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Yarn Properties of Blended Fiber Pineapple Leaf Fiber/Cotton

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Abstract: Yarns with natural fibers are becoming increasingly popular with the increase of environmental awareness. This is mainly because the hybridization of fiber may reduce the use of synthetic fibers in the making of yarns. Note that cotton currently dominates the natural textile industry all over the world. On the other hand, pineapple leaf fiber (PALF) has been proven to be biodegradable and compatible with the environment. This study observed the properties of cotton fiber with different composition of PALF. The physical and mechanical analysis such as surface morphology, fineness of sliver and yarn, and tensile strength test were conducted on yarn. Apart from that, the morphology analysis of different PALF composition was observed through Optical Microscope (OM). At the beginning of this study, the optimum characteristics of PALF/cotton sliver subjected to the different composition of PALF were determined. The finding demonstrated that the yarn characteristics could be effectively controlled by varying the PALF composition. Following this, PALF/cotton yarn of three different weight ratios were developed (50:50, 40:60 and 30:70). The findings showed that the physical and mechanical properties of sliver and yarn could be effectively controlled by varying PALF composition. The composition of 30% PALF exhibited an excellent physical property. It was noted that the 50% PALF and 40% PALF had improved in mechanical properties. Nevertheless, the subsequent increase in the composition of PALF did not increase the strength of the yarn.

Keywords: *Natural fiber, Physical, Mechanical, Fineness, Tensile strength*

1. Introduction

In most pineapple-growing locations, only the fruit is used, not the leaf [1]. Pineapples are well-known. Only the fruit itself has worth; toss away the rest. It's wrongdoing.

Pineapple leaf Fiber (PALF) is a natural cellulosic fiber. Each year, a small fraction of PALF is consumed. As it matures, it gets elongated and develops spirally organized fibrous leaves. Each adult plant produces 80 leaves of varying shapes and lengths. 3ft long, 2-3in broad, dark green, sword-shaped

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leaves with spines. The leaves are long, thin, waxy, and sharply pointed, with a built-in rigidity at the tip [2]. Cotton is bred for lint fiber, which dominates natural textiles worldwide [3]. Cotton genetic resources, which include material from 50 species, offer a unique opportunity to study the evolution of farmed cotton from its wild ancestors. One of the biggest challenges in the cotton industry is timely harvesting of high-quality cotton fiber. Since the 1950s, mechanical harvesting after defoliation has caused massive losses. Most cotton harvesters are "stripper" or "spindle" pickers. The "stripper" collects lint and plant debris [4]. In equal proportions, PALF and cotton yarns were spun, and their counts, tensile properties, uniformity, and starvation were tested. In this research, yarn structure and performance were emphasized. This study will help manufacturers and processors blend pineapple leaf fibers and cotton.

The increased manufacturing of pineapple processed foods leads to huge waste creation. Pineapple by-products are no exception, and they mostly consist of the remaining pulp, peels, stem, and leaves. Waste management in the fruit and vegetable processing industries is a critical and challenging job worldwide**.** It is possibility that the discarded fruits and waste materials would be used for other industrial uses such as fermentation, bioactive component extraction, and functional ingredient extraction. This is mostly due to the selection and deletion of components that are unfit for human ingestion. Furthermore, harsh handling of fruits and exposure to severe environmental conditions during transit and storage may result product waste [6].

However, there are issues with blending a natural fiber to produce yarn as well. Yarn in the spinning zone has fewer twists than that in the balloon zone because the yarn guider lowers twist transmission to the spinning zone. The spinning strand will experience end breakage if its minimum strength is less than the minimum spinning tension; as a result, the end-breaking rate and ring spinning continuity are dictated by the strength of the spinning triangular strand [7]. Since the structure of natural fiber is not compact, it is more likely to break. Thus, currently there are no apparel for yarns made from mixed cotton fiber and pineapple leaf fiber.

2. Materials and Methods

The procedures of fiber preparation, yarn preparation, and yarn analysis are also covered in this chapter. According to the norm, each stage of the development was subjected to thorough and detailed testing.

2.1 Materials

Extracted PALF were obtained from Malaysian Pineapple Industry Board (MPIB) Pontian, Johor, as much as 5kg has been supplied. All this pineapple fiber has been extracted by MPIB workers. After that, the bundled cellulose strands are taken to a nearby river to be cleaned and then strung up to dry. The PALF was manually cut into short pieces measuring between 3 and 4 cm in length, and then it was kept in a container that prevented moisture build-up so that it would remain dry. An indicator that has been measured and adjusted to a specific size is used to cut the fiber as shown in Figure 1.

Figure 1: Short pieces pineapple leaf fiber

2.2 Blending Process

Blends can contain any number of fiber types. Because a blend is a mixture of two or more fibers, in this investigation, PALF and cotton fiber were blended using a carding machine located at UTHM. The speeds of the carding machine's parameters will be maintained at their current levels. Fiber blending will involve manually hand-blended before feeding them into a carding machine according to the specified percentage by weight. The pineapple and cotton fibers were prepared in three different weight ratios, 50:50, 40:60. And 30:70 of PALF/cotton.

Figure 2: Carding machine

2.3 Spinning process

In the process of converting fibers into yarn, the ring frame is the very last machine in the production chain. Drafting and twisting are the two processes that are used to transform roving into finished yarn on this machine. Yarn twist was change for every sample of different ratios which is 800rpm and 900rpm. Increases in twist for a single spun yarn result in a higher strength up to a certain point, and any twist over this optimum will reduce the strength. For any given fiber, the twist angle for optimum strength remains constant throughout a variety of yarns, while the quantity of twist required for optimal strength depends on the twist angle.

The finished yarn is coiled on a bobbin in a specific pattern that makes it ready for the subsequent steps in the sequence. In most cases, the purpose of a ring spinning machine is to transform the sliver into an extremely tiny strand that is referred to as yarn. This method is able to generate the physical qualities of the yarn very fine, which is highly significant in the process of making fabric due to the significance of this feature.[8]

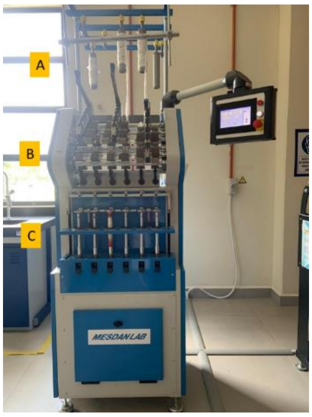


Figure 3: Ring Spinning

2.4 Test procedure

The physical and mechanical evaluation of PALF/cotton yarn were assessed accordingly. Its characteristic such as fineness, force and tenacity were examined. This also include physical properties of sliver which is sliver fineness.

2.5 Physical properties of sliver

Determine the fineness of sliver, weigh balance metal plate length and the average of sliver of PALF/cotton with 50:50, 40:60 and 30:60 compositions were recorded using the observed data.

2.6 Physical and mechanical properties of yarn

The physical and mechanical evaluation of PALF/cotton yarn were assessed accordingly. Its characteristic such as fineness, force and tenacity were examined.

Fineness, by tex value were obtained by finding the right value and has involved carefully analyzing up to 10 samples for each different ratio with length has been set to 1 meter. The weight of yarns was measured, to calculate the fineness of yarn using yarn fineness formula.

$$Fineness, tex = \frac{Weight(g)}{Length(m)} \times 1000$$

The effects of various PALF/cotton ratios on the mechanical characteristics of yarn, such as force and tenacity. During the tensile test, the yarn is connected to the upper and lower fixture. It stretches or lengthens to the breaking point and quantifies the force necessary to break the yarn.

3. Results and Discussion

Data analysis from experiments and tests done throughout the study's production of the PALF/cotton yarn. The chosen method was applied to conduct the experiments and testing.

3.1 Physical properties analysis

3.1.1 Sliver fineness

The physical properties of the sliver fineness are measured, and the average values for its diameter and fineness are discussed in detail in the Table 1. Sliver with the highest fineness is 30% PALF composition. Because there are more surfaces and more surfaces means that there is a higher cohesion due to friction, finer fibers result in more fiber cohesion. Additionally, because of the same increased frictional force, finer fibers twist less. As a result, finer yarns can be spun with the same amount of twist as coarser fibers. Therefore, sliver with more than 5% CV% is uneven and likely to break further process which is in spinning process.

Table 1 : Fineness of PALF/cotton sliver

Sample	Weigh balance metal plate length (cm)	Average Weight (g)	STDEV (g)	CV%	Fineness (Tex)
PALF/Cotton 50:50	17.8	0.44	0.11	25.17	1050
PALF/Cotton 40:60		0.37	0.05	12.84	2004
PALF/Cotton 30:70		0.37	0.05	13.76	2079

3.1.2 Yarn fineness

The effects of different ratios on the yarn physical properties, fineness was determined as in Table 2 Yarns are frequently described in terms of their fineness. Figure 4 demonstrates the effects of PALF/cotton blended yarn with different composition of PALF in the terms of fineness. The yarn's uniformity is directly proportional to the number of cross fibers. Therefore, the finer the fiber, the more consistent the yarn. When the yarn is uniformly lighted, it possesses additional desired qualities, such as increased tensile strength, extensibility, and sheen. Additionally, it results in fewer breaks while spinning and weaving. In reality, fiber fineness is one of the most influential factors in establishing a yarn's maximum count. In contrast, the PALF/cotton ratio of 30:70 generated yarn with the lowest fineness rating according to Table 2.

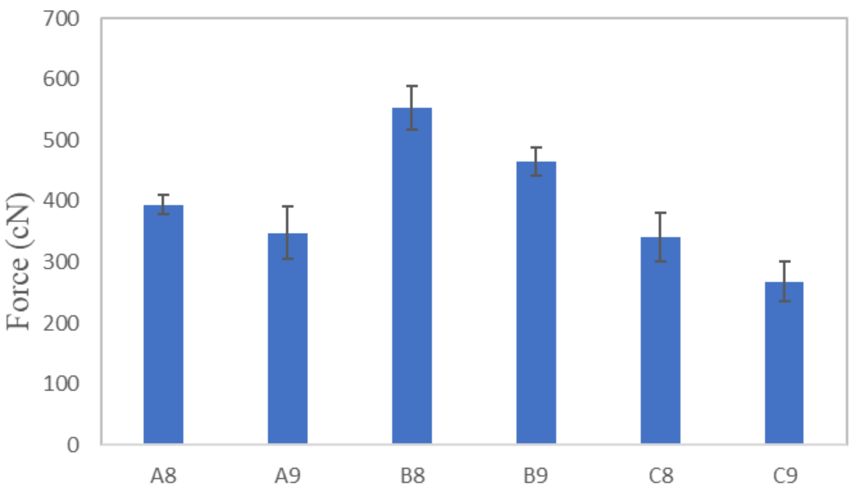
3.2 Mechanical properties analysis

The effects of various PALF/cotton ratios on the mechanical characteristics of yarn, such as force and tenacity, were investigated and has been state in Table 2. Figure 4 illustrates test results for mechanical characteristics. From force graph, it is found that sample of 40:60 PALF/cotton need the highest force to break the yarn followed by 30:70 PALF/cotton. Two sample of 40:60 PALF/cotton are B8 with value 480.781nN and B9 with value 419.393. B8 is higher than B9 is because twisted added in yarn made the yarn stronger. The tensile strength of a staple yarn is governed by the fiber characteristics, structural geometry, and spinning conditions.

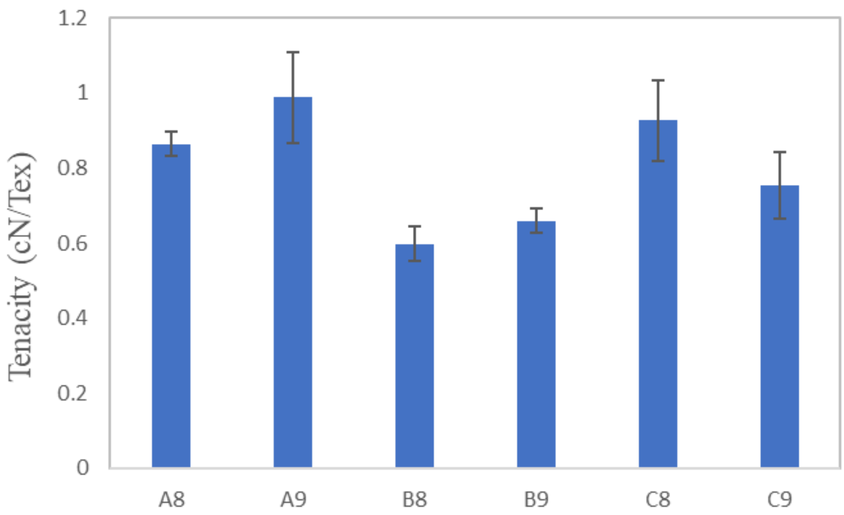
The conventional method for measuring the strength of a fiber or yarn is called its tenacity. Calculating tenacity requires the yarn's final breaking force when a thread or yarn is stretched to its breaking point and its linear density. From tenacity graph, sample for 30:70 PALF/cotton has the highest value of tenacity. Highest value 10.573cN/tex is A9 with twist 900 rpm followed by sample C8 with 50:50 PALF/cotton and 800 rpm of twist with value 9.048cN/tex as showed in Table 4.2.

Table 2: Yarn physical and mechanical characteristic

Sample	Force (cN)		Tenacity (cN/Tex)		Fineness (Tex)
	Average	CV%	Average	CV%	
A8	439.150	12.663	6.746	42.330	465
A9	372.177	15.396	10.573	15.396	352
B8	480.781	17.774	4.593	64.890	916
B9	419.393	20.450	4.455	46.484	706
C8	332.970	21.755	9.048	21.755	368
C9	268.287	23.055	6.594	73.220	356



(a)



(b)

Figure 4: Mechanical characteristic of yarn sample graph; (a) Force (b) Tenacity

3.3 Morphology analysis

The morphological and structure of the palf/cotton yarn with different composition ratios were observed under Optical Microscope (OM). OM was used in this study to observe the effects of different blending ratio for the yarn structure. The OM image analysis was taken with 5x magnifications shown in Figure 5. By visual observation of the PALF/cotton yarn, the lowest composition of PALF had a smoother and highest finesses structure which is yarn with 30:70 ratio since it is the compact fiber yarn. In the meanwhile, a PALF/cotton yarn sample with a ratio of 50:50 revealed a structure that was both more open and more abrasive. This was because the fibers did not interlock with one another, and the PALF was not blended very uniformly, particularly for this sample blending ratio.

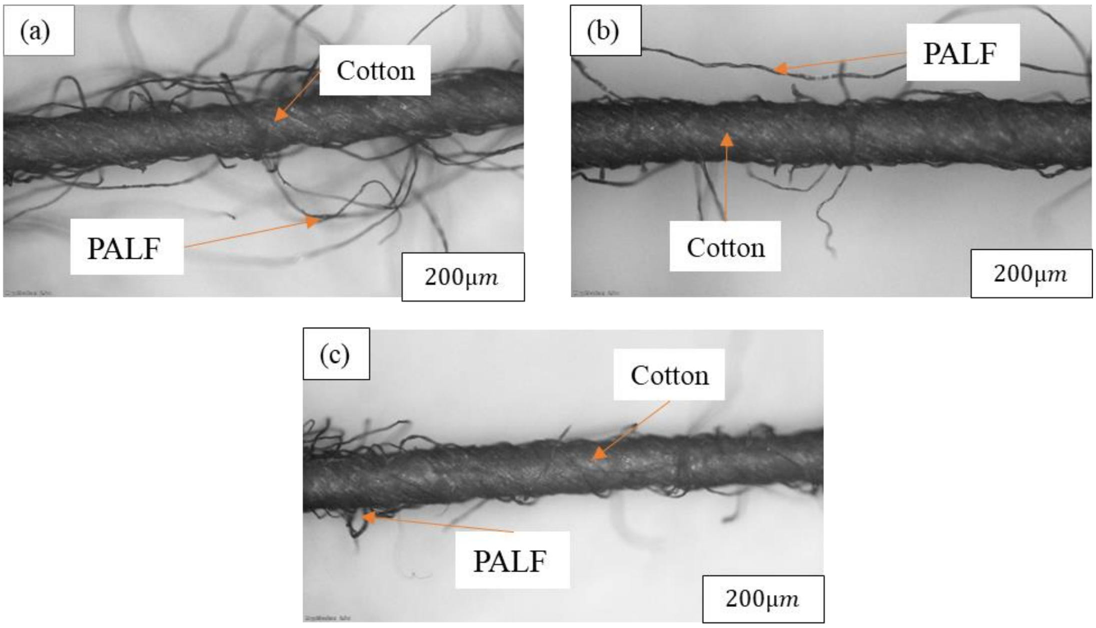


Figure 5: Microscopic view of PALF/cotton yarn ; (a) 50:50 (b)40:60 and (c) 30:70

4. Conclusion

As the conclusion, the fundamental aim of this study, which was to effectively create and produce yarn from the combination of pineapple leaf fiber and cotton, has been accomplished. The yarn produced can be usable for clothing and home furnishings as a result of the specific characteristics.

The production of PALF/cotton yarn proved successful up to a weight percentage of 50%. Next, different PALF compositions have substantial influence on the fineness, size, and weight of sliver. Visual inspection revealed that PALF and cotton fibers were effectively mixed, however cotton fibers seemed to dominate the sliver and served as wrapper fibers for all samples. PALF fibers did not function as wrapper fibers but were still present on the surface of the sliver. Under magnification, it is evident that PALF fiber's structure is thicker than cotton fiber's structure and varies in thickness. Thus, the PALF/cotton sliver created with a 30% PALF composition exhibited a superior fibers mix, compact structure, and smooth texture as compared to the 50% composition. PALF/cotton yarn with a 30% PALF mix produced a cleaner surface but was thinner and lighter than others.

Different PALF compositions influence the tensile strength and structure of yarn during analysis. In terms of compact structure and tensile strength, PALF/cotton yarn containing 30% PALF showed enhanced structure. Finally, it can be said that the thesis's objectives were achieved in that it produced important research and design knowledge on PALF/cotton yarn, which will be extremely helpful to the industry and community.

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