

## Effect of yarn preparation methods on physical properties of paper mulberry woven fabrics

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### ABSTRACT

Paper mulberry plants are used as the main material for making paper from past to present, however in this research offer another aspect of paper mulberry which have been utilized in the eco textile. The objective of this research was to experimentally produce paper mulberry fabrics by hand weaving using different methods of yarn preparation and determine the characteristics and physical properties of the obtained fabrics. The materials used for this study were the paper mulberry yarns spun by the modified hemp spinning method (MH) with 2, 4 and 6 mm bark strips (long fiber) and the modified cotton spinning method (MC) using 3.5, 5 and 6.5 cm fibers (short fiber). It was found that the MH fabric was dense and smooth which made from long fiber. In contrast, the MC woven fabrics were fuzzy and thick because of the short fiber. The woven fabrics made from the yarns spun by six different methods had statistically different thickness, weight, weft count, strength in warp and weft direction, elongation in warp and weft direction. Thus, the woven fabrics made from the MH2 nm yarn were the most suitable for the fabric production in this study.

**Keywords:** paper mulberry fabric, physical properties, hand woven, eco-textile

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## Introduction

Over the last 100 years the ancient art of hand weaving has been a tradition in Thailand, within its long history of beautiful fine weaving textiles. Thais are familiar with Thai native fabric in ceremonial dress and everyday clothing. Weaving is the main skill for employment in many provinces in Thailand, such as Chiang Mai, Nong Khai, Khon Kaen and Sukothai. Cotton, silk and hemp have been the main fibers used. These fabrics still remain today, with a growing demand in export to Europe for ecological, sustainable and environmentally friendly clothing. In addition, there is a growing demand for furniture production and paper materials. Most natural materials are woven, and handmade yarns are still favorite for general customers and weavers. Fiber of paper mulberry (*Broussonetia papyrifera* (L.) Vent.) is one of the most interesting materials due to its characteristics and properties such as high tenacity and high elongation. It is the main raw material for handmade paper in Thailand (Ujjin *et al.* 2000). In previous study, the characteristics and physical properties of paper mulberry yarns spun by the two methods

developed: the modified hemp spinning method (MH) using 2, 4 and 6 mm bark strips and the modified cotton spinning method (MC) using 3.5, 5.0 and 6.0 cm fibers were determined. It was found that the MH method could produce much smoother yarns than the MC method. In contrast, the yarns spun by the MC method were more fuzzy and rough. The MH method produced the yarns with higher count, higher breaking strength and higher elongation while the yarns spun by the MC method had higher yarn twist. Moreover, the yarns spun by six different methods statistically had significant yarn count, yarn twist, yarn breaking strength and yarn elongation ( $P < 0.05$ ) (Chonsakorn, 2014). The resulting yarns were used to make woven fabrics (Elsasser, 2005). The objective of this study was to experimentally produce paper mulberry fabrics by weaving and determine the characteristics and physical properties of the fabrics obtained.

## Materials and methods

The materials used for this study were the paper mulberry (*Broussonetia papyrifera* (L.) Vent.) yarns spun by the two hand spinning methods; the modified

hemp spinning method (MH) and the modified cotton spinning method (MC). Their characteristics and properties of the paper mulberry woven fabrics made from the yarns spun by the six different methods were discussed.

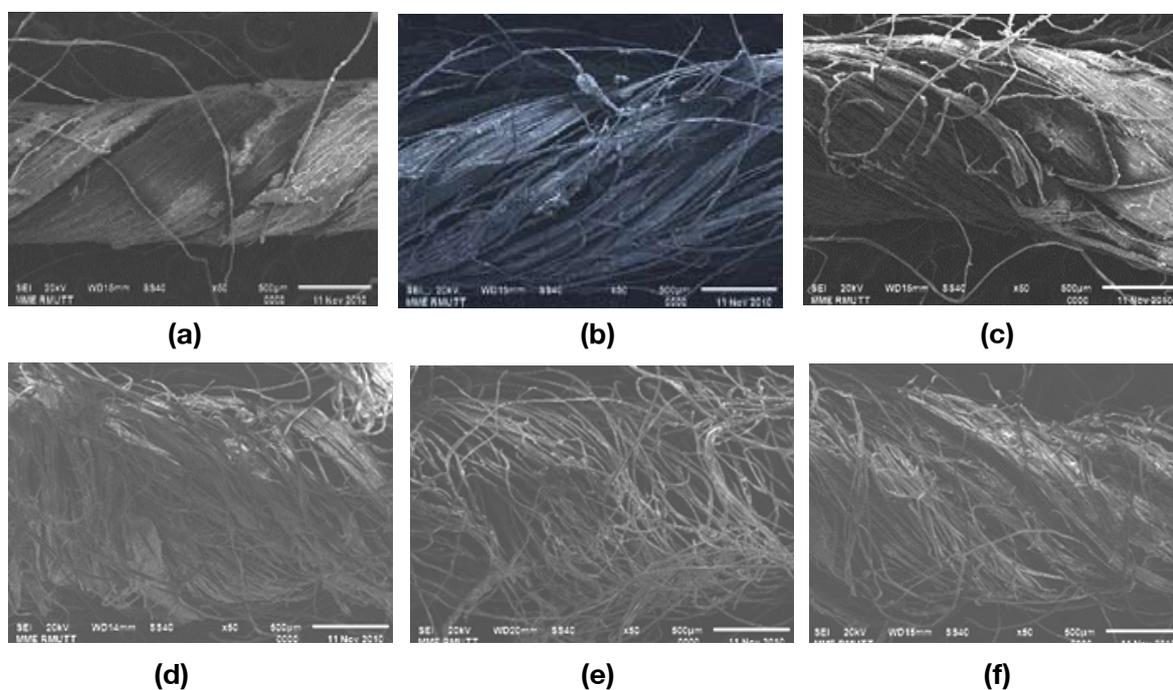
### 1. Weaving of the paper mulberry fabrics

The paper mulberry woven fabrics were experimentally produced on a Thai hand loom in plain weave construction using the harness No. 24 (12 warp yarns per inch).

### 2. Testing of the paper mulberry fabrics characteristics and physical properties

The characteristics and physical properties of the paper mulberry fabrics were determined according to the American Society of Testing and Materials (ASTM) Standards as follows:

1) Fabric thickness was tested according to the ASTM D1777-96 Standard Test Method for Thickness of Textile Materials (ASTM International, 2005).



**Figure 1** The characteristics of the paper mulberry yarns used in this study (a) MH with 2.0 mm strips spun yarn, (b) MH with 4.0 mm strips spun yarn, (c) MH with 6.0 mm strips spun yarn, (d) MC with 3.5 cm fibers spun yarn, (e) MC with 5.0 cm fibers spun yarn, and (f) MC with 6.5 cm fibers spun yarn

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

Methods of Yarn Preparation	Count (tex)	Twist (turns/inch)	Breaking Strength (cN/tex)	Elongation (%)
MH with 2.0 mm strips	963.48	5.60	264.22	13.33
MH with 4.0 mm strips	1310.14	4.60	352.71	17.07
MH with 6.0 mm strips	1683.88	5.00	551.06	25.36
MC with 3.5 cm bers	1271.70	10.80	36.14	14.05
MC with 5.0 cm bers	1150.68	9.80	83.44	19.41
MC with 6.5 cm bers	1022.78	8.80	66.39	17.80

2) Mass per Unit Area (weight) of fabric was tested according to the ASTM D3776-96 Standard Test Method for Mass per Unit Area (weight) of Fabric (ASTM International, 2005).

3) Woven fabric count was examined according to the ASTM D3775-03a Standard Test Method for Warp End Count and Filling (weft) Pick Count of Woven Fabric (ASTM International, 2005a).

4) Fabric strength was tested according to the ASTM D5034-95 Standard Test Method for Breaking Strength and Elongation of Textile Fabric (ASTM International, 2005b).

5) Fabric characteristics was determined using an electron microscope.

The samples were conditioned in the standard laboratory atmosphere for testing (271 °C and 652% RH) for 24 hours.

### 3. Experimental design and data analysis

Completely Randomized Design (CRD) of 6 methods of yarn preparation with 5 replications per method was conducted. Analysis of Variance (ANOVA) was performed to determine the effect of spinning methods on paper mulberry woven fabrics. Mean and standard deviation of paper mulberry fabrics characteristic and physical properties of each method were analyzed. Therefore the best yarn from the six spinning methods for paper mulberry fabrics could be determined.

## Results and Discussion

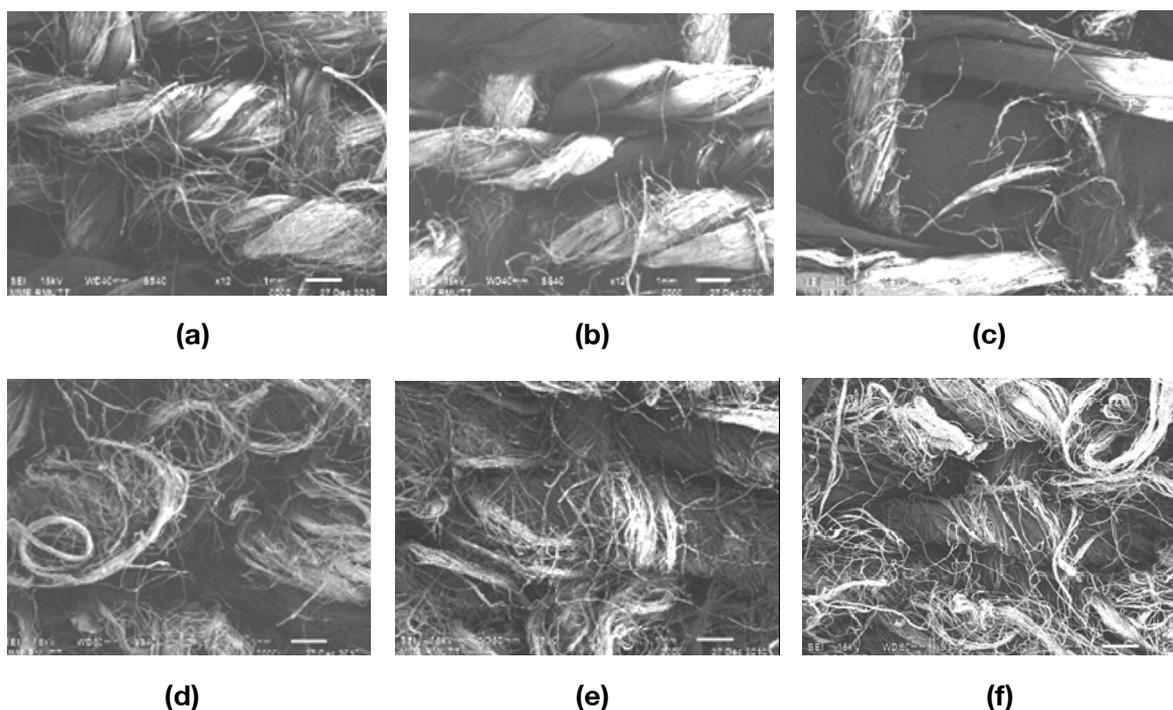
### 1. The Characteristics of the paper mulberry woven fabrics

The characteristics of the paper

mulberry woven fabrics produced from different yarns are shown in Figure 2.

The yarns spun by the MH methods (a), (b) and (c) could produce smoother fabrics, while the paper mulberry woven fabrics made from the yarns spun by the MC methods were fuzzier and

thicker (d), (e) and (f). Due to 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 method were made from staple fiber, resulting in greater hairiness in the yarns and fabrics.



**Figure 2** The paper mulberry woven fabrics made from (a) MH with 2.0 mm strips spun yarn, (b) MH with 4.0 mm strips spun yarn, (c) MH with 6 mm strips spun yarn, (d) MC with 3.5 cm fibers spun yarn, (e) MC with 5.0 cm fibers spun yarn, and (f) MC with 6.5 cm fibers spun yarn

## 2. Physical properties of the paper mulberry woven fabrics

### 2.1 Fabric thickness

Paper mulberry woven fabric made from the yarn spun by the MC method with 3.5 cm fibers had the

highest thickness (4.19 mm) followed by yarn spun by the MH method with 6.0 mm strips (Table 2), while the woven fabric made from the yarn spun by the MC method with 6.5 cm fibers had the lowest thickness (2.29 mm). All of the

paper mulberry woven fabrics in this study could be classified as thick fabrics (>0.47 mm thick) (Collier and Epps, 1999).

### **2.2 Fabric weight**

The woven fabric 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 the MC method with 6.5 cm fiber (Table 2), whereas the woven fabric of the yarn spun by the MH method with 6.0 mm strips (4.52 g/m<sup>2</sup>) was the lightest. Although woven paper mulberry fabrics were thick, the average weight of the fabric in this study was lighter than 35 g/m<sup>2</sup> which could be classified as light-weight fabrics.

### **2.3 Weft count**

The weft count, shows that the woven fabric made from the yarn spun by the MC method with 6.5 cm fibers has the highest weft count followed by the fabric made from the yarn spun by the MC method with 5.0 cm fibers (Table 2). While, the woven fabric made from the yarn spun by the MH method with 6.0 mm strips had the lowest weft count. However, all of the paper mulberry woven fabrics produced which had 12 warp yarns/inch, were classified as low count

since they had less than 40×40 yarns/inch (Elsasser, 2005).

### **2.4 Strength in warp**

The strength in warp shows that the woven fabric made from the yarn spun by the MH method with 2.0 mm strips had the highest strength in warp direction followed by the woven fabric made from the yarn spun by the MH method with 4.0 mm strips. In contrast, the woven fabric made from the yarn spun by the MC method with 3.5 cm fibers had the lowest strength (Table 2)

### **2.5 Fabric strength in weft direction**

Result in Table 3 shows that the woven fabric made from the yarn spun by the MH method with 4 mm strips had the highest strength in weft direction followed by the fabric made from the yarn spun by the MH method with 6 mm strips. Whereas the woven fabric made from the yarn spun by the MC method with 3.5 cm fibers had the lowest strength .

### **2.6 Elongation in warp direction**

The elongation in warp shows that the woven fabric made from the yarn spun by the MC method with 5.0 cm fibers had the highest elongation in warp direction (19.25%) followed by the fabric made from the yarn spun by the MC

**Table 2** Means of thickness, fabric weight, weft count, strength in warp direction of the paper mulberry woven fabrics made from different yarns preparations

Methods of Yarn Preparation	Fabric Thickness (mm)	Fabric Weight (g/m <sup>2</sup> )	Weft Count (yarns/inch)	Strength in Warp Direction (N)
	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$
MC with 3.5 cm bers	4.19 <sup>a</sup> ±0.30	7.67 <sup>a</sup> ±0.22	13.60 <sup>c</sup> ±1.14	97.82 <sup>f</sup> ±0.79
MH with 6.0 mm strips	4.13 <sup>a</sup> ±0.58	4.52 <sup>e</sup> ±0.07	8.80 <sup>e</sup> ±0.48	293.32 <sup>c</sup> ±7.07
MH with 4.0 mm strips	3.77 <sup>b</sup> ±0.60	7.00 <sup>b</sup> ±0.40	12.20 <sup>d</sup> ±0.45	493.53 <sup>b</sup> ±2.85
MC with 5.0 cm bers	3.40 <sup>b</sup> ±0.20	5.88 <sup>d</sup> ±0.20	15.60 <sup>b</sup> ±0.55	106.27 <sup>e</sup> ±0.70
MH with 2.0 mm strips	3.11 <sup>c</sup> ±0.40	6.34 <sup>c</sup> ±0.51	12.20 <sup>d</sup> ±0.48	581.51 <sup>a</sup> ±6.19
MC with 6.5 cm bers	2.29 <sup>d</sup> ±0.19	7.59 <sup>a</sup> ±0.05	18.20 <sup>a</sup> ±0.84	114.86 <sup>d</sup> ±0.62
<b>CV(%)</b>	<b>10.92</b>	<b>3.69</b>	<b>4.90</b>	<b>1.08</b>

Means in the same column, followed by a common letter are not significantly different at 5 % level by DMRT

method with 3.5 cm strips (17.63%).

Meanwhile, the woven fabric made from the yarn spun by the MH method with 2.0 mm strips had the lowest elongation (Table 3)

### 2.7 Elongation in weft direction

The elongation in weft shows that the woven fabrics made from the yarn spun by the MH method with 4 mm strips had the highest elongation in weft direction followed by the fabric made from the yarn spun by the MH method with 6 mm strips. While, the woven fabric made from the yarn spun by the MC method with 6.5 cm fibers had the lowest elongation in weft direction (Table 3).

### Conclusions

The paper mulberry woven 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 fuzzy and thick. These fabrics were thick, light weight and low count with high strength and high elongation. The paper mulberry woven fabric made from the yarn spun by the MC method with 3.5 cm fibers had the highest thickness and the heaviest weight while the fabric made from the yarn spun by the MC method with 6.5 cm

**Table 3** Means of strength in weft direction, elongation in warp direction, elongation in weft direction of the paper mulberry woven fabrics made from different yarns preparation

Methods of Yarn Preparation	Strength in Weft	Elongation in	Elongation in
	Direction	Warp Direction	Weft Direction
	(N)	(%)	(%)
	$\bar{X}$	$\bar{X}$	$\bar{X}$
MC with 3.5 cm bers	95.10 <sup>f</sup> ±0.75	17.63 <sup>b</sup> ±0.40	7.42 <sup>c</sup> ±0.23
MH with 6.0 mm strips	158.10 <sup>b</sup> ±1.77	7.54 <sup>e</sup> ±0.41	9.58 <sup>b</sup> ±0.43
MH with 4.0 mm strips	204.54 <sup>a</sup> ±1.94	11.03 <sup>d</sup> ±0.61	10.75 <sup>a</sup> ±0.38
MC with 5.0 cm bers	115.82 <sup>e</sup> ±0.64	19.25 <sup>a</sup> ±0.54	6.51 <sup>d</sup> ±0.36
MH with 2.0 mm strips	125.92 <sup>d</sup> ±0.75	7.36 <sup>e</sup> ±0.40	4.93 <sup>e</sup> ±0.51
MC with 6.5 cm bers	132.35 <sup>c</sup> ±2.36	16.25 <sup>c</sup> ±0.50	4.35 <sup>f</sup> ±0.42
<b>CV(%)</b>	<b>0.99</b>	<b>3.64</b>	<b>5.37</b>

Mean in the same column, followed by the common letter are not significantly different at 5% level by DMRT

fibers had the highest weft count. The fabric made from the yarn spun by the MH method with 2.0 mm strips had the highest strength in warp direction while the fabric made from the yarn spun by the MC method with 5.0 cm fibers had the highest elongation in warp direction. This research is a new concept of the paper mulberry use in textiles which are production of semi-industrial from the Thai wisdom in the North and Northeast. Therefore, the results of research are the new knowledge to convey to the community that can value added and career to agricultural planting of paper mulberry in the future.

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### References

ASTM International. 2005a. Standard Test Methods for Testing and Materials. *ASTM Standards Book of Standard*. vol.07.01 (2005): D 76-D 4391.

- ASTM International. 2005b. Standard Test Methods for Testing and Materials. *ASTM Standards Book of Standard*. vol.07.02 (2005): D 4393- latest.
- Chonsakorn, S. 2014. *Characteristics and Properties of Paper Mulberry Yarn and Fabric*. Doctor of Philosophy (Tropical Agriculture) Thesis. Kasetsart University. 161 p.
- Collier, B.J. and H.H. Epps. 1999. *Textile Testing and Analysis*. Merrill, an imprint of Prentice Hall, Inc., U.S.A. 374 p.
- Elsasser, V.H. 2005. *Textiles Concepts and Principles*. 2<sup>nd</sup> ed. Fairchild publications, Inc., New York, U.S.A. 252 p.
- Ujjin, S., S. Samakprakone, P. Siriacha, Y. Mongkolsuk and V. Haruthaithanasan. 2000. Fiber Characteristic of Paper Mulberry from Various Clones, pp. 27-38. *In Proceeding of the 38<sup>th</sup> Kasetsart University Annual conference, 1-4 February 2000*, Kasetsart University, Bangkok Thailand.