© Kamla-Raj 2018 J Soc Sci, 57(1-3): 29-36 (2018)
PRINT: ISSN 0971-8923 ONLINE: ISSN 2456-6756 DOI: 10.31901/24566756.2018/57.1-3.2231

A Comparative Study on Wicking Behavior of Blended Knitted Fabrics and Their Relationship with Structural Parameters

Shikha Bajaj[1], Sandeep Bains[2] and Pritpal Singh[3]

[1,2]Department of Apparel and Textile Science, College of Home Science,
[3]Department of Plant Breeding & Genetics, College of Agriculture,
Punjab Agricultural University, Ludhiana 141004, Punjab, India
E-mail: [1]<shikhabajaj26@gmail.com>, [2]<sandeepct@pau.edu>,[3]<pritpal@pau.edu>

KEYWORDS Blend. Moisture.Silk. Viscose. Wicking.Yarn

ABSTRACT Ability to wick moisture is a property of paramount importance for any fabric intended for apparel use. The present compositionexplains wicking performance of six different circular knitted fabrics blended by using mulberry silk waste and viscose fibre.Knitted fabrics were constructed on circular knitting machine by using yarns blended in three proportions viz. 60 percent mulberry silk waste: 40 percent viscose, 50 percent mulberry silk waste: 50 percentviscose and 40 percent mulberry silk waste: 60 percent viscose, in two unlike yarn densities. Investigation was carried out for both wale-wise and course-wise directions. Variables like yarn count, fabric thickness, tightness factor and GSM were used for experimental design. It was revealed that rise in values of yarn count, fabric thickness and GSM bring about a fall in wicking distance by the fabric.

INTRODUCTION

Property of wicking is measure of water absorbency and high ability to wick is an enhancement to serviceable properties of the material (Mittal and Bahners 2017). Enhanced moisture wicking properties lead to soft and silk like appearance of the fabric (Shoemaker 2005). Skin in contact with textiles has a significant relation with the comfort of clothing because the properties of fabrics are closely related to their surface and frictional behavior. Many researchers have studied comfort over the past years and found that it was perfect harmony between human being and environment. Moisture transmission is an important property involved in comfort providing parameters **(**Valsang and Patil 2013)**.** Sweating on skin surface leads to sense of discomfort (Song 2011).Wicking explains the liquid transport performance of fibrous bunch and plays a crucial role in establishing the comfort characteristics of fabrics (Kumar and Das 2014). Movement of liquid moisture in fabrics is a manifold phenomenon which banks on the hydrophilic characteristics of the intrinsic fibres, inter and intra-yarn capillaries and hygroscopicity (water absorption capacity) of the fibres (Williams 2009). Hydrophilic fibres show more affinity for the water and slow down the wicking rate. Small, uniformly distributed and interconnected pores over the fabric surface are found to be effective in faster wicking, while large pores, structural irregularities, and poor connectivity of the poreswithin the geometry show poor wicking ability. Theporosity of knitted fabrics is affected by number of courses and wales per unit length, of thefabric structure, and hence candetermine their capillary grid (Kumar and Das 2014).

Transmission of liquid moisture mostly occurs in two directions viz. horizontal and vertical. Horizontal or lateral wicking effect is spreading water into the surface of the fabric and movement of liquid from one side to the other is known as vertical wicking (Williams 2009). The horizontal wicking rate shows the water absorption and diffusion ability is created by the capillary effect of the fabric in the horizontal direction (Yu et al. 2015). On the other hand, vertical wicking determines the ability of vertically aligned fabric specimens to transport liquid along and/or through them.

Moisture transmission properties of clothing materials are crucial to apparel thermal comfort as these influence the direct and latent heat loss from the human body (Valsang and Patil 2013). Fangueiro et al. (2010) compared various laboratory test procedures for measurement of wicking performance which revealed that determination of the wicking heights in numerous fabrics gives indication a lower contact angle gives rise to higher wicking rates.Wicking rate is a specially significant property for measurement of a fabric's ability to remove sweat from contact with the body (AATCC News 2013).Objective measurement of the moisture transfer properties of clothing is therefore important to apparel product development (Valsang and Patil 2013).

Objectives

In the present paper, the researchers intend to study the vertical wicking performance of six knitted fabrics blended in several proportions of mulberry silk waste and viscose fibre, in two different yarn counts.

MATERIAL AND METHODS

Vertical wicking behavior of knitted fabrics was evaluated by using JIS L1907 test method. The fabrics were preconditioned before testing and test was conducted in standard working conditions of 20 ± 2°C and 65 ± 2% relative humidity. Swatches of knitted fabrics were cut in rectangular shape measuring 200 mm × 25 mm in size for both wale wise and course wise directions. Distilled water was filled in a beaker and fabric strips were hung up vertically with their lower ends plunged in distilled water at a depth of 20 mm (Fig. 1). Lower end of fabric strip hanging in distilled water was clamped with a clip weighing 4 g. During wicking, distance travelled by distilled water on fabric specimens was measured for first 5 minutes. Since thetime required by the moisture to transport across the fabric thickness is typically very short, it is crucial to measure wicking height at initial stage (Miao and Xin 2017). After this, the distance was checked again at regular intervals of 5 minutes, for 30 minutes.

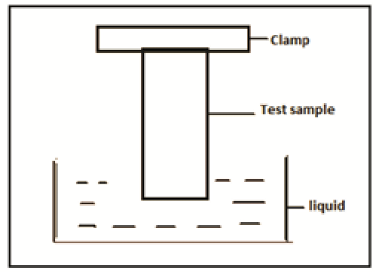

Fig. 1. Schematic diagram of wicking
Source: Author

RESULTS AND DISCUSSION

Test fabrics were knitted by using yarns blended in three proportions viz. 60 percent mulberry silk waste: 40 percent viscose, 50 percent mulberry silk waste: 50 percent viscose and 40 percent mulberry silk waste: 60 percent viscose, in two yarn counts (15 and 20 Nm). Knitting was carried out on circular knitting machine and single jersey structures were produced on 10 gauge. Structural details of fabrics like fabric thickness and GSM have been furnished in Table 1. Since, twist per inch is a parameter that influences output behavior of yarns, it was viewed as being held constant. Variables are viewed as changing while parameters typically either don't change or change more slowly (Nykamp 2012), therefore, all the yarns were incorporated with same amount of twist (10 twists per inch).

Table 1: Structural details of test samples

Fabric composition	*Knitted structure*	*Yarn count (Nm)*	*Twist per inch*	*Fabric thickness (mm)*	*Tightnes factor*	*GSM*	*Fabric code*
60% Mulberry silk waste: 40% Viscose	Single jersey	15	10	0.820 ± 0.023	4.527 ± 0.025	184.564.667 ± 0.540	A_1
60% Mulberry silk waste: 40% Viscose	Single jersey	20	10	0.790 ± 0.043	4.529 ± 0.015	142.630 ± 0.704	A_2
50% Mulberry silk waste: 50% Viscose	Single jersey	15	10	0.763 ± 0.012	4.530 ± 0.002	203.667 ± 0.333	A_3
50% Mulberry silk waste: 50% Viscose	Single jersey	20	10	0.663 ± 0.012	4.532 ± 0.002	175.333 ± 0.667	A_4
40% Mulberry silk waste: 60% Viscose	Single jersey	15	10	0.883 ± 0.024	4.534 ± 0.003	180.667 ± 0.667	A_5
40% Mulberry silk waste: 60% Viscose	Single jersey	20	10	0.703 ± 0.003	4.529 ± 0.000	134.333 ± 0.333	A_6

Findings for wicking heights for various test specimens,in wale-wise direction, have been shown in Figure 2. For course-wise direction, wicking heights have been depicted in Figure 3. Maximum wicking height (2.63 cm), in the direction of wales,was achieved by fabric A_4followed by fabric A_6 and A_5, which attained a height of 2.41 and 2.26 cm respectively. Fourth on order was fabric A_3 which achieved a height of 2.0 cm. Fabric A_2 and A_1 were on last with wicking heights of 1.78 and 1.68 cm respectively. A significant difference was observed among the val-

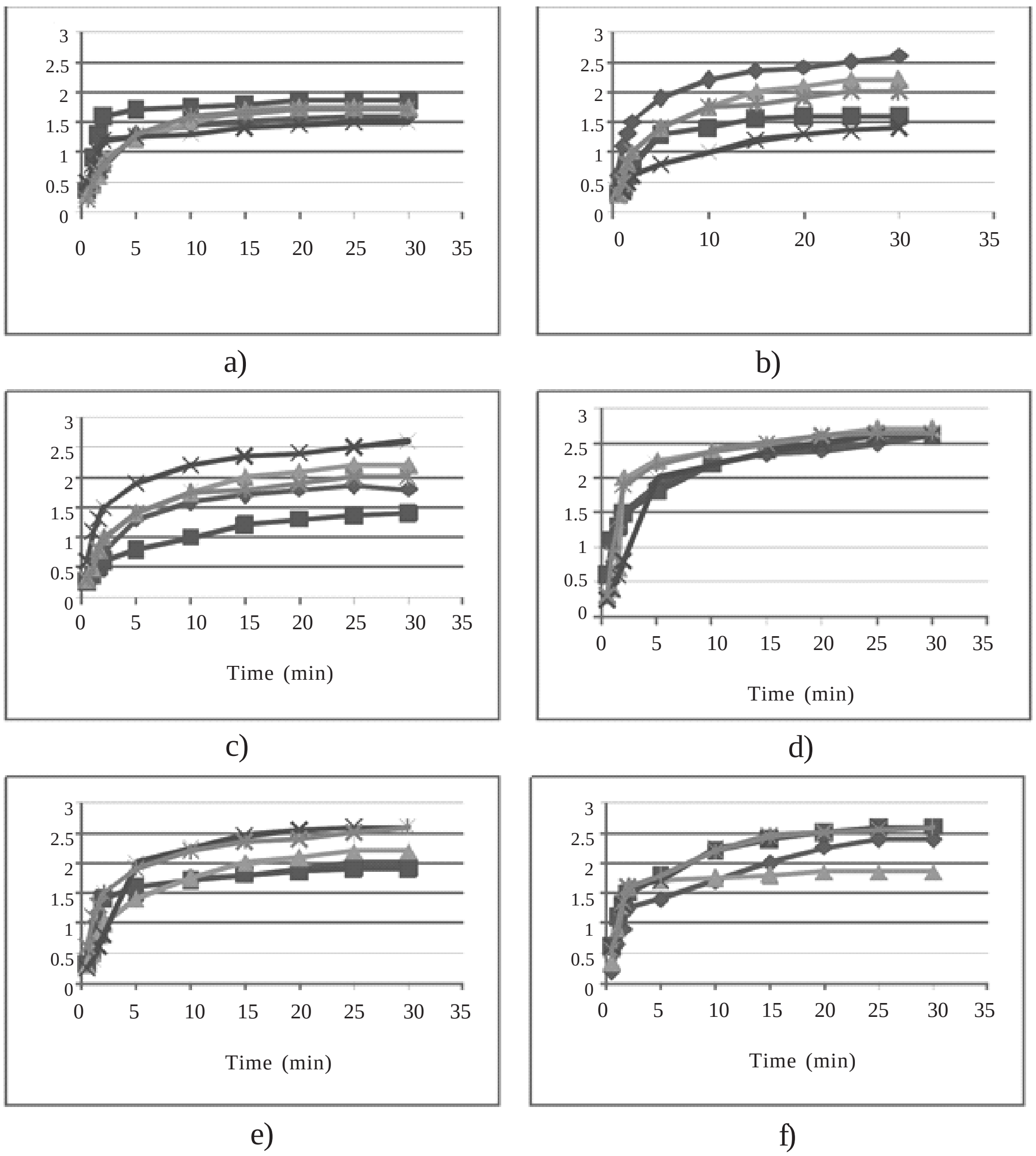

Fig. 2. Wicking heights for wale-wise direction (five readings) for a) Fabric A_1,b) Fabric A_2,c) Fabric A_3,d) Fabric A_4, e) Fabric A_5 and f) Fabric A_6
Source: Author

ues obtained for different fabrics (Table 2). For the direction of courses, maximum wicking distance 2.26 cm was attained by fabric A_4 as well. Similar to the findings of wale-wise direction, fabric A_6 and A_5 can be placed on second and third position with their wicking heights of 2.18 cm and 2.09 cm respectively. A lesser distance of 1.8 cm was travelled by liquid for fabric A_3. In case of fabrics A_2 and A_1, wicking heights of 1.69 cm and 1.63 cm were obtained respectively. Figures for course-wise direction also differed significantly. The trend might be observed due to difference in thickness of fabrics. Fabric A_4 having lowest thickness showed highest wicking height. The water transmission properties are highly influenced by thickness of the fabric (Yu et al. 2014). While studying wicking behavior of warp knitted fabrics, Yu et al. (2014) was found that fabrics with lesser thickness and lower GSM attained higher wicking heights. Wicking height decreases with rise in thickness majorly because area with compactness increases and number of air spaces decrease. As opined by Parsons (1993), thickness, number of fibres in yarn and fibre diameter influence micro capillary radius. Since same fibres have been used for knitting all the fabrics, fibre diameter remains equal for all of them, however, thickness of fabric in this case has played an important role in deciding the wicking behavior fabrics. Since higher thickness makes higher microcapillary radius, which in turn decreases capillary pressure will required wicking, thus, reducing the wicking. Lower pressure in capillariesis responsible for lower moisture transmission through wicking. Because of this theoretical reason, wicking height is reduced as pick density is increased. According to Chatterjee and Singh (2014), change in thickness of fabric will affect the macrocapillary radius. Also, micro capillaries act as reservoir which may enhance the wicking height. Therefore, in this case, higher wicking heights are seen in fabrics with lower thickness (fabric A_4 and A_6) values and the wicking heights decrease with rise in thickness of fabric (Fig. 4). The phenomenon was confirmed by computation of correlation coefficient (Table 3) between thickness values of fabrics and wicking distances travelled, collectively for both wale-wise and course-wise directions, and fairly negative correlation coefficient were obtained indicating rise of wicking height with fall in thickness of the material. The relationship was found to be significant with p value of 0.001141 at 95 percent confidence level. Apart from this, tightness factor among knitted fabrics is a vital parameter to be noticed in wicking distances. As the yarn density increased, volume pores must have lessened. Nelson and Henry (2000) opined that pore geometry of the fabric plays an important part in moisture transmission. Fabrics can also behave differently while achieving wicking heights. This was because of the different tightness factors for all. It was suggested that fabrics with maximum tightness can achieve higher wicking heights. In the present experiment, there was not much difference noticed among the tightness factors of blended knitted fabrics.

Table 2: Maximum wicking heights for wale-wise and course-wise direction

Fabric code	*Maximum wicking height (wale-wise)*	*Maximum wicking height (course-wise)*	*t-value*
A_1	1.68^c	1.63^b	0.310
A_2	1.78^b	1.69^b	0.390
A_3	2.00^a	1.80^a	0.534
A_4	2.63^a	2.26^a	3.995*
A_5	2.26^a	2.09^a	0.294
A_6	2.41^a	2.18^a	0.269
Critical difference	0.391	0.489	-

^{a,b,c} Significant at 5 % level of significance, same alphabet= no significant difference, different alphabet= significant difference, CD= Critical difference

Also, it was noticed in the Figures 2 and 3 that initially water transmission occurred with a high rate, however after a time span of five minutes, water tend to rise slowly. Initially, the space inside fabric material is occupied with air, which has low viscosity. It poses less resistance to water at the initial stage, therefore liquid travels at a higher rate, however, later liquid enters the fabric materials and occupies the space. Liquid in this case has higher viscosity than air and the resistance is more than the earlier, therefore the process of wetting slows down (Masoodi and Pillai 2012).

Fabric A_5 with higher value of thickness than fabric A_2, shows more wicking height. This can be understood by stating the higher moisture absorbing nature of viscose fibre in comparison to silk fibre. According to Balazsy and Eastop (2012), moisture absorption in case of viscose fibre can go as far as 16 percent, however silk fibre in general cannot gain more than 11 per cent.

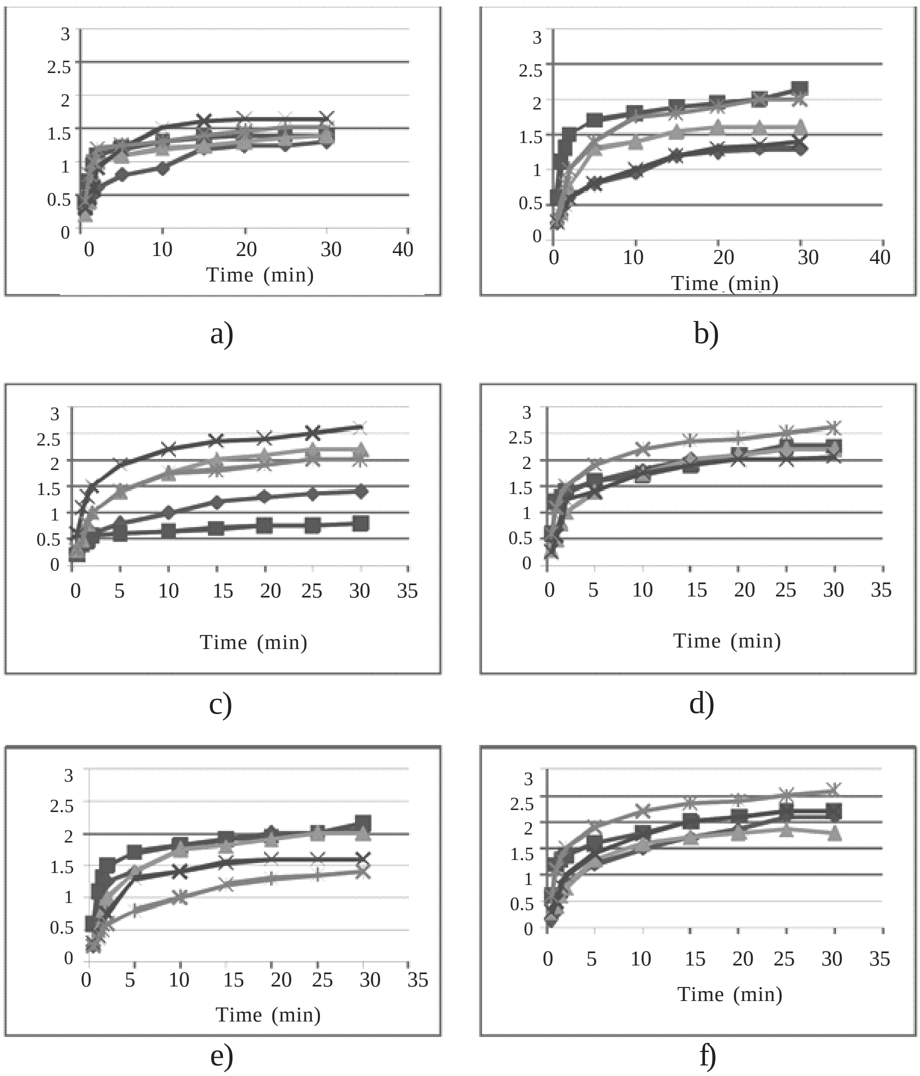

Fig. 3. Wicking heights for course-wise direction (five readings) for a) Fabric A_1,b) Fabric A_2,c) Fabric A_3,d) Fabric A_4, e) Fabric A_5 and f) Fabric A_6
Source: Author

Fabric A_5, with its higher viscose content was able to obtain higher wicking height. Hydrophillic fibres when used in fabric construction, initial wetting of fabric facilitate the molecules of liquid to reach the surface of material. After this, the molecules are pushed to polymer arrangement till the polymer gets doused (Au 2011).

Fabric weight or GSM also plays a significant role in deciding wicking behavior of fabrics. Cruz et al. (2017), concluded in a study that moisture absorption in fabrics was significantly related to fabric weight. Fairly negative correlation coefficientshows that high values will cause a fall in wicking heights (Table 3 and Fig. 5). The findings were significant with p value <0.0001 at 95 percent confidence level. Single faced fabrics with GSM between 100 to 200, are considered to have superior wicking and siphoning characteristics (Anonymous 2011). In a study by Ramachandran and Kanakaraj (2012), non-woven

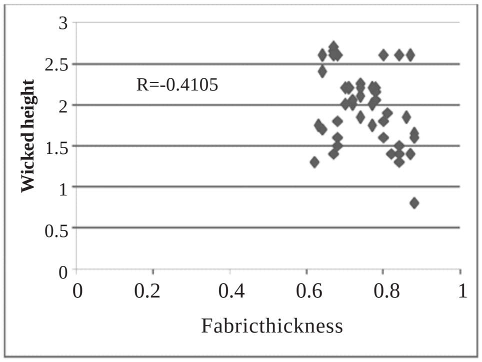

Fig. 4. The correlation between fabric thickness and wicked height
Source: Author

fabric sample with lower GSM was recommended for use in comparison to fabric of higher GSM because of its higher wicking rates. It can be witnessed that fabrics A_4, A_6 and A_5 were having higher wicking distances in comparison to fabrics A_3, A_2 and A_1. The effect can be attributed to lower GSM values of the former fabrics. Vertical wicking rates for fabric with lower density, crossed those carrying higher densities during experimentation by Chatterjee and Gupta (2002).

It was observed that fabrics A_4, A_6 have obtained relatively higher wicking heights. Fineness of yarn can be the attributing factor (Fig. 6). Both of these fabrics were knitted by using finer yarns in comparison to their composition counterparts. In a study by Anonymous (2018), it was concluded that fabrics with higher tax value (lower value for Nm), were found to have higher capillary rise of moisture. Same was confirmed by negative correlation coefficient calculated between yarn counts and wicking heights (Table 3). For calculation of correlation coefficient, values of yarn count were converted to direct yarn numbering system (Tex) in order have an easier understanding of relationship between the two variables. The results were significant in this case with p value <0.00001 at 95 percent confidence level.

Table 3: The correlation coefficients of structural variables with wicked heights

Variables	*Correlation coefficient (r)*	*P value*
Fabric thickness	-0.4105	0.001141*
GSM	-0.7426	<0.00001*
Yarn count	-0.6176	<0.00001*

*Significant at 5% level of significance

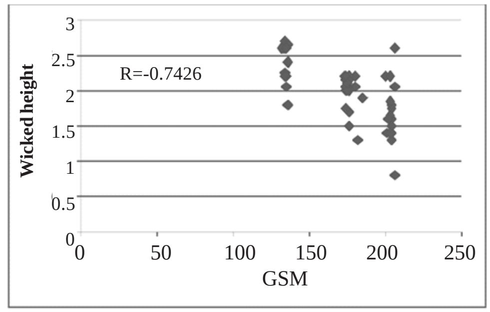

Fig. 5. The correlation between GSM and wicked height
Source: Author

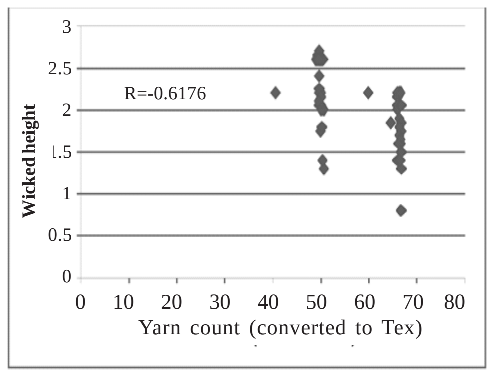

Fig. 6. The correlation between yarn count (Converted to Tex) and wicked height
Source: Author

Figure 7 elucidates the comparison between wicking heights accomplished by all the six fabrics, in both wale-wise and course-wise direc-

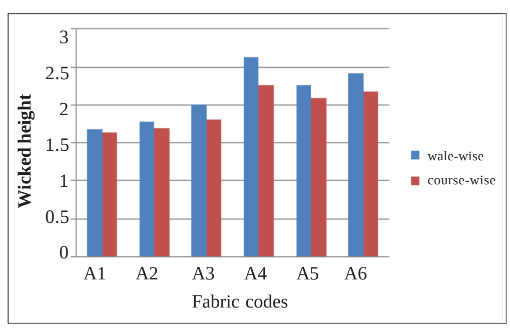

Fig. 7. Comparison of wicking heights in wale-wise and course-wise direction

tion. Greater wicking heights were marked in the direction of wales for all the fabrics.There was significant difference found in the wicking heights achieved by fabric A_4 in both directions (Table 2). Yu et al. (2014), studied wicking heights of knitted fabrics and also found that distance travelled by liquid exceeded by 8 cm along the wale-wise direction. It was opined by the authors that same was general feature of knitted fabrics. Apart from this, in a study by Sampath et al. (2011), wicking lengths of wale-wise direction were observed as higher than course-wise direction.

CONCLUSION

The level of comfort provided by blended knitted fabrics varies with their structural parameters. Longest wicking distance was travelled on knitted fabric blended in 50 percent mulberry silk waste: 50 percent viscose fibre, in 20 Nm yarn count.

The fabric thickness, yarn and fabric densities were seen to impact the resultant wicking behavior of blended knitted fabrics, it was observed that increased values of fabric thickness affect the capillary action, reduce the liquid pressure and hence, final wicking heights were reduced in blended knitted fabrics. GSM when increased also tended to hinder the moisture transmission, and lowered the wicking distances. Lesser yarn densities,that is, fabrics knitted by using 20 Nm yarn were found to obtain longer wicking heights.

Fairly negative correlation coefficients (-0.4105, -0.7426 and -0.6176 respectively) were recorded for alliance between fabric thickness, GSM and yarn count with achieved wicking heights by different fabrics. Initial rate of liquid transmission was more due to less resistance posed by occupying air, which becomes more at later stage when moisture enters and saturates the fabric.Wale-wise wicking lengths were higher than course-wise lengths.

RECOMMENDATIONS

GSM when increased also tended to hinder the moisture transmission, and lowered the wicking distances. Lesser yarn densities that is fabrics knitted by using 20 Nm yarn were found to obtain longer wicking heights and therefore are recommended use in temperate regions.

Knitted fabric blended in 50 percent mulberry silk waste: 50 percent viscose fibre, in 20 Nm yarn count is recommended the most for apparel construction because of its unmatched absorbent qualities and high wicking lengths achieved. The draft of wicking behavior developed can be further utilized to study the significance of other variables of fabric construction.

ACKNOWLEDGEMENTS

We owe sincere thanks to staff members of M.S. Randhawa Library, Punjab Agricultural University, Ludhiana, for their cooperation during accessing books and literature which could lead to successful completion of the work. Financial help from UGC is duly acknowledged.

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Paper received for publication on November 2018
Paper accepted for publication on December 2018