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Article

The Potential of Sea Pandan (*Pandanus tectorius*) Fiber as a Non-Food Industry Material Towards Sustainable Development

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Abstract. *Pandanus tectorius* in certain areas has potential that is utilized in the field of handicraft industry, because it has good and strong fiber. However, there are still some coastal areas in Indonesia that have not utilized *Pandanus tectorius* optimally, especially in Central Kalimantan. The purpose of this study is to determine the potential of *Pandanus tectorius* fiber can be used as a non-food industrial material towards sustainable development. This research method is a laboratory experiment with a qualitative descriptive approach that uses different variations in NaOH concentrations, namely 0% (control), 2.5%, 5% and 7.5%. Research data was obtained from fiber tests in the laboratory which included fineness, tenacity, and elongation tests. Laboratory test results show *Pandanus tectorius* fiber in 5% NaOH treatment is more optimal when compared to 0% NaOH treatment (Control), 2.5% and 7.5%. This is indicated by the average fineness value of 2529.16 Tex, the extension value of 15.11%, the tenacity value of 153.71 (mN/Tex) and 15.68 (gf/Tex). Based on the results of the analysis, it is known that *Pandanus tectorius* fiber has excellent characteristics for use as a non-food industrial material. Therefore, the utilization of the potential of *Pandanus tectorius* fiber can be directed as a step in the development of creative industries that contribute to sustainable development. It is hoped that the findings of this study can provide the latest insights and contribute positively to the implementation of sustainable development in the field of non-food industry.

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1. Introduction

The introduction is a little different from the short and concise abstract. The reader needs to know the background to your research and, most importantly, why your research is important in this context. What critical question does your research address? Why should the reader be interested? Sea Pandan (*Pandanus tectorius*) is one of the monocotyledonous plants from the Pandanaceae tribe that grows a lot and is often found in almost all parts of the Indonesian archipelago, especially in coastal areas [1-2]. These plants live in groups on the beach so they are considered lifeguard plants [3-4].

The growth of *Pandanus tectorius* which is fertile and wild is a problem for people living on the coast because it can close road access. The characteristics possessed by sea pandanus are considered dangerous for road users because there are sharp thorns on the leaves [5]. However, even though it is considered a nuisance plant for sea pandan leaves, it is known for a long time that it is often used by the community as a traditional medicine material, woven products, roofs, bags, and ropes [6-8].

Pandanus tectorius is known to have good fiber on the leaves. The leaves contain high cellulose ranging from 83-88% with lignin compound content between 18-22% [9-10]. The high cellulose content in leaf fibers provides strong tensile strength to the cells [11-12]. In addition, it produces fiber flexibility that is good for use in the non-food industry [13].

The use of *Pandanus tectorius* leaf fiber as raw material in the industrial world can be one of the innovations in the industrial field because it utilizes natural materials. In addition, the resulting industrial products can have advantages when compared to industrial products made of synthetic fibers. This is because it is renewable, recyclable, and safer for the environment and health [14]. Natural fibers also have better mechanical characteristics, because they are elastic and not easily broken. These advantages certainly have an impact on the production equipment used, because they are not easily worn or damaged, as well as the costs incurred and lower density when compared to synthetic fibers [15-17].

Some coastal areas in Indonesia, such as in Teluk Wondama Regency, have utilized *Pandanus tectorius* plant fiber. For example, the Roswar community uses fiber from *Pandanus tectorius* to make various woven handicraft products, including mats, hats, koba-koba and bags [18-20]. *Pandanus tectorius* fiber is also used for fillers and polyethylene terephlate as a matrix in the manufacture of composite raw materials for electronic product casings [9][21], materials for making Seed Tape [22], as materials for the textile and furniture industry, nanofiber/nanosheet raw materials [24] and pulpmaking materials [25].

Pandanus tectorius fiber can also be used as raw material for making biocomposites, car interior materials such as car bumpers and others [26-27]. However, in Central Kalimantan *Pandanus tectorius* plants are still not optimally used so this plant is often considered a nuisance because it can close road access to the beach. Therefore, it is necessary to utilize and manage *Pandanus tectorius* optimally, in order to provide economic value to the plant.

The use of *Pandanus tectorius* leaf fiber in industry can support the economy because it is a source of income and opens up jobs for coastal communities, especially areas that still do not manage *Pandanus tectorius* [28]. Sustainable use of natural materials not only has an impact on the economic growth of the community, but also affects the sustainability of nature. In this case, there is a need for principles and concepts of life that prioritize the balance of nature for a better life, namely by utilizing natural resources as a supporting capacity for life as a whole without neglecting future interests [29].

The use of sea pandan fiber towards sustainable development focuses on three important aspects in creating sustainable development, namely sustainable in ecology (environment), economy and social [30-33]. This is in line with the Sustainable Development (SDGs) goal point 8 on Decent Work and Economic Growth with the aim of building sustainable economic growth in order to create maximum and decent employment opportunities for the community at this time until the future [34].

In addition, the management of natural resources in life also has an impact on the environment because it is in line with the concept of SDGs point 15 on life on land which aims to preserve the environment and biodiversity by protecting, restoring and encouraging the sustainable use of terrestrial ecosystems [34]. Understanding the potential of *Pandanus tectorius* fiber and integrating it into the non-food industry is expected to make a positive contribution to sustainable development efforts, both in terms of economy, social and environment. Therefore, further research and development related to the use of *Pandanus tectorius* fiber is important to support the vision of sustainable development.

2. Experimental Section

2.1. Tools and Materials

The tools used in this study were thermometers, pH meters, refractometers, basins, iron plates and analytical balances. The materials used are aluminum foil, sea pandan leaves and NaOH solution which will be used in soaking in the manual fiber separation process.

2.2. Method

This research was carried out on the moon. The method used in this study was experimental in the laboratory which previously carried out habitat identification, morphology and anatomy of fiber cross-cutting leaves. Experimental methods in the laboratory there are two main activities carried out, namely manual fiber separation and fiber smoothness, strength and extensibility tests. The research flow diagram is shown in Figure 1.

2.2.1 Manual Fiber Separation

Manual separation of *Pandanus tectorius* fibers is carried out at the Glass Laboratory of IAIN Palangka Raya. The Working Procedure of separating fibers from leaves consists of 6 steps. First, cutting *Pandanus tectorius* leaves from the base that is slightly old with a size of 30-60 cm, this is in accordance with the opinion of [18] which states that the good part of pandan leaves to be used as raw material for making natural fiber products is old leaves or leaves that come from the base and middle of the crown.

Second, degumming of *Pandanus tectorius* leaves for 3 hours with a fixed temperature of 80oC This boiling is carried out based on the opinion of [35] who states the effective time and temperature of the degumming process, namely for 3 hours with a temperature of 75°C-80°C. The purpose of this boiling is to soften and facilitate the separation of fibers from the leaves. Third, Water retting or soaking *Pandanus tectorius* leaves for 1 week in a closed container. Soaking is done to help the decay process on the leaves so that the fiber separation process and also serves to strengthen the fiber. This is in line with [21] which states that *Pandanus tectorius* leaf fibers can be easily separated from other leaf parts by rotting *Pandanus tectorius* leaves.

Fourth, Scraping / grinding to separate the fiber from the leaf part by scraping it using iron plates. This is according to what was stated by [36], namely this erosion is carried out to remove substances that are still attached or remaining in the fiber. Fifth, soaking with NaOH, the fiber is soaked with NaOH solution for two hours with three different concentrations. In this process, there are three concentrations used, namely 2.5%, 5%, and 7.5%. The concentration adjusts from references from [37] . Sixth, after soaking with NaOH the fiber is washed using clean water and soaked with clean water for 3 days. The last process carried out is to dry the fibers at normal room temperature by aerating. This is in line with the research of [38] related to drying the fiber in aerated so that the drying of the inside and outside of the fiber is dry in a balanced manner.

2.2.2 Fiber Fineness, Tenacity and Elongation Test

The process of manual fiber separation activities is completed followed by tests of smoothness, strength and extension of fibers at the Bandung Textile Physics Evaluation Laboratory. After the data comes out, proceed to analyze the data with a qualitative descriptive approach.

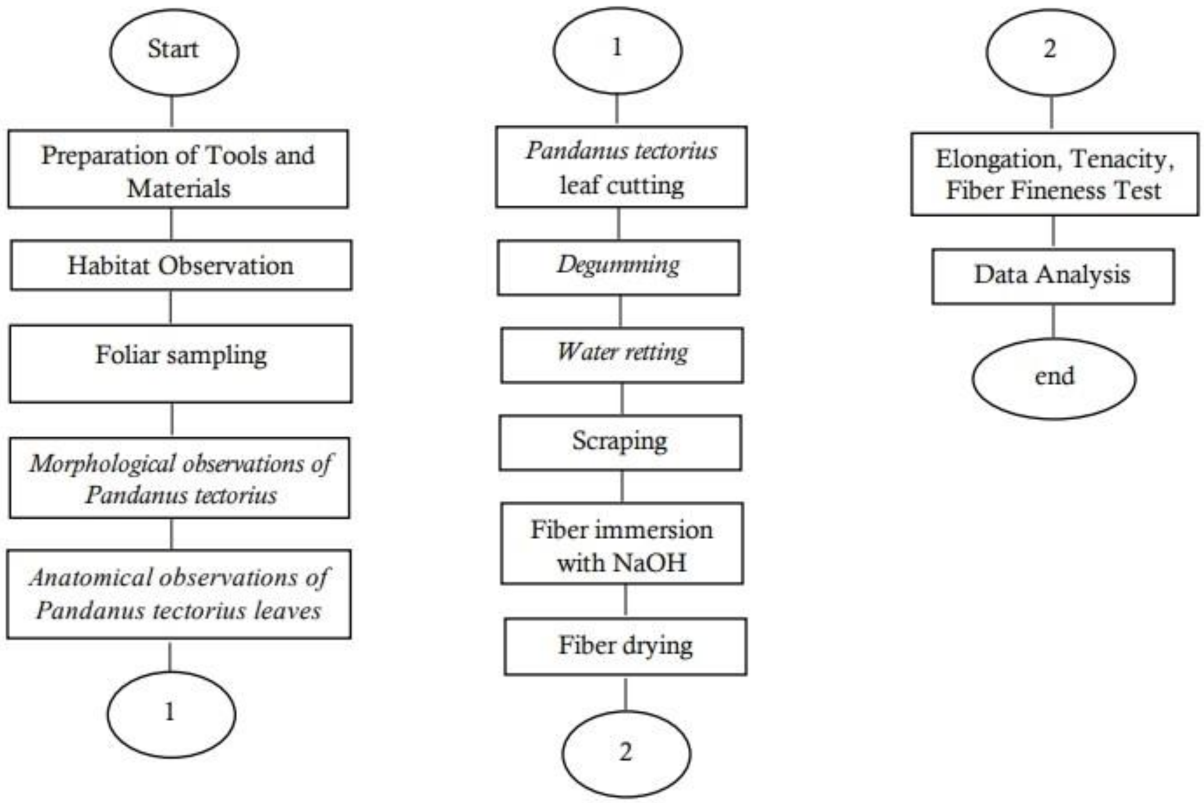

Figure 1. Flowchart of research

3. Results and Discussion

3.1 Habitat and Morphology of *Pandanus tectorius*

Sea pandanus based on observations grows along the coast, the soil subtract is predominantly sandy, with soil temperatures ranging from 29-32°C with a soil pH of 6-7, the pH of the water is at 7.6-7.9 with the salinity content of the water at 3-4 [39-40]. The sea pandanus used in this study has morphological characteristics, namely the length of the leaves between 50 cm to 90 cm with a leaf width of 5 cm, the leaves of the sea pandan have sharp thorns on the right side, left side and spine of the leaves whose thorn color is greenish-white. The stem of a single sea pandan plant that has a grayish-brown color, with rings of scars attached to the leaves [41].

Sea pandan fruit has a compound cone shape that hangs down to form a ball, a bit similar to pineapple. The fruit has a hard texture like a stone. The roots of sea pandan plants are in the form of supports with many root characteristics that function as a habitat for marine animals and to withstand waves in preventing abrasion of beach sand. The morphology of sea pandanus can be seen more clearly in figure 2.

Figure 2. Morphology of *Pandanus tectorius* a) *Pandanus tectorius* tree, b) *Pandanus tectorius* leaves, c) *Pandanus tectorius* stem, d) *Pandanus tectorius* roots, e) *Pandanus tectorius* fruit (Source: Personal Documentation, 2023).

3.2 Leaf Anatomy Cross-section of *Pandanus tectorius*

The results of the identification of sea pandan leaf fibers were carried out anatomical observations transversely (c.s) and longitudinally (l.s) using a 10x magnification microscope, it was seen that there was a cross-section of fibers coated by lignin. It can be clearly seen in figure 3.

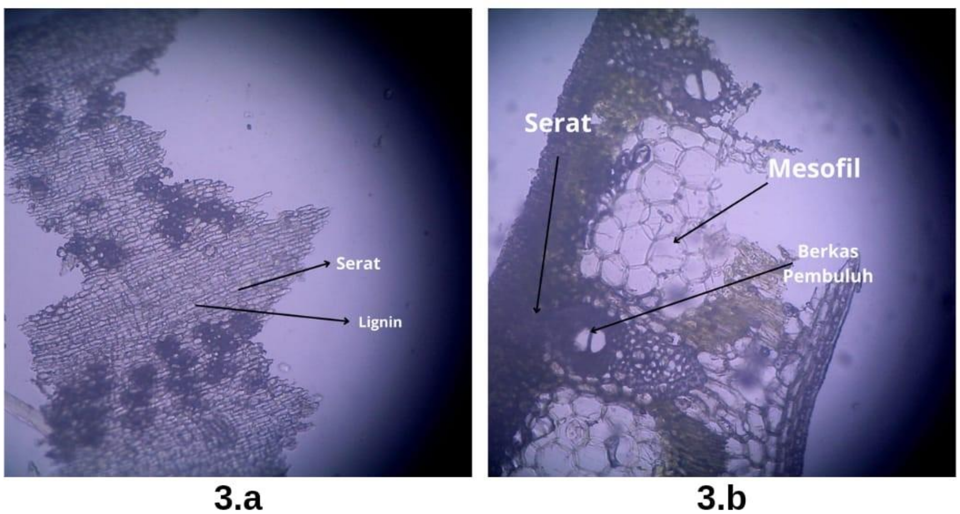

Figure 3. Anatomy of *Pandanus tectorius*: a) Cross section of a leaf in a longitudinal position; b) Cross section of a leaf in a transverse position

In figure 3 is presented a picture of the fibers found in the leaves of the sea pandanus, in figure a there is a cross-section of the longitudinal position of the leaves visible fibers that are connected to each other with lignin. In figure b from the side of the transverse leaf can be seen the fibers around the vascular network and in the part close to the leaf epidermis whose fiber position is not too tight. The results of the cross-section of the leaf anatomy of *Pandanus tectorius* prove the presence of fibers that are interconnected with lignin compounds in the leaves. In this study, *Pandanus tectorius* fiber is not too tight which makes pandan leaves still have flexible properties.

3.3 Fiber Separation Results

The results of Fiber Immersion at each concentration that is not given and given immersion treatment with NaOh solution have different fiber characteristics presented in figure 4.

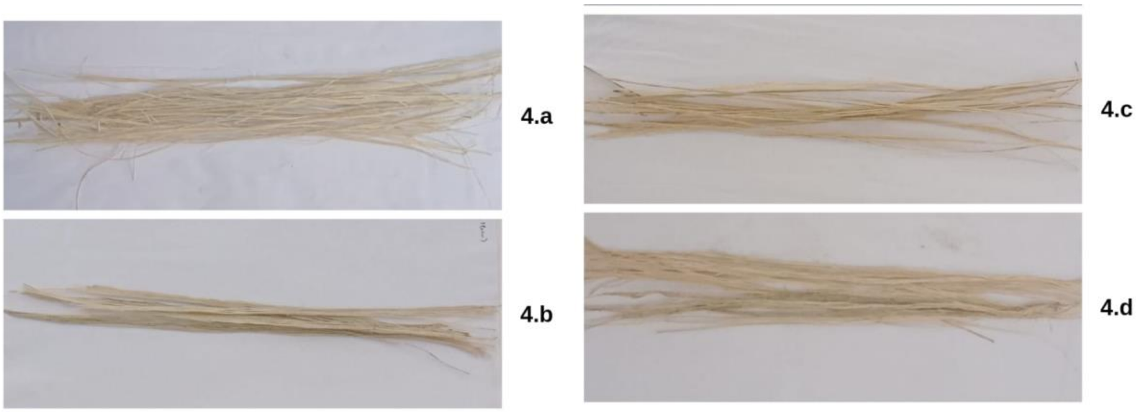

Figure 4. *Pandanus tectorius* Fibers Based on NaOH Immersion: a) Control, b) 2.5% NaOH Treatment, c) 5% NaOH Treatment, d) 7.5% NaOH Treatment

Figure 4 describes the texture characteristics of fibers treated with NaOH or without NaOH treatment. Figure 4a describes fibers that received 0% NaOH immersion treatment (Control) have rigid characteristics with a coarse fiber texture. Figure 4b explains that fibers that receive 2.5% NaOH soaking treatment have the characteristic of still being rigid with a slightly finer coarse texture.

Figure 4c explains that fibers that receive 5% NaOH soaking treatment have more flexible characteristics with the right fiber texture, not too coarse and not too fine. Figure 4d shows that fibers that receive 7.5% NaOH soaking treatment have flexible characteristics but are too fine until the fibers become curly or curly textured. From this explanation, it can be seen that soaking with NaOH solution can affect the texture characteristics of the fibers [14][15][42].

3.4 Results of Fineness, Tenacity and Elongation

Test results of tensile strength, flexibility and fineness of fibers in the Laboratory with Srandar Nasional Indonesia (SNI) 08-1112-1989. The results of laboratory tests can be seen in Table 1**.**

Table 1. *Pandanus tectorius* fiber laboratory test results

Treatment		Fineness	Tenacity (mN/Tex)	Tenacity (gf/Tex)	Elongation (%)
Control (0%)	X	1604.72	110.96	11.32	13.06
	S		4.20	0.43	1.81
	Cv		3.78	3.78	13.87
NaOH 2.5%	X	2396.36	147.13	15.01	13.56
	S		11.12	1.13	1.00
	Cv		7.56	7.56	7.40
NaOH 5%	X	2529.16	153.71	15.68	15.11
	S		15.57	1.59	1.37
	Cv		10.13	10.13	9.06
NaOH 7.5%	X	2958.40	148.16	15.12	16.20
	S		24.31	2.48	4.84
	Cv		16.41	16.41	29.86

Pandanus tectorius fiber parts must have good characteristics so that they can be used in the manufacture of non-food industrial products or textiles, to find out these characteristics there needs to be a test of fineness, strength and extensibility of *Pandanus tectorius* fiber with SNI number 08-1112-1989 concerning tensile strength and creep tests of bundle rod fibers. The fineness value of a fiber can show its potential to be utilized by looking at the size of the fiber diameter. This is in line with [43-44] which states that fineness in a fine fiber itself is a relative measure of diameter expressed in weight per unit length.

Based on Table 1 of the fineness test, it is known that *Pandanus tectorius* fibers that have a good average fineness value are in fibers treated with 5% NaOH with a fineness value of 2529.16 Tex. with this fineness value, it will be more suitable to be used for handicraft raw materials, non-food industries and furniture turning materials. The material for making yarn and weaving itself is not suitable, because the fineness is still lacking. This is in line with [45], namely the fineness of the finest fibers suitable for weaving and fabric manufacturing is 5.9-36.9 Tex.

Tenacity is the tensile strength of fibers is a property of fibers that is very important to know. Tensile strength expressed in force per fiber fineness [26][46]. In Table 1, it can be seen that the tenacity or strength of the fiber in each treatment has a different tenacity value both based on fiber length and fiber weight. From these data, a high tenacity value is in the 5% NaOH treatment with an average value of 153.71 mN/Tex.

The tenacity (mN/Tex) test result is the result of a fiber strength test based on the length of each strand. In the tenacity test based on fiber weight per bundle, a high and good tenacity value is in the 5% NaOH treatment with an average value of 15.68 gf / Tex. The tenacity test result (gf / Tex) is the test result based on the weight of the fiber per bundle. With both test values, the tenacity of *Pandanus tectorius* fiber can be used as a material for making non-food industrial products and as furniture material, because the average tex value is above 30. This is in line with [44][47] which stated that the greater the strength of the fiber, the better the fiber produced.

The percentage of fiber elongation in this study is the same as stated by [36], namely the delay is the change in maximum length when stretching occurs until the fiber sample is broken. Based on the results of the fiber flexure test or creep in table 1, all fibers from those not given NaOH (Control) treatment or treated with NaOH 2.35, 5% and 7.5% all have good elongation values. From the results of the elongation data or flexibility of *Pandanus tectorius* fiber, all of these fibers have a good elongation value because the value is above 10%. This is in line with [36] the percent value of the outreach test has a less good category if the value is less than 10%.

Based on the elaboration of the data on the value of the fineness, strength and extituency test results obtained for *Pandanus tectorius* fibers that have optimal value results are fibers that are treated with immersion of 5% NaoH solution. This shows that the administration of NaOH in the pandan soaking process when fiber production affects the level of fineness, extensibility and strength of fiber [48].

The characteristics of fineness, extensibility and strength of *Pandanus tectorius* fibers are good in line with [49] explained that the results of *Pandanus tectorius* fibers have fibers of good quality and strong. These fiber characteristics make *Pandanus tectorius* has the potential to be utilized in a more innovative non-food industry.

Based on the results of Table 1 analysis of the optimal value of *Pandanus tectorius* fiber has the potential to become one of the materials in producing non-food industrial products that can be used to add economic value to the surrounding community. The use of natural fibers from *Pandanus tectorius* is one way to open opportunities in the non-food industry, especially as raw material for making mats, bags, shoes, brushes and others. This is in line with SDGs Point 8 on the economy which includes opening new jobs for coastal communities that will have an impact on reducing unemployment [50-51].

Sustainable Development Goal (SDGs) point 8 is in line with law number 11 of 2020 on job creation which regulates the economy in Indonesia to increase economic competitiveness and create jobs for coastal communities [52-53]. The job creation law can also support sustainable development involving economic, social, and environmental aspects that have the potential to improve the welfare of the surrounding community [54].

The use of *Pandanus tectorius* fiber also supports SDGs point 15 on the environment, ecologically the use of *Pandanus tectorius* can maintain environmental sustainability stably, especially the role in the food chain in an ecosystem [55]. *Pandanus tectorius* fruit is one of the foods favored by squirrels because it has a slightly sweet and fibrous taste. *Pandanus tectorius* fruit has a high content of protein, carbohydrates, fat and calcium [56]. In addition, sea pandan fruit contains carotenoid pigments and xanthophylls which can be utilized for natural dyes in various products [57-59].

The sustainable use of *Pandanus tectorius* plants does not only affect ecology (environment) and economy. But affecting the social aspect, namely the use of fiber in industry, can empower MSMEs, people who live around *Pandanus tectorius* plants and the community will have knowledge and expertise in utilizing sea pandanus optimally can be passed on to the next generation. So, with *Pandanus tectorius* used sustainably will build balance in terms of environment, economy and social in coastal communities.

4. Conclusion

Based on the results of the analysis that has been done, it can be concluded that *Pandanus tectorius* fiber has the potential to be used as an innovative non-food industry material. *Pandanus tectorius* fiber has good characteristics in SNI 08-1112-1989. This is shown by the results of laboratory tests, with a concentration of 5% NaOH treatment has an optimal value than 0%, 2.5%, and 7.5% treatment, namely the average value of fineness 2529.16 Tex, the value of elongation 15.11%, the tenacity value of 153.71 (mN/Tex) and 15.68 (gf/Tex). The potential utilization of *Pandanus tectorius* fiber can provide economic and ecological value, especially to coastal communities. In addition, sustainable management of *Pandanus tectorius* can support the creative economy, especially in the non-food industry

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