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## RESEARCH ARTICLE

### SUGAR PALM PEDUNCLE FIBERS FOR HANDLOOM FABRIC BLEND: A SUSTAINABLE APPROACH TO UTILIZING LOCAL AGRICULTURAL WASTE IN PHANG-NGA, THAILAND

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#### ABSTRACT

This research aims to study the properties of sugar palm's peduncle fibers (*Arengapinnata*Merr.) and the physical properties of handloom fabrics blended with sugar palm's peduncle fibers. The peduncle of sugar palm used as raw material for fiber extraction and weaving were obtained from sugar palm found in Bor-Saen Subdistrict, Thap Put District, Phang Nga Province, Thailand. The research findings reveal: 1. A 10% w/v sodium hydroxide solution was most effective for extracting sugar palm fibers. The fibers yielded  $43.21 \pm 0.30\%$ . The extracted fibers contained  $41.71 \pm 0.35\%$  cellulose,  $18.49 \pm 0.98\%$  hemicellulose,  $2.94 \pm 0.07\%$  lignin, with a yarn count (Ne) of  $8.65 \pm 0.05$ , maximum tensile strength of  $1,256.32 \pm 43.75$  gf, and elongation at break of  $17.75 \pm 0.43\%$ . The fibers had a diameter of 50 micrometers, a long bundle fiber structure, and a rough surface texture. 2. The handloom fabric blended with sugar palm peduncle's fiber had a slightly glossy surface texture and a relatively coarse feel, making it more suitable for developing decorative textile products or creating unique community product identities than apparel products. The fabric weight was  $190.71 \pm 8.10$  g/m<sup>2</sup>, classified as medium weight. The maximum tensile strengths in the warp and weft directions were  $254.08 \pm 8.52$  N and  $433.12 \pm 9.45$  N, respectively. The fabric had a yarn count of 78 threads per square inch, with 31 warp and 47 weft threads per square inch.

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## INTRODUCTION

The sugar palm (*Arenga pinnata* Merr.) is a monocot plant from the same family as the palm tree and Thai people called "Chok". It grows in mountainous, rocky areas in some provinces in Thailand, Malaysia, Indonesia, Sri Lanka. It has a straight trunk and can reach a height of 20-25 meters when fully mature. Its leaves are approximately 3 meters long, resembling coconut leaves but larger and sturdier. The commonly utilized components include the edible fruits, the sap which can be processed into palm sugar and granulated sugar, and the leaves which are used for weaving and thatching roofs (Sapuan, et al., 2019). Additionally, in the past, villagers employed the flower stalks as a substitute for ropes to lead animals such as cattle and buffaloes. However, currently, these flower stalks are not being utilized, thus rendering them an abundant and undervalued natural material. Furthermore, there is an increasing trend in the usage of natural fibers, yet a dearth of fibrous natural raw materials, leading to an imbalance between the demand and supply of natural fibers. Consequently, synthetic fibers are still heavily utilized in textile production (Ahmed, Ogulata & Gulnaz, 2023). However, the diversity of plants on Earth means there are plants with high potential for extracting natural fibers that have not yet been extracted and utilized to the extent they should be (Madasamy, Ramasubbu & Nambirajan, 2022). The areca palm is a plant in the Arecaceae family, which is the same family as the palm, coconut, and sugar palm trees, which have components that can be used as beneficial fibers (Imraan et al., 2023).

In general, fibers extraction from plants can be done in several ways, such as water retting, mechanical extraction, dew retting, enzyme retting, and chemical retting. The commonly used chemicals include acids. Chemical treatments include alkaline and acid solutions (Lee et al., 2020; Kale, Alemayehu & Gorade, 2020). The method of fiber extraction from plants using an alkaline solution helps modify the fiber surface by removing a large amount of lignin, hemicellulose, pectin, and oily substances from the fibers. The degree of fiber surface modification depends on the treatment time, temperature, and concentration of the alkaline solution (Vardhini et al., 2016; Colom & Carrillo, 2002). Furthermore, the method of fiber extraction from plants using an alkaline solution increases the density of the fibers and the percentage of crystallinity by removing non-cellulosic components from the fibers (Kumar & Das, 2016; Bar & Chaudhary, 2023). There has been research studying the amount of fibers present in the palm family plants as follows: palm fibers contain 59.60% cellulose, 12.5% hemicellulose, and 28.5% lignin (Pradeep & Edwin, 2015), while sugar palm fibers contain 56.80% cellulose, 7.90% hemicellulose, and 24.99% lignin (Huzaifah et al., 2017). Additionally, it was found that fibers from the palm family also have outstanding properties in terms of strength and biodegradability. Mukhtar et al. (2016) studied on the utilization of fibers from the sugar palm was found that fibers produced from four different parts of the sugar palm, namely the stem, panicle, leaves, and bagasse, can be used as reinforcement in composite materials. Sugar palm fibers have a low density and can be used with polymer materials to produce

partially biodegradable composite materials. Moreover, sugar palm fibers have the potential to be used for weaving due to their high strength and outstanding reusability (Hrabe, 2018). However, it was found that the development of utilization of fibers from palm family plants is still limited due to insufficient research data. Therefore, research on the utilization of fibers from the palm family is interesting (Imraan *et al.*, 2023). Based on the aforementioned, the researchers conducted this research with the objectives were (i) to study the properties of sugar palm's peduncle fibers and (ii) to study the physical properties of handloom fabrics blended with sugar palm's peduncle fibers. These are abundant natural waste materials found locally in Phang Nga Province, Thailand. The aim is to add value to these local natural materials by developing woven fabrics blended with sugar palm peduncle's fibers. The data obtained from this research will serve as a basis for developing creative community products to generate occupations in Phang Nga Province, Thailand. Furthermore, this research is a small cog contributing to the United Nations' Sustainable Development Goal (SDG) No. 8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" (United Nations 2015).

## MATERIAL AND METHODOLOGY

**Material:** Dried sugar palm peduncles were collected from the area of Ban Khlong Bo San, Village No. 3, Bo San Subdistrict, Thap Put District, Phang Nga Province. They had a moisture content of  $11.45 \pm 0.12\%$ , a cellulose content of  $46.07 \pm 1.82\%$  by weight, a hemicellulose content of  $34.30 \pm 0.80\%$  by weight, and a lignin content of  $18.05 \pm 0.60\%$  by weight. The moisture content analysis followed the ASTM method (American Society for Testing and Materials (2015, while the cellulose, hemicellulose, and approximate lignin contents were determined using the AOAC method (Association of Official Analytical Collaboration international 2019).

**Extraction of sugar palm peduncle's fibers:** The dried sugar palm peduncles were then subjected to fiber extraction through the following process:

1) The sugar palm peduncles were soaked in clean water for 24 hours. Figure 1 shows the sugar palm peduncle used as the raw material for fiber extraction.



Fig. 1. Sugar palm peduncle

2) After soaking, the sugar palm peduncles were pounded until broken apart and then boiled in sodium hydroxide (NaOH) solutions with varying concentrations for each experimental set, using 5%, 10%, and 15%w/v concentrations, respectively. The ratio of peduncle to NaOH solution was 1 Kg. to 10 L. Each set was boiled for 3 hours. After boiling, the peduncles were rinsed with clean water, and the

sheaths were manually peeled off until the peduncles were no longer slippery. A nail brush with dimensions of 6 cm. wide and 8 cm. long, consisting of 8 columns and 4 rows of 1 mm. wide and 1 mm. long nails, was used to separate the peduncle fibers by brushing from the base to the tip of the peduncle. Figure 2 shows the brush used.



Fig. 2. Nail brush used to separate the peduncle fibers

3) The obtained fibers were hung on a rack to drain excess water, then soaked in a 3%w/w sodium hypochlorite solution for 24 hours. Subsequently, the fibers were rinsed under running water for 5 minutes while gently squeezing to remove any remaining sodium hypochlorite odor.

4) The sugar palm peduncle's fibers were air-dried for 48 hours, ensuring a moisture content below 15%. Figure 3 shows the dried sugar palm peduncle's fibers ready for weaving.



Fig. 3. Dried sugar palm peduncle's fibers

**Study of Properties of sugar palm peduncle's fibers:** The sugar palm peduncle's fibers obtained from extraction using 5%, 10%, and 15%w/v sodium hydroxide solutions will be evaluated for the following properties: Fibers yield (percentage), Moisture content (percentage) according to ASTM D629 standard (American Society for Testing and Materials 2015), Cellulose content (%), Hemicellulose content (%) and Lignin content (%) according to AOAC method (Association of Official Analytical Collaboration international 2019), Yarn count (Ne) according to ASTM D1059 standard, Tensile strength (grams-force) and elongation at break

(percentage) according to ASTM D3822 standard (American Society for Testing and Materials 2001), using an Instron 5566 Tensile Testing Machine manufactured in the United Kingdom, with a testing speed of 15 mm/min and a gauge length of 25 mm. The results obtained from properties will be statistically analyzed. Subsequently, the longitudinal and cross-sectional micrographs of the fibers extracted from the experimental set with the highest extraction efficiency will be studied using an Olympus BX41 microscope manufactured in Japan, at 200x magnification. The analysis will be conducted at the laboratory facilities of the Thailand Textile Institute.



Fig. 4. The weaving process for the handloom fabric blended with sugar palm peduncle's fibers



Fig. 5. Longitudinal sectional view of sugar palm peduncle's fibers

Table 1. Properties of sugar palm peduncle's fibers in each experimental set

Properties	Fibers from experiment set 1 NaOH 5%w/v	Fibers from experiment set 2 NaOH 10%w/v	Fibers from experiment set 3 NaOH 15%w/v
Fibers Yield (%)	44.32 <sup>a</sup> ±1.10	43.21 <sup>a,b</sup> ±0.30	41.96 <sup>b</sup> ±0.66
Moisture Content (%)	9.35 <sup>a</sup> ±0.12	9.24 <sup>a</sup> ±0.11	9.30 <sup>a</sup> ±0.23
Cellulose Content (%)	41.72 <sup>a</sup> ±0.47	41.71 <sup>a</sup> ±0.35	41.34 <sup>a</sup> ±1.54
Hemicellulose Content (%)	27.52 <sup>a</sup> ±1.00	18.49 <sup>b</sup> ±0.98	17.21 <sup>b</sup> ±0.63
Lignin Content (%)	2.96 <sup>a</sup> ±0.36	2.94 <sup>a</sup> ±0.07	2.85 <sup>a</sup> ±0.08
Yarn Count (Ne)	8.37 <sup>a</sup> ±0.15	8.65 <sup>a</sup> ±0.05	8.95 <sup>a</sup> ±0.65
Tensile Strength (gforce)	1395.60 <sup>a</sup> ±9.11	1,256.32 <sup>b</sup> ±43.75	1176.98 <sup>c</sup> ±49.39
Elongation at Break (%)	16.78 <sup>a</sup> ±0.21	17.75 <sup>b</sup> ±0.43	19.61 <sup>c</sup> ±0.37

Note: The letters a-c are different in each row. Indicates a statistically significant difference at the 0.05 level.

**Study of physical properties of handloom fabric blended with sugar palm peduncle's fibers:** The weaving of handloom fabric blended with sugar palm peduncle's fibers was carried out using a modified hand-loom shuttle weaving process. The reed width was 75 centimeters. The warp threads used for weaving were cotton yarns, specifically clean-boiled cotton yarns of size 30/2, weighing 4.51 kilograms (77 skeins), with a total of 220 warp threads. The sugar palm peduncle's fibers were used as the weft threads, which were interlaced perpendicular to the warp threads. The handloom fabric blended with sugar palm peduncle's fibers was then tested for the following properties: Fabric mass per unit area according to the ASTM D3776 standard (American Society for Testing and Materials 2009a), Maximum tensile strength according to the ASTM D5034 standard (American Society for Testing and Materials 2009b), and thread count per unit length according to the ASTM D3775 standard (American Society for Testing and Materials 2008). The image of the weaving process for the handloom fabric blended with sugar palm peduncle's fibers is shown in Figure 4.

**Statistical Data Analysis:** The results from the analysis of sugar palm peduncle's fiber properties and the properties of woven fabrics blended with sugar palm peduncle's fibers will be analyzed to obtain the mean ( $\bar{x}$ ) and standard deviation (S.D.). Analysis of variance (ANOVA) will be performed, and the differences between means will be compared using Duncan's Multiple Range Test (DMRT) at a 95% confidence level, utilizing a computer software program.

## RESULTS AND DISCUSSION

### Results

**Properties of sugar palm peduncle's fibers:** The properties of sugar palm peduncle's fibers obtained from fiber extraction using 5%, 10%, and 15% w/v sodium hydroxide solutions across the three experimental sets are shown in Table 1.

From Table 1, it is observed that the fibers yield extracted from experimental sets 1 and 3 were significantly different statistically ( $p < 0.05$ ). However, the fibers yield from experimental set 2 did not significantly different statistically ( $p > 0.05$ ) from sets 1 and 3. The moisture content, cellulose content, and lignin content of the sugar palm peduncle's fibers extracted from all three experimental sets were not significantly different statistically ( $p > 0.05$ ). The hemicellulose content of the sugar palm peduncle's fibers extracted from experimental set 1 was significantly different statistically ( $p < 0.05$ ) in sets 2 and 3. However, the hemicellulose content did not significantly different statistically ( $p > 0.05$ ) between experimental sets 2 and 3. However, the linear density of the sugar palm peduncle's fibers were not significantly different statistically ( $p > 0.05$ ) among the three experimental. The maximum tensile strength and elongation at the break of the sugar palm peduncle's fibers extracted from all three experimental sets were significantly different statistically ( $p < 0.05$ ). The maximum tensile strength was highest for experimental set 1, followed by sets 2 and 3, respectively. Regarding elongation at break, the sugar palm peduncle's fibers from experimental set 3 exhibited the highest value, followed by sets 2 and 1, respectively. From the above data, it can be observed that the fibers yield extracted in experimental set 2 was 43.21±0.30%, which was not significantly different from sets 1 and 3. The fiber properties in set 2 differed from set 1 but were not significantly different from set 3. Considering the hemicellulose content, which is a polysaccharide contaminant present with cellulose and an indicator of fiber purity in plants, it decreased

and was significantly different statistically ( $p < 0.05$ ) from set 1 but not different from set 3, which utilized a higher concentration of the chemical solution. When factoring in the chemical cost, set 2 had a lower chemical cost compared to set 3. Therefore, experimental set 2 was determined to be the most efficient method for extracting sugar palm peduncle's fibers. Consequently, the researcher proceeded to study the microscopic images of the fibers extracted from experimental set 2. The longitudinal and cross-sectional micrographs of the sugar palm peduncle's fibers were obtained using a microscope with 200x magnification, as shown in Figures 5 and 6 respectively.



Fig. 6. cross sectional view of sugar palm peduncle's fibers

As illustrated in Figure 5, it can be observed that the sugar palm peduncle's fibers exhibit a multifilament structure, which individual filaments are bundled together. Figure 6 reveals that the sugar palm peduncle's fibers have a diameter of approximately  $50\mu\text{m}$  and the cross-section of the fibers displays a bean-shaped morphology with a tubular structure.

**Properties of handloom fabric blended with sugar palm peduncle's fibers:** By utilizing the sugar palm peduncle's fibers as the weft yarns and cotton fibers as the warp yarns, a handloom fabric blended with sugar palm peduncle's fibers was produced, exhibiting the characteristics shown in Figure 7.



Fig. 7. The handloom fabric blended with sugar palm peduncle's fibers

The handloom fabric blended with sugar palm peduncle's fibers exhibited a relatively coarse surface texture with a slightly lustrous appearance. Upon analyzing the properties of the handloom fabric

blended with sugar palm peduncle's fibers, the obtained values are presented in Table 2.

Table 2. Properties of the handloom fabric blended with sugar palm peduncle's fibers

Properties	$\bar{x} \pm \text{S.D.}$
Fabric Weight (grams per square meter)	$8.10 \pm 190.71$
Maximum Warp Tensile Strength (Newtons)	$254.08 \pm 8.52$
Maximum Weft Tensile Strength (Newtons)	$433.12 \pm 9.45$
Yarn Count (ends per square inch)	78
Warp Yarn Count (ends per square inch)	31
Weft Yarn Count (ends per square inch)	47

As illustrated in Table 2, it was found that the handloom fabric blended with sugar palm peduncle's fibers had an average fabric weight of  $190.71 \pm 8.10$  grams per square meter. The average maximum tensile strength in the warp and weft directions were  $254.08 \pm 8.52$  and  $433.12 \pm 9.45$ , respectively. The handloom fabric blended with sugar palm peduncle's fibers had a yarn count of 78 threads per square inch, with a higher number of weft threads than warp threads. Furthermore, the researchers experimented with cutting and sewing the handloom fabric blended with sugar palm peduncle's fibers into products. The images of the products sewn from the handloom fabric blended with sugar palm peduncle's fibers are shown in Figure 8.



Fig. 8. Products sewn from handloom fabric blended with sugar palm peduncle's fibers (a) handbag; (b) purse; (c) backpack; (d) hobo bag

As illustrated in Figure 8, the handloom fabric blended with sugar palm peduncle's fibers demonstrates its potential for further development and fabrication into various products.

## DISCUSSION

In this section, the results will be discussed according to the research objectives of this study, i.e., (i) to study the properties of sugar palm's peduncle fibers and (ii) to study the physical properties of handloom fabrics blended with sugar palm's peduncle fibers. The results of the sugar palm peduncle's fiber properties were presented in the results

section from Table 1, that the fibers yield extracted, and the hemicellulose content were significantly different statistically ( $p < 0.05$ ). Such experimental results may be due to the extraction of fibers using sodium hydroxide solutions with increasing concentrations resulted in a decrease in the amounts of hemicellulose and lignin, as hemicellulose and lignin dissolve well in sodium hydroxide solutions (Srikanth, Rajanarender, & Nageshwa, 2020; Hua & Hafeezullah, 2020). Nevertheless, some residual hemicellulose remained in the fibers, since hemicellulose can form hydrogen bonds with the cellulose fibrils better than lignin can. This could contribute to a decreasing trend in fiber yield (Been *et al.*, 2019). The experimental results showed that the linear density (Ne) of the sugar palm peduncle's fibers increased with increasing sodium hydroxide concentration, indicating a smaller fiber diameter. As the sodium hydroxide concentration increased, the fiber size decreased and became stable at concentrations of 10% and above. Kumar & Das (2016) and Srikanth, Rajanarender & Nageshwa (2020) reported the sodium hydroxide solution partially removed the hemicellulose and lignin bound to the fibers, resulting in smaller fiber sizes. Higher Ne values correspond to finer yarns and fabrics, while lower values indicate coarser yarns and fabrics (Hua & Hafeezullah, 2020). The maximum tensile strength and elongation at the break of the sugar palm peduncle's fibers extracted were significantly different statistically ( $p < 0.05$ ). Such experimental results in the results section from Table 1, which may be due to the maximum tensile strength of the sugar palm peduncle's fibers decreased as the concentration of the sodium hydroxide extraction solution increased. This may be attributed to the depolymerization reaction caused by the sodium hydroxide solution, which removes hydroxyl groups from the hemicellulose and lignin bound to the fibers. This results in partial removal of hemicellulose and lignin from the fibers, reducing their strength (Been *et al.*, 2019). Fibers not extracted with sodium hydroxide exhibit higher strength, but lower elongation compared to those extracted with sodium hydroxide (Kumar & Das 2016). Therefore, the depolymerization reaction between fibers and alkaline solutions leads to a reduction in fiber strength (Srikanth, Rajanarender, & Nageshwa, 2020). The results from Table 1 showed the elongation at the break of the sugar palm peduncle's fibers was higher when using a higher concentration of sodium hydroxide for fiber extraction, which may be due to the elongation at the break of the sugar palm peduncle's fibers increased as the concentration of the sodium hydroxide extraction solution increased. This may be due to the mercerization reaction that occurs when the sodium hydroxide concentration exceeds 5%, which induces a decrease in the crystallinity of the fibers.

Specifically, the alkaline solution penetrates into the fibers, causing them to swell and undergo a structural rearrangement from the original cellulose I form to cellulose II. This results in an increase in the amorphous regions and a decrease in the crystalline regions, leading to enhanced fiber elongation (Been *et al.*, 2019). The sugar palm peduncle's fibers structure in Figure 5 showed the lack of crimp and possess the rough outer surface with the multifilament structure, which individual filaments are bundled together. The lack of crimp and possess the rough outer surface of the fiber affected to reduced resilience, reduced abrasion resistance, and reduced cohesiveness with other fibers (Akter & Helali, 2021; Subhankar, 2014; Singha & Singha, 2013). The sugar palm peduncle's fibers have a diameter of approximately 50  $\mu\text{m}$ , which is comparable to the size range of other natural fibers in the research of AL-Oqila (2014) such as palm fibers (1000–20  $\mu\text{m}$ ), coconut fibers (450–100  $\mu\text{m}$ ), banana fibers (200–50  $\mu\text{m}$ ), and pineapple leaf fibers (200–25  $\mu\text{m}$ ). The cross-section of the fibers displays a bean-shaped morphology with a tubular structure and a central lumen (Das, 2013). This lumen serves as a vascular bundle for water transport, a characteristic feature commonly observed in fibers obtained from other plant sources (Srikanth, Rajanarender, & Nageshwa, 2020). The results of physical properties of handloom fabrics blended with sugar palm's peduncle fibers were presented in the results section from Table 2 which showed the handloom fabric blended with sugar palm peduncle's fibers exhibited a relatively coarse surface texture with a slightly lustrous appearance. This may be attributed to the slightly rough surface of sugar palm's peduncle

fibers used as the weft yarns in the weaving process. Fibers with such a surface characteristic tend to exhibit low luster. If developed into products or textiles, these fibers would impart a rough surface texture, making the products more susceptible to soiling compared to lustrous fibers (Akter & Helali, 2021; Subhankar, 2014; Singha & Singha, 2013). The average maximum tensile strength in the warp and weft directions of handloom fabrics blended with sugar palm's peduncle fibers were 254.08  $\pm$  8.52 and 433.12  $\pm$  9.45, respectively. This indicates that the sugar palm peduncle's fibers used as the weft yarn had a higher maximum tensile strength compared to the cotton fibers used as the warp yarn. The weight of the handloom fabric blended with sugar palm peduncle's fibers was 190.71  $\pm$  8.10 grams per square meter, which falls into the medium-weight fabric category according to the criteria of University of Fashion (2014) which classifies fabrics into 5 types based on weight: very lightweight (50–100  $\text{g/m}^2$ ), lightweight (100–170  $\text{g/m}^2$ ), medium weight (170–230  $\text{g/m}^2$ ), heavyweight (230–340 grams per square meter), and very heavyweight (340–450  $\text{g/m}^2$ ).

From the physical properties of the sugar palm peduncle's fibers, it was found that the fibers are large and have a rough surface. Additionally, they are not suitable for blending with other fibers, such as cotton, due to their lack of crimp. Therefore, they are more suitable for developing into decorative textile products or for creating unique identities for community products rather than being used for apparel development. This is because direct contact with the skin may cause irritation when wearing garments made from these fibers (Venkatraman, 2016, p. 53–86). However, the handloom fabric blended with sugar palm peduncle's fibers had a higher number of weft yarns compared to warp yarns, resulting in higher maximum tensile strength in the weft direction than in the warp direction. Typically, the number of warp yarns is greater than the number of weft yarns, and warp yarns are smaller than weft yarns. The lower number of yarns per square inch is due to the larger yarn size, leading to a relatively coarse fabric surface texture caused by the abrasion between the weft and warp yarns. Additionally, using the sugar palm peduncle's fibers can abundant natural waste materials found locally in Phang Nga Province, Thailand. Also, value added to these local natural materials by developing the blended handloom fabrics that can be used for value added in community products that support local economies (Pigunthong & Soodsang, 2023). The handloom fabric blended with sugar palm peduncle's fibers demonstrates its potential for further development and fabrication into various products. Consequently, the handloom fabric blended with sugar palm peduncle's fibers presents an alternative approach to enhance the value of natural waste materials. This practice constitutes an efficient and sustainable utilization of natural resources, thereby fostering long-term sustainability.

## CONCLUSION

The extraction of sugar palm peduncle's fibers using a 10% W/V sodium hydroxide solution was the most efficient method, yielding 43.21  $\pm$  0.30% of fibers. The extracted fibers contained 41.71  $\pm$  0.35% cellulose, 18.49  $\pm$  0.98% hemicellulose, 2.94  $\pm$  0.07% lignin, had a linear density (Ne) of 8.65  $\pm$  0.05, maximum tensile strength of 1,256.32  $\pm$  43.75 gf, and elongation at break of 17.75  $\pm$  0.43%. As the concentration of the sodium hydroxide solution increased, there was a decreasing trend in fiber yield, hemicellulose content, lignin content, linear density, and maximum tensile strength, while the elongation at break increased. The physical properties revealed that the sugar palm peduncle's fibers were coarse with a rough surface and unsuitable for blending with other fibers like cotton due to their lack of crimp. Handloom fabrics blended with sugar palm peduncle's fibers had a relatively coarse texture, low luster, higher maximum warp tensile strength than the cotton weft, and were classified as medium-weight fabrics with good draping ability, suitable for garment construction. These blended fabrics were considered environmentally friendly as they were made from natural fibers that degrade more easily than synthetic fibers. Due to the coarse texture, cotton blossom stem fiber blended fabrics are better suited for developing non-apparel products,

home textiles, or souvenir items rather than apparel, as direct contact with the skin may cause irritation.

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