# Diversity and use of Sago (Metroxylon sagu Rottb.) from Meranti Islands as Road Reinforcement

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## Abstract

Sago (*Metroxylon sagu*) processing in Meranti Islands Regency is currently still conventional and only produces semi-finished materials in the form of sago starch, so it is important to recognize other potentials of this sago through its anatomical characteristics, lignin, and cellulose content. The anatomical features of fiber dimensions were observed by making maceration preparations using the Schultze method. The obtained wood anatomy data were analyzed descriptively and presented in tables, figures, and photographs. SNI 14-0492-1989 is used to determine lignin content, and SNI 14-0444-1989 is used to determine cellulose content. Especially for road reinforcement, which has a high potential. The results obtained by the two types of sago in Meranti Islands Regency, Riau Province include class II fiber and lignin content (23.14% and 22.14%), as well as cellulose content (44.12% and 42.4%), and have the potential to be used as reinforcement on road subgrades. According to the findings of this study, sago bark waste has a high potential for processing in the industrial sector, particularly for road reinforcement, which has a high potential.

## Introduction

Many crop failures of food commodities, particularly rice, have been caused by global and microclimate change. Drought caused many rice fields to fail to harvest as a result of the prolonged drought. A long rainy season, on the other hand, causes many paddy fields to be submerged or swept away by floods, resulting in crop failure or decreased production; events like this will become more common and more difficult to predict (Bujang, 2018). The growth of a very large population frequently causes issues with food availability. This occurs so that it is not matched by an adequate supply of food. One of these issues is caused by foodstuffs that are only focused on one type of staple food. This issue occurs in almost every region of Indonesia. This is because rice is still regarded as a staple food (Konuma, 2018).

Sago is a type of palm plant native to Maluku also Irian and widely used as foods. This plant species lives in freshwater swamps, peat swamps, watersheds, water sources, and swamp forests. Sago palms adapt quickly to marginal areas where food crops or plantation crops do not grow well (Pasolon, 2015). In 1983, the world's sago field area was approximately 2.2 million ha, with Indonesia accounting for half of this total (Sidiq et al. 2021) The potential for Indonesian sago is enormous, accounting for approximately 60% of the world's sago area; the total area of Indonesian sago is estimated to be 1.2 million ha. Sago plants have the potential to be a starch source. Dry sago starch production can reach 25 tons/ha/year, compared to 1.5 tons/ha/year for cassava and 5.5 tons/ha/year for corn (Suebu et al. 2020).

Sago plants can be found in a variety of Indonesian regions, including West Kalimantan, Southeast Sulawesi, and Riau.Meranti Islands Regency is a region in Riau Province that is a major producer of sago starch in Indonesia. Meranti Islands Regency has 50,000 ha of sago plantation land. Meranti Islands Regency in Riau produces a variety of sago-based foods, including instant sago noodles, gobak sago, plates, puran, and spolet. Maluku research discovered that combining Molat sago flour and shrimp produced high-quality crackers (Bujang, 2018). The results showed that a mixture of tuna, sweet potato, and sago was ideal for producing Kamoboko (Utami, 2018). Kamaboko is a traditional Japanese dish made from fish. Sago plants in Meranti Islands Regency have been developed and used by the community for a long time, and their economic value is sufficient to help the community surrounding the sago area. To date, the main product of the sago plant is starch, which is processed through refineries, which totaled 63 units in 2012, with an installed capacity of over 80 – 1,500 tual per day. This sago starch is packaged in 50 kg sacks and is generally sent to the city of Cirebon as a raw material for the vermicelli industry, in addition to being used for various food products such as noodles and pastries. At last, some starch is exported to Malaysia as raw materials for the food and non-food industries, including biodegradable plastic products. Meranti Islands Regency, Riau Province, has prospects and opportunities to become an Integrated Sago Processing Industry Center in Indonesia due to its strategic location as a gateway for exports abroad. As a result, in addition to infrastructure, various supporting technologies, such as increasing sago productivity, must be prepared. Superior seeds and good cultivation technology have the potential to boost sago plant production and productivity.

Sago processing in Meranti Islands Regency is still done traditionally, producing only semi-finished materials in the form of sago starch. In 2011, the sago refinery produced 144,927 tons of sago starch, which has always increased at a 6% annual rate, and sago starch production in 2017 was 205,051 tons (Bujang, 2018). Currently, the use of sago is limited to its main product, sago starch. The development of downstream products such as noodles, crackers, sago rendang, and vermicelli is still relatively limited. The byproduct, sago peel waste (uyung), has not been used to its full potential. Refinery owners and the community in general use a small portion of the sago bark (uyung) for fuel, while the rest is used as machine foundations or load bearings. Unfortunately, the majority of the sago skin is only burned to prevent accumulation. Wild boar, in addition to being a biomass, has the potential to be used as a raw material for pulp or as a road subgrade. This potential can be determined by anatomical characteristics, lignin content, and cellulose content. According Natural fibers include fibers produced by plants, animals, and geological processes that can be reprocessed (Arsyad et al. 2019, Siruru et al. 2019, Kadir et al. 2021). Plant fibers, which are typically composed of cellulose and hemicellulose and may contain lignin, are the most common types of natural fibers. Cotton and hemp fiber, palm fiber, coconut fiber, rosella fiber, and other types of fiber are examples of this type. While wood fibers are derived from woody plants, animal fibers are generally composed of specific proteins; examples of animal fibers used by humans include silk and sheep wool (wool), and mineral fibers, which are derived from asbestos naturally present in the form of long fibers. Natural fibers are currently gaining attention from composite materials experts due to their high specific strength their low density. To determine the potential of sago peel waste as reinforcement for road subgrades, it is necessary to know the diversity of sago as well as its lignin and cellulose content. This study aims are to see how potency skin stem sago for made reinforcement on road subgrade.

## Materials And Methods

# Experimental Part

# Study area

This research was conducted in the Meranti Islands Regency of Riau Province. Population monitoring and sago plant sample collection were conducted in one sub-district, namely the Lemang Sub-district, which included four hamlets: Peranggas, Lemang, East Harjosari, and West Harjosari. This district is home to both public and private sago plantations. From April to September 2022, the study was carried out. The anatomical characteristics of fiber dimensions were observed by making maceration preparations using the Schultze method (Marta et al. 2022), while staining was accomplished by adding safranin using the Sass method in (Marta et al. 2022). The obtained wood anatomy data were descriptively analyzed and presented in tables, figures, and photographs. SNI 14-0492-1989 is used to measure lignin content, and SNI 14-0444-1989 is used to measure cellulose content (Zainal et al. 2018).

## Data Collection

In this study, the test materials were Bemban and Sangka sago, with Duri sago serving as a comparison. Field auxiliary materials include roll meters, cloth meters, axes, chainsaws, phylox paint, sitting scales, cake scales, plastic bags, knives, mixers, filters, plastic basins, markers, and other items. The surveying of several sago populations at the study site is used to determine the sago sample population. The sago population was visually observed, and a sago sample population was determined based on a stretch of sago that was quite compact in growth, had clumps with gradual age levels, and some of these clumps had sago trees ready to be harvested. The content of sago lignin and cellulose was analyzed at Universitas Andalas Laboratory of Organic Chemistry and Natural Materials.

**Characterization of Sago (** Metroxylon sagu **)**

# 1. Lignin Rate (SNI Method 14-0492-1989)

Weigh 1 gram of dry pulp dissolved in 99% ethanol for 8 hours before testing, then wash with hot water. The sample is then transferred to a glass 100 ml cup, and 15 ml of sour 72% sulfate is added slowly over 2–3 minutes. Close it with a glass watch and leave it for 2 hours after the dispersion is perfect. The sample was then transferred to a 500 ml glass cup and diluted with water to a volume of 575 ml. The solution was heated to a boil and then left for 4 hours. The precipitate on the left settled perfectly and was transferred to a weighted paper filter. The lignin precipitate is washed in hot water until it clears. Following the precipitate, a paper filter was dried in an oven at 105°C for 60 minutes and weighed until the weight was constant. The lignin content of the pulp was determined using the following formula:

$$Lignincontent = \frac{LigninDepositWeight}{Ovendrypulpweight}\text{x}100\%$$

## 2. Cellulose Content (SNI Method 14-0444-1989)

We weighed 3 grams of dry pulp and placed it in a glass beaker. The pulp is then wetted with 15 ml of 17.5% NaOH and stirred for 1 minute. Stir in 10 mL of 17.5% NaOH for 45 seconds. 10 ml of 17.5% NaOH was added and stirred for 15 seconds. The mixture was left for 3 minutes. Another 10 mL of 17.5% NaOH is added and stirred for 10 minutes. After 2.5, 5, and 7.5 minutes, I added 10 ml of 17.5% NaOH three times. closed for 30 minutes I added 100 ml of distilled water and let it sit for 30 minutes. The sediment was then extracted from the mixture by filtering it. The sediment was then washed 5 times with 50 ml aqua dest. 12.5 ml acid acetate 2 N was added and stirred for 5 minutes. Then, using paper litmus, wash with aqua dest until the acid is gone. The precipitate was dried in an oven at 105° C for 60 minutes, then cooled in a desiccator and weighed until the weight remained constant. Cellulose content is calculated using the following formula:

$$Selulosacontent = \frac{SelulosaDepositWeight}{Ovendrypulpweight} x100$$

# Data analysis

The first step in analyzing the research data was to average each measurement of all the anatomical characters of lignin, cellulose, and fiber content from each field sample of sago bark, which was then tabulated and descriptively analyzed each quantitative property measured, namely fiber length, diameter, and fiber wall thickness, was done 25 times. The Chesson method was used to determine the chemical components of sago wood (Zainal et al. 2018). 1 gram of sago stem powder was mixed with 150 mL of distilled water and refluxed for 2 hours. The samples were then filtered and washed until the pH was neutral, dried in an oven at 105°C, weighed, and the water-soluble extractive content equation was used to calculate them. Residue 1 was refluxed in 150 mL of 0.5M $H_2SO_4$ for 2 hours. The samples were then filtered and washed until the pH was neutral, dried in an oven at 105°C, and weighed using the hemicellulose content equation. The obtained residue 2 was added to 10 mL of 72% $H_2SO_4$ and stirred at room temperature for 4 hours. The sample was then mixed with 150 mL of 0.5M $H_2SO_4$ and refluxed for 2 hours. The samples were then filtered and washed until the pH was neutral, dried in an oven at 105°C, weighed, and calculated using the cellulose content equation. The obtained residue 3 was placed in the crucible and left until the smoke dissipated before being placed in the furnace for 5 hours at 550°C and cooled. Then bake at 105°C for at least 2 hours before weighing and calculating using the lignin content equation.

## Results

# Diversity of Sago in the study area

The acceleration of the diversification of non-rice food, especially from sago, has even received appreciation from the business world by placing the Meranti Islands Regency Government as the primary winner of an innovative Regional Government in developing non-rice alternative foods in 2019. In addition, efforts to promote sago as an alternative food source are also carried out through the Nusantara Sago Festival (FSN), centered in Meranti Islands Regency, Riau Province. (Kadir et al. 2021) and (Arwam et al. 2021), sago is a staple food that provides living needs as an integral part of the function of forests and life activities for the community. Because of the importance of sago, most coastal communities live in areas where sago grow, such as rivers and swamps, to ease access to the resource.

Sago (Genus Metroxylon) consists of two main types, namely thorny sago (sangka) and non-thorny sago (bemban). Thorny sago (sangka) has thorns on its fronds and non-thorny sago (bemban) does not have thorns on its fronds. Sago has the characteristic of cross-pollination (cross-over pollination) so many new varieties emerge with the transitional characteristics of the two types.

## Fiber Content Of Sago In The Study Area

The fiber length of the Bemban sago bark is 1.517 mm, and the length of the Sangka sago fiber is 1.582 mm, according to observations and analysis. Sago bark fiber is classified as long because it is longer than 1 mm in length. The stiffness and tensile resistance of fiber are affected by its length. According to (Vita, 2017), the longer the pulp fiber of the wood, the greater the strength of the wood. This is because long fibers provide a larger area of contact and better webbing between fibers, allowing more hydrogen bonds to form between the fibers (Table 1).

Table 1
Dimensions of Bark Fiber Sago Meranti Islands

| No | Local name | Fiber length (mm) | Wall thickness (µm) | Fiber diameter (µm) | Lumen diameter (µm) |
|---|---|---|---|---|---|
| 1. | *Bemban* | 1,517 | 3.65 | 27.16 | 18.28 |
| 2. | *Sangka* | 1,582 | 3.70 | 38.39 | 31.11 |

The thickness of the sago bark fiber wall is the next anatomical characteristic to be measured. The wall thickness of sago bark fiber is 3.65 m and that of sangka bark fiber is 3.70 m, which is less than the thickness obtained by (Arsyad et al. 2021), which is 5.36–13.54 m. The results of measuring fiber dimensions in sago bark show that sago bark fiber has a higher dimension value than empty nipa palm fruit bunches (Wistara et al. 2017).

The average diameter of sago bark fiber from loaded sago bark and sangka is 27.16 m and 38.39 m, respectively. The diameter of sago bark fiber falls into the large category because it exceeds the 10–25 m range (Situmorang & Harianja, 2018). Fiber diameter influences sheet formation, bonding between fibers, and fiber strength in sheets. The lumen diameter of the sago bark is the next anatomical characteristic measurement. The loaded sago skin has a lumen diameter of 18.28 m, while the Sangka sago skin has a lumen diameter of 31.11 m. This value is higher than the lumen diameter of sago skin reported by (Arsyad et al. 2021) on sago bark from Kalimantan, which is around 7.06 -25.01m.

According to Suryanto et al. (2018), the use of natural fibers and organic fibers reduced plastic deformation and permanent deformation for mixtures without fiber reinforcement compared to SMA mixtures with fiber reinforcement, with an increase in optimum asphalt content for mixtures containing organic fibers versus mixtures mixed with mineral fibers. The diameter and length of the fiber are also important factors. It was explained that the use of fiber with a smaller diameter (0.03 mm) and short fibers have the potential to result in the formation of a greater number of clusters (percentage of 10% particle loss) when compared to using fiber with a larger diameter (0.2 mm) and long fiber. It is advised to use 0.2% – 0.5% fiber with a fiber length of 0.8 mm. The longer the fiber, the greater the possibility of length loss or changes due to the compaction process.

Table 2
Bark Fiber Derivatives Sago Meranti Islands

| **Parameter** | ***Bemban*** | **Nominal** | ***Sangka*** | **Nominal** |
|---|---|---|---|---|
| Fiber length (mm) | 1,517 | 50 | 1.582 | 50 |
| Runkel Ratio (R.R.) | 0.40 | 75 | 0.24 | 100 |
| Weaving power (F.P.) | 55.87 | 50 | 41.23 | 50 |
| Muhsteph Ratio (%) | 54.72 | 75 | 34.34 | 75 |
| Flexibility ratio (F.R.) | 0.67 | 75 | 0.81 | 100 |
| Coefficient of Rigidity (C.R.) | 0.13 | 75 | 0.10 | 75 |
| Total Nominal | 400 | | 450 | |
| Class | II | | II | |

Sago bark has a Runkel ratio of 0.40, which places it in the class 2 category. Sago bark has a Runkel ratio of 0.24, placing it in the class 2 category. If the Runkel ratio is low, it is simple to grind with wider fiber bonds to produce pulp with a high tensile and breaking strength (Hasan et al. 2022). The weaving power of burdened sago bark is 55.87, placing it in the category of class 3. Sago sangka bark has a weaving power of 41.23 and is classified as class 3. The weaving power results show a high number of inter-fiber bonds, resulting in fiber degradation potential and interlocking bonds. Also high in fiber. The woven power value is the fiber length-to-fiber diameter ratio.

Sago bark has a Muhsteph Ratio of 54.72, placing it in the class 3 category. Sago sangka bark has a Muhsteph Ratio of 34.34, placing it in the class 2 category. Sago bark has a coefficient of rigidity of 0.13 and belongs to the class 3 category. Sago sangka bark has a Coefficient of Rigidity of 0.10 and is classified as class 3. Paper with high tensile and breaking strength can be made from wood fibers with thin fiber wall thickness and large fiber diameter (Rasyid et al. 2020).

Sago sangka bark has a flexibility ratio of 0.67 and is classified as class 2. Sago sangka bark has a flexibility ratio of 0.81 and is classified as class 2. The stiffness will be affected by the Flexibility Ratio value (Pasolon, 2015; Konuma, 2018; Tiro et al. 2018; Rasyid et al. 2020).

Table 3
Lignin and Cellulose Levels in Stem Bark
Sago from the Meranti Islands

| No | Sago | Lignin | Cellulose |
|---|---|---|---|
| 1 | Bemban | 23.54% | 44,125% |
| 2 | Sangka | 22.86% | 47.65% |

The lignin content of these two types of sago was 23.54% and 22.86%, respectively. Whereas in previous studies it was obtained at 29.38%. Siruru et al. (2019), this is due to the sago bark consisting primarily of peripheral cells composed of hard sclereid cells with thick secondary cell walls. Meanwhile, the lignin content of sago bark is also lower than that of oil palm bark, which is 33.61% (Wistara, 2017). With a carbon percentage of about 61%, lignin is the main component contributing carbon in activated carbon products; cellulose and hemicellulose carbon percentages are 42% and 40%, respectively (Pasolon, 2015). The higher the lignin content, the more aromatic groups form, and the higher the charcoal yield (Konuma, 2018). The presence of lignin on the surface of the fiber serves to reinforce it and protect it from weather and temperature factors. The lignin on the surface of the palm fiber serves as a protector and demonstrates the stiffness properties of the palm fiber, allowing it to withstand weathering and chemical compound element attack.

The cellulose content of these two types of sago bark was 44.125% and 47.65%, respectively, while obtained 44.00%. This study builds on previous work by Wistara, (2017) who found that the cellulose content was higher than that of oil palm skin. Because cellulose is a homogeneous compound, its purity is frequently expressed as a percentage of cellulose. Because cellulose has a strong tendency to form hydrogen bonds in straight chains, it has a crystalline structure, as opposed to amorphous hemicellulose, which has a branched structure and more free OH groups (Arsyad et al. 2021). The number of OH groups in a compound can influence its hygroscopic properties (Bujang, 2018).

The requirements for the strength of materials used for structural (load-bearing) building materials or furniture must not be less than strength class III, according to the Indonesian state standard (SNI.01-0608-89). The two types of sago are classified as class II fibers based on the test results of fiber dimensions, lignin, and cellulose content.

**Local use of Sago (** Metroxylon sagu) **in Riau**

Because the progress of this research has not been matched by developments at the practical and market levels, this enormous potential has yet to be realized. Starch is the main ingredient that sago has the potential to produce, and its demand is rapidly increasing to keep up with the increasing demand for industrial food. The food industry uses starch as a thickener, filler, and binder to produce sweeteners and syrups for the beverage, bakery, and other food product industries, as well as to produce sugar and alcohol, which are widely used in the food and chemical industries. Sago's contribution is still very limited (Bujang, 2018).

The potential of sago in Meranti Islands Regency, Riau Province is quite large, and there are still many people who are unaware of the many benefits of sago because the people there only manage sago as food ingredients such as instant sago noodles, gobak sago, plates, puran, and spolet. The dregs are then used as animal feed, waste sago stems as firewood, and sago leaves as roofing material.

### Potential of Sago ( Metroxylon sagu ) as road reinforcement

The potential for starch production from sago forests in Papua is around 5 tons/ha/year, whereas, in Meranti Islands Regency, Riau Province, semi-cultivated natural sago fields have productivity of around 10 tons/ha/year (Bujang, 2018). It is estimated that intensive cultivation could increase the potential yield of sago starch to 15 tons/ha/year. According to Twikromo (2020), some research results on sago, with better cultivation techniques, the productivity of sago starch can be increased to 20 tons/ha/year and the results of other studies state that productivity can be increased by up to 25 tons/ha. This increase in productivity will be directly proportional to the amount of sago bark waste produced, implying that sago bark waste has a high potential for processing in the industrial sector, particularly for road reinforcement.

Sago growing conditions in the Meranti Islands, Riau, is poor because the spacing is irregular, very tight, and unmaintained. Sarawak sago trees are planted very regularly in Malaysia with good maintenance, so the sago trees that can be harvested are around 150–250 trees/ha/year, with starch production of around 150–250 kg/tree. Sago can be grown with a spacing of 8 m x 8 m to 10 m x 10 m and a population of 100–156 young plants/ha. It is expected to grow 50–239 clumps/ha/year at harvest age, which is 8–12 years.

Based on the research findings, the Meranti Islands sago development has the potential to increase productivity to 15–20 tons/ha. Increasing sago production and productivity can be accomplished through the use of superior seeds, more regular spacing of sago fields and clumps, and better maintenance of blocks and plants, including the regulation of water canals to prevent long-term inundation during the rainy season. Sago stalks have a high potential for use as road reinforcement.

### Conservation of Sago ( Metroxylon sagu ) in Riau

In expand sago's role, a pilot model for sago management areas as a type of business unit is required, supported by an adequate and economically profitable starch production process and sago plantations. This is intended to take advantage of the sago plant and drive the economy of the surrounding community so that it can play a role in the regional economy. Furthermore, examples of sago-based food products that are acceptable to people who are not sago consumers must be developed. As a result, sago starch is made in the form of noodles.

To ensure the supply of sago, an area unit was established as a supplier of sago raw materials. Furthermore, the sago species population from Meranti Islands Regency, Riau Province has been released as a national superior variety under the name Selatpanjang Meranti sago variety; for development, it can use superior seeds from the Selatpanjang Meranti sago variety.

## Conclusions

The potential for sago in Meranti Islands Regency, Riau Province is quite large, and many people are still unaware of the many benefits of sago aside from processed food. Meanwhile, sago productivity in the area is around 10 tonnes/ha/year, which is directly proportional to the sago bark waste produced. The results obtained by the two types of sago in Meranti Islands Regency, Riau Province are included in class II fiber and lignin content (23.14% and 22.14%) and cellulose content (44.12% and 42.4%) and have the potential to be used as reinforcement on road subgrades. According with findings of this analysis, sago bark waste has a high potential for processing in the industrial sector, especially for road reinforcement, which has a superior potential.

## Declarations

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**Data Availability** The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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# Figures

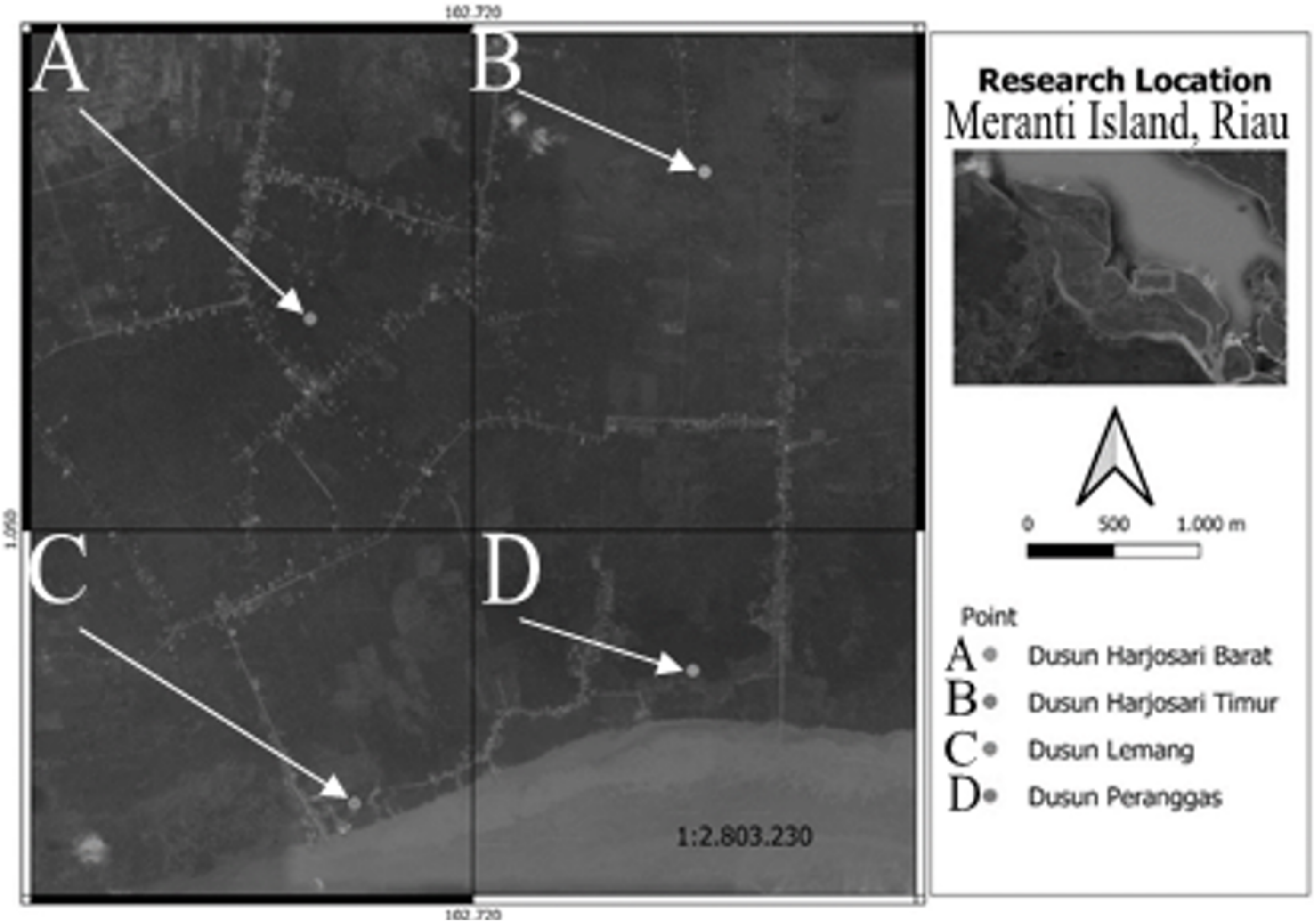


**Figure 1**

Location map Collection Sago (*Metroxylon sagu*)

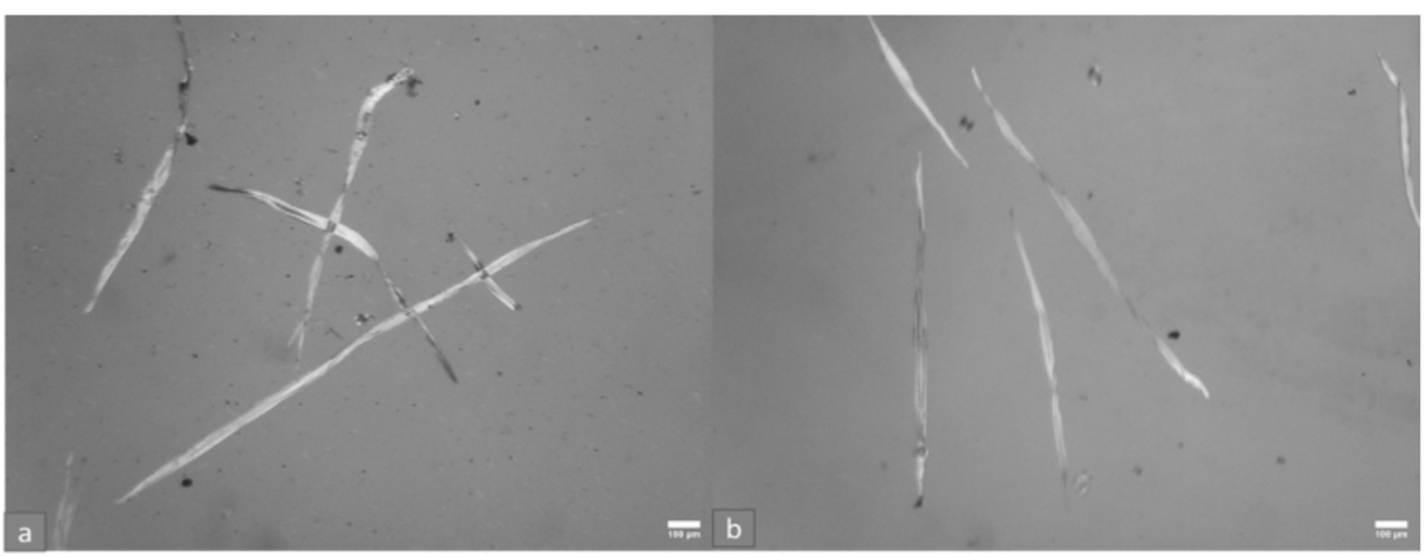


**Figure 2**

Stem fibers sago (a. sangka , b. bemban)