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Characteristics and Properties of Knitted Paper Mulberry Fabrics

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Abstract

The objective of this research was to experimentally produce paper mulberry fabrics by knitting and determining the characteristics and physical properties of the fabrics obtained. The materials used for this study were the paper mulberry yarns spun by the modified hemp spinning method (MH) using 2, 4 and 6 mm bark strips and the modified cotton spinning method (MC) using 3.5, 5 and 6.5 cm fibers. The knitted fabrics were produced by hand and tested for physical properties according to the ASTM standards. It was found that the knitted paper mulberry fabrics made from the yarns spun by the modified hemp spinning methods were dense and smooth. In contrast, the knitted paper mulberry fabrics made from the yarns spun by the modified cotton spinning methods were rough and fuzzy. The knitted fabrics made from the yarns spun by the six different methods statistically had different thickness, weight, course count and wale count at the 0.01 level.

Keywords: Paper Mulberry Fabric; Physical Properties; Hand Knitted

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Introduction

Saa, or the popular name of the paper mulberry tree, is a coarse, strong, rigid material and has a natural base fiber. It is the main raw material for handmade paper in Thailand [1]. From the saa tree, paper mulberry is produced as a very popular raw material used for making paper in Japan, Taiwan and Korea for the past twenty years. There are many named varieties, such as the preferred scientific name "*Broussonetia papyrifera* (L.) Vent" and the family name, "Moraceae". Related to the fig tree family, the common and widely used name is "paper mulberry". The most popular name for the material in Thai to date, is generally called "Por Sa or Saa". The mulberry tree is widely cultivated in East Asia for the fiber of its bark. A fast growing, deciduous tree measuring 15 metres in height. Left undisturbed at the foot of the mountains, the tree's growth invades rapidly where the soil is fertile. It has fruits that can be harvested for future growth, leaves, wood, stem, bark, and fibers. At present, being a natural, sustainable, and environmental friendly farmed resource, the demand of paper mulberry inner bark is rapidly increasing for use in paper and other material production. In Thailand, it was referred to for many years as the best choice for its weaving properties and paper manufacturing and for its sustainable, robust and durable properties. The stem of the paper mulberry has reddish brown hairs; the bark is tan in color and the inner bark is smooth to moderately furrowed. Paper mulberry is unique, long and very strong fiber. It is the best choice for many in making high quality paper. Also of importance is the susceptibility and durability to various treatments and their reaction to finishing processes. Much of the variety, beauty and texture of fabrics is due to yarn differences, creating individual and unique finishes [2]. In previous study, the characteristics and physical properties of paper mulberry yarns spun by the two methods developed: the modified hemp spinning method (MH) and the modified cotton spinning method (MC) were examined. It was found that the MH methods could produce much smoother yarns than the MC methods. In contrast, the yarns spun by the MC methods were more fuzzy and rough. The MH methods produced the yarns with higher count, higher breaking strength and higher elongation while the yarns spun by the MC methods had higher yarn twist. Moreover, the yarns spun by different methods statistically had different yarn count, yarn twist, yarn breaking strength and yarn elongation at the 0.01 level [2]. Therefore, in this study, the characteristics and physical properties of the paper mulberry knitted fabrics using different yarns spun by different methods were determined.

Objective

To experimentally produce knitted paper mulberry fabrics and determine the characteristics and physical properties of the fabrics obtained.

Research methodology

Materials

The materials used for this study were the paper mulberry (*Broussonetia papyrifera* (L.) Vent.) yarns spun by the six hand spinning methods; the modified hemp spinning methods (MH) using inner barks into strips in three width sizes; 2 mm, 4 mm and 6 mm and the modified cotton spinning methods (MC) using inner barks in three sizes length; 3.5, 5 and 6.5 cm. Their characteristics are shown in Figure 1, and their physical properties are shown in Table 1.

Methods

1. Knitting of the Paper Mulberry Fabrics

The knitted paper mulberry fabrics were experimentally produced by hand in weft-knit construction using two No. 6 pins.

2. Testing of the Paper Mulberry Fabrics

The characteristics and physical properties of the paper mulberry fabrics were determined according to ASTM standards as follows:

1) Fabric thickness was tested according to ASTM D1777 – 96 Standard Test Methods for Thickness of Textile Materials [3].

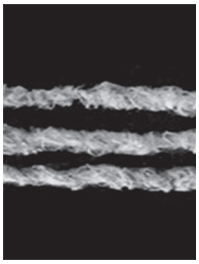
2) Fabric weight was tested according to ASTM D 3776 – 96 Standard Test Methods for Mass per Unit Area (weight) of Fabric [3].

3) Woven fabric count was tested according to ASTM D 3775 – 03a Standard Test Methods for Warp End Count and Filling Pick Count of Woven fabric [3].

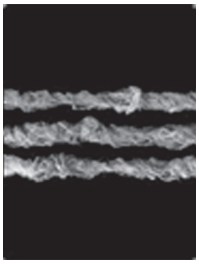
4) Fabric strength was tested according to ASTM D 5034 – 95 Standard Test Methods for Breaking Strength and Elongation of Textile Fabric [4].

5) Fabric characteristics were determined using an electron microscope.

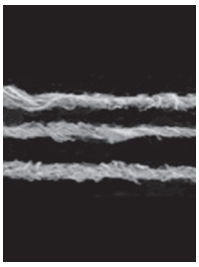
The samples were conditioned in the standard laboratory atmosphere for testing (27±1 ^{o}C and 65±2% RH) for 24 hours.



(a) MH with 2 mm strips spun yarn



(b) MH with 4 mm strips spun yarn



(c) MH with 6 mm strips spun yarn

(d) MC with 3.5 cm fibers spun yarn

(e) MC with 5 cm fibers spun yarn

(f) MC with 6.5 cm fibers spun yarn

Figure 1 The characteristics of the paper mulberry yarns used in this mm strips spun yarn

Results and Discussion

The Characteristics of the Knitted Paper Mulberry Fabrics

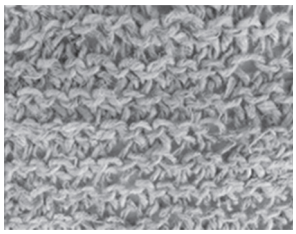
The characteristics of the knitted paper mulberry fabrics produced from different yarns are shown in Figure 2.

Figure 2 shows that the yarns spun by the MH methods could produce more smooth fabrics (a), (b) and (c). In contrast, the paper mulberry fabrics made from the yarn spun by the MC method were fuzzier and thicker fabrics (d), (e) and (f).

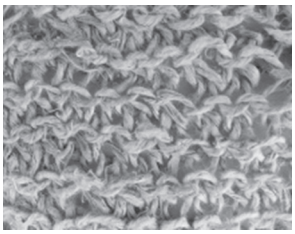
The yarns spun by the MH methods were made from long fibers, resulting in smoother yarn and therefore, smoother fabrics, while the yarns spun by the MC methods were made from short fibers, thus, resulting in much more hairiness in the yarns and in the fabrics. The fabrics produced had different texture which might be suitable for different products.

Table 1 Physical properties of the paper mulberry yarns used in the study

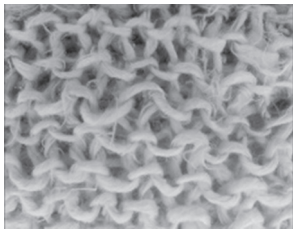
Yarn Spinning Methods	Count (tex)	Twist (turns/inch)	Breaking Strength (cN/tex)	Elongation (%)
MH with 2 mm strips	963.48	5.60	264.22	13.33
MH with 4 mm strips	1310.14	4.60	352.71	17.07
MH with 6 mm strips	1683.88	5.00	551.06	25.36
MC with 3.5 cm fibers	1271.70	10.80	36.14	14.05
MC with 5 cm fibers	1150.68	9.80	83.44	19.41
MC with 6.5 cm fibers	1022.78	8.80	66.39	17.80



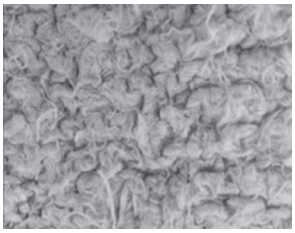
(a) fabric made from MH with 2 mm strip spun yarn



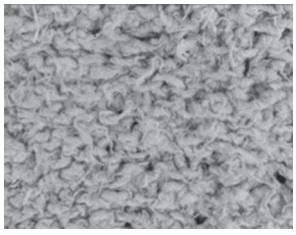
(b) fabric made from MH with 4 mm strip spun yarn



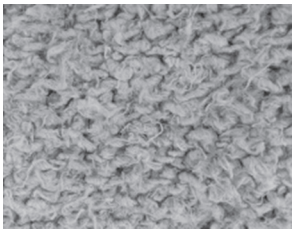
(c) fabric made from MH with 6 mm strip spun yarn



(d) fabric made from MC with 3.5 cm fiber spun yarn



(e) fabric made from MC with 5 cm fiber spun yarn



(f) fabric made from MC with 6.5 cm fiber spun yarn

Figure 2 Knitted paper mulberry fabrics made from different yarns

Physical Properties of the Knitted Paper Mulberry Fabrics

The knitted fabrics made from the yarns spun by the six spinning methods were investigated in four aspects: fabric thickness, fabric weight, fabric count: course per inch and wale per inch, using the ASTM standards. The results are shown as follows:

Fabric thickness

Table 2 Means of thickness of the knitted paper mulberry fabrics made from different yarns

Spinning Method of the Yarn Used	Fabric Thickness (mm)	
	$\overline{X}$	S.D.
MC with 3.5 cm fibers	5.28[a]	0.41
MC with 5 cm fibers	4.61[b]	0.31
MH with 6 mm strips	4.30[bc]	0.23
MH with 4 mm strips	3.97[cd]	0.22
MC with 6.5 cm fibers	3.68[d]	0.45
MH with 2 mm strips	2.95[e]	0.37

[a]Mean of duplicate observations. Means in the same column, followed by a common letter are not significantly different at 5% level by DMRT

Table 2 shows that the knitted paper mulberry fabric made from the yarn spun by the MC method with 3.5 cm fibers had the highest thickness. Followed by the fabric made from the yarn spun by the MC method with 5 cm fibers. While, the knitted fabric made from the yarn spun by the MH method with 2 mm strips had the lowest thickness. The paper mulberry knitted fabric made from the yarn of the MC method with 3.5 cm fibers had the highest thickness because the yarn used was fuzzier than the others. All of the knitted paper mulberry fabrics produced were thick fabrics (>0.47 mm thick) [5]. Different yarns tended to produce fabrics with different thickness. Variation analysis of the means of fabric thickness revealed that different yarns resulted in different fabric thickness at the 0.01 level.

The result of Least Significant Ranges (LSR) analysis to measure the mean difference of fabric thickness of the knitted fabrics made from different yarns revealed that the thickness of the fabric made from the yarn spun by the MC method with 3.5 cm fibers was statistically higher than those of the others at 0.05 level. The thickness of the knitted fabric made from the yarns spun by the MC method with 5 cm fibers was

statistically higher than those of the fabrics made from the yarns spun by the MH method with 4 mm strips, the MC method with 6.5 cm fibers and the MH method with 2 mm strips at 0.05 level. The knitted fabric made from the yarn spun by the MH method with 6 mm strips was statistically higher than those of the fabrics made from the yarns spun by the MC method with 6.5 cm fibers and the MH method with 2 mm strips at the 0.05 level. The knitted fabric made from the yarn spun by the MH method with 4 mm strips was statistically higher than the thickness of the fabrics made from the yarns spun by the MH method with 2 mm strips at 0.05 level.

Fabric weight

Table 3 Means of weight of the paper mulberry knitted fabrics made from different yarns

Spinning Method of the Yarn Used	Weight (g/m^2)	
	$\overline{X}$	S.D.
MC with 3.5 cm fibers	122.22[a]	0.41
MC with 5 cm fibers	108.10[b]	0.31
MC with 6.5 cm fibers	108.10[b]	0.45
MH with 4 mm strips	105.72[b]	0.22
MH with 6 mm strips	105.04[b]	0.23
MH with 2 mm strips	95.40[c]	0.37

Table 3 shows that the knitted fabrics made from the yarn spun by the MC method with 3.5 cm fibers was the heaviest, followed by the fabric made from the yarn spun by MC method with 5 cm fibers and 6.5 cm fibers. The knitted fabric made from the yarn spun by the MH method with 2 mm strips was the lightest. The paper mulberry fabrics were classified as very light weight fabrics [5]. Different yarns tended to produce fabrics with different weight. Variation analysis of the means knitted fabric weight revealed that the six different yarns resulted in different fabric weight at the 0.01 level.

The result of Least Significant Ranges (LSR) analysis to measure the mean difference in fabric weight of the knitted fabrics made from different yarns revealed that the weight of the fabrics made from the yarn spun by the MC method with 3.5 cm fibers was statistically higher than those of the others at the 0.05 level. The knitted fabrics made from the yarns spun by the MC method with 5 cm fibers, 6.5 cm fibers, the MH method with 4 mm strips and 6 mm strips were statistically higher than those of the fabric made from the yarn spun by the MH method with 2 mm strips at the

0.05 level. The result showed that the heavier fabric was those made from the yarns spun by the MC methods. This might be because the yarns spun by the MC methods had high density of fibers than the yarns spun by the MH methods, therefore, resulting higher weight fabrics.

Course per inch

Table 4 Means of course per inch of the paper mulberry knitted fabrics made from different yarns

Spinning Method of the Yarn Used	Course/inch	
	$\overline{X}$	S.D.
MC with 3.5 cm fibers	5[a]	0
MC with 6.5 cm fibers	5[a]	0
MC with 5 cm fibers	4[b]	0.55
MH with 4 mm strips	4[bc]	0.45
MH with 2 mm strips	4[c]	0
MH with 6 mm strips	3[d]	0

[a]Mean of duplicate observations. Means in the same column, followed by a common letter are not significantly different at 5 % level by DMRT

Table 4 shows that the knitted fabric made from the yarn spun by the MC method with 3.5 cm fibers and 6.5 cm fibers had the highest count, followed by the fabric made from the yarn spun by MC method with 5 cm fibers. While, the knitted fabric made from the yarn spun by the MH method with 6 mm strips had the lowest count. The six different yarns tended to produce fabrics with different course count. Variation analysis of the means knitted fabric course count revealed that different yarns resulted in different fabric course count at the 0.01 level.

The result of Least Significant Ranges (LSR) analysis to measure the mean difference of course per inch of the knitted fabrics made from different yarns revealed that the course per inch of the fabrics made from the yarn spun by the MC method with 3.5 cm fibers and 6.5 cm fibers were statistically higher than those of the others at the 0.05 level. The course per inch of the knitted fabrics made from the yarns spun by the MC method with 5 cm fibers and the MH method with 4 mm strips were statistically higher than the course per inch of the fabrics made from the yarn spun by the MH method with 2 mm strips and 6 mm strips at the 0.05 level.

Wale per inch

Table 5 Means of wale per inch of the paper mulberry knitted fabrics made from different yarns

Spinning Method of the Yarn Used	Wale /inch	
	$\overline{X}$	S.D.
MH with 2 mm strips	6[a]	0.89
MH with 4 mm strips	5[b]	00
MH with 6 mm strips	5[b]	00
MC with 6.5 cm fibers	5[b]	00
MC with 5 cm fibers	5[b]	0.45
MC with 3.5 cm fibers	4[c]	00

[a]Mean of duplicate observations. Means in the same column, followed by a common letter are not significantly different at 5 % level by DMRT

Table 5 shows that the knitted fabric made from the yarn spun by MH method with 2 mm strips had the highest wale per inch, followed by the knitted fabrics made from the yarn spun by the MH method with 4 mm strips and 6 mm strips and the MC method with 6.5 cm fibers. Whereas, the knitted fabric made from the yarn spun by the MC method with 3.5 cm fibers had the lowest wale per inch. Therefore, the knitted paper mulberry fabrics produced could be classified as low count fabric. Different yarns tended to produce fabrics with different wale count. Variation analysis of the means of theknitted fabric wale count revealed that the six different yarns resulted in different count at the 0.01 level.

The result of Least Significant Ranges (LSR) analysis to measure the mean difference of wale per inch of the knitted fabrics made from different yarns revealed that the wale per inch of the fabric made from the yarn spun by the MH method with 2 mm strips was statistically higher than those of the others at the 0.05 level. The wale per inch of the knitted fabrics made from the yarns spun by the MH method with 4 mm strips and 6 mm strips, the MC method with 6.5 cm fibers and 5 cm fibers were statistically higher than that of the fabric made from the yarn spun by the MC method with 3.5 cm fibers at the 0.05 level.

Conclusions

The knitted paper mulberry fabrics made from the yarns spun by the modified hemp spinning methods (MH) had more density and smoothness, while the paper mulberry woven fabrics made from the yarns spun by the modified cotton spinning methods (MC) were rough and fuzzy. The knitted paper mulberry fabrics produced were thick, heaviest-weight and low count. The knitted paper mulberry fabrics made from the yarns spun by different methods statistically had different thickness, weight, course per inch and wale per inch at the 0.01 level. The characteristics and the properties of the paper mulberry fabrics produced is good for home textile, upholstery and accessory products.

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