# Effect of regenerated cellulosic fibre content in polyester/regenerated and cotton/regenerated blend yarns on comfort properties of woven fabrics

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**ABSTRACT – REZUMAT**

**Effect of regenerated cellulosic fibre content in polyester/regenerated and cotton/regenerated blend yarns on comfort properties of woven fabrics**

*This study investigates some comfort properties of cotton and polyester fabrics blended with varying ratios (%) of regenerated cellulosic fibres including Viloft®, ProModal®, and bamboo fibre. 23 types of woven samples made of Viloft®, ProModal®, and bamboo regenerated cellulosic fibres blended with polyester and cotton at different proportions (100%, 67/33%, 50/50%, 33/67%) besides with 100% cotton and 100% polyester fabrics were produced. Woven samples were subjected to some comfort tests including air permeability (mm/sec), wicking rate (mm/sec), water absorption ratio (%), and water vapour permeability index was also obtained. Statistical test results regarding fibre type, fibre blend components, and blend ratio (%) on fabric comfort properties were evaluated by using the SPSS program. In the content of this experimental work, it was revealed that fibre type, fibre blend components, and blend ratio have a significant effect on some comfort properties such as air permeability, wicking rate, and absorption ratio. However, those parameters did not have any significant effect on the water vapour permeability index at a 95% significance level.*

**Keywords:** *regenerated cellulose fibre, Viloft®, ProModal®, bamboo, wicking rate, water vapour permeability index*

**Influența conținutului de fibre celulozice regenerate din fire în amestec de poliester și bumbac regenerat asupra proprietăților de confort ale țesăturilor**

*Acest studiu investighează unele proprietăți de confort ale țesăturilor din bumbac și poliester în amestec cu proporții diferite (%) de fibre celulozice regenerate, inclusiv Viloft®, ProModal® și fibre de bambus. Au fost produse 23 de tipuri de mostre țesute din fibre celulozice regenerate Viloft®, ProModal® și bambus amestecate cu poliester și bumbac în diferite proporții (100%, 67/33%, 50/50%, 33/67%) pe lângă țesături din 100% bumbac și 100% poliester. Probele țesute au fost supuse unor teste de confort, inclusiv permeabilitatea la aer (mm/sec), viteza de absorbție (mm/sec), raportul de absorbție a apei (%) și indicele de permeabilitate la vapori de apă a fost, de asemenea, determinat. Rezultatele testelor statistice privind tipul de fibre, componentele amestecului de fibre și raportul de amestec (%) asupra proprietăților de confort ale țesăturii au fost evaluate folosind programul SPSS. În conținutul acestei lucrări experimentale, a fost evidențiat faptul că tipul de fibre, componentele amestecului de fibre și raportul de amestec au o influență semnificativă asupra unor proprietăți de confort, cum ar fi permeabilitatea la aer, viteza de absorbție și raportul de absorbție. Cu toate acestea, acești parametri nu au avut nicio influenţă semnificativă asupra indicelui de permeabilitate la vapori de apă la un nivel de semnificație de 95%.*

**Cuvinte-cheie**: *fibre celulozice regenerate, Viloft®, ProModal®, bambus, rata de absorbție, indice de permeabilitate la vapori de apă*

## INTRODUCTION

The blending of fibres is a way of improving fibre features for emphasizing the good qualities and minimizing the poor qualities. Different fibre blending allows fabric production with high comfort and durability at the same time. Regenerated cellulosic fibres have been generally utilized in fibre blends for new yarn types [1] Those yarn types also may be presented as new raw material alternatives for new functional products. Today some regenerated fibres such as viscose, bamboo, Promodal®, Tencel®, Viloft® are frequently used in fibre blends at different ratios (%). Viloft® fibre which is known for its softness may be blended with cotton and polyester blends. This special fibre containing 70% air gap with a crenellated surface may be utilized in comfortable fabrics [2]. It was observed that Viloft® rich blends generally improved the thermal properties of the fabrics. According to the comparison of mechanical properties of Viloft® blend fabrics with that of polyester, Viloft® reach fabrics were found to be having lower bursting strength and pilling properties [3, 4].

Sportswear knitted fabrics produced from Viloft® and its blends with natural, synthetic, and functional fibres were evaluated in terms of mechanical and thermal comfort properties in another study. The authors concluded that Viloft®/wool blends of fabrics indicated higher thermal resistance and water vapour resistance while Viloft®/Coolmax fabrics revealed high liquid moisture comfort among Viloft® blended fabrics which showed they might be preferable for sportswear [5]. Tencel® known for its nanofibril structure absorbing a high amount of liquid and quickly releasing it again also provides a soft feeling. Promodal is a blend of Tencel and Modal which has a smooth structure and cotton-like section therefore combining the advantages of both Tencel and Modal fabrics rich in Promodal® are used for activewear, casual wear, intimate apparel, and home textiles [6]. Moisture management properties of bamboo, viscose and Tencel® single jersey knitted fabrics were investigated where the overall moisture management capacity decreased as the Tencel® content increased [7]. In another study, sportswear fabrics were developed from polypropylene and Tencel® fibres in a special knitted structure of "Ponte de roma".

Fabric properties were investigated in terms of structural, mechanical and comfort properties and the researchers concluded that Tencel®/polypropylene fabric is most suitable for active sportswear [8]. Bamboo fibre is also a kind of modal cellulosic fibre made from bamboo pulp. Bamboo can be utilized alone or may be blended with other fibres such as rayon, cotton, wool, silk, modal, etc. according to the required quality of the products. Bamboo fibre contributes the tenacity, thermal conductivity, resistivity to bacteria and high water and perspiration adsorption of textile products [9]. Majumdar et al. investigated the thermal properties of different knitted fabric structures produced from cotton, regenerated bamboo, and cotton/bamboo blended yarns. Three blends of fibres (100% cotton, 50/50% cotton/bamboo and 100% bamboo) were used as the raw material at three yarn counts (30, 24 and 20 tex). It was concluded by the authors that the thermal conductivity of knitted fabrics decreased as the proportion of bamboo fibre increased [10]. In the research conducted by Chidambaram and Govindan, cotton, bamboo fibre and blends of the two fibres (100% cotton, 100% bamboo, 50/50% cotton/bamboo, 67/33% cotton/bamboo, 33/67% cotton/bamboo) were spun into identical linear density (20 tex). Each of the yarns was converted to single jersey knitted fabrics with loose, medium and tight structures. It was analysed that the thermal conductivity of the fabrics decreased with an increase in the proportion of bamboo fibre. An increase in water vapour permeability and air permeability of the fabrics were also observed with the increase in bamboo fibre content [11].

Tausif et al. studied bamboo as an eco-friendly alternative to cotton fibre in polyester/cellulosic blends. Single jersey weft knitted fabrics made of polyester/bamboo and polyester/cotton blended yarns were produced. The yarn tensile strength, fabric bursting strength, bending length, thermal resistance and moisture management properties were evaluated. Authors concluded that polyester/bamboo blended fabrics had better mechanical properties and lower thermal properties in comparison to polyester/cotton blended fabrics [12].

To the best of our knowledge, most of the studies are evaluated in terms of some mechanical and comfort properties of knitted fabrics made of yarn blends with common regenerated fibres including viscose, bamboo, Modal etc. The objective of this study was to conduct an in-depth study for the evaluation of some comfort properties including air permeability (mm/sec), wicking height (cm), wicking rate (mm/sec), absorption rate (%) and water vapour permeability of polyester and cotton fabric samples blended with varying ratios of regenerated cellulose fibres including Viloft®, ProModal® and bamboo fibres which are yet to be investigated thoroughly.

## MATERIALS AND METHODS

### Materials

As raw material cotton with 4.5 micronaire fineness and 30 mm staple length was selected for the study. The physical properties of the rest of the raw materials used for this study (polyester, Viloft®, ProModal® and bamboo fibres) are given in table 1. Viloft®, ProModal® and bamboo regenerated cellulosic fibres were selected to be blended with cotton and also with polyester at different blending ratios (67/33%, 50/50% and 33/67%). The ring-spun yarn samples with 19.7 tex linear density were produced at the same production parameters (10.000 rpm spindle speed, ae=3.7). Additionally, 100% polyester, 100% cotton, 100% Viloft®, 100% ProModal® and 100% bamboo yarns were also prepared for a proper comparison [13]. Table 2 indicates yarn properties. Then, by using these yarn samples as weft yarn, a totally of 23 types of fabrics with different yarn blends were woven on a Picanol Optimax model weaving machine. As a warp, 100% cotton ring-spun yarn at 29.5 tex linear density was used for this study. Finally, woven fabric samples were processed with further singeing, de-sizing and finishing processes and thermal fixation at the same parameters for all woven fabric types.

Table 1

PROPERTIES OF RAW MATERIAL

| Raw material | Linear density (dtex) | Staple length (mm) |
|---|---|---|
| Polyester | 1.3 | 32 |
| Viloft® | 1.9 | 38 |
| ProModal® | 1.3 | 38 |
| Bamboo | 1.5 | 38 |

### Methods

Before all tests, all fabrics were conditioned for 24 hours in standard atmospheric conditions (at the temperature of 20 ± 2°C and relative humidity of 65 ± 4%). Since woven fabrics produced within the study are expected to be used for apparel garments, some comfort properties were considered to be evaluated. Comfort properties including air permeability

Table 2

| YARN PROPERTIES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fibre type | Fibre blend type | Blend ratio (%) | Tenacity (cN/tex) | Elongation (%) | Unevenness (%CVm) | IPI | Hairiness (H) | Diameter (2DØmm) |
| CO Blend | Viloft® | 100/0 | 13.88 | 5.16 | 13.51 | 59.00 | 6.24 | 0.241 |
| | Viloft® | 67/33 | 12.00 | 5.09 | 13.79 | 60.50 | 6.74 | 0.233 |
| | Viloft® | 50/50 | 10.79 | 5.30 | 14.34 | 82.50 | 7.07 | 0.235 |
| | Viloft® | 33/67 | 9.56 | 6.68 | 14.32 | 60.50 | 7.52 | 0.235 |
| | Viloft® | 0/100 | 10.30 | 9.73 | 17.05 | 332.50 | 9.48 | 0.239 |
| | ProModal® | 67/33 | 14.71 | 5.37 | 13.11 | 105.50 | 5.59 | 0.226 |
| | ProModal® | 50/50 | 15.18 | 5.67 | 12.32 | 69.50 | 5.63 | 0.222 |
| | ProModal® | 33/67 | 15.33 | 6.78 | 12.19 | 46.00 | 5.82 | 0.224 |
| | ProModal® | 0/100 | 20.36 | 8.24 | 12.78 | 51.50 | 5.86 | 0.217 |
| | Bamboo | 67/33 | 13.30 | 5.01 | 12.58 | 58.50 | 5.56 | 0.229 |
| | Bamboo | 50/50 | 12.62 | 5.33 | 12.49 | 38.50 | 5.25 | 0.221 |
| | Bamboo | 33/67 | 11.75 | 5.56 | 12.72 | 47.50 | 5.08 | 0.219 |
| | Bamboo | 0/100 | 13.98 | 12.72 | 14.11 | 56.50 | 5.20 | 0.214 |
| PES Blend | Viloft® | 100/0 | 27.43 | 10.80 | 15.49 | 40.00 | 5.66 | 0.212 |
| | Viloft® | 67/33 | 19.39 | 10.56 | 15.30 | 111.00 | 7.99 | 0.232 |
| | Viloft® | 50/50 | 16.77 | 10.28 | 16.06 | 198.00 | 7.44 | 0.229 |
| | Viloft® | 33/67 | 13.89 | 10.46 | 16.77 | 284.00 | 8.76 | 0.236 |
| | ProModal® | 67/33 | 24.19 | 9.52 | 12.34 | 53.50 | 5.74 | 0.219 |
| | ProModal® | 50/50 | 24.50 | 9.97 | 11.85 | 33.50 | 6.01 | 0.218 |
| | ProModal® | 33/67 | 22.55 | 9.62 | 13.15 | 30.63 | 5.96 | 0.218 |
| | Bamboo | 67/33 | 25.35 | 11.60 | 11.39 | 19.50 | 5.30 | 0.214 |
| | Bamboo | 50/50 | 22.83 | 11.21 | 11.40 | 22.50 | 5.13 | 0.213 |
| | Bamboo | 33/67 | 20.88 | 12.44 | 11.71 | 23.00 | 5.38 | 0.215 |

(mm/sec), wicking rate (mm/sec), water absorption (%) and water vapour permeability index were measured. Air permeability of the fabrics was measured based on EN ISO 9237 standard using a SDL Atlas Digital Air Permeability Tester Model M 021A at 20 ± 2°C and 65 ± 4% humidity. Measurements were performed by application under 200 Pa air pressure drop per 20 $cm^2$ fabric area. Averages of measurements from 10 different areas of fabrics were calculated. Wicking is described as the flow of the liquid in a porous substance concerning capillarity. There are many ways introduced for conducting wicking measurements in early research [14]. In this study, the wicking properties of the fabrics were evaluated in terms of wicking height (cm) and wicking rate (mm/s). Vertical wicking properties of the woven samples in the weft direction were evaluated with the help of the 20×2.5 cm strip test specimens which were suspended vertically with their 3 cm of lower end immersed in a reservoir of distilled red coloured water [15–19]. Wicking height (cm) of liquid was measured and recorded after 5, 10, 20 and 30 minutes. Wicking heights after 30 minutes were used for determined the wicking rates (mm/s) [14–16]. All the tests were completed over five samples for each fabric type. Water absorption area (%) is also an indicator for wettability. When the fabric is wetted, the interaction between the forces of cohesion and the forces of adhesion determines whether wetting takes place or not. To determine the absorption areas of the fabrics after dropping off 0.2 ml water, the image processing method was conducted by analysing the acquired image frame after 2 minutes. The image processing method was applied where the liquid existence after absorption will lead to different light transmission level in comparison to dry parts. The image frames were acquired just after solution drop fall and after 2 minutes. The water absorption area (%) was calculated as a percentage of absorbed area to the whole sample area. First, the acquired image frame was converted to a grey image. And then to increase image enhancement, some filters were applied. After improving the image quality, a suitable threshold value was applied so the image frame was transformed into binary form. The black pixels in the binary image referred to the liquid absorbed area and the white pixels referred to a dry area. The developed image acquisition system is indicated in figure 1. The results of image processing applied to the absorbed area is investigated in figure 2. Water vapour permeability should also be considered since the body requires to perspirate when the body temperature increases [20]. Water vapour permeability is the ability of a fabric to allow perspiration in water vapour

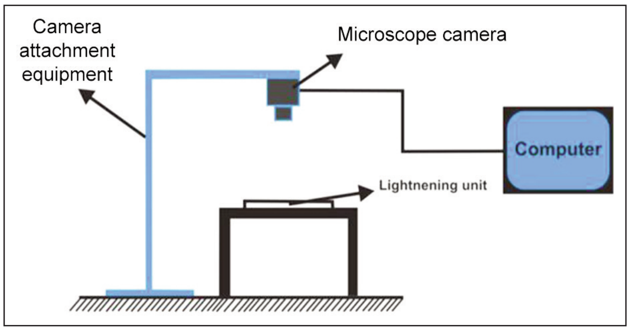


Fig. 1. Image acquisition system

form. A fabric of low moisture vapour permeability is unable to allow sufficient perspiration and this may lead to sweat accumulation in the clothing and hence discomfort. Within the study, water evaporation tests were measured by using SDL Atlas water evaporation tester according to the standard of BS 7209-1990.

### Statistical analysis

For the evaluation of the statistical significance of fibre type, fibre blend type and blend ratio (%) on woven samples' comfort properties including air permeability, wicking rate, absorption ratio, water vapour permeability index, randomized three-direction ANOVA was performed. Besides ANOVA results, Student-Newman-Keuls (SNK) multi comparison tests (to evaluate the significance different of subgroups regarding fibre blend type were conducted for the comparison of means of the above-mentioned properties. The treatment levels in SNK tests were marked by the mean values and levels marked by a different letter (sorted by a, b, c) indicating the significant differences. The significance level ($\alpha$) selected for all statistical tests in the study is 0.05.

## RESULTS AND DISCUSSION

Fabric construction parameters (table 3) such as warp and weft density, fabric weight, fabric thickness is so closer to each other; yarn fibre type, fibre blend type and the blend ratio were considered as the main variables regardless of other fabric parameters.

### Comfort performance properties

Air permeability of cotton and polyester blended woven samples are indicated in figure 3.

Within cotton blended and polyester woven samples, ProModal® and bamboo blended fabrics generally indicated higher air permeability values compared to Viloft® blended fabrics. 100% cotton samples generally have higher air permeability values compared to those Viloft®, ProModal® and bamboo blended fabrics. There was a prominent decrease in the air permeability of the cotton/Viloft® blended samples as the Viloft® fibre ratio increased. This result may be attributed to the fibre cross-section of Viloft fibre which effects intra-yarn gaps and which further affects the fabric porosity. The grooved structure of Viloft® fibre may decrease the porosity of the material by decreasing intra-yarn gaps which in turn leads to lower air permeability [21].

A fluctuating trend for air permeability was observed among Promodal® blended fabrics with varying ratios of fibre blends. Additionally, the increment of bamboo blend ratio did not seem to influence air permeability results of cotton/bamboo blended fabrics.

Considering polyester blended fabrics; it is prominently observed that 100% polyester fibres indicated lower air permeability than that of regenerated fibre blended samples. The air permeability values of blended samples generally seemed to be increased as the polyester content decreased. Our result is also supported by Tyagi et al.'s study where the air permeability decreased significantly with the increase in polyester content due to increased yarn diameter [22]. In another study related to the effects of regenerated cellulose fibres on thermal comfort properties

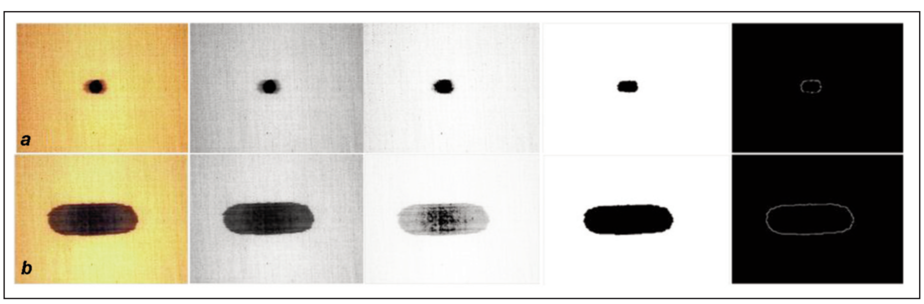


Fig. 2. Results of image processing applied on:
*a* – the absorbed area; *b* – solution drop fall after 2 minutes

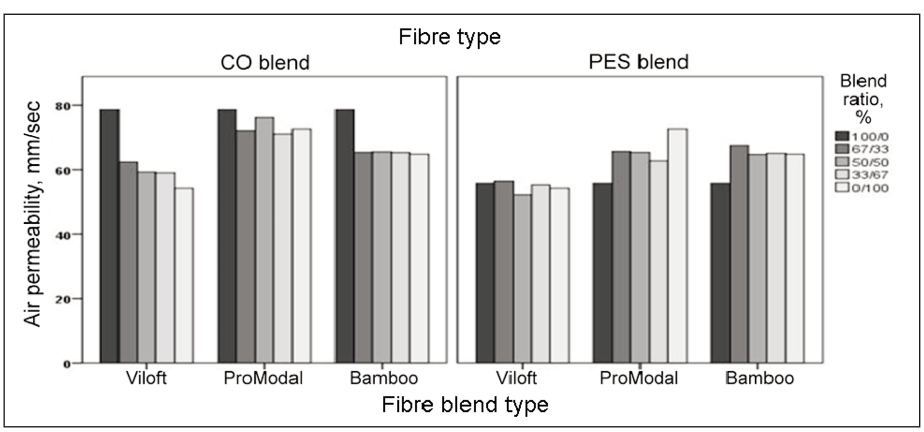


Fig. 3. Air permeability (mm/sec)

Table 3

| FABRIC CONSTRUCTION PARAMETERS | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fibre type** | **Fibre blend type** | **Blend ratio (%)** | **Yarn characteristic** | **Warp sett (ends/cm)** | **Weft sett (picks/cm)** | **Weight ($g/m^2$)** | **Thickness (mm)** |
| CO Blend | Viloft® | 100/0 | 100% Cotton | 46 | 28 | 159.33 | 0.33 |
| | Viloft® | 67/33 | 67/33% Cotton/Viloft® | 49 | 28 | 158.33 | 0.32 |
| | Viloft® | 50/50 | 50/50% Cotton/Viloft® | 50 | 28 | 157.33 | 0.33 |
| | Viloft® | 33/67 | 33/67% Cotton/Viloft® | 50 | 27 | 159.67 | 0.33 |
| | Viloft® | 0/100 | 100% Viloft® | 49 | 28 | 160.67 | 0.33 |
| | ProModal® | 67/33 | 67/33% Cotton/ProModal® | 49 | 28 | 155.67 | 0.33 |
| | ProModal® | 50/50 | 50/50% Cotton/ProModal® | 49 | 28 | 154.33 | 0.32 |
| | ProModal® | 33/67 | 33/67% Cotton/ProModal® | 49 | 28 | 156.00 | 0.32 |
| | ProModal® | 0/100 | 100% ProModal® | 49 | 28 | 160.00 | 0.31 |
| | Bamboo | 67/33 | 67/33% Cotton/Bamboo | 50 | 28 | 160.67 | 0.33 |
| | Bamboo | 50/50 | 50/50% Cotton/Bamboo | 49 | 27 | 157.00 | 0.34 |
| | Bamboo | 33/67 | 33/67% Cotton/Bamboo | 49 | 27 | 161.33 | 0.32 |
| | Bamboo | 0/100 | 100% Bamboo | 52 | 28 | 165.00 | 0.31 |
| PES Blend | Viloft® | 100/0 | 100% Polyester | 49 | 28 | 168.67 | 0.33 |
| | Viloft® | 67/33 | 67/33% Polyester/Viloft® | 50 | 27 | 164.33 | 0.32 |
| | Viloft® | 50/50 | 50/50% Polyester/Viloft® | 50 | 27 | 161.67 | 0.33 |
| | Viloft® | 33/67 | 33/67% Polyester/Viloft® | 52 | 28 | 162.67 | 0.32 |
| | ProModal® | 67/33 | 67/33% Polyester/ProModal® | 52 | 27 | 160.33 | 0.31 |
| | ProModal® | 50/50 | 50/50% Polyester/ProModal® | 50 | 28 | 161.33 | 0.32 |
| | ProModal® | 33/67 | 33/67% Polyester/ProModal® | 51 | 28 | 160.00 | 0.31 |
| | Bamboo | 67/33 | 67/33% Polyester/Bamboo | 52 | 28 | 164.33 | 0.32 |
| | Bamboo | 50/50 | 50/50% Polyester/Bamboo | 52 | 27 | 163.00 | 0.32 |
| | Bamboo | 33/67 | 33/67% Polyester/Bamboo | 52 | 28 | 163.33 | 0.32 |

of compression stockings, knitted samples made of regenerated samples revealed higher air permeability compared to those made of 100% synthetic fibres [23]. To investigate the effect of fibre type, fibre blend type and blend ratio on air permeability properties of the samples; ANOVA was conducted (table 4). It was obtained that fibre type, fibre blend type and blend ratio have a significant effect on the air permeability of the samples at a significance level of 0.05. All interactions of independent parameters were also found as significant on-air permeability of the fabric samples at a significance level of 0.05. SNK results (table 5) also revealed that fabrics produced from different fibre blend type possessed different air permeability values at a significant level of 0.05. ProModal® blended fabrics indicated the highest air permeability while Viloft® blended fabrics revealed the lowest air permeability.

Wicking properties of synthetic fibres are generally known as better than natural fibres. Fabric wicking height results within 30 minutes period are indicated in figure 4. According to figure 4, the wickability properties

Table 4

| ANOVA results of comfort properties | | | | |
|---|---|---|---|---|
| **Main source** | **Air permeability (mm/sec)** | **Wicking rate (mm/sec)** | **Absorption ratio (%)** | **Water vapour permeability index** |
| Fibre type | 0.00* | 0.00* | 0.00 | 0.56 |
| Fibre blend type | 0.00* | 0.00* | 0.01 | 0.23 |
| Blend ratio | 0.00* | 0.00* | 0.00 | 0.08 |
| Fibre type * Fibre blend type | 0.00* | 0.00* | 0.24 | 0.22 |
| Fibre type * Blend ratio | 0.00* | 0.00* | 0.00 | 0.08 |
| Fibre Blend type * Blend ratio | 0.00* | 0.00* | 0.66 | 0.46 |
| Fibre type * Fibre blend type * Blend ratio | 0.00* | 0.00* | 0.77 | 0.29 |

Note: * statistically significant ($P < 0.05$).

Table 5

| SNK results for comfort properties | | | | |
|---|---|---|---|---|
| **Parameter: Fibre blend type** | **Air permeability (mm/sec)** | **Wicking rate (mm/sec)** | **Absorption rate (%)** | **Water vapour permeability index** |
| Viloft® | 58.75 a | 0.046 b | 10.84 ab | 0.45 a |
| Bamboo | 65.75 b | 0.043 a | 10.53 a | 0.47 a |
| ProModal® | 69.27 c | 0.047 c | 11.64 b | 0.47 a |

Note: The different letters next to the counts indicate that they are significantly different from each other at a significance level of 0.05.

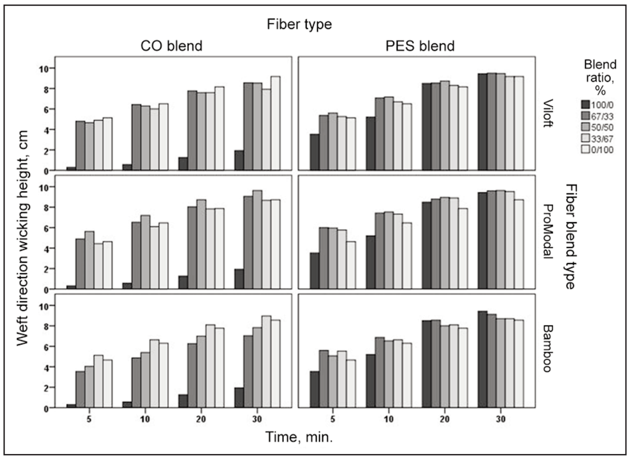


Fig. 4. Wicking height (cm) in the weft direction

of the fabrics improved as the Viloft® ratio in the blend increased. Wickability of 100% cotton fabrics were by far lower than the wickability of cotton/Viloft® blended fabrics. A gradual increment of wicking height was observed among the 100% polyester and also among the polyester/Viloft® blended fabric samples during the wicking period of 5, 10, 20 and 30 minutes. At the end of the 30 minutes, polyester/Viloft® blended samples indicated similar wicking height results with each other. When it comes to cotton blends with ProModal® fibre, it was observed that 100% cotton fabrics revealed the lowest wicking height compared to its blends with ProModal®. The groups of 67/33% cotton/ProModal® and 50/50% cotton/ProModal®, 33/67% cotton/ProModal® and 100% ProModal® blend ratios revealed an increasing trend for wickability during the wicking period of 5, 10, 20 and 30 minutes.

Considering the evaluation of polyester/ProModal® blends; 100% polyester fabrics first indicated low wickability then reached up to the similar wickability level with their counterparts of polyester/ProModal® blends after the 20th minutes. Considering the cotton/bamboo blends; cotton has indicated far lower wickability compared to samples of cotton/bamboo blends. It is clear that wickability increases with the increase in the bamboo blend ratio (%). When considering the polyester/bamboo blends; in the first 10 minutes, 100% polyester revealed lower wickability compared to polyester/bamboo blended fabrics. However, after 20 minutes, 100% pure polyester fabrics revealed slightly higher wickability compared to its blends with bamboo fibre.

The wicking rate after 30 minutes in the weft directions is indicated in figure 5. The wicking rate of the 100% cotton fabrics revealed lower values compared to cotton blends of Viloft®, ProModal® and bamboo fabrics. 100% Viloft® fabrics show the highest wicking rate within cotton/Viloft® blended fabrics. Blended fabric samples of 50/50% cotton/ProModal® have the highest wicking rate within cotton/ProModal® blended fabrics. Finally, 33/67% cotton/bamboo blended fabrics provided the highest wicking rate within the cotton/bamboo blends. Increment of cellulosic regenerated fibres blend ratio in the blend generally improved the wicking rates within cotton blended fabrics. However, increment of Viloft®, ProModal® and bamboo blend ratio within the blend resulted in a lower wicking rate after 30 minutes within the polyester blended fabrics. ANOVA analysis results were given in table 4. It was observed that fibre type, fibre blend type and blend ratio had a significant effect on the wicking rate of the fabrics after 30 minutes. The interactions between fibre type and fibre blend type, fibre type and blend ratio, fibre blend type and blend ratio also the interaction between fibre type, fibre blend type and blend ratio were influential factors on the wicking rate of the fabrics after 30 minutes at a significance level of 0.05. SNK results also indicated that fabrics produced from different fibre blend type possessed different wicking rate after 30 minutes. According to SNK results (table 5), the highest wicking rate was obtained from ProModal® blended fabrics while the lowest wicking rate was obtained from bamboo blended fabrics.

Water absorption rate after 2 minutes of the samples are given in figure 6. 100% Cotton fabrics prominently have a lower water absorption rate compared to its blends with Viloft®, ProModal® and bamboo fibres.

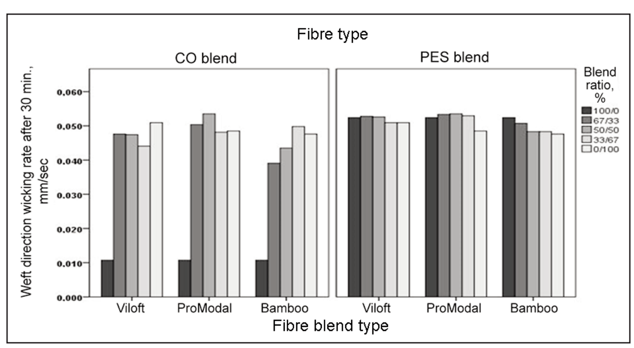


Fig. 5. Wicking rate after 30 minutes in weft direction (mm/sec)

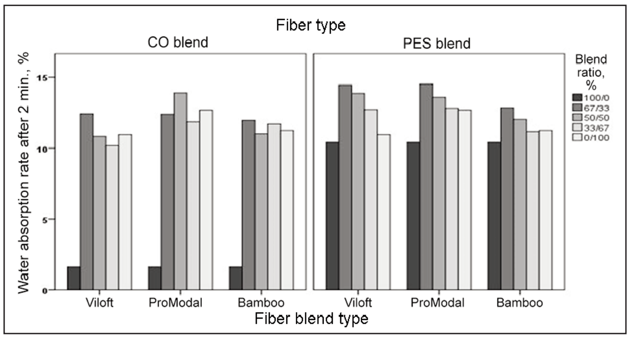


Fig. 6. Water absorption rate after 2 minutes (%)

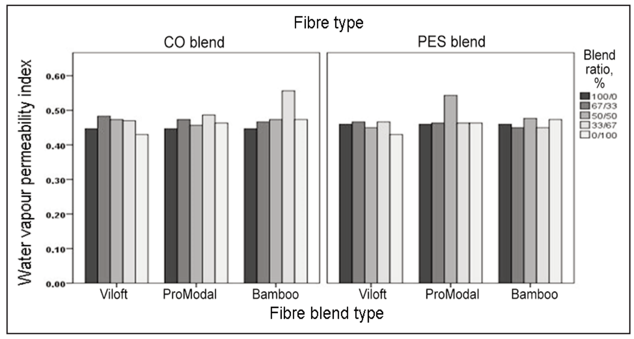


Fig. 7. Water vapour permeability index

Within the cotton/Viloft® blends; the highest water absorption was obtained from 67/33% cotton/Viloft® blended fabric samples. 50/50% cotton/ProModal® blended fabric samples indicated the highest water absorption rate among the cotton/ProModal® blends. Regarding bamboo blends. 67/33% cotton/bamboo blended fabrics indicated the highest water absorption rate among the cotton/bamboo blended fabrics. Increment of regenerated fibre blend ratio within the blends generally contributed positively to the water absorption for cotton blended fabrics. Considering the polyester blended fabrics; it can be said that cellulose fibre content has a significant contribution to the water absorption rates of the fabric samples. However, when the effect of blend ratio was analysed, it can be concluded that higher cellulosic fibre content (more than 33% within the blend) may lead to lower absorption rates. Fabric samples made of pure 100% Viloft®, Promodal® and bamboo fibre revealed higher water absorption rates compared to 100% polyester samples.

The further analyse related to ANOVA results (table 4) revealed that fibre type, fibre blend type, blend ratio factors have a significant effect on water absorption ratios, separately at a significant level of 0.05. Interaction of fibre type and blend ratio was found as a significant factor while the interaction of fibre type and fibre blend type, the interaction of fibre blend type and blend ratio and finally the interaction of fibre type, fibre blend type and blend ratio was found as non-significant factors on water absorption ratio of woven samples at 0.05 significance level. SNK results (table 5) also indicated that bamboo blended fabrics indicated the lowest absorption ratio whereas ProModal® blended woven samples revealed the highest absorption ratio regarding fibre blend type parameter.

The water vapour permeability may vary depending on the macro-porous structure of the constituent fibres [11]. Water vapour permeability index of the Viloft®, ProModal® and bamboo blends of cotton and polyester woven samples are revealed in figure 7. Viloft® and ProModal® cotton blended fabrics indicated similar water vapour permeability index values between each other. 100% pure Viloft® fabric samples provided a lower vapour permeability index compared to cotton/Viloft® blended fabrics. 33/67% cotton/bamboo blended fabrics revealed the highest water vapour permeability index among the cotton blends of regenerated cellulose fibres. When considering Polyester blended fabrics, 50/50% polyester/ProModal® blended fabrics revealed the highest water vapour permeability among the others.

There was not a prominent change in the fabrics' water vapour permeability index regarding regenerated fibre blend ratio among the polyester blended fabrics. Additionally, ANOVA results (table 4) indicated that; fibre type, fibre blend type and blend ratio were not found as influential factors on water vapour permeability index at a significance level of 0.05. None of the interactions between fibre types, fibre blend type and blend ratio parameters was found as significant factors on the water vapour permeability index at a significance level of 0.05.

## CONCLUSIONS

This study has been conducted to make a detailed comparison between the cotton blended and polyester blended fabrics with varying blend ratios of regenerated cellulose fibres including Viloft®, ProModal® and bamboo fibres in terms of some comfort properties.

- Considering the ANOVA test results for comfort properties; fibre type, fibre blend type and blend ratio parameters have a statistically significant effect on air permeability, wicking rate, absorption ratio rate properties. However, those parameters did not significantly influence the water vapour permeability index at a significance level of 0.05. ProModal® and bamboo blended cotton fabrics indicated higher air permeability values compared to Viloft® blended cotton fabrics. 100% cotton samples generally revealed higher air permeability compared to its blends with Viloft®, ProModal® and bamboo fibre. Air permeability values generally improved with the increment of regenerated cellulosic fibre blend ratio in the blend within the polyester blends.
- Wickability of 100% polyester fabrics generally indicated better values compared to regenerate cellulose fibre blends of polyester also compared to regenerated cellulose fibre blends of cotton fabrics. 100% cotton fabrics prominently revealed a lower water absorption rate compared to its blends with

Viloft®, ProModal® and bamboo fibre. An increment in the ratio of the cellulosic fibre blends first improved the water absorption rate values. However further increment led to lower water absorption rates for the polyester blended fabrics. It can be concluded that fibre type, fibre blend type and also fibre blend ratio parameters have statistical significance on both the wicking rate and water absorption rate of woven fabric samples.

- Water vapour permeability index of cotton blends with regenerated fibres did not vary prominently regarding fibre type nor blend ratio. Bamboo blended cotton fabrics with a ratio of 33/67% indicated the highest water vapour permeability. Among the polyester blended fabrics, 50/50% polyester/ProModal® blended fabrics revealed the highest water vapour permeability index value.
- As a general conclusion, the comfort properties of polyester woven fabrics with regenerated cellulosic blends seem to be giving more satisfying results compared to fabrics made of cotton/regenerated cellulosic blended yarns. Polyester fabrics with regenerated cellulosic blends enhance high water absorption rates as well as high wickability property with considerable durability.

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