

## Pineapple Leaf Fiber as a New Potential Natural Fiber in Rope Making

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**Abstract.** The current development of new potential fibers is widening the areas of application. One of the current potential fibers developed is pineapple leaf fiber (PALF). PALF have been widely used as a raw material for pulp and paper making industry in Malaysia recently. Due to its enhanced properties, PALF now is commercialized as an alternative textile fiber. PALF is one of the high textile grade fibers which are commonly extracted by decorticator machine. PALF is silky, fine and textile grade. Hence, it has been widely used to make apparel. Apart from being used as an alternative fiber for home textile and apparel, PALF meet the basic requirement to be used as technical fibers. This paper presented the possibility of PALF utilization as technical fibers in rope making. PALF have similarity properties with others natural rope fibers and its can be spun into rope yarn. Instead of having a good strength, PALF also have a reasonable length as well as can be pliable. All of these are the main principle of rope making fibers. As PALF have meet this entire requirement, it can be said that its have huge potential to be used as rope making fibers.

### Introduction

Most of the agricultural byproducts can be categorized as lignocellulosics comprised of cellulose, hemicelluloses, and lignin. Part of the agricultural byproducts have a big potentials to be used as raw materials in composite, textile, as well as pulp and papermaking since they have incredible composition, properties, and structure. Lignocellulosic fibers are renewable sources, low cost, light and have marketing demand. Among the plant waste fibers that getting more attention in industry nowadays is pineapple leaf fiber (PALF). PALF contributed to the highest cellulose contents that make it mechanically sound [1].

There has been relatively few studied on PALF especially in Malaysia, and its exposure in industrial is new compared to other natural fibers such as flax, hemp, and sisal. Now, the main aim of Malaysia pineapple industry is various foodstuffs being processed from its fruits and leaving the leaves as agricultural byproducts. The common approached in order to eliminate these kinds of wastes are by burned or decomposed. Besides just wasting source of potential fibers, burning also led to environmental pollution, soil erosion and decreased soil biological activity. Regarding to these concerned, there are few research carried out to figure out the possibility adding values to pineapple leaves.

Recently, PALF is used as a raw material for pulp and papermaking by some researchers in Malaysia. Based on the obtained results, paper made from PALF contributed significant properties of basic paper that could be written, be torn, and can absorb moisture [2]. Besides that, PALF also being utilized as a reinforced agent in composites industry as well as a raw material for particle boards manufacturing. PALF have been used as threads and textile traditionally in Malaysia. However, sort of efforts have only at the beginning to commercialize them as textile materials. One of the parts to expand PALF utilization as textile materials and threads is cordage and rope making. Among the familiar natural fibers in rope making are hemp, sisal, abaca, cotton, ramie and jute. It is believed that PALF have huge potential in rope making since it is graded between jute and cotton, or jute and ramie [3]. Besides that, it also has similar properties with the other natural fibers used in rope making.

### Related Work

**Review.** In this sections, there will be a review on several studied have been done related with this kind of study. The review is focused on the common natural fibers that have been used as a rope making fibers. Besides that, there will be a comparison between PALF properties with other natural rope making fibers properties. In addition, the chemical composition of PALF is also being analyzed and compared with the other natural rope making fibers. This kind of data is significant since it will be further used in determining either PALF is suitable as a rope making fibers.

**Natural Fibers for Rope Making.** The natural fibers used in rope making can be classified according to their type. They can be categorized to seed fibers, bast fibers, and leaf fibers. Leaf fibers also can be called as hard fibers. Table 1 summarized some of the principle natural fibers used for rope making and their category. PALF, as its name, are being classified as leaf fibers.

Table 1 Principle Natural Fibers for Rope Making [4]

FIBER	BOTANICAL NAME	LOCATION IN PLANT
Abaca	<i>Musa textilis</i>	Leaf
Sisal	<i>Agave sisalana</i>	Leaf
Henequen	<i>Agave fourcroydes</i>	Leaf
PALF	<i>Ananas comosus</i>	Leaf
Jute	<i>Corchorus</i>	Stem
Hemp	<i>Cannabis sativa</i>	Stem
Flax	<i>Linum usitatissimum</i>	Stem
Cotton	<i>Gossypium</i>	Seed

**Chemical Composition Analysis.** Table 2 showed the chemical analysis of several natural fibers that have been use for cordage and rope making. It can be observed that, PALF have chemical compositions that are in the range with other familiar natural fibers for rope making. From the chemical analysis, PALF is being graded between jute and cotton as stated before. Furthermore, it can be said that PALF have huge potential as alternatives rope making fibers as its comprised most of the properties of rope making fibers.

Table 2 Chemical Analysis of Natural Fibers for Rope Making [4]

FIBER	CELLULOSE (%)	WATER (%)	ASH (%)	LIGNIN (%)	EXTRACTIVE (%)
Abaca	64	12	1.0	22	1.6
Sisal	77	6.2	1.0	15	1.1
Henequen	78	4.6	1.1	13	3.6
Jute	63	9.9	0.7	24	1.4
Hemp	77	8.8	0.8	9.3	4.0
Flax	76	9.0	1.0	10	3.5
Cotton	90	8.0	1.0	0.5	0.8
PALF	67-82	10-13.5	0.1-2.7	4-12.7	0.97-5.0

**Technical Fiber Characteristics.** A list of typical comparative of yarn properties of rope fibers are shown in Table 3. The good quality fiber will lead to strong yarn. The shock absorbing capacity of the rope is depended on the fibers elongation and the tenacity [5]. In addition, for a specialized application such as technical products (rope), the elastic elongation needs to be considered significantly. The stability of the dimensional after repeated used is depended on the recovery from the elongation matters. On the other hand, the fibers with high modulus showed that it will resist to initial deformation as well as the flexural rigidity of the yarn.

Table 3 Physico-mechanical properties of Rope Making Fibers [5]

No.	Properties	Natural Fibers					
		Jute	Flax	Cotton	Sisal	Abaca	PALF
<b>A Ultimate Cell</b>							
1	Length (L, mm)	0.8-6	25-65	15-60	0.5-6	3-12	3-9
2	Breath (B, i)	5-25	10-35	15-20	5-40	10-32	4-8
3	L/B ratio	110	1700	1300	150	250	450
<b>B Filament</b>							
1	Fineness, tex	1.25-5	2.5-6	0.1-0.3	16-35	20-35	2.5-6
2	Tenacity, g/tex	30-50	45-55	20-45	40-45	35-45	25-45
3	Breaking elongation, %	1-2	2.5-3.5	6.5-7.5	2.5-4.5	2-3	2.5-4
4	Torsional rigidity, $10^{10}$ dyne/cm <sup>2</sup>	0.25-1.3	0.8-1.05	0.8-1.2	0.3-1	0.3-1.2	0.3-1
5	Flexural rigidity, dyne/cm <sup>2</sup>	3-6	1.8-2.5	0.3-1	125-175	150-200	2.5-4
<b>C Bundle</b>							
1	Tenacity, g/tex	13-35	30-36	NA	22-36	20-35	20-30
2	True density, g/cc	1.45	1.55	1.55	1.45	1.45	1.5
3	Apparent density, g/cc	1.23	1.44	NA	1.2	1.2	1.28
4	Moisture regain @65% RH	12.5	7	7	11	9.5	13

### Proposed Work of Study

**From Waste to Wealth.** Here we have proposed an alternatives natural fiber as a textile material for rope making. In this work, PALF have been chosen as a new rope making fibers. Figure 1 showed the theoretical frame work of proposed study.

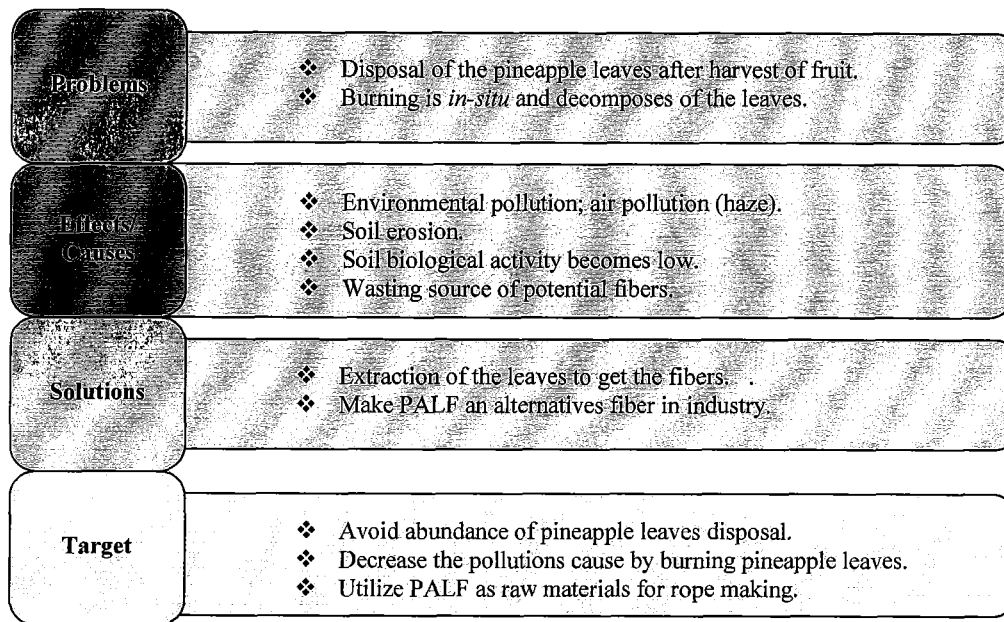


Figure 1 Theoretical Frame Work

**Nomenclature of Proposed Study.** The proposed study comprised of several steps as shown in Figure 2. Generally, there are four steps need to be considered in this study included materials identification, rope manufacturing, rope testing, and lastly recognition and documentation part.

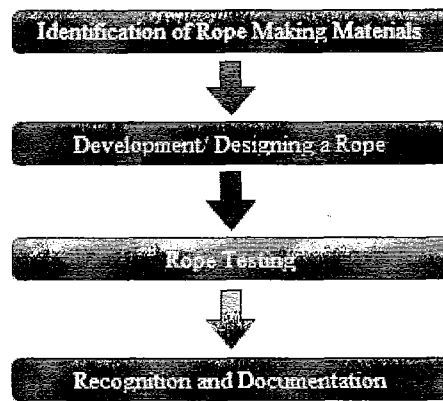


Figure 2 Methodology of Proposed Study

### Identification of Rope Making Materials

Almost all natural fibrous material can be spun into good rope included PALF. There are four main principles of rope making fibers. First of all, the fibers must have a reasonable length. Then, the fibers must contribute with moderate strength, must be pliable, and lastly must have grip factor [6]. From the properties analysis, PALF is one of the fibrous materials that have all of these principles.

### Rope Construction

The flow of rope construction can be summarized as shown in Figure 3.

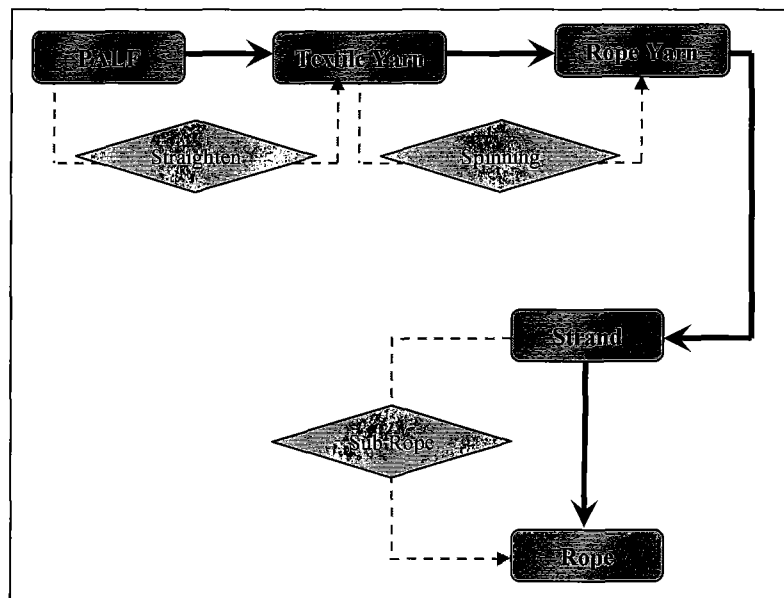


Figure 3 Rope Construction

### Testing

Several tests need to be conducted in order to measure various properties of rope fibers. Testing act like a benchmark in development, production, and use of ropes. The testing that will be carried out is based on the common test that has been fixed for rope testing [4]. Some of the expected testing that will be conducted is listed as follow:

- Strength test
- Hardness test
- Fatigue test
- Creep test
- Flexing test

### General Routes for Rope Production

Furthermore, there are several aspects need to be take into account in rope production. At stage of converting the raw fibers to textile yarn, there is a concern on what types of yarn want to be produced. On the other hand, to convert the textile yarn to rope yarn, there are many types of spinning method that can be considered. Basically, type of yarns produced and type of spinning method selected is based on the specific applications. Usually for rope construction type of yarn will be monofilament yarn and the spinning method advisable is friction-spurn yarns [7]. Next, from strands to rope there is two common method that is twisting or braiding. This will be decided later depends on the type of rope produced.

The principal routes for rope production can be summarized in Figure 4.

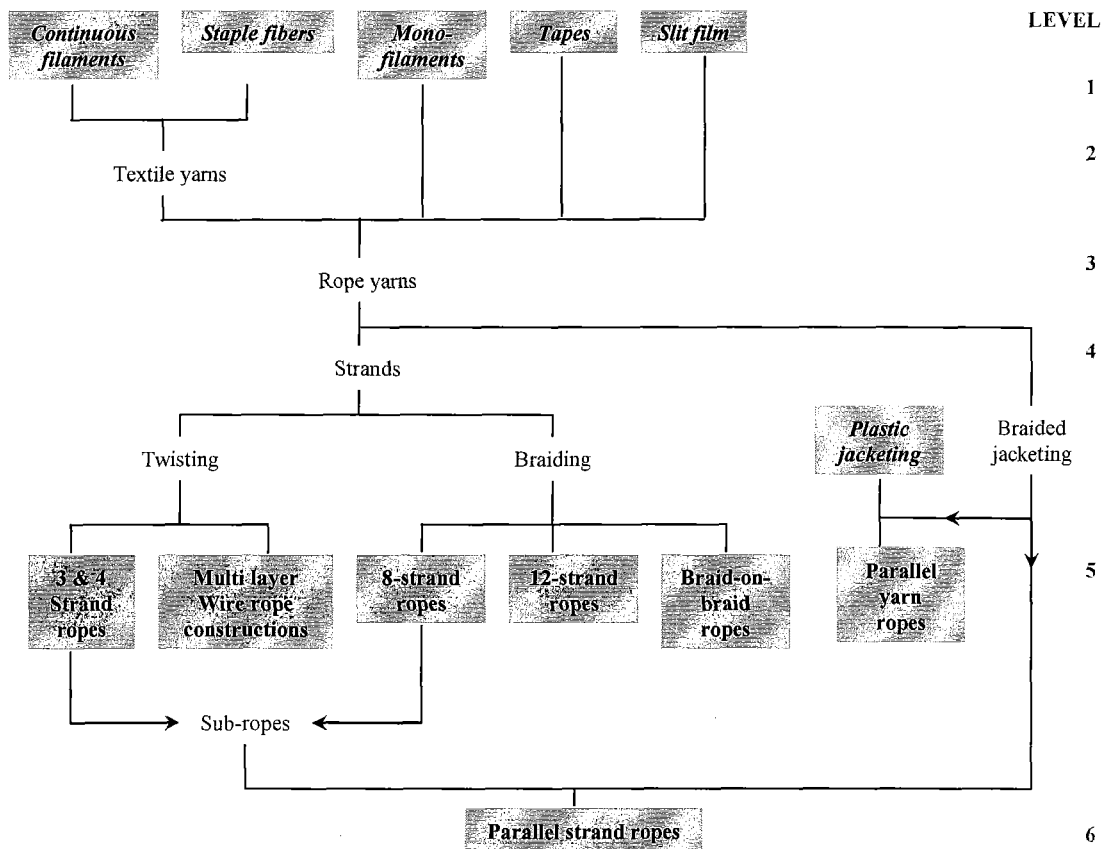


Figure 4 Principal Routes for Rope Production [4]

### Summary

Pineapple leaf fiber has the excellent properties as a textile fiber. On the other hand, its have big potential as a new technical fiber. PALF is graded between jute and cotton. It comprised of mostly textile properties that make it possible to locate PALF among natural fibers as potential commercial grade textile fiber. The proposed study is aiming to commercialize PALF as new rope making fiber. Fibers for rope making can be obtained from many fibrous leaved plants included PALF. The technologies and methods involved for rope manufacture in this study will be further decided and confirmed later depended on type of rope will be produced. The recent development on PALF showed that PALF will be able to capture significant used among natural fibers but there is a concern on to assure the enough supply in industry.

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### References

- [1] A.K. Mohanty, M. Misra, and L.T. Drzal, in: *Natural Fibers, Biopolymers and Biocomposites* (Taylor & Francis, Boca Raton, FL. 2005)
- [2] Y. Yusof, M.R. Ahmad, M.S. Wahab, M.S. Mustapa, and M.S. Tahar, : Producing Paper using Pineapple Leaf Fiber: *Advanced Materials Research* Vol.383-390 (2012), p. 3382
- [3] S. Banik, D. Nag, and S. Debnath: Utilization of Pineapple Leaf Agro Waste for Extraction of Fiber and the Residual Biomass for Vermicomposting: *Indian Journal of Fiber & Textile Research* Vol.36 (2011), p.172
- [4] H.A. McKenna, J.W.S. Hearle, and N. O'Hear, in: *Handbook of Fibre Rope Technology*. (Woodhead Publishing in Textiles, England 2004).
- [5] P.K. Das, D. Nag, S. Debnath, and L.K. Nayak: Machinery for Extraction and Traditional Spinning of Plant Fibres. *Indian Journal of Traditional Knowledge* Vol. 9 (2) (2010), p.386
- [6] Information on <http://chrismolloy.com/>: Ropes & Cords in: *Grave's Bushcraft Books*.
- [7] *Technical Textile Yarns*, edited by R. Alagirusamy, and A. Das in *Industrial and Medical Applications*, Woodhead Publishing Series in Textile (2010)

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