Jurnal Hutan Lestari, 6(1), 6 2–70.

Rout, P., Singh, S., Kumar, N., & Basak, U. C. (2015). Nutritional and Antioxidant Potential of Some Selected Edible Mangrove Fruits of Odisha Coast. Food Science and Biotechnology, 31(2) , 349– 355. doi: 10.7439/ijasr.v1i9.2624

Sahil, J. , & Soamole, I. (2013) . Pemanfaatan Buah Mangrove Sebagai Sumber Makanan Alternatif Di Halmahera Barat, Maluku Utara. Biogenesis: Jurnal Ilmiah Biologi, 1(2) , 91–96. doi: 10.24252/bio.v1i2.453

Salem, M. , & Mercer, D. E. (2012). The Economic Value of Mangroves: A Meta-Analysis. Sustainability, 4(3) , 359–383. doi: 10.3390/su4030359

Sarungallo, Z. L., Santoso, B., & Tethool, E. F. (2010). Sifat Fisikokimia Dan Fungsional Pati Buah Aibon (Brugueira Gymnorhiza L.). Jurnal Natur Indonesia, 12(2) , 156–162. doi: 10.31258/jnat.12.2.156-162

Singh, A., Hung, Y.-C., Corredig, M., Phillips, R. D., Chinnan, M. S., & McWatters, K. H. (2005). Effect of Milling Method on Selected Physical and Functional Properties of Cowpea (Vigna Unguiculata) Paste. International Journal of Food Science and Technology, 40(5) , 525–536. doi: 10.1111/j.1365-2621.2005.00964.x

Sofia, I. U. , Kumalasari, I. D., & Osman, N. B. (2022). Potential of Active Compounds in Mangroves as Food Preservatives: A Literature Review. Sainteks, 19(1) ,

89. doi: 10.30595/sainteks.v19i1.13453

Subandriyo, & Setianingsih, N. I. (2016). Extraction Process for Reducing Tannin of Mangrove Fruit [Bruguiera Gumnorrhiza (Lamarck, 1798)] as a Raw Material for Food Flour. Aquatic Procedia, 7 , 231–235. doi: 10.1016/j.aqpro.2016.07.032

Sudirman, S., Nurjanah, & Jacoeb, A. M. (2014). Proximate Compositions, Bioactive Compounds and Antioxidant Activity from Large-Leafed Mangrove (Bruguiera Gymnorrhiza) Fruit. International Food Research Journal, 21(6) , 2387–2391.

Sulistyawati, Wignyanto, & Kumalaningsih, S. (2013). Low Tannins and HCN of Lindur Fruit Flour Products as an Alternative Food. Jurnal Teknologi Pertanian, 13(3) , 187–198.

Sumartini, Harahap, K. S., & Mujiyanti, A. (2020). Brownies from mangrove fruit flour: The use of variation of flours as an alternative to high food nutrition. Indonesian Food and Nutrition Progress, 17(1) , 1–7. doi: 10.22146/ifnp.55188

Talib, A., Tamrin, A., & Deni, S. (2018). Study about potential fruit mangrove as a food alterternatif in the future. International Journal of Agronomy and Tropical Plants, 1(1) , 1–8.

Titisari, P. W., Elfis, Chahyana, I., Janna, N., Nurdila, H., & Widari, R. S. (2022). Management Strategies of Mangrove Biodiversity and the Role of Sustainable Ecotourism in Achieving Development Goals. Journal of Tropical Biodiversity and Biotechnology, 7(3) , 1–24. doi: 10.22146/jtbb.72243

Triastuti, J., Nashir, N. G. A., & Nirmala, D. (2022). The Effect of Avicennia Marina Fruit Flour as a Wheat Flour Subtitution on the Quality and Fibre Enhancement in Crackers. Journal of Marine and Coastal Science, 11(2) , 74–80. doi: 10.20473/jmcs.v11i2.35021

Tubay, H . S., Pattiasina, J., & Matitaputty, J. K. (2022). Teneh fui sebagai makanan lokal potret kearifan lokal masyarakat desa lahanglau kabupaten kepulauan aru. Jurnal Pendidikan Sejarah Dan Humaniora, 2(1) , 99–107.

Umayah, S., Gunawan, H., & Isda, M. N. (2016). Tingkat Kerusakan Ekosistem Mangrove Di Desa Teluk Belitung Kecamatan Merbau Kabupaten Kepulauan Meranti. Jurnal Riau Biologia, 1(1) , 24–30.

Wang'ondu, V. W., Kairo, J. G., Kinyamario, J. I., Mwaura, F. B., Bosire, J. O., Dahdouh-Guebas, F., & Koedam, N. (2013). Vegetative and Reproductive Phenological Traits of Rhizophora Mucronata Lamk. and *Sonneratia alba* sm. Flora - Morphology, Distribution, Functional Ecology of Plants, 208(8) , 522–531. doi: 10.1016/j.flora.2013.08.004

Widiastuti, M. M. D., Ruata, N. N., & Arifin, T. (2016). Valuasi ekonomi ekosistem mangrove di wilayah pesisir kabupaten merauke. Jurnal Sosial Ekonomi Kelautan Dan Perikanan, 11(2), 147-159. doi: 10.15578/jsekp.v11i2.3856

Winarno, F. G. (1997). Kimia Pangan Dan Gizi. Cirebon: Gramedia.

Zhang, X. , Lin, P., & Chen, X. (2022). Coastal Protection by Planted Mangrove Forest during Typhoon Mangkhut. Journal of Marine Science and Engineering, 10(9) , 1288. doi: 10.3390/jmse10091288

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