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Pineapple Fibre Thread as a Green and Innovative Instrument for Textile Restoration

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Abstract

Natural fibre is becoming less-frequently used in the current textile industry with the development of new technology whereby the use of synthetic fibre becomes eminent. Since the use of the nature-based thread in the textile restoration has not been thoroughly explored through scientific research, the objective of this study was to determine and analyze the suitability and potentiality of pineapple fibre as instrumental threads in the restoration of *batik* textile. Two methods of investigation were adopted. First, the traditional making of pineapple leaves as fibre thread was conducted through several stages of material preparation involving extracting and removing the fibre from the surface of pineapple leaves. Second, a series of experiments were conducted to analyze and determine the mechanical and physical properties of the thread including acidity, tensile strength, density and moisture content tests. The study found that this thread has weak acidity and it has useful potential values in tensile strength and extensibility, density and moisture content which make it suitable for textile restoration. Also, it was found based on its compatibility with the *batik* dye and fabric; the thread has suitable physical properties for the restoration work of the textile. The use of the pineapple fibre thread in the textile restoration is not only safe for the artifact but also is an innovative way of caring for and maintaining the artifact from further damage. Extensive research works on the chemical properties; biotechnology and engineering aspects of the pineapple fibre are required in order to improve the quality and properties of the thread.

Keywords: *Fibre thread; textile restoration; pineapple leave; innovative material*

1. Introduction

Pineapple fibre has potential to become an eco-friendly material in conservation. The term fibre is defined as a long and fine continuous thread or filament created from natural materials or by chemical processes [1]. The use of this raw material from renewable resources has been constantly developed by modern people up to today. Similarly, the potential use of natural fibre has caught the interest of the academic and scientific sectors for a new criterion of materials. It takes into account not only the mechanical properties performance, cost and availability, but also environmentally-related issues, such as biodegradability, renewability and energy use, along with the promotion of social and economic development of the economically-challenged segment of the population [2]. Until today, a number of utilization techniques based on natural fibres have been developed for several purposes including textile technology and commercial products. For example, pineapple fibres have been used in the Philippines for textile production, mostly to make wedding dresses [3]. The production of pineapple cloth is specific to the Philippines and West India. Woven by hand from the leaf fibre of the pineapple plant, and inflated with intricate embroidery, this highly-valued fabric was fashioned into clothing and accessories that were a part of the traditional Filipino cultural heritage for centuries. In addition, the fibre also has the advantage whereby it is suitable for design and making patterns in fabric form although sometimes this heavy fibre can be creasy and flammable [4,11]. This prior usage shows that pineapple fibre is a suitable material to be used in textile production. Pineapple fibre is made from the waste of pineapple fruit productionand is rich in lignin and cellulose. Joseph [5] claims that pineapple fibre is soft and has a high cellulose content. This is the reason why pineapple fibre has been chosen to make cloth in textile production. George et al. [6] posit that the main advantages of these fibers are: it is low cost, low density, high specific strength and eco friendly.

Nowadays, man-made fibres are spun and woven into a huge number of consumer and industrial products including their use in textile conservation. Many conservators prefer to use man-made synthetic fibre. These man-made fibres are very light in weight but contain chemical components in their structure. Their properties are significantly modified during the manufacturing process. Polymers used in man-made fibres can potentially react with textile artefacts and damage the objects over a short or long period of time.

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Choosing the right materials for restoration work in textiles is a significant aspect that some conservators ignore. Selection of appropriate thread or fabric, especially to fix frayed fabric, is very important for short or long term restoration. Conservation does not only entail collecting a wide variety of artefacts, but also involves preserving and taking serious care toward objects which are fragile and sensitive.

A study on pineapple fibre is considered to be useful to determine its potential to replace the use of man-made fibre in restoration of textiles. Thus far, no research was conducted to investigate the use of pineapple fibre as potential thread in restoration of textiles. Hence, the aim of this study is to investigate the potential use of pineapple fibre in the restoration of traditional textiles, in this case, in the restoration of *batik* textile. Restoration can be classified as the act of repairing something (artefacts) to a satisfactory state [7]. This paper primarily presents an experimental investigation on the potential use of pineapple fibre as an instrumental thread. Besides, fibres from pineapple leaves are renewable resources and could be continuously supplied for textile restoration work as well as for industrial products. Therefore, the pineapple fibre thread is considered as a 'green' instrument and is safe not only to the textile artefact but also to the community and environment. According to a study conducted by Joseph [5], natural fibres can have high performance in mechanical properties. The fibres pose no health hazard and this material could provide a solution to certain environmental pollution.

2. Research Methods

This research entails two basic stages of investigation, namely material preparation to make fibre thread from pineapple leaves, followed by fundamental experimentation on the chemical and physical properties of the fibre.

2.1. Preparation of the material

The preparation of material for making pineapple fibre thread involved 3 processes: (1) selection of leaves, (2) cleaning of leaves, and (3) extraction of fibre from leaves. This traditional method was proposed by Mat Tahir, a Museum officer from Pontian Johor. This is because the application of the traditional method produces a good quality of fibre. For this reason, the power of the human body is used during the extraction of the fibre from the pineapple leaf. The use of human power can be managed and controlled so that the fibre will not be damaged. Pineapple fibre has been extracted from the leaves of Josopine type pineapples. The pineapple leaves were taken from the Pineapple museum in Pontian, Johor. In 1996, the Malaysian Agricultural Research and Development Institute (MARDI) introduced this type of pineapple which is a hybrid between the Sarawak and Johor pineapples. According to Mat Tahir, the pineapple fibre extracted from the Josopine type creates a very fine and high quality thread because the leaves` fibre is fine and rich in cellulose. The thread is very suitable for making cloth, especially when using the traditional method to extract the fibre. Sricharussin [1] states that the pineapple leaf fibres are lignocelluloses fibres, whereby these fibres have the proven potential to produce yarns and fabrics of a good quality. Hence further analysis on the potential application techniques of the fibres in restoration work is recommended for the next step of research. This would determine the use of pineapple leaf fibre as a potential thread in the restoration work for textile.

Josopine pineapple leaves, as shown in Fig. 1a, are spiky and long. The length is from 10 cm to 30 cm depending on how mature the tree is. The fibres were extracted using traditional tools known as *Peralatan Meraut Daun Nenas* (pineapple fibre extracting tools). Fibre was extracted from the leaves manually using this tool as shown in Fig. 1c & Fig. 1d. Natural fibres are different from man-made fibres because natural fibre, for example leaf fibres need to go through some processes to split them from their outer surface [8]. This process also helps to soften the outer layer, thus making it easy to remove the fibre. Unlike experts, the researcher required extra time to extract the fibre from a bunch of leaves. In this experiment, a total of 30 pineapple leaves were used to make the leaf fibre.

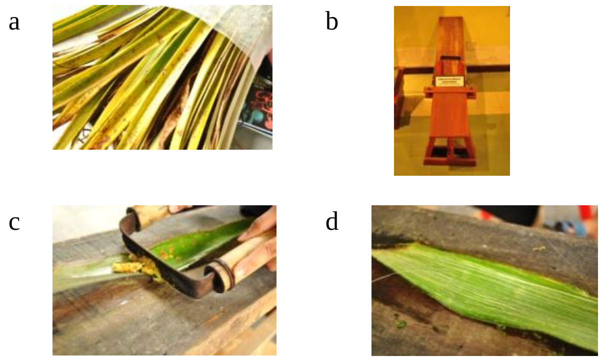

Figure 1 (a) pineapple leaves, (b) fibre extracting tool, (c) extracting the upper surface of the leaves, and (d) a leave after extraction

2.2. Experimental work

This stage of research is basic experimental work that was conducted on the fibre to determine its: 1) acidity, 2) moisture content, 3) density ratio and shape identification, and 4) tensile strength and extensibility.

First, the pH test was done to check the acidity of the pineapple fibre thread. This test was conducted to determine whether the thread was suitable to be used for the textile restoration work. If the pH ranges from 5–6, it is safe to use the fibre for textile restoration work. However, the fibre is not suitable to be used if the reading is more or less than the standard range. This test used two instruments to determine the pH level including pH indicator paper and a pH meter. This step requires soaking the pineapple fibre that was cut into small pieces in 20 mL warm distilled water for 10 minutes then pH paper was used to measure the acidity. Then the following test involved using the pH meter to measure the exact pH level and water temperature.

Figure 2 Test the water using pH paper and pH meter AB 15 to determine pH level

Second, the moisture content test was conducted by the oven-drying method to determine how much water was contained in the fibre. The method was to carefully weigh the specimen in its original state, then to dry the specimen, followed by re-weighing. How this is accomplished depends upon the material used. Usually this oven-drying method is done in a large oven-like chamber at a temperature above the boiling point of water, for example, by long drying times at reduced pressures. The reduced atmospheric pressure causes a lower boiling point in the water, but often has no effect on the material. This brings the required test temperature below the point where damage to the sample would occur. The following formula was used to obtain the moisture content:

- Weight of the fibre before placing into the oven (W_1)
- Weight of the fibre after removal from the oven (W_2)

The fibre weight before and after drying were measured 5 times to get the average weight change. Moisture content will affect the quality of the fibre. This experiment is also known as the direct method of measurement, which uses the volume of the materials and a drying oven. The moisture content (θ) was calculated using the following formula:

$$\theta = \frac{W_1 - W_2}{W_1} \times 100 \qquad (1)$$

The moisture content is expressed as a percentage.

Table 1 Mass of wet and dry fibre (pre / post drying)

Wet Mass(g), W1	Dry Mass (g), W2
1.2098	1.0487
1.2068	1.0486
1.2048	1.0529
1.2056	1.0569
1.2055	1.0570
Total Average: 1.2065	**Total Average:** 1.0528

So the average moisture content of the pineapple fibre is,

$$\theta = \frac{1.2065 - 1.0528}{1.2065} \times 100$$

$$\theta = \underline{12.74\%}$$

Third, the fibre density was determined using Archimedes' principle. A dried beaker was put on the balance and then a rolled piece of paper was inserted vertically into it. This was done to ensure that no fibre would stick to the internal wall of the beaker. The fibres were then transferred into the beaker. The paper was then removed and the fibres weight was recorded as M. The next step was to add distilled water into the beaker via burette until it reached certain level, L. The volume of distilled water consumed was recorded as V_1. The beaker was then cleaned and dried for the following step. The distilled water was left to flow in the empty beaker again until it reached level L. The volume of the distilled water was recorded as V_2. Thus, the density of the fibre obtained could be estimated using below equation:

$$\rho = \frac{V_2 - V_1}{M} \qquad (3)$$

For the density test for natural fibre, the best result should be in the range between 1.2–1.5, this is the suitable density range for the type of a long natural fibre.

Hence, M = 1.2065.
V_1 = 80ml
V_2 = 81.567ml
So,

$$\rho = \frac{81.57 - 80}{1.2059} = \underline{1.301}$$

Fourth, a tensile strength test was carried out to determine the strength of fibre of specific cross-sectional area. This test is related to extensibility and elongation breaking. It is sometimes defined as the maximum stress that a material can endure while being stretched or pulled before necking. Necking is when the specimen's cross-section starts to significantly contract. Tensile strength is the opposite of compressive strength, and the values can be quite different. This test usually involves taking a small sample with a fixed cross-sectional area, and then by pulling it with controlled force, gradually increasing the force until the sample changes shape or breaks.

Figure 3 Universal Testing Machine - for tensile and flexural testing

As the tensile test is applied, the specimen elongates; the resistance of the sample expansion was detected by a load cell. This load value (F) is recorded until a break of the specimen occurs. This test must be done to 10 samples in order to get accurate data. The modulus of elasticity is a measure of the stiffness during the initial period of the bending process. This tangent modulus is the ratio within the elastic limit of stress to corresponding strain. A tangent line will be drawn to the steepest initial straight line portion of the load deflection curve.

2.3. Compatibility of *batik* dye on fibre thread and the use of thread in restoration of *batik* fabric

Tie and dye, is a process for colouring the fibre. It is also one of the techniques of patterning fabric by tying parts of it in different ways to prevent the penetration of dyes. For this experiment, *batik* colour was applied to the pineapple fibre to examine whether the fibre can absorb the colour. Fig. 4 shows the *batik* colour powder of dyes in red, blue and yellow that were used to colour the pineapple fibre thread. This colour powder was mixed with distilled water to give a liquid as illustrated in the figure.

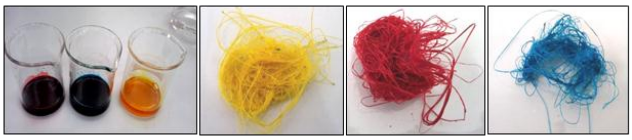

Figure 4 *Batik* dye on fibre thread

Figure 5 Application of the dyed fibre thread on the ripped section

3. Results and Discussion

From the experiment for the pH level for pineapple fibre, the result shows that the fibre acid level is in the range between 5–6. The nature of acidity of pineapple which contains citric acid is in the normal range 5.5–6 (it is a weak acid) and will not harm the textile [5]. This shows that this fibre is in a normal range of precipitation pH which is 5.63 as shown in Fig. 6. Hence this fibre does not contain strong acids, and is thus safe to be used as a thread in restoration works for textile artefacts. The non acidic materials will not react with the artefact and will not harm it.

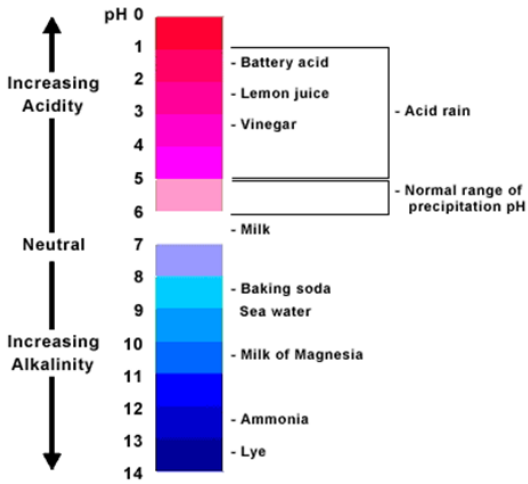

Figure 6 Normal range of precipitation pH for pineapple fibre

Table 2 pH reading is under the range 5-6 which is considered as weak acid

Pineapple pH Reading
5.63
5.74
5.64
5.55
5.78
Average: 5.67

Table 3 Pineapple diameter

Pineapple Diameter(μm)
196.3
198.3
203.8
206.5
201.9
Average: 201.36 μm

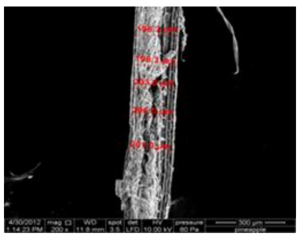

Figure 7 Fibre shape with lignin (zooming up to 200) using SEM to measure its diameter

For the moisture content, the range for the natural fibre to be of good quality is 6–15; hence the pineapple fibre is a good quality for restoration work for textile artefacts. Moisture content is needed to determine the quantity of water contained in the fibre to ensure the good quality of the fibre. The oven test can be a useful tool not only for verifying the readings from electronic moisture meters, but also for understanding what is happening inside the fibre as it dries. In some cases, the oven test can be in error because of environmental factors, for example, the temperature inside the oven, despite being an important tool [9]. Density for natural fibre, should be between 1.2-1.5. This is the best range to ensure good mass. From the results above, the pineapple fibre is about 1.301 (g/cm³). Results obtained show that this is within the range of standard density for natural fibre. Fig. 8 shows the graph of the tensile strength test.

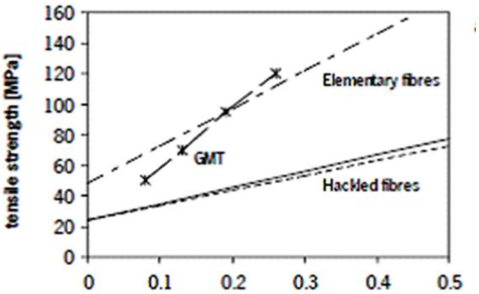

Figure 8 The strain curve graph

Tensile strength as well as elongation at break for a natural fibre is generally weaker than the man-made fibre. This is because man-made fibre contains petro chemical compounds which gives more strength to the fibre. The result from the tensile test shown in the graph above indicates that the tensile strength was not more than 30 MPa which is the standard strength for natural fibre [6].

Table 4 Mechanical properties (tensile strength)

Pure Pineapple Fibre (KGf)	**Pineapple Fibre With Cmc Glue**(KGf)
0.22	0.46
0.25	0.44
0.21	0.38
0.22	0.50
0.26	0.51
0.27	0.43
0.25	0.42
0.25	0.42
0.22	0.43
0.22	0.43
Average : 0.237 KGf	**Average : 0.422** KGf

After adding the CMC glue, it is proven that the adhesive strengthened the pineapple fibre significantly with a value of 0.422 KGF as compared to the first test with a value of 0.237 KGF.

Results on the dye compatibility shows that the pineapple fibres have the ability to absorb the *batik* colour. Based on the restoration work on the fabric, the pineapple fibre thread is fine and compatible with the fabric because it is not easily seen. The pineapple fibres are easy to dye since the fibre is colourless in nature and due to this, it is hardly noticed when applied to the *batik* fabric for restoration work. In this demonstration process the pineapple fibre thread was used to fix the ripped section of the fabric. A couching stitch type of sewing technique was used to fix the ripped parts, as one of the appropriate stitching styles for the restoration of fragile fabric. The damage of the textile in this case was categorized as physical degradation which is probably caused by extreme heat leading to the dehydration and brittleness onto fabric. Deteriorations in all textiles are caused by a variety of agents including light, insects, microorganisms, and corrupted air. These agents can individually or collectively give effects on the textiles. These factors of deterioration will cause significant loss of tensile strength and flexibility [10].

Figure 9 Compatibility of fibre thread on *batik* fabric

This study found that the thread has high potential values in tensile strength, extensibility, shape and moisture content which is suitable for application in textile restoration, although the fibre is a little bit harder when compared to synthetic thread which is more flexible and durable. Its potential was also found based on its compatibility with the *batik* dye and fabric.

4. Conclusion and recommendations

Pineapple fibres have a potential as an instrumental thread to be applied in the conservation field especially in relation to textile restoration. As found in this study, the leaves of pineapples produce a strong, white, fine and silky fibre. The yield is approximately 2.5-3.5% of the weight of the fresh green leaves. The aspect ratio is four times higher than jute and the strength is as good as sisal. Acidity also shows that the natural fibre is eco-friendly towards the environment and if this fibre is made as a thread, the probability to react with the artefact is very small. Hence, the use of pineapple fibres to replace the man-made synthetic fibres in restoration of textiles is highly recommended. The use of the pineapple fibre thread in the textile restoration is not only safe to the artefact but also is an innovative way of caring for and maintaining the artefact from future damage. The pineapple fibre that comes from renewable resources has potential to become an eco-friendly material in restoration work. This certainly requires extensive research on the chemical properties, biotechnological and engineering aspects of the pineapple fibre to improve its quality and application. For example, further scientific research is required to significantly improve the chemical properties of the fibre thread so that it would become more flexible and durable, softer and lustrous for textile restoration. Further research can also be conducted on design and development of technologies to convert agro-waste leaves to useful fibres.

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