

# Assessing the carrying capacity of mangroves as raw materials for culinary products: Case study in Serdang Bedagai, North Sumatra, Indonesia

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**Abstract.** Purwoko A, Susilowati A, Situmorang AI. 2023. Assessing the carrying capacity of mangroves as raw materials for culinary products: Case study in Serdang Bedagai, North Sumatra, Indonesia. *Biodiversitas* 24: 250-257. Many studies have focused on the ecological and socio-economic benefits of the mangrove ecosystem, yet limited information is available regarding the potential uses of non-timber products from mangroves for creative culinary products. This study aims to assess the production and carrying capacity of raw materials derived from mangrove vegetation to make processed food products using a case study from mangrove ecosystem in Kampung Nipah Mangrove Tourism Area, Sei Nagalawan Village, Perbaungan Sub-district, Serdang Bedagai District, North Sumatra Province, Indonesia. In doing so, we analyzed the species composition and abundance of mangrove vegetation to result in the production potential of raw materials used for culinary purposes. Ten mangrove species were recorded in the studied area with *Acanthus ilicifolius*, *Rhizophora apiculata* and *Avicennia marina* were the most important species at the seedling, sapling and tree level, respectively. The Kampung Nipah Mangrove Tourism Area utilizes three mangrove species as raw materials for food, namely *A. marina*, *Sonneratia caseolaris*, and *A. ilicifolius* which are used as raw materials for making mangrove *dodol* (a sweet toffee), fruit syrup, and crackers, respectively. Based on the abundance of species used for mangrove culinary products, the abundance of *A. marina* and *A. ilicifolius* are highly available, while *S. caseolaris* is scarce. These results imply that the abundance of *A. marina* and *A. ilicifolius* is sufficient for *dodol* and crackers production, yet the abundance of *S. caseolaris* is not sufficient as raw material for syrup processing. Therefore, it is necessary to enrich the population *S. caseolaris* to support the production of mangrove syrup.

**Keywords:** Mangrove carrying capacity, mangrove food, mangrove tourism, Kampung Nipah, Sei Nagalawan

## INTRODUCTION

Mangrove ecosystem has an important role ecologically and economically. Ecologically, it is a coastal protector from wind, sea waves, storms and seawater intrusion (Barbier 2016) which serves as a natural barrier for settlements, buildings, and agricultural activities. Menéndez et al. (2020) stated mangrove ecosystem also provides important habitat for biodiversity and stores a great amount of carbon which significantly contributes to climate change mitigation. This shows that mangroves are essential as natural defense of coastal areas at global, national, and local scale.

Economically, products derived from mangroves can be used for daily needs such as firewood and charcoal, building materials, household needs, paper raw materials, sources of medicines, and various compounds from bark extract. The leaves and fruit of vegetation can be processed into various foods and drinks (Pinheiro et al. 2012; Kristensen et al. 2017). Menéndez et al. (2020) found that mangroves provide food production benefits to communities that receive more than \$US 65 billion per year. If mangroves are lost, then more than 15 million people will lose their food sources every year around the world.

Mangroves provide various ecosystem goods and services that contribute significantly to the livelihoods of

local communities. However, the economic benefits of mangroves are currently recognized largely from aquaculture products than the whole benefits of its goods and services from mangrove ecosystems. The economic value derived from the mangrove ecosystem should far exceed the value obtained from aquaculture. Malik et al. (2015) research in South Sulawesi, Indonesia, shows that the total economic value (TEV) of mangroves per year is in the range of 4,000-8,000 USD per hectare, with the largest contribution (94%) coming from indirect use value, while commercial aquaculture only contributes to 3,000 USD per hectare per year.

The gap between the potential economic benefits of mangrove ecosystems and what is understood by the community requires stakeholders involved in mangrove ecosystem management to be able to explore the economic benefits of the ecosystem, manage and market it into goods and services with economic value. An example of such initiatives is carried out by a cooperative managed by local community in Sei Nagalawan Village, Perbaungan Sub-district, Serdang Bedagai District, North Sumatra which develops nature tourism based on mangrove ecosystems (Purwoko et al. 2021). This cooperative has also obtained permit to utilize the environmental services and non-timber forest products. In addition to the aesthetics and microclimate condition which serve as the main tourist

attractions, various types of mangrove plants are also processed and marketed as culinary products for tourist attractions and educational purposes.

The development of mangrove-based ecotourism in Sei Nagalawan Village is largely supported by the high diversity of mangrove vegetation occurring in the area. Generally, mangrove ecosystems have a variety of species, including trees and undergrowth, which have benefits as a source of food (Purwoko et al. 2021). Various plant species in Sei Nagalawan Village have been used as raw material for processed food and beverages (Purwoko et al. 2021; Harefa et al. 2020), however the community has not utilized the potential uses of the mangrove vegetation. The potential for producing processed food is not limitless and is closely related to the capacity and quality of the mangrove ecosystem as the source of raw materials (Baderan et al. 2015). Therefore, the capacity and sustainability of the ecosystem should be considered when managing the mangroves and using it as a food source. This study aimed to analyze mangrove abundance, species composition, and their carrying capacity as raw materials to produce processed mangrove foods in Sei Nagalawan Village, Perbaungan Sub-district, Serdang Bedagai District.

## MATERIALS AND METHODS

### Study area and period

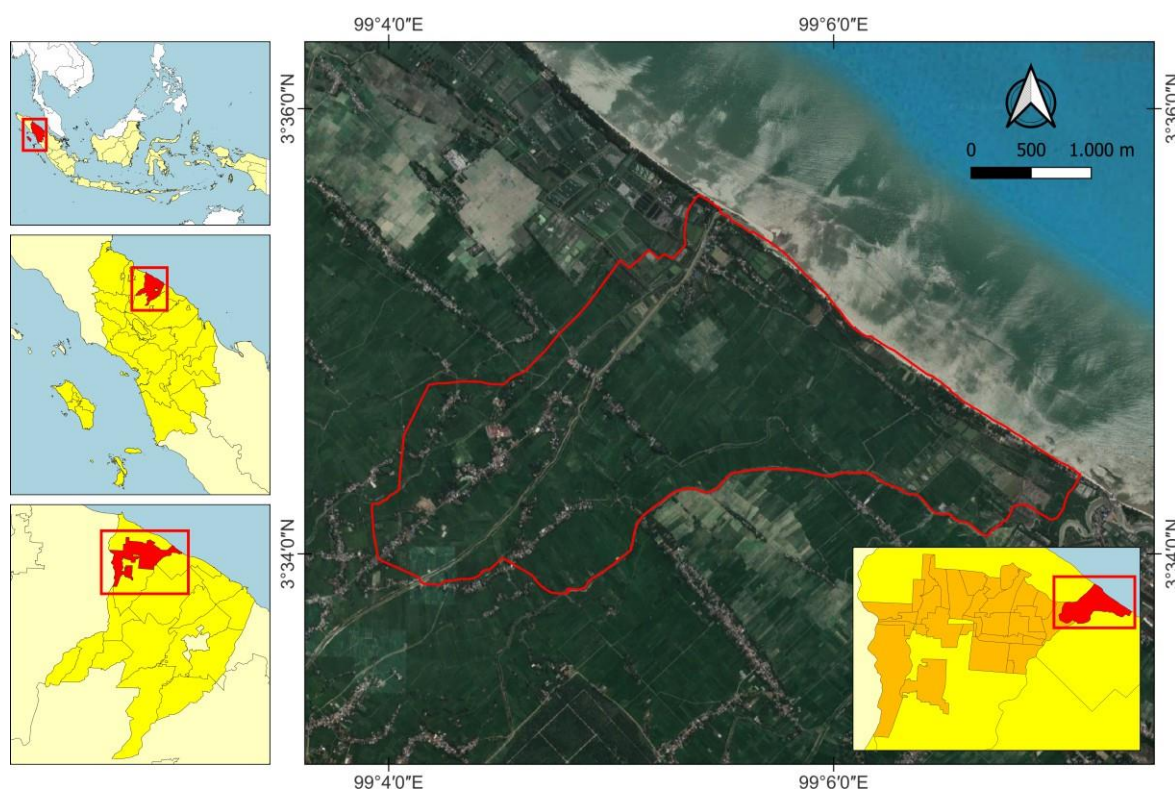
The study was conducted in Kampung Nipah, Sei Nagalawan Village, Perbaungan Subdistrict, Serdang

Bedagai District, North Sumatra Province, Indonesia, 03°59'27.8" - 03°59'31.4" N and 99°40'76.5" - 99°40'79.3" E, from April 2018 to March 2019 (Figure 1). The study area had a total extent of 5 ha in which 3 ha was covered by mangrove vegetation. According to the biophysical conditions, Perbaungan Subdistrict has a temperature range of 24-33° C, an average rainfall of 217 mm/year, and a relative humidity range of 56-84% (Farida et al. 2022; Ramadhani and Yusuf 2020). An average water pH of 7 was obtained at the location of river estuaries, mangrove rehabilitation areas and natural habitats. Water salinity at the mouth of the river, mangrove rehabilitation area and mangrove natural vegetation area was 200/00, 280/00 and 240/00, respectively. Mangrove areas were dominated by mud (69.9%), followed by sand (29.9%) and gravel (0.2%). The type of substrate found in river estuaries and rehabilitated mangrove areas is sandy substrates, and in the natural mangrove area is a muddy substrate (Sari et al. 2017).

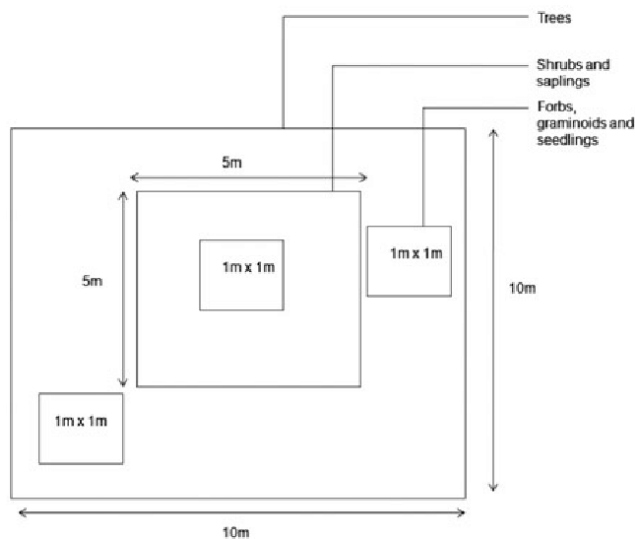
### Data collection procedure

#### *Vegetation composition*

Purposive sampling using the path method was employed to sample mangrove vegetation to determine its diversity and abundance (Kusmana 2017). The sampling density was 5%, resulting in 25 plots needed for an area of 5 ha as used by Utami et al. (2017), Barcelete Jr. et al. (2016), and Jumawan et al. (2015).



**Figure 1.** Study area of Kampung Nipah, Sei Nagalawan Village, Perbaungan Sub-district, Serdang Bedagai District, North Sumatra Province, Indonesia



**Figure 2.** The design of sample plots on observation path to collect data on mangrove potential and carrying capacity

Data on the potential and abundance of processed mangrove raw materials in Sei Nagalawan Village were obtained by making transects, of which a total of 10 transects were made (Ngo-Massou et al. 2018; Shah et al. 2018). Transect observations were carried out using sample plots based on mangrove growth stages determined based on plant height and trunk diameter, including seedlings, saplings, and trees, as carried out by Purida and Patria (2020) and Priosambodo (2019). Furthermore, observation plots for the tree level, the sub-plots for the sapling level, and the seedling level were made with 10 x 10 m<sup>2</sup>, 5 x 5 m<sup>2</sup>, and 2 x 2 m<sup>2</sup> sizes (Figure 2).

#### Mangrove utilization

A group of women processing *Avicennia marina*, *Sonneratia caseolaris*, and *Acanthus ilicifolius* leaves, who were the members of the Muara Tanjung Women's Group, were selected as the informant for mangrove utilization analysis. Furthermore, actual data about the need for raw materials in food processing is obtained from this farmer group.

The potential of mangroves as a source of food raw materials was analyzed by identifying the abundance of each mangrove species that either in whole or part of its biomass which can be processed into food. Meanwhile, the carrying capacity of mangroves as food raw materials is analyzed by calculating the annual production capacity of raw materials used as processed food for each mangrove species. The capacity to produce food made from mangroves was calculated based on field simulations involving actors who processed the food and references related to raw material-producing species.

#### Data analysis

##### Vegetation composition

The existence of raw materials for making processed mangrove products in Sei Nagalawan Village was analysed from the mangrove species on the observation path. Data

analysis was carried out by calculating the Important Value Index (IVI) which is the sum of relative density, relative frequency and relative dominance (Kusmana 2017); Bengen 2002) as follow:

The density of a species (Ds): the total individuals of species in a unit area:

$$Ds = \frac{\text{Individual species}}{\text{sample plot area}}$$

Relative density (RDs): the ratio between the total individuals of a species and all species in an area:

$$RDs = \frac{\text{Density of species}}{\text{density of all species}} \times 100\%$$

Frequency of species (F): the number of plots where a species occur:

$$F = \frac{\text{Sub plot found of a species}}{\text{Sub plot found of all species}}$$

Relative frequency (RF): the ratio between the total frequency of a species and all species in an area:

$$RF = \frac{\text{Frequency of a species}}{\text{frequency of all species}} \times 100\%$$

Dominance (D): total basal area of a species in a unit area:

$$D = \frac{\text{Base area of a species}}{\text{sample plot area}}$$

Relative dominance (RD): the ratio between the dominance of a species and all species in an area:

$$D = \frac{\text{Dominance of a species}}{\text{dominance of all species}} \times 100\%$$

The Important Value Index is a value that indicates the dominance of a species in a plant community (Asigbaase et.al. 2019). The Important Value Index ranges from 0 to 300 %. The formula to calculate the important value index for the level of saplings and trees is as follow:

$$IVI = RDs + RF + RD$$

Meanwhile, the important value index for the seedling and sapling levels is calculated using the formula below:

$$IVI = RD + RF$$

#### Production capacity and carrying capacity

The production capacity of processed mangrove products was determined from the ability to absorb the production of raw materials from the mangrove ecosystem and the production amendment of each type of processed mangrove product. The amendment was carried out by conducting field trials with resource persons, both from fruits and leaves of each type of plant that will be processed into mangrove products. The calculation of the carrying capacity of the mangrove ecosystem as raw material for various processed mangrove food products was carried out by comparing the carrying capacity with the market capacity of absorbing the products produced.

## RESULTS AND DISCUSSION

### Mangrove species composition

There were ten species of mangrove in the Sei Nagalawan, namely *Acanthus ilicifolius*, *Avicennia marina*, *Rhizophora apiculata*, *Rhizophora stylosa*, *Rhizophora*

*mucronata*, *Bruguiera gymnorrhiza*, *Excoecaria agallocha*, *Sonneratia caseolaris*, *Avicennia alba*, and *Bruguiera sexangula*. Based on their growth stages, seedling and undergrowth have the highest number of species diversity.

#### Seedlings and understoreys

At the seedlings and understoreys, there were five species, namely *A. ilicifolius*, *A. marina*, *R. apiculata*, *R. stylosa*, and *R. mucronata* (Table 1). Species with the highest and lowest IVI value were *A. ilicifolius* and *R. mucronata*, accounting for 100.4% and 7.1%, respectively. Akhirianti and Gustomi (2020) explained that IVI shows the level of importance of a species in a vegetation community. A high IVI value illustrates that the species greatly affects the stability of the ecosystem. In Table 1, it can be seen that the IVI values of some species were relatively low, indicating that the role of these species was weak in maintaining ecosystem stability at the study site. The large number of *A. ilicifolius* is one of the indicators that the mangrove ecosystem was no longer natural or has been damaged. This species grows and develops rapidly when mangrove habitats open and get enough light growing space (Sreelekshmi et al. 2018; Akter et al. 2020).

*Avicennia* was abundant and well-distributed due to the location of the Kampung Nipah, which is a muddy coastal ecosystem around the river. The habitat has silty sand sediment from river mouths carried by waves. Additionally, the site conditions are ecologically compatible with the growing typology of the *Avicennia* species (Ryck et al. 2016). This plant grows rapidly naturally due to sufficient space (Saputra et al. 2020). The *Rhizophora* species was relatively low in density and frequency because of the dynamic growing site, which is a muddy sand beach. Changes in the physical landscape occur when big waves or tidal flooding wash away the sand beach or create a new one. The habitat of *Rizhopora*, which

was previously favorable because it was accessible by the tides, becomes unsuitable due to the accumulation of sand which hinder the tidal flow as the *Rhizophora* species depend highly on tides in their habitat (Jacotot et al. 2019). However, Ahmed and Abdel-Hamid (2007) observed no significant effect of tides on *R. mucronata* growth in Egypt. Meanwhile, *Rhizophora* seeds are planted by managers and tourist visitors as part of educative and conservation tourism attractions.

#### Sapling

The result of the vegetation analysis showed seven species observed at this stage: *A. marina*, *B. gymnorrhiza*, *E. agallocha*, *R. apiculata*, *R. mucronata*, *R. stylosa*, and *S. caseolaris*. The species with the highest IVI value was *R. apiculata*, followed by *A. marina*, while species with the lowest IVI value was *S. caseolaris*.

*Avicennia marina* species has the same abundance as the seedling, due to the habitat's suitability to the growing conditions (Ryck et al. 2016). The *Rhizophora* species in this location had a high density and distribution because this species was widely planted by managers and tourists and the stands of the *Rhizophora* species that existed were the result of planting a few years earlier. However, the species *E. agallocha* is not widely found here because this location was not a natural ecosystem, but rather the result of planting interventions, so its existence depends on the planting activities carried out. This species has a broad spectrum of habitat but rather grows on rocky and sandy beaches. This location is not the most preferred habitat because it is dominated by muddy sand, hence does not naturally regenerate well (Cresswell et al. 2011). Meanwhile, because the direct and processed benefits are not known and used by the surrounding community, this species was less popular and rarely planted.

**Table 1.** Results of vegetation analysis at seedling and understorey levels

Species	Ds (ind/ha)	RDs (%)	F	RF (%)	IVI (%)
<i>Acanthus ilicifolius</i>	157,086	91.55	0.15	8.89	100.44
<i>Avicennia marina</i>	10,507	6.11	0.89	53.33	59.449
<i>Rhizophora apiculata</i>	2,011	1.16	0.33	20.00	21.166
<i>Rhizophora stylosa</i>	1,203	0.69	0.19	11.11	11.809
<i>Rhizophora mucronata</i>	800	0.46	0.11	6.67	7.136
Total	171,607	100	1.67	100	

Note: Ds: Density of a species, RDs: Relative Density, F: Frequency of species, RF: Relative Frequency, IVI: Important Value Index)

**Table 2.** Results of vegetation analysis at sapling level

Species	Ds (ind/ha)	RDs (%)	F	RF (%)	IVI (%)
<i>Rhizophora apiculata</i>	7,029.85	50.30	0.67	33.3	83.60
<i>Avicennia marina</i>	5,238.81	37.50	0.70	35.2	72.70
<i>Rhizophora mucronata</i>	1,208.96	8.65	0.33	16.7	25.35
<i>Rhizophora stylosa</i>	343.28	2.46	0.15	7.4	9.86
<i>Bruguiera gymnorrhiza</i>	29.85	0.21	0.07	3.7	3.91
<i>Excoecaria agallocha</i>	104.48	0.75	0.04	1.9	2.65
<i>Sonneratia caseolaris</i>	14.93	0.11	0.04	1.9	2.01
Total	13,970.16	100	2.00	100	

Note: Ds: Density of a species, RDs: Relative Density, F: Frequency of species, RF: Relative Frequency, IVI: Important Value Index

### Tree

The vegetation analysis results showed five species of mangroves were found at tree stage (Table 3), including *A. marina*, *R. apiculata*, *R. mucronata*, *A. alba*, and *B. sexangula*. Based on the IVI value, *A. marina* and *B. sexangula* had the highest and lowest value with 162.7% and 11.83%, respectively. The high IVI of *A. marina* is because it can regenerate and highly adaptable to various conditions in the environment. Mangrove areas with high importance value index indicate a good habitat condition (Upadhyay and Mishra 2014). A bad habitat due to reduced soil quality or changes in sedimentation and damage due to human activities decreases the quality of the mangrove ecosystem. Therefore, improvements are required to maintain the balance of the ecosystem (Onyena and Sam 2020; Kathiresan 2012).

Table 3 shows that the highest density at the tree level was *A. marina* with 248.1 ind/ha and the lowest was *B. sexangula*, *R. apiculata*, and *R. mucronata*, with 3.70 ind/ha. The total density at the tree level was 277.6. Furthermore, the highest relative density was in *A. marina* with 89.3%, and the lowest was in *B. sexangula*, *R. apiculata*, and *R. mucronata* species with 1.33%. The low density at tree level was because the trees were used as materials to construct various facilities for tourism objects. According to the Environment Minister Decree Number 201 of 2004, mangrove vegetation with tree density of less than 1,000 is included in the low density category.

The highest and lowest density at the sapling level was *A. marina* and *S. caseolaris* species with 5,238.81 tree/ha, and 14.93 tree/ha, respectively (Table 2), resulting in relative density of 37.5% and 0.11%, respectively. *A. marina* was commonly found in the front row, in areas with a relatively soft muddy substrate that supports the growth and density. According to Prihadi et al. (2021) and Yunus et al (2020), *Avicennia* spp. are usually overgrown in areas toward the sea on relatively sandy substrates. The mangrove forests are dominated by *Rhizophora* spp. as it moves toward the land.

Some species, like *A. alba* and *B. sexangula*, were absent at the levels below the tree level. This is because these species are crop trees which were not maintained continuously, hence they were only found in some stages. Conversely, some species such as *R. stylosa* and *S. caseolaris* were not found in the tree stage. The tree's existence depends on the presence or absence of planting activities conducted by managers and tourists, while natural regeneration is difficult to occur because intensive tourism activities which impacted the habitat. The sand movement

caused by waves and tidal flooding also alters the habitat and hinders natural regeneration.

### Abundance of mangrove species used as culinary raw materials

Among the 10 species of mangroves in the observation plot in Sei Nagalawan, there were 3 species used as raw materials for making mangrove culinary, namely *A. marina*, *S. caseolaris* and *A. ilicifolius*. The potential of raw materials for *dodol api-api* was calculated from the availability of *Avicennia* plants at the tree stage. The raw materials for *jeruju* chips were calculated from the total individuals *A. ilicifolius* present at the study site. The raw materials for *pedada* syrup were calculated from individual of *S. caseolaris* trees at the tree or pole level that are already able to produce fruit, and at the study site there was only one individual tree that has been able to bear fruit (Table 4).

In total, there were 744 individuals of *A. marina* at the tree level in the studied site that can be potentially used as the source of *dodol api-api* raw materials (Table 4). At the sapling level, the total number of individuals was 15,762, consisted of 15,717 individuals of *A. marina* and 45 individuals of *S. caseolaris*. At the seedling level, there were a total of 502,779 individuals, consisted of 31,521 of *A. marina* and 471,258 of *A. ilicifolius*. Table 4 shows that there are more individuals at the seedlings and sapling levels than trees of *A. marina*. This is because local people sometimes take wood from trees with a diameter of more than 10 cm for various purposes, such as the construction of tourist facilities, firewood, or other purposes, even if they are not commercialized. In addition, mangrove plants are generally not planted for a long time, so most mangroves are still at the sapling level. Such variations in diameter class distribution show differences in the ability of trees to compete (Foster et al. 2016).

**Table 4.** The number of individual plants of mangrove species used as culinary raw materials at the level of seedlings, saplings and trees

Species	Number of individuals (ind)		
	Tree	Sapling	Seedlings and understoreys
<i>Avicennia marina</i>	744	15,717	31,521
<i>Sonneratia caseolaris</i>	-	45	0
<i>Acanthus ilicifolius</i>	-	-	471,258
Total	744	15,762	502,779

**Table 3.** Results of vegetation analysis at tree level

Species	Ds (ind/ha)	RDs (%)	F	RF (%)	D	DR (%)	IVI (%)
<i>Avicennia marina</i>	248.10	89.3	0.37	62.5	0.07	10.9	162.70
<i>Avicennia alba</i>	18.52	6.67	0.11	18.75	0.49	71.4	96.82
<i>Rhizophora apiculata</i>	3.70	1.33	0.04	6.25	0.06	8.33	15.91
<i>Rhizophora mucronata</i>	3.70	1.33	0.04	6.25	0.04	5.14	12.72
<i>Bruguiera sexangula</i>	3.70	1.33	0.04	6.25	0.03	4.25	11.83

Note: Ds: Density of a Species, RDs: Relative Density, F: Frequency of Species, RF: Relative Frequency, IVI: Important Value Index

**Table 5.** Production capacity of foodstuffs generated from mangrove plants

Species	Part used	End product	Production/ind.	Raw material production	Foodstuff production
<i>Avicennia marina</i>	Fruit	Flour for <i>dodol</i>	6 kg/ind./year	1,116 kg/year	279 kg/year
<i>Sonneratia caseolaris</i>	Fruit	Syrup	10 kg/ind./year	10 kg/year	14 liter
<i>Acanthus ilicifolius</i>	Leaf	Cracker dough	7.14 gr/ind./season	3,366 kg/year	26.926 kg

Table 4 shows that *A. ilicifolius* was the mangrove species used as culinary raw material with the most abundant population in the area studied. This plant is an understory species with a high ability to adapt to its environment (Aluri et al. 2017; Akter et al. 2020; Hilal & Hilal 2019). It has thick leaves which is beneficial to store water, absorb seawater, and excrete salt through desalination glands (Rosyid 2020). The existence of this plant indicates that the ecosystem condition had been damaged (Akter 2020). There were many *Avicennia* trees in the study location, but they cannot produce fruits throughout the year, hence processed food products from this species are not regularly available.

Species with the fewest number of individuals was *S. caseolaris* in which only one individual able of bearing fruit found on the observation plot. The tree of *S. caseolaris* was difficult to find in the study location, and the availability of raw materials has decreased, becoming almost non-existent. This plant can grow naturally and is usually found in riverside swamps. Ecologically, this tree lives in muddy and swampy tidal areas (Rahim and Bakar 2018) and it is often called the *perepat* or *prepat* tree in Kampung Nipah and its surroundings.

### Production and carrying capacity of mangrove plants to generate food products

As explained above, there were three mangrove species used as food raw materials in the studied location, namely *A. marina*, *S. caseolaris*, and *A. ilicifolius* for mangrove *dodol*, syrup and crackers, respectively. Table 5 shows the production capacity of each species to generate food products.

The *A. marina* bears fruit yearly, with the peak fruiting season occurring in June. This is consistent with a report by Agungguratno and Darwanto (2016) on the coast of Mangunharjo, Tembalang Sub-district, Semarang, Central Java, stating that *Avicennia* can be harvested once a year from May to October. The harvesting season lasts for three months, depending on the fruiting period of sapling to trees, the stages which this plant bear fruit. An *Avicennia* tree usually yields fruit at an average of 6 kg/year, with variations based on the tree size. The bigger the tree, the more fruits are produced. *Avicennia* produces fruit on an average of 6 kg/ind/year which was then assumed to be used to make processed foods. Accounting for a population of 744 trees, this resulted in the production of raw material of 1,116 kg/year. One kg of *Avicennia* fruit usually yields 2-3 ounces (0.25 kg average) of flour. Therefore, the amount of flour produced is 0.25 x 1,116 kg, which is 279 kg/year. Based on the current market conditions for *dodol* (sweet toffee) products, this raw material is sufficient for

production throughout the year, although the harvesting period is uneven.

The *S. caseolaris* tree in Kampung Nipah provides raw materials in the form of fruits at 10 kg/year, whereas one tree can produce about 5-20 kg of fruit. According to Rahim and Bakar (2018), this tree has a reproduction cycle of 4-5 months. Flowering occurs during the dry season, while fruit fall occurs during the rainy season. Potentially, during the fruiting season, each mangrove tree produces 2 kg of fruit per day (Jariyah et al. 2014). At the study location, there was only one *Sonneratia* tree and it produced fruit. About 14 liters of syrup can be produced annually using 5 kg of raw fruit, which will yield 7 liters of syrup. The raw material needed to process *Sonneratia* syrup is not adequate for this production capacity. Therefore, it requires enrichment planting to increase the available raw materials to meet market needs.

About 1 kg of *A. ilicifolius* leaves with a mixture of other ingredients is required to make cracker to produce 8 kg of cracker dough. Generally,  $\pm 140$  harvested plants will produce 1 kg of leaves. From 471,258 individual plants, 3,366 kg of leaves were produced throughout the year that can be processed into 26.926 kg of cracker mixture. Based on the current market potential of *A. ilicifolius* cracker products, this raw material is still relatively abundant to be processed throughout the year. Therefore, *A. ilicifolius* in Nipah Village is still more than enough to support the production of crackers by the Muara Tanjung Farmer Group. So far, the constraint is the capacity of the market. Nevertheless, the maintenance of the *A. ilicifolius* plant still needs to be done so that there are always available raw materials with good leaf quality.

Overall, the mangrove ecosystem in the studied area should be maintained. Pambudi et al. (2020) stated that a good mangrove ecosystem has a positive socio-economic impact on the surrounding community. Conversely, damage to the mangrove ecosystem reduces its economic value for the surrounding community (Bann 1998). The conservation of the mangrove ecosystem in Kampung Nipah is carried out by the community, local government, NGOs, students, and lecturers. This is achieved by rehabilitating and encouraging a sense of responsibility and participation (Harefa et al. 2020). Additionally, tourism promotion via online media should be improved, as many are unaware of the tourism potential in Kampung Nipah. This is due to the lack of information about ecotourism areas, especially digital-based promotions, hence the number of visits has declined in the last three years (Purba et al. 2019).

In conclusion the study recorded ten mangrove species in Kampung Nipah, Sei Nagalawan Village, Perbaungan

Subdistrict, Serdang Bedagai District, North Sumatra Province. *Acanthus ilicifolius* was the most important species at the seedling and understoreys level, while *Rhizophora apiculata* and *Avicennia marina* were the most important species at the sapling and tree level, respectively. There were three mangrove species used as food raw materials in the Kampung Nipah Tourism Area, namely *A. marina*, *S. caseolaris*, and *A. ilicifolius* which are used to make mangrove *dodol*, syrup, and crackers, respectively. Based on the abundance of species used for mangrove food products, the *A. marina* and *A. ilicifolius* are highly available. Conversely, *S. caseolaris* is scarce because there is only one fruit-bearing tree in the study location. Furthermore, the production capacity of *Avicennia* fruit and *A. ilicifolius* is sufficient for *dodol* and crackers production. However, *S. caseolaris* is insufficient as raw material for syrup processing. Therefore, it is necessary to enrich the *S. caseolaris* population to support the production of mangrove syrup.

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