

# Physical Properties of Banana Leaf-Patterned Fabric Made of Weft Yarns of Cotton, Blended with Banana Fibers and Eri Silk for Value-Added Use of Banana Trees

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**Abstract-**This research aimed to study physical properties of banana leaf-patterned fabric made of number 20 Ne and 3 Ne natural yarns prepared from cotton, banana fibers and Eri silk with the designated ratio of 80:10:10. The experimental yarns were used as weft for the designated woven fabric, in which the fabric pattern was designed to represent leaf pattern on banana leaves referring to organic origin and unique characteristics of nature ; the parallel lines symbolizing the distinctive texture of banana leaves were created by yarns of different sizes. Upon testing the physical properties of the woven fabric, this research showed that the banana leaf-patterned fabric made of yarns from cotton, blended with banana fibers and Eri silk has quite less thread count in both warp and weft per square inch. Due to large size of the yarn, the fabric structure has moderately open spaces between yarns, allowing exceptionally good flow of air. Also, the fabric is proved to be strong and have high tensile strength in both warp and weft floats and the dimensional change in the shrink after washing and drying was less than that of the warp yarn.

**Keywords:** Banana fibers, banana yarn, Eri silk, physical properties, banana leaf pattern

## 1. Introduction

'Kluai nam wa' is one of the banana trees belonging to Musaceae Family (Udomkun & Innawong, 2018), commonly known as Pisang Awak (Ritthison, 2012). Its scientific name is *Musa* (ABB Group) (Wiwatchaimanee, 2011) and has its origin in Southeast Asia (Bunpanya, 2010), more specifically in the Malay Peninsula (Jarawa, 2007). In Thailand, Pisang Awak is commonly found throughout the country and is considered as the most planted bananas in the country due to its more resistance to weathering nature than other bananas (Sopitphapa, 2010) and easiness to manage and maintain (Chanthawongsa, 2010). Various beneficial uses could be developed from different parts of the Pisang Awak tree (Nonthong, 2010); its trunks and leaves are suitable for developing a number of products (Chunbubpha, 2010) and its fruits are edible (Jarawa, 2007). There is a high tendency that the economic significance of this plant would have steadily increased (Manantee, 2010) due to higher demands from domestic and international markets (Suttipong, 2020). Presently, Klong Chet Banana Integrated Cluster of Entrepreneurship and One Banana Co., Ltd are business groups that serve as dealers for Rajamangala University of Technology, Thanyaburi's research network in cultivating and distributing Gros Michel and Pisang Awak from over 3,000 Rai for consumption and market distribution (Jangsawang, 2012). From 3,000 Rai of cultivated bananas in the farm results in Gros Michel and Pisang Awak tree waste for roughly 30,000 tons annually, in which the only usage for the time being is to produce organic fertilizer. Hence, previous studies have established that banana fibers have uniquely strong and resilient

characteristics and glossy surface, easily spun into yarns and suitable for weaving into woven fabric and other home textile products. By doing so, it could reduce organic waste from production process, which increases values in textile industry's fiber development process and scales down the amount of imported organic fibers from other countries; a satisfying movement for domestic textile industry. Additionally, it provides alternative choices of natural fiber fabric for fashion and home textile businesspersons (Lecturer of Textile and Garments, 2019).

The banana fiber extraction process consists of 2 alternative methods as follows. 1) Manual extraction is an ancient process that has been practiced since 13<sup>th</sup> century by handpicking only top new leaves and full-grown leaves then peeling off the outer barks before extracting the fibers from those peeled barks. The quality of fibers depends on the age of the tree. 2) Linear extraction is a process that extracts microfibers into cone-shape fibers. The cross section of these short fibers illustrates an almost-round oval shape, lumens are clearly visible with rather thin cell walls. The fibers are fairly strong and coarse with glossy surface similar to silk (Loetanarak, 2015). Banana fibers and Eri silk share similar trait of possessing the ability to slightly adjust the temperature since Eri silk fibers contain cavities within its fibers, allowing the air to be reserved in those cavities; thus upon wearing Eri silk clothes during summer would make its wearers feel cool and relaxing, while in cold season, warm and comfortable. The fiber cavities allow good ventilation of air. Eri silk has fairly cotton-like characteristics but with more refined and glossier surface, easy to maintain (Sirimungkararat, 2019).

The Eri silkworms are insects belonging to Order Lepidoptera, Family Saturniidae. The life cycle is within 45-60 days in 4 phases ; egg, larva, chrysalis and butterfly. Eri silkworms are wild silkworms or non-mulberry silkworms, feed on Cassava and Castor bean leaves. Thus, fibers produced by Eri silkworms have unique characteristics and could produce cocoons and silks for textile weaving (Thamee & Rattanapitigorn, 2011). Traditionally, wild silkworm farming is popular in India, Pakistan and Nepal before gradually spread throughout Asia such as Japan and China. In 1974, Department of Agriculture under Ministry of Agriculture and Cooperatives had introduced the imported Eri silkworms from India to study (Atthathom *et al.*, 2002) for further farming and continuous management until successfully reinforce the public agricultural sector upon such matter. The target group is cassava farmers who could easily cultivate cassava leaves to feed Eri silkworms without causing damage to their agricultural products, which could earn them extra income from Eri silkworm farming and benefit the textile industry (Sannamwong *et al.*, 2006). World renown, Thailand is one of the world's top-quality hand-woven textile producers, internationally recognized that traditional Thai folk arts are of top quality and Thai ancestors had finest and skilled craftsmanship in hand-woven textiles. Historical evidence show that Thai people were fond of their own clothes and textiles (Sukonthamane, 2019). In the past, the folk wisdom and craftsmanship were passed down from generation to generation especially folk-art regarding textile weaving techniques in rural areas. Each area has their own techniques and patterns that represents the area and their distinguished identities. These techniques were heavily

influenced by folk culture and customs, community lifestyle and traditional beliefs (Amaranonta, 1999) that are considered as valuable handicraft which could reinforce communities' economy. In terms of business, some development must be taken in order to establish strong communities that produce fine quality textiles to serve industrial needs. The quality, patterns and details should be adapted to serve international demands more while maintaining their own identities. These fine-quality folk textiles could become new trendsetters that increase income to rural communities ; another alternative for rural community development that could help shape and build strong communities. The core philosophy of this community development is based on believing in human's potentials (Polsri, 2004), therefore, it emphasizes on giving opportunities for locals in the communities to learn and develop their skills, promoting justice and community engagement. The essential objective is to encourage morality, quality and joyfulness to locals, in the meantime, to develop a strong and sustainable community (Poungngamchuen & Sakkatat, 2011).

Due to the aforementioned reasons, we have acknowledged the significance of banana fiber textile products. Hence, the experimental product should create unique characteristics and identity for the woven fabric for value adding and sustainability, also to raise awareness regarding the organic origin of the finished textiles. This matches with the core research aim ; to study the physical properties of banana leaf-patterned fabric made of yarns of cotton, blended with banana fibers and Eri silk, which is considered as a further research from the banana fiber study

initiated in 2019 with Saengtawan Housewife Group, Sam Khok sub-district, Krachang district, Pathum Thani Province.

## 2. Materials and Methods

### 2.1 Materials

Pisang Awak fibers  
Kongkiat Textile Ltd,'s Eri fibers  
Kongkiat Textile Ltd,'s cotton

### 2.2 Tools and Instruments

1. Fiber extraction machine
2. Kongkiat Textile Ltd,'s Ring Spinning machine
3. Chaiyaporn Weaving Co., Ltd.'s industrial weaving machine
4. Physical property testing tools

-For the fiber analysis of mixing ratio, the machine was used following the AATCC TM 20A: 2018 standard

-For the thread count per length, the Pick Counter was used following ASTM D 3775: 2008 standard

-For the Air Permeability test,

the Air Permeability machine was used following the ASTM D 737: 2004 standard

-For the fabric tensile strength, the Tensile Testing machine (Instron Model 5566) was used following the ASTM D 5034: 2009 standard

-For the tear resistance testing, the Elmendorf Tester was used following the ASTM D 1424: 2009 standard

-For the dimensional change in washing and drying, the Whirlpool washing machine model 3XGSC9455JQ was used following the AATCC TM 135: 2015 standard

### 2.3 Experimental Methods

The Pisang Awak fiber extraction and quality improvement study

1) The banana fibers were prepared by separating 3 layers of banana leaf sheaths and putting them into the fiber extraction machine. The mechanical extraction would produce fibers from leaf sheaths, which would then be sun-dried until they are completely dry before securing them tightly in clean bags. Displayed in (Figure 1) is the appearance of the mentioned banana fibers.



**Figure 1.** Extracted Pisang Awak banana fibers. (A) banana fiber extraction (B) air-dried banana fibers

2) Experimenting yarn spinning by 3 different formulas and ratios of blended cotton, banana fibers and Eri silk ; 80:10:10 for the first formula, 70:20:10 for the second formula and 60:30:10 for the third formula, respectively. The finest-quality

yarns which enriched with smoothness and of considerably durable nature produced by this process is of the first 80:10:10 formula. The sizes of the yarns are at 20 Ne and 3 Ne, accordingly. The procedure is shown in the following (Figure 2).

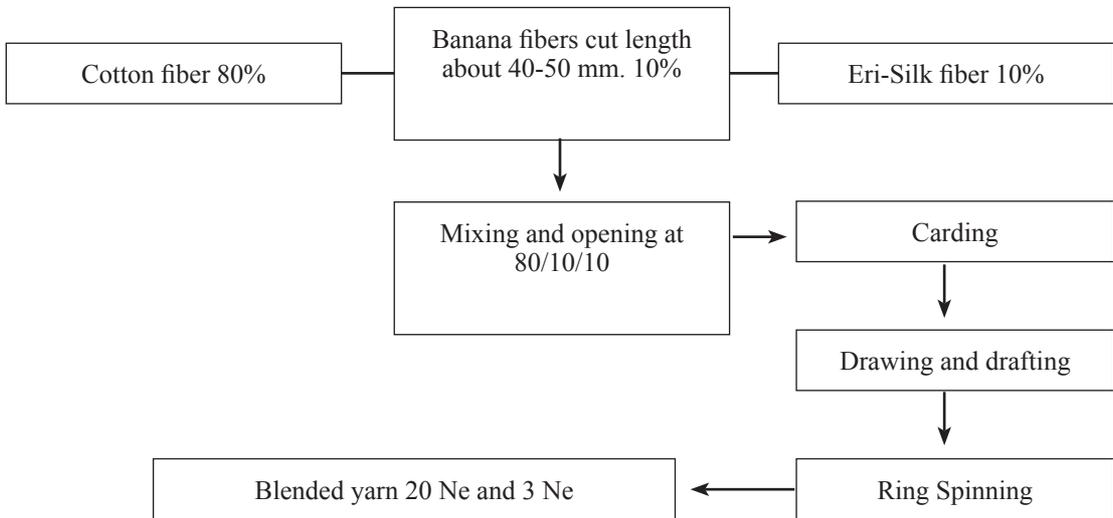


Figure 2. Spinning process in a laboratory cotton spinning systems.

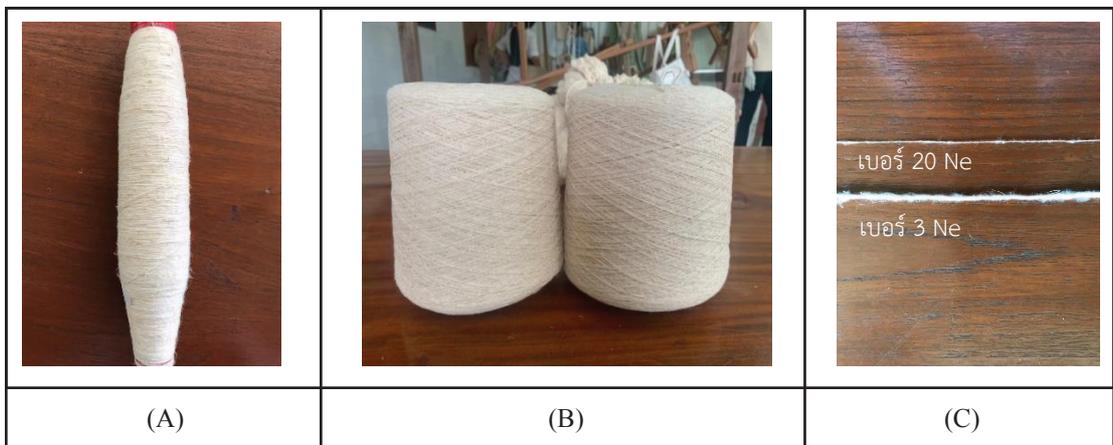
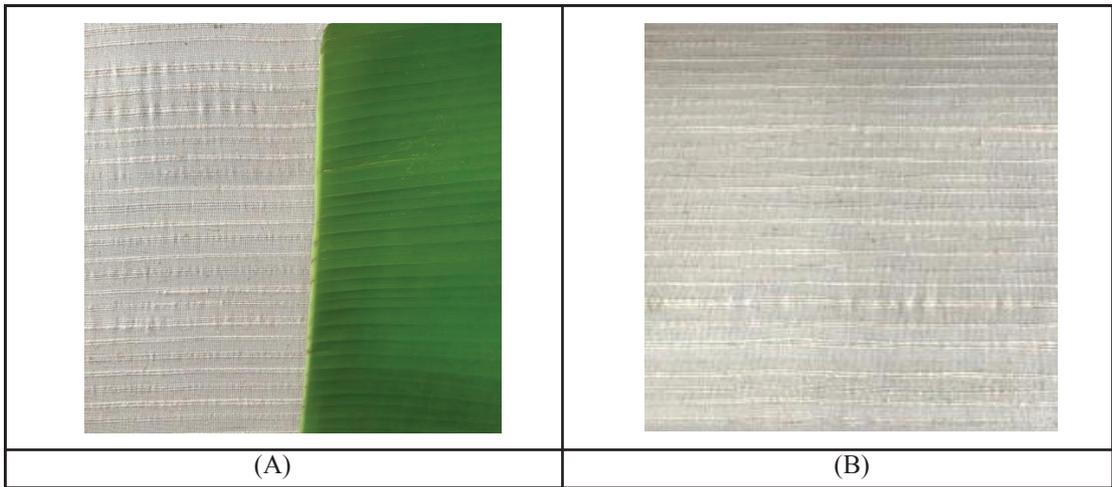


Figure 3. Blended banana fiber and Eri silk yarns. (A) mixture of banana fibers and Eri silk yarns number 20 Ne (B) number 3 Ne yarns (C) comparison of both sizes

3) Experimental weaving of fabric into the designated banana leaf-patterned fabric

Weaving the banana leaf-patterned fabric is the process of creating complex weft filling pattern which would result

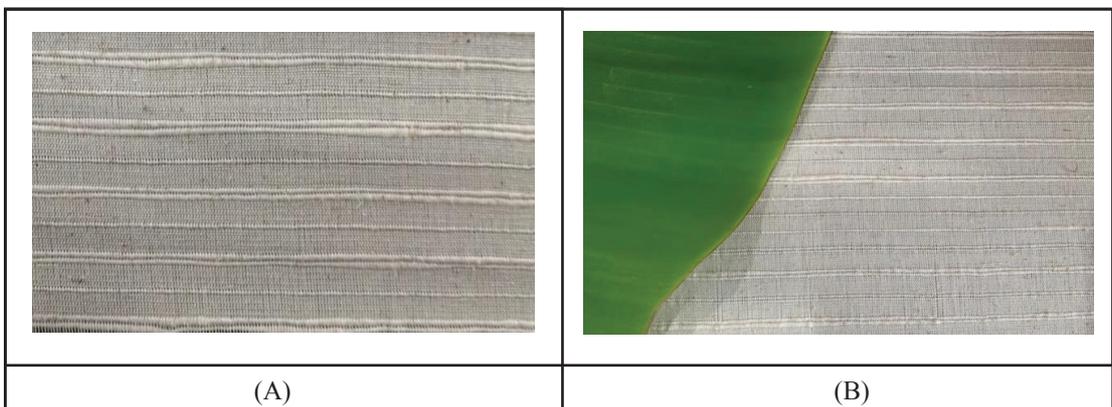
as banana leaf-like structure. The pattern represents characteristics and charms of nature. The dissimilar sizes of yarns create a unique parallel texture which resembles those on banana leaves.



**Figure 4.** Testing fabric in order to find the pattern most similar to real banana leaf surface. (A) testing fabric (B) comparison of the woven pattern with the real banana leaf

4) Upon discussing with experts, the research showed that to design any fabric pattern, the specific pattern should correspond with the characteristics of chosen yarns in order to convey the distinguished features of each fabric. The banana leaf pattern was chosen, inspired by the profound paralleled lines seen on banana leaves. Upon weaving the fabric, yarns number 20 Ne and 3 Ne were alternately used as weft. The 20 Ne

will fill 10 times then rotate to 3 Ne for 2 times and back to 20 Ne for 10 times and finish with 3 Ne 1 time. By doing so, this process creates a pattern similar to real banana leaf surface. Banana is the core inspiration of this research since Pathum Thani Province has a number of agricultural banana farms. It also represents folk art and hidden beauty of Thai culture.



**Figure 5.** Banana leaf-patterned fabric weaving test. (A) banana leaf-patterned fabric made of blended banana fibers and Eri silk (B) comparison of the fabric pattern with the real banana leaf

5) Producing the banana leaf-patterned fabric, which emphasizes the identity building and distinct characteristics of local textiles in order to create added value and sustainability.

### 3. Results and Discussion

The study has established that yarns produced from mixtures of cotton, banana fibers and Eri silk are fairly uneven with some excess fibers sticking out of the spun yarns. Owing to the straight characteristics of banana fibers, it results in the unevenness of produced yarns, which corresponded with the study of Sinha and Ghosh (1978) regarding the analysis conducted on the

nature of large natural fibers twisted into yarns in which excess fibers are common, resulting the less even surface throughout the yarns. This also is in consistent with Anunvrapong *et al.* (2016) stating that by weaving fabric using different sizes of yarns, it would add characteristics to the finished fabric. Fabric produced by such method would have its unique feature, and is suitable to transform into various products such as table or floor lamps.

Study Results of the Fabric made of Yarns of Banana Fibers Blended with Eri Silk with Banana Leaf Pattern

The results of this study could be clarified from (Table 1) to (Table 6) below.

**Table 1.** Results of the Fiber Mixing Ratio Test (following the AATCC TM 20A: 2018 standard)

Types of yarns	Warp		Weft		
	Cotton	Eri-Silk	Cotton	Banana Fibers	Eri-Silk
Ratio (percentage)	95.76	4.24	81.70	10.20	8.10

According to (Table 1), Results of the Fiber Mixing Ratio Test, the warp end of cotton is at 95.76 percent while Eri silk is at 4.24 percent. Also, the weft consists of cotton at 81.70 percent, of banana fibers at 10.20 percent and Eri silk at 8.10 percent. Consulted with experts on mixing fiber proportions along with the study results, it is assumed that yarns from the mixtures

of cotton, banana fibers and Eri silk using the first formula mixture (80:10:10) might have lost some of the fibers during the mixing process. However, the laboratory test had confirmed that all remained intact. Thus, both warp and weft in woven fabric contains Eri silk while banana fibers were used for weft floats only.

**Table 2.** Results of Thread Count per Length Test (following the ASTM D 3775: 2008 standard)

Types of yarns	Thread count per length (number per square inch)
Vertical warp	52
Horizontal weft	37
Thread count	89

From (Table 2), results of thread count per length Test, the study shows that the number of threads count in vertical warp are approximately 52 threads of square inch, much higher than 37 threads per square inch of the horizontal weft. The

blended fabric of banana fibers and Eri silk consists of less thread counts in both warp and weft floats owing to the considerably large fibers spun into large yarns. The woven fabric from such yarns are reasonably heavyweight and somewhat thick.

**Table 3.** Result of fabric air permeability test (following the ASTM D 737: 2004 standard)

Types of yarns	Air Permeability (square centimeter)
Banana leaf-patterned fabric of blended banana fibers and Eri silk	101.94

(Table 3), results of fabric air permeability test, indicates the tested results of air permeability of this fabric as approximately 101.94 square centimeters, given the exceptional level of ventilation.

According to Soiraya (2009), banana fabric has high tendency to absorb water with good flow of air, similar to cotton or linen, making it a fine choice for household wardrobe.

**Table 4.** Results of Tensile Strength Test (following the ASTM D 503 ASTM D 5034: 2009 standard)

Types of yarns	Tensile strength (Newtons)
Vertical warp	377.32
Horizontal weft	196.82

**Note:** test piece: GRAB  
Test piece condition: temperature at  $21 \pm 1$  °C, relative humidity at  $65 \pm 2\%$

(Table 4), results of tensile strength test, suggests that the weft's tensile strength is at 377.32 Newtons, exceptionally higher than the warps' 196.82 Newtons ; the woven fabric has fairly satisfying tensile strength in both vertical and horizontal dimension with moderately strong fibers. This could be assumed that due to the less specific strength nature of banana fibers compared to cotton (Anonymous, 2004), it produced

a moderately strong yarn with moderate tensile strength, which is suitable to use in common textile work and clothing. This is also in consistent with Yongyuth (2009) that Pisang Awak banana fibers are more resilient than other kinds of bananas. Thus, they would fit to produce fine furniture walls.

**Table 5.** Results of tear resistance test (following the ASTM D 1424: 2009 standard)

Types of yarns	Tear resistance (Newtons)
Vertical warp	45.75 <sup>(1)</sup>
Horizontal weft	52.37 <sup>(2)</sup>

**Note:** test piece condition: temperature at  $21 \pm 1^\circ\text{C}$ , relative humidity at  $65 \pm 2\%$

<sup>(1)</sup> test machine limitation: 6,400 grams

<sup>(2)</sup> test machine limitation: 12,800 grams

According to (Table 5), Results of Tear Resistance Test, it shows that the tear resistance of the vertical warp is at 52.37 Newtons, a little higher than the horizontal weft's 45.75 Newtons. Thus, this fabric is averagely durable as its tear resistance properties in both vertical warp and horizontal weft are moderate, suitable

for durable textile works. The result matches with what Khumhan *et al.* (2016) had established that banana fibers are another kind of valuable yarns suitable for weaving industry. The yarns add value to banana commonly found in Thailand, especially in communities with strong enthusiasms in developing creative economy.

**Table 6.** Dimensional Change in Washing and Drying (following the AATCC TM 135: 2015 standard)

Types of yarns	Dimensional change per 1 wash (percentage)
Vertical warp	-6.6
Horizontal weft	-3.0

**Note:** testing methods: Normal cycle, Wash load ballast type 1 (1.8 KG)

Washing temperature at  $41 \pm 3^\circ\text{C}$

Drying method: Low Thumb dry

Type of detergent: 1993 AATCC Standard reference detergent

Total weight of test piece and wash load:  $1.8 \pm 0.1$  kilogram

The sign (-): indicates shrinking

(Table 6), dimensional change in Washing and Drying, suggests that the changing dimension of the horizontal weft is at -3.0 percent, less than the vertical warp's -6.6 percent. Therefore, after washing, the vertical dimension would shrink more than its horizontal dimension.

#### 4. Conclusion

The experiment on creating blended fabric from cotton, banana fibers and Eri silk using the 80:10:10 ratio formula in the laboratory

showed the most suitable formula for mechanically extracted fibers to prepare yarns and produced a satisfying result. The fabric was woven into the unique parallel design resembling the distinctive surface of banana leaves; the crucial sources of fibers woven to create this fabric. The designed pattern aimed to express and represent folk wisdom and art, to display the hidden beauty of Thai culture and to add value to Thai folk art for sustainability. Laboratory tests for physical properties of the fabric made of yarns of cotton, blended

with banana fibers and Eri silk showed satisfactory results in both vertical warp and horizontal weft floats, while banana fibers were used only in horizontal weft floats. This resulted in less thread counts per square inch in both warp end and weft filling, owing to the size of yarns which produced the somewhat heavyweight and thick fabric.

## 5. Acknowledgement

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