*Research Article*

# Influence of Blend Ratio on Thermal Properties of Bamboo/ Cotton Blended Woven Fabrics


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**Abstract**

Thermal comfort characteristics of plain woven fabrics made out of $30^s$ $Ne_c$ cotton in warp and $30^s$ $Ne_c$ 100% bamboo, bamboo/cotton blended yarns in weft have been studied. The fabric characteristics such as air permeability, wicking, thermal resistance, relative water permeability related to comfort characteristics are discussed. The experimental results show that $30^s$ $Ne_c$ cotton in warp and $30^s$ $Ne_c$ bamboo in weft plain woven fabric exhibits higher air permeability when compared to other samples, $30^s$ $Ne_c$ cotton in warp and $30^s$ $Ne_c$ bamboo in weft plain woven fabric shows very low thermal resistance and higher wicking rate than other samples. Relative water permeability value of $30^s$ $Ne_c$ cotton in warp and $30^s$ $Ne_c$ bamboo in weft fabric is higher and that of $30^s$ $Ne_c$ cotton both in warp and weft fabrics are lower when compared to other samples.



***Key Words:*** Thermal properties; Air-permeability; Water-vapour permeability; Thermal resistance; Wickability


## Introduction

Life standard is nowadays getting higher. The demands of people in all areas are increasing, as well as the requirements regarding new textile materials with new or improved properties which are important for the required higher comfort or industrial use.

Comfort, which defined as states in which there are no driving impulses to correct the environment by the behaviour (Li, 2001). Clothing comfort is closely related to thermal comfort (Watkins et al., 1981; Pac et al., 2001). The body produces lots of heat energy and the body temperature increases. To reduce the high temperature, the body perspires a lot in liquid and vapour form. While this perspiration is transmitted to atmosphere, the body temperature reduces and then the body feels cool. So the garments should allow the perspiration to pass through, otherwise it will result in discomfort.

Bamboo is an important forest biomass resource. Bamboo textiles have many fantastic properties when used as textile materials such as high tenacity, excellent thermal conductivity, resistant to bacteria, and high water and perspiration adsorption. Yarns of bamboo fibre provide the desirable properties of high absorbency, anti-microbial and soft feel in textiles and made ups. Currently, regenerated bamboo fibres are used in apparels including undergarments, sports textiles, t-shirts and socks. They are also suitable for hygienic products and sanitary materials such as sanitary napkins, absorbing pads, masks, bandages and surgical gowns (Saravanan et al., 2007; Prakash et al., 2011).

Blending of different fibres is a very common practice in the spinning industries. Blending different types of fibres is a widely practiced means of enhancing the performance and the aesthetic qualities of a fabric. Bamboo blended with cotton is usually 50/50 combinations (Abhijit Majumdar et al., 2010).

Okubo et al. (2005) studied the mechanical properties of bamboo fibres and concluded that the strength of bamboo fibres was equivalent to that of glass fibres. Grineviciute et al. (2007) revealed that hand properties of bamboo fibre better than cotton fabrics. Gun et al. (2008) reported that fabrics made from 50/50 bamboo/ cotton yarns had a similar appearance as compared with those made from 50/50 viscose/cotton and 50/50 modal/cotton. They concluded that the weight, thickness and air permeability was independent of the fibre type. Kawahito (2008) indicated that cotton fabrics had a higher tenacity, greater thickness under a heavier load, faster water absorption and better drying properties than bamboo fabrics.

Filiz Sekerden (2011) studied that the effect of the yarn and weave types on the physical and mechanical properties of the bamboo blended fabrics were examined. He found that the weave type affected the physical and mechanical properties of the fabric more than the fibre mix and type in the weft yarn.

Many researchers have conducted studies to evaluate and analyse the thermal comfort of woven fabrics (Senthilkumar et al., 2010; Tyagi et al., 2011). The work was aimed to investigate the influence of the bamboo content and compare the thermal comfort parameters of woven fabrics made from 100% cotton yarn, 100% bamboo and bamboo/cotton blended yarns. In this study testing air, moisture and thermal transfer properties such as air permeability, relative vapour permeability, thermal resistance and wickability of plain weave fabrics and studying their comfort characteristics.

**Materials and Methods**

In this study, 100% bamboo, 70/30 bamboo/cotton, 50/50 bamboo/cotton, 30/70 bamboo/cotton and 100% cotton yarns were procured from pallava spinning mills (p) ltd, India. It was ensured that all of the yarns produced had the same mean linear density of $30^s$ $Ne_c$. The properties of fibre and yarns were given in Table 1 and 2. In this study, plain woven fabrics were chosen and these fabrics were washed thoroughly with hot and cold water, and given scouring treatment using appropriate recipe. The geometrical properties of woven fabrics are given in Table 3. The test parameters related to thermal and moisture related comfort characteristics are given in Table 4. Weaving process was performed using unsized warp, bamboo fibre was inserted only in the weft system.

**Table 1** Properties of the fibres

| Fibre properties | Bamboo | Cotton |
|---|---|---|
| Fibre length, mm | 36 | 27.27 |
| Fibre fineness, dtex | 1.52 | 1.70 |
| Tenacity, cN/tex | 19.87 | 33.33 |
| Elongation at break, % | 21.11 | 6.1 |

**Table 2** Characteristics of bamboo-cotton yarns

| Blend ratio | 100 % Cotton | 70:30 % Cotton/ Bamboo | 50:50 % Cotton/ Bamboo | 30:70 % Cotton/ Bamboo | 100% Bamboo |
|---|---|---|---|---|---|
| Yarn Diameter mm | 0.198 | 0.185 | 0.177 | 0.166 | 0.150 |
| Twist/meter | 937 | 912.3 | 1075 | 869.6 | 802 |
| Tenacity RKM | 10.67 | 10.32 | 7.26 | 7.34 | 11.00 |
| Tenacity CV % | 28.93 | 21.85 | 28.53 | 31.23 | 21.08 |
| Elongation at break % | 3.22 | 3.79 | 3.40 | 3.72 | 6.77 |
| Elongation at cv% | 30.11 | 15.23 | 22.01 | 38.35 | 31.97 |
| Thin place/km (-50%) | 4540 | 2036 | 1096 | 1433 | 550 |
| Thin place CV% | 3.89 | 11.28 | 18.81 | 55.93 | 25.92 |
| Thick place/km (+50%) | 3725 | 2628 | 1464 | 2102 | 1027 |
| Thick place CV% | 2.36 | 7.39 | 11.59 | 35.62 | 4.71 |
| Neps/km | 3942 | 2862 | 1713 | 2083 | 1358 |
| Neps CV% | 2.56 | 8.57 | 19.21 | 20.09 | 9.66 |
| Single yarn strength(g) | 210.1 | 203.2 | 143 | 144.7 | 216.7 |

**Testing**

The following tests were carried out for the woven fabrics such as fabric mass, fabric thickness, air permeability, relative water permeability, thermal conductivity and thermal resistance. The standard test procedure BS 2471, 1974 was followed for determining the fabric mass of woven fabrics in this study. Shirley thickness gauge was used for the measurement of fabric thickness as per ASTM D1777. The wicking properties were measured by the technique of vertical wicking test as per TAPCC standard. The Lees disc method was used to measure fabric thickness and thermal resistance; water vapour permeability was measured on a Permetest instrument working on simulated skin principle as recommended in ISO 11092; fabric air permeability was measured according to the TS 391 EN ISO 9237 using Tester FX3300. All the fabric samples are conditioned at standard atmospheric condition 65% ±2% RH and 27°C±2°C.

**Table 3** Geometrical property of woven fabrics

| **Sample** | **Warp yarn** | **Weft yarn** | **Fabric Thickness mm** | **Ends/inch** | **Picks/inch** | **Warp cover factor ($K_1$)** | **Weft cover factor ($K_2$)** | **Fabric cover factor ($K_c$)** |
|---|---|---|---|---|---|---|---|---|
| A | 100% cotton | 100% Bamboo | 0.26 | 80 | 72 | 14.61 | 11.69 | 20.89 |
| B | | 70:30 Bamboo: Cotton | 0.28 | 80 | 70 | 14.61 | 12.05 | 20.72 |
| C | | 50:50 Bamboo: Cotton | 0.33 | 80 | 69 | 14.61 | 12.59 | 20.63 |
| D | | 30:70 Bamboo: Cotton | 0.36 | 80 | 66 | 14.61 | 12.78 | 20.37 |
| E | | 100% Cotton | 0.46 | 80 | 64 | 14.61 | 13.15 | 20.19 |

**Table 4** Thermal transfer properties of plain woven fabrics

| Sample | Fabric mass, ($g/m^2$) | Thermal resistance, ($mkm^2/w \times 10^{-3}$) | Relative water permeability (%) | Fabric wicking height, (cms) | Air permeability, ($cm^3/cm^2/sec$) |
|---|---|---|---|---|---|
| A | 197.32 | 60.38 | 48.32 | 14.4 | 117 |
| B | 204.78 | 71.89 | 45.11 | 12.1 | 106 |
| C | 208.66 | 80.55 | 43.22 | 10.4 | 99 |
| D | 214.89 | 89.35 | 41.17 | 9.2 | 97.9 |
| E | 239.98 | 97.81 | 40.04 | 8.1 | 97 |

## Results and Discussion

### Air permeability

The air permeability results of the fabrics are shown in Figure 1. The results indicate that air permeability is higher in the sample A, and when the bamboo fibre content drops below 50%, the fibre proportion is not so effective in air permeability. This can be explained in terms of the enhanced rate of air flow as a consequence of the reduced bulk of bamboo-majority yarns. Higher air permeability value of Sample A compared with samples B, C, D and E could be because of lower fabric cover factor values. Gün et al. (2008) compared fabrics produced from mixes of 50/50 bamboo/cotton, 50/50 viscose/cotton and 50/50 modal/cotton, and reported that air permeability is independent of fibre type. When Figure 1 is examined, it is observed that air permeability decreases when the proportion of bamboo in the mix decreases.

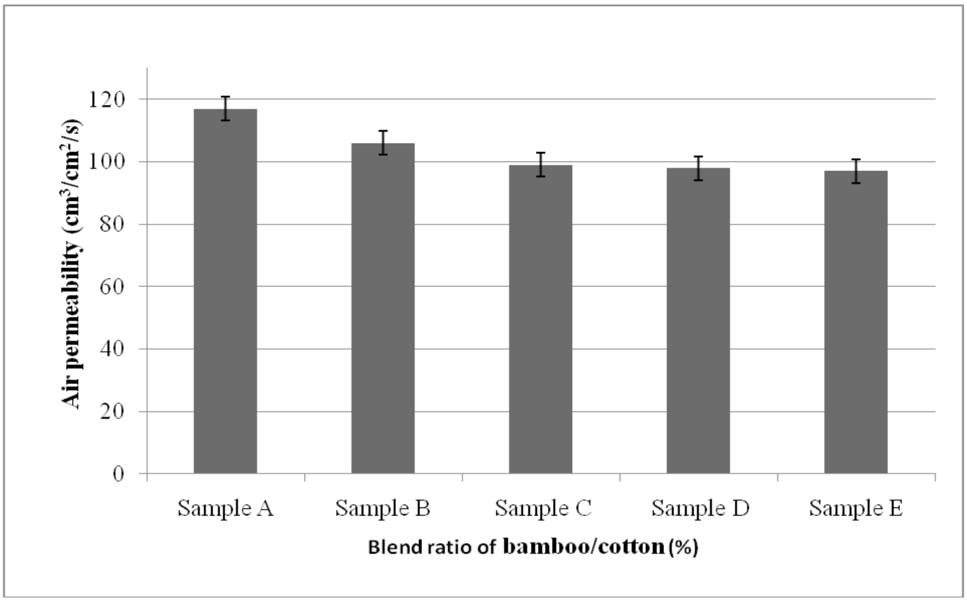


**Figure 1** Influence of bamboo/cotton blend ratio on air permeability

**Thermal resistance**

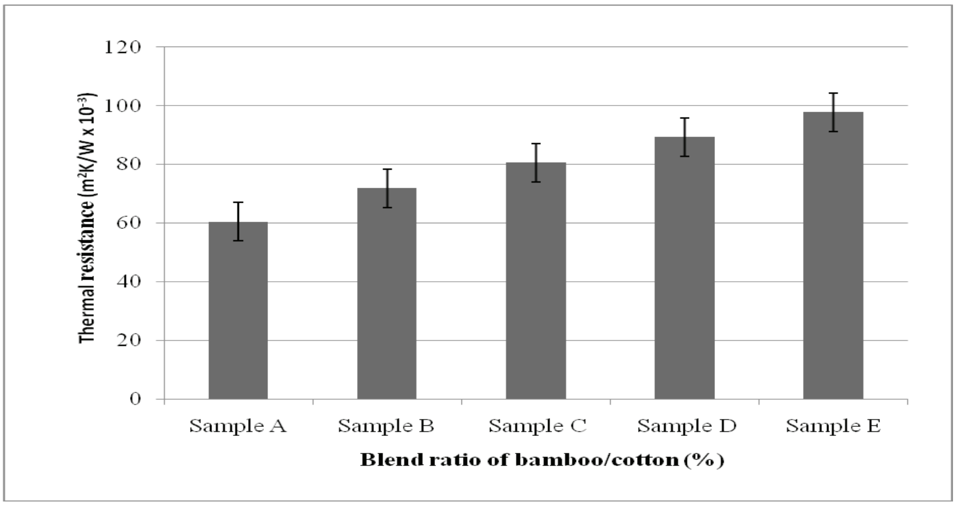


**Figure 2** Influence of bamboo/cotton blend ratio on thermal resistance

The thermal resistance of Sample E fabric exhibits higher value when compared to all other samples. This is due to the higher fabric thickness and higher fabric cover factor. From the results, it is observed that higher thermal resistance values are noticed in the case of thicker fabric. Sample A exhibits lower thermal resistance when compared to all other samples. This may be due to higher air permeability. An increase in the cotton content in the fibre-mix improves the thermal resistance. The increased cotton content traps the air, making the structure more thermally resistant. Figure 2 also shows that sample E fabrics have significantly higher thermal insulation values than other samples.

**Wicking**

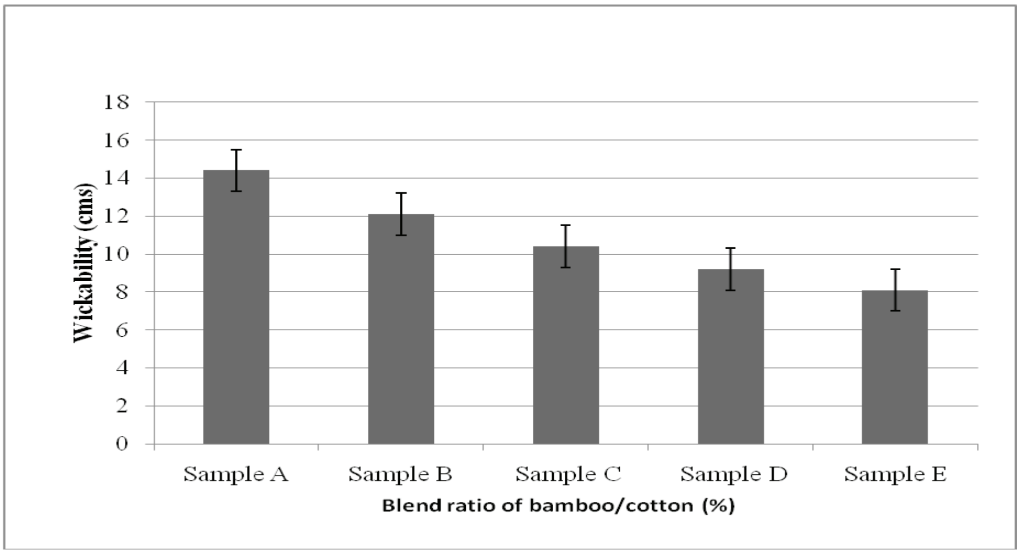


**Figure 3** Influence of bamboo/cotton blend ratio on wickability

Figure 3 shows the results of wickability test. The wicking property of a fabric mainly depends on characteristics of fibre and structure of component yarns and fabric. The experimental results show that Sample A has higher wicking rate when compared to all other samples. Wicking can only occur when fibre assemblies with capillary spaces between them are wetted by a liquid. Sample D exhibits wicking height up to 14.4mm due to better capillary rise and the yarn has soft and smooth feel. As stated, the higher hydrophilicity together with macro channels presented in the bamboo cellulose account for the enhanced wickability of bamboo-majority fabrics (Erdumlu et al., 2008).

**Water vapour permeability**

Figure 4 illustrates the values of water vapour permeability with respect to blend ratio of bamboo. The water vapour permeability is highly dependent on the macro-porous structure of the constituent fibres. The water vapour permeability is considerably higher for the sample A fabrics compared with those for the other samples. Higher moisture regain together with the macro channels presented in bamboo fibre represents no hindrance to moisture transfer in hydrophilic systems (Erdumlu et al., 2008).

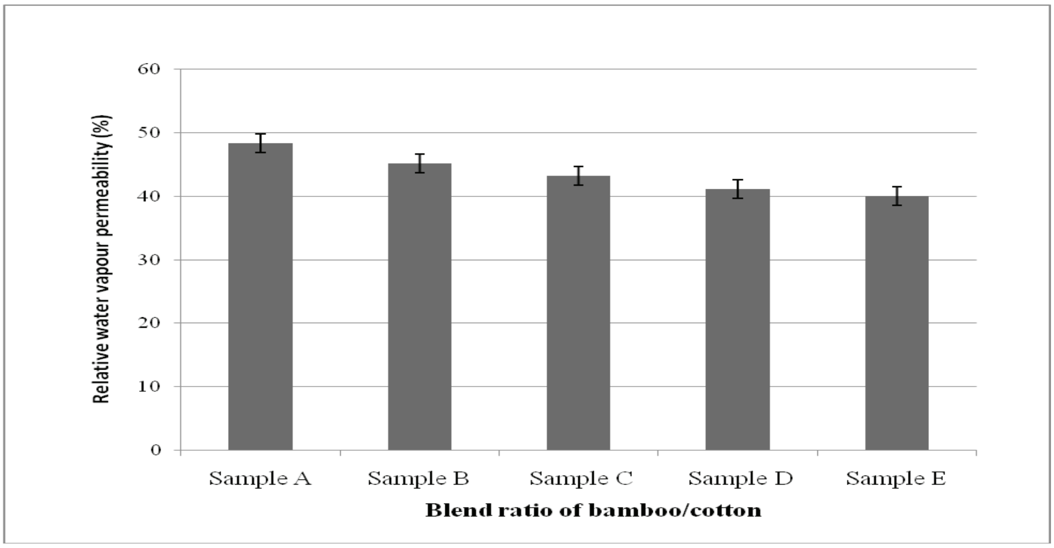


**Figure 4** Influence of bamboo/cotton blend ratio on water vapour permeability

## Conclusion

The thermal comfort parameters of woven fabrics made from 100% cotton yarn, 100% bamboo and bamboo/cotton blended yarns have been analyzed. The fabric comfort characteristics such as air permeability, wicking, water absorption and thermal resistance have been studied. The fabrics produced with higher bamboo content, in general, are substantially more air and water permeable, more absorbent, have lower thermal resistance and yield higher wickability than the equivalent fabrics produced with cotton fabrics.

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