

Effect of bamboo/silk blending on moisture management characteristics of fabrics

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Received 8 December 2022; revised received and accepted 22 March 2023

This study aims at determining the moisture management behavior of the silk/bamboo blended fabrics. It is observed that the fabric made from the higher bamboo content has lower wetting time and the fabric made from the higher silk content has higher wetting time. Higher bamboo content fabric has a higher absorption rate, accumulative one-way transport index, spreading speed and overall moisture management capacity as compared to higher silk content fabric.

Keywords: Bamboo, Blended fibre, Comfort, Knitted fabrics, Moisture management, Silk

1 Introduction

Silk, a naturally available fibre with more protein content, can be woven to textiles. The main component of the silk fibre is fibroin, which is obtained from the insects to develop cocoons. The best quality silk is derived from the *Bombyx mori*. The shiny appearance of silk is because of the triangular shape (cross-section) of the fibre, which refracts light fallen on the fabric at various angles¹. Silk is classified into two types, namely mulberry silk and wild silk (tasar silk, eri silk and muga silk). However, there are four different varieties of natural silk which are commercially known and manufactured across the world. From this, the mulberry silk is the most popular and holding about 90% of world manufacturing. Hence, the word 'silk' is commonly referred as silk of mulberry silkworm. Other types of silk fibres are non-mulberry silks, like tasar silk, eri silk and muga silk. Some other varieties of non-mulberry silk, are identified in Asia and Africa, are agara silk, anaphe silk, coan silk, spider silk and mussel silk².

The silk fibre is mainly known for its commercial properties, such as low density, high resistance to deformation, high strength, good insulation properties and shiny nature of the fibres. The low density of the

fibre helps to develop the comfortable and light clothing. High resistance to deformation tends to manufacture industrial fabrics. Good insulation behaviour helps to keep warm in winter and cool in summer. Shiny behaviour of the fibre leads to develop attractive clothing³. Regenerated bamboo fibre is made up of 100% cellulose, which is biodegradable and also environment friendly fibre. The fabrics made from this fibre are very soft and antibacterial with a minimal of creasing and pilling. Fabrics woven from bamboo fibre have very good in physical characteristics⁴. The bamboo fibre needs a very low quantity of dye materials for the shade as compared to the cotton fabrics. Also, the colorant is absorbed faster and better than in dyed bamboo fabric and cotton fabrics. The bamboo fibre has a very good air permeability and water vapour permeability characteristics because of its micro-gaps structure⁵.

The mechanism of moisture management in a textile fabrics is mainly depending on the dynamic liquid passage from the inner fabric layer (layer next to the skin) to the outer layer of the fabric; i.e. the amount of water transferred between the two layers of the fabric, and the textile liquid passage process dynamically and quantitatively⁶⁻⁷. Accumulative one-way transport index (AOTI) is the change in the moisture cumulative content, which is present in the outer and inner layers of the fabric. This is evaluated using the following equation:

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$$AOTI = \frac{\int U_b - \int U_t}{T}$$

where U_b is the rate of water content accumulated with respect to time on the fabric's bottom surface; U_t , the rate of water content accumulated with respect to time on the fabric's top surface; and T , the total time of testing⁸.

It is observed that various studies have been done on the blended fabrics for their physical, thermal comfort and the moisture management properties. But, to the best of our knowledge, the studies on the moisture management properties of the bamboo/silk fabric is not available in the existing literature. Hence, this work is aimed at studying the moisture management properties of bamboo/silk fabrics woven from the bamboo/silk blended yarn.

2 Materials and Methods

Bamboo fibres and cut strands of mulberry silk were used to prepare a series of silk/bamboo blended yarns with the blend proportions 70:30, 50:50, and 30:70. In addition, a 100% spun silk yarn and a 100% bamboo yarn were also used. This blending procedure was done in the Lakshmi line machines to create 60s Ne (9.84 tex) yarn. Using an unevenness tester at a testing speed of 100 m/min, the evenness of the yarn was evaluated.

2.1 Moisture Management Characteristics

AATCC 195-2009 standard was used to measure the moisture management properties of the fabric on SDL-ATLAS moisture management tester. This is based on the theory that electrical resistance varies according to the amount of water present in a fabric sample at the time when it is exposed to a wet environment. The electrical conductivity of the water and the surface area of fabric with water content

influence the electrical resistance. Nearly 24 h prior to the testing, all fabric samples underwent pre-treatment and conditioning.

2.2 Statistical Analysis

One-way analysis of variance (ANOVA) was used to examine the significance of the relationship between the blend ratio of the silk/bamboo blended fabrics. If the value of P is equal to or less than 0.05, both the variables and the experiment are statistically significant.

3 Results and Discussion

The test results of moisture management properties of bamboo/silk fabric as grades are shown in Table 1.

3.1 Effect of Bamboo/Silk Blending on Wetting Time

Table 1 depicts how quickly the bamboo/silk blend fabric dries. According to Yao *et al.*⁶, WT_t and WT_b are the times at which the top and bottom surfaces of the cloth sample first get wet. It should be noted that the wetting time of the bamboo and silk fibres blended fabric varies on the back and face of the materials. The outcome shows that for all the cloth samples, the bottom surface typically takes longer to wet than the top surface, as the time a cloth takes to dry mostly depends on how absorbent a fabric is⁹. It is observed that the fabrics having more bamboo fibre content take less time to wet in both bottom and top surfaces as compared to the fabric having silk fibre content¹⁰. This is because of the low packing density of the bamboo fibres, which, in turn, develop more pores in the yarn. As the silk fibre content increases, the yarn will tightly packed and it will resist process of wetting. So, when the content of bamboo fibre increases the wetting time of fabric will decrease¹¹.

3.2 Effect of Bamboo/Silk Blending on Absorption Rate

The rates of moisture absorption by the bottom and top surfaces of the bamboo/silk blended fabrics are as

Table 1 — Moisture management properties and grade of bamboo/silk blended fabrics

Blend ratio (Bamboo/Silk)	WT_t , s (Grade)	WT_b , s (Grade)	AR_t , %/s (Grade)	AR_b , %/s (Grade)	MWR_t , Mm (Grade)	MWR_b , Mm (Grade)	SS_t , mm/s (Grade)	SS_b , mm/s (Grade)	AOTI, % (Grade)	OMMC (Grade)
100/0	6 (3)	6.2 (3)	98 (4)	100 (4)	4.2 (4)	4.3 (4)	20 (5)	21 (5)	402 (5)	0.7 (4)
70/30	6.7 (3)	7 (3)	86 (4)	89 (4)	4 (4)	4.2 (4)	19 (4)	20 (5)	360 (4)	0.63 (4)
50/50	7.3 (3)	7.5 (3)	76 (4)	81 (4)	3.9 (4)	4.1 (4)	18 (4)	19 (5)	220 (4)	0.55 (3)
30/70	8 (3)	8.3 (3)	65 (4)	70 (4)	3.6 (4)	3.9 (4)	17 (4)	18 (4)	160 (3)	0.49 (3)
0/100	8.8 (3)	9 (3)	53 (4)	56 (4)	3.2 (4)	3.3 (4)	16 (4)	17 (4)	60 (2)	0.42 (3)

WT_t – wetting time top; WT_b – wetting time bottom; AR_t – absorption rate top; AR_b – absorption rate bottom; MWR_t – maximum wetted radius top; MWR_b – maximum wetted radius bottom; SS_t – spreading speed top; SS_b – spreading speed bottom; AOTI -accumulative one-way transport index; and OMMC – overall moisture management capability.

shown in Table 1. It is observed that the absorption rate has a great impact on the bamboo/silk blended fabrics. The rate of absorption is defined as the ability of moisture absorption by the top and bottom fabric surfaces within 20 s. The absorption rate increases as the bamboo fibre content increases. This is primarily because of the higher air spaces between the fibres and low packing density of fabric made with higher bamboo fibre content as compared to the fabric made with higher silk fibres content¹². The absorption rates of the top fabric surfaces are found higher than the bottom fabric surfaces of bamboo/silk blend fabric. This demonstrates, how the moisture liquid spreads out uniformly across the underside of the cloth samples¹³.

3.3 Effect of Bamboo/Silk Blending on Spreading Speed

The effect of bamboo/silk blending on spreading speed of the fabric is shown in Table 1. The result shows that the spreading speed is more in the fabric sample having more bamboo fibre content. The lower spreading speed in fabric with more silk fibres is due to the lower yarn hairiness which acts as a water transporting medium. However, the fabric made with higher bamboo content shows more hairiness and have higher spreading speed¹⁴. So, the spreading speed of the fabric increases with the increase in bamboo fibres content and decrease with the increase in silk fibres.

3.4 Effect of Bamboo/Silk Blending on Maximum Wetted Radius

The influence of bamboo/silk blending on the maximum wetted radius of the fabrics is shown in Table 1. The result proves that the maximum wetted radius increases when the bamboo fibre content increases in the fabrics. This is due to the lower packing density when bamboo fibre increases and hence availability of more space to pass the liquid¹⁵. Hence, the spreading speed increases when the bamboo fibre content is increased.

3.5 Effect of Bamboo/Silk Blending on AOTI

The effect of bamboo/silk blending yarn on accumulative one way transport index (AOTI) of the fabric is shown in Table 1. Accumulative one way transport index is defined as the change in accumulated moisture between the bottom and top fabric surfaces. It is found that the blending of bamboo/silk affects the accumulative one way transport index of the fabrics. It is clearly observed

that the AOTI of fabrics is increased when the bamboo content of fibre increases and it is decreased when the silk fibre content has increased.

3.6 Effect of Bamboo/Silk Blending on OMMC

The overall moisture management capability (OMMC) is primarily influences the absorption rate, spreading speed and one-way liquid transport index of the textile fabric sample. Table 1 shows the results of OMMC of the fabric. The results are analyzed and compared with the scale of standard grading (>0.8 excellent, 0.6-0.8 very good, 0.4-0.6 good, 0-0.2)⁶. It is observed from the above grading that the overall moisture management capability of the fabrics increases when the bamboo fibre content in the fabric is increased. This is because of the excellent spreading speed, wetted radius, absorption rate, and wetting time of the fabric. The overall moisture management capacity decreases when the silk fibre content has increased. This is because of the lower rate of absorption, lower wetted radius, lower spreading speed, and the slower wetting time of the fabric. All the fabric samples are categorized under the water penetration fabric⁶.

3.7 Data Analysis

ANOVA testing has been carried out to interpret the statistical significance of bamboo/silk blending on the moisture management characteristics of the fabric. Analysis of variance (ANOVA) is carried out by SAS System (version 8 for Windows) (alpha level of 0.05) to determine any significant changes in the properties of the moisture management. If the probability (p) value is less than 0.05, the variables are deemed significant. Table 2 presents the one-way ANOVA findings for the fabric's moisture management properties.

From the Table 2, it is observed that the value of p for moisture management characteristics of the bamboo/silk blended fabric is less than 0.05. This clearly shows that the bamboo/silk blending has a significant impact on the on the moisture management characteristics of the fabric at 95% confidence level. Hence, it is concluded that the bamboo/silk blending influences wetting time of bottom and top surfaces, rate of absorption of bottom and top surfaces, spreading area of bottom and top surfaces, spreading speed of bottom and top surfaces, accumulative one way transport index and overall moisture management capability of the fabrics.

Table 2 — One-way ANOVA on wetting time of top surface of fabric and blend ratio

Response	Source of variation	SS	Df	MS	F	P-Value	F-Crit
Top wetting time, s	Blend ratio	52.18	4	13.04	825.68	1.84E-41	2.58
	Error	0.71	45	0.02			
	Total	52.89	49				
Bottom wetting time, s	Blend ratio	42.71	4	10.68	1160.02	9.29E-45	2.54
	Error	0.41	45	0.01			
	Total	43.12	49				
Top absorption rate, %	Blend ratio	11573.48	4	2893.37	3981.70	9.81E-57	2.54
	Error	32.7	45	0.73			
	Total	11606.18	49				
Bottom absorption rate, %	Blend ratio	11376.08	4	2844.02	1838.80	3.22E-49	2.54
	Error	69.6	45	1.55			
	Total	11445.68	49				
Top maximum wetted radius, mm	Blend ratio	100	4	25	37.5	8.54E-14	2.54
	Error	30	45	0.67			
	Total	130	49				
Bottom maximum wetted radius mm	Blend ratio	100	4	25	32.61	8.98E-13	2.54
	Error	34.5	45	0.77			
	Total	134.5	49				
Top spreading speed, mm/s	Blend ratio	9.97	8	1.24	229.96	2.32E-52	2.54
	Error	0.43	81	0.005			
	Total	10.40	89				
Bottom spreading speed , mm/s	Blend ratio	6.08	4	1.52	198.26	5.91E-24	2.54
	Error	0.345	45	0.01			
	Total	6.425	49				
AOTI	Blend ratio	1852618	4	23157	481.7093	6.03E-65	2.54
	Error	38940	45	480.74			
	Total	1891558	49				
OMMC	Blend ratio	0.49	4	0.12	400.11	1.55E-34	2.54
	Error	0.01	45	0.0003			
	Total	0.50	49				

4 Conclusion

The wetting time of the fabric is slower when the silk fibre content increases. On the other hand, the wetting time of fabric is faster when the bamboo fibre content increases. The absorption rate of the fabric is slower when the of silk fibre content increases, while it is faster when the bamboo fibre content increases. The spreading area of the fabric is lower when the silk fibre content increases, while it is higher when the bamboo fibre content increases. The spreading speed of the fabric is lower when the silk fibre content increases, while it is higher when the bamboo fibre content increases. The accumulative one-way index of the fabric is lower when the silk fibre content increases, while it is higher when the bamboo fibre content increases. All the fabrics are in the category of ‘good’ overall moisture management capacity. The bamboo/silk blending has a significant influence on the overall moisture management capacity of the fabric with respect to the absorption rate, wetting time,

spreading area, spreading speed, and accumulative one way transport index of the fabric. Hence, overall moisture management capacity of the fabric is improved when the content of bamboo fibre increases.

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