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# COMFORT PROPERTIES OF JUTE-COTTON FABRICS

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Studies were undertaken to assess physiological and comfort properties of six different jute-cotton union fabrics *viz.* Diamond, Twill, Ribbon, DW plain*, two types of Jeans (Jeans A and Jeans B) and five other commercially available cotton fabrics *viz.* Gueberdine, Poplin, Jeans (Jeans C), Khaddar (a local trade name) and Drill. Of all the samples, Jeans C showed highest value of thermal conductivity (116.11mW/m°C) while Khaddar showed the lowest (51.11 mW/m°C). Jeans B showed highest absorbency while Diamond showed lowest absorbency. In addition to previous eleven samples, five more samples of different materials were tested for generation of static charge. Jeans C, Markin and Mattress cover were found to generate lowest static charge ($4.8 \times 10^{-9}$ coulomb/m$^2$) while polyester generated highest static charge ($29.2 \times 10^{-2}$ coulomb/m$^2$.). Drill had been found to have the best comfort properties in respect of thermal conductivity, water absorbency and static charge while Jeans A had the better comfort properties among all the tested jute-cotton union fabrics. Microbiological examinations were carried out on two samples. Mycotoxin producing fungi and allergy producing fungi were not found in the samples.

***Key words:*** Thermal conductivity, Water absorbency, Static charge.

## Introduction

Comfort is a nebulous term which cannot be clearly defined, but a person can very easily recognize the sensation of comfort. It involves a number of factors [1] such as movement of heat and water vapour through a fabric, stretch, absorbency, fibre type, thickness, texture, weight, breathability and fitness etc. Of these, movement of heat, water absorbency and generation of static charge are probably the most important factors in clothing comfort. It is obviously impossible to give a quantitative definition of comfort, since it is a subjective phenomenon. The best that can be done is to attempt a qualitative one, given in literature [2] in which comfort is defined as a pleasant state of physiological, psychological and physical harmony between a human being and the environment. Rodwell *et al.* [3] reported that comfort is influenced by the physiological reactions of the wearer. Kostrz [4] discussed the physiological effects of such climatic variables as temperature, relative humidity and air movement on a body situated in the particular conditions studied. Welfers [5] assessed the effect of clothing factors, particularly fabric geometry, pore volume and enclosed air content, on physiological as well as physical parameters. Slater [6] reported that there is a wide spread agreement on two facts. The first clearly identifies a satisfactory thermal equilibrium as the most important single comfort criterion for modern people. Secondly, the state of comfort can only be achieved when the most complex interactions between a range of physiological and physical factors take place in a satisfactory manner. It may also be said that although heat transmission may be critical for survival in cold weather, moisture vapour transmission is crucial to comfort in both cold and hot weather.

Free movement of water to the fabric surface is essential if perspiration discomfort, causing fabric wetness which results in freezing in winter or clamminess in summer, is to be prevented. The ability of a fabric to absorb liquid water is occasionally of importance in comfort behaviours and natural fibers, with high regain, are supposed to be superior in this respect. The hydrophobic nature of synthetic materials is often of critical importance in comfort. The movement of liquid water through a fabric can help determine two comfort aspects. It is desirable that water from an external source, such as rain, should be prevented from reaching the body. On the other hand, water produced on the body surface as perspiration should be removed as quickly and efficiently as possible if comfort is desired. Behmann [7] compared wool and polyamide fibre clothing of identical construction for sweat loss and for physiological sensations and found that wool performed better as a result of its higher ability for moisture uptake. Stas and Beuvaert [8] pointed out that the theory of surface tension can be related to the textile water proofing finishes. In the ideal case the pores of a fabric should be of sufficient size to permit free access of water vapour but the combination of pore size and material surface should be such that liquid water is prevented from entering the structure by surface tension.

However, the works discussed above have been done on cotton and synthetic fabrics and no work has so far been done

*DW = Double Warp

on jute-cotton union fabrics. A trend has now begun among the environment-conscious countries to use jute and jute products on a greater scale as they are friendly to environment and cause no environmental pollution. In this regard a number of jute-cotton union fabrics are now being produced with the objective of using them as outer garments. But to recommend jute-cotton union fabrics for use as apparels or outer garments, it is imperative to assess their comfort properties. Hence, this study has been undertaken to make a comparative study among cotton, jute-cotton, polyester, polyester-cotton and tetron-cotton fabrics in respect of physiological and comfort properties.

## Materials and Methods

Six different fabrics *viz.* Diamond, Twill, Ribbon, DW plain and two types of jeans (Jeans A and Jeans B) were collected from Mechanical processing Division of Bangladesh Jute Research Institute. The samples were made of 60% jute and 40% cotton. Jeans A was slightly heavier than Jeans B. Besides, ten more fabrics including seven cotton fabrics (Gueberdine, Poplin, Jeans (Jeans C), Khaddar, Drill, Markin and Mattress cover), one polyester, one polyester-cotton and one Tetron-cotton fabrics were purchased from the local market.

*(a) Determination of thermal conductivity.* Several methods of measuring thermal conductivity of textile products have been reported [9-14]. Korlinsky [15] has discussed the parameters that bring about changes in thermal conductivity. He has investigated the effect of knitted construction, fabric thickness, mass per unit area, number of walls and apparent fabric density in thermal insulation properties of knitted goods under free convection conditions. He has observed that fabric thickness has a decisive effect on the thermal insulation properties. Slater [16] has reported that thickness is one of the important factors that affect the thermal conductivity of jute and textile materials. The determination of thermal conductivity of textile materials is accompanied by certain difficulties inherent to the nature of the materials. It has been suggested that a simple measurement of thickness provides an adequate measure of thermal insulation. However, this is only acceptable, if a common value can be assumed for the thermal insulation per unit thickness. The transmission of heat through a fabric can occur not only by conduction through the fibres and the entrapped air but also by radiation through the air spaces within the fabrics. Because of this, there is a considerable variation in thermal insulation per unit thickness.

Thermal conductivity of the samples were measured in units of $mWm^{-1}{}^{\circ}C^{-1}$ (milli Watt per meter per degree Celsius) by Lees Electrical apparatus [17]. The samples were pre-conditioned at the standard atmosphere of 65±2% R.H. and 20±2°C temperature for 24 hours. These conditioned samples were then placed between hot and cold discs. Temperatures were noted when the discs were found to attain steady state. After knowing the temperature of discs A, B and C at the steady state, thermal conductivity K was evaluated by the formula,

$$K = \frac{ed}{2\pi r^2 (T_B - T_A)} \left[ a_S \frac{T_A = T_B}{2} + 2a_A T_A \right] \text{mW/m°C}$$

When K = thermal conductivity of the sample.

$a_A$, $a_B$, $a_C$ & $a_S$ = exposed surface area of discs A, B, C and sample S respectively. $T_A$, $T_B$, $T_C$ = temperature of discs A, B & C at steady state.

r = radius of the circular copper disc.
d = thickness of the sample.
e = the amount of heat radiated from each exposed unit area of surface per sec. per °C above ambient temperature and calculated as,

$$e = VI \left[ a_A T_A + a_S \frac{T_A + T_B}{2} + a_B T_B + a_C T_C \right]^{-1} \text{mW/m}^2\text{°C}$$

Where V is the potential difference across elements in volts and I is the current flowing in amperes.

*(b) Cloth cover.* Cloth cover [18] of the fabrics was determined by counting the threads with the help of a travelling thread counter and using the formula.

$$K_C = K_1 + K_2 - \frac{K_1 K_2}{28}$$

Where $K_1$ = warp cover factor.
$K_2$ = weft cover factor.

*(c) Absorption test.* Absorption [19] was measured by placing the sample of a fabric on a horizontal frame and dropping one drop of distilled water from a height of 0.95 cm (3/8 inch) on the cloth and measuring the time for disappearance of specular reflection from the water.

*(d) Static charge.* A simple experimental technique [20,21] was developed by which the static charge generated by a fabric was measured. In practice, the fabric was allowed to move between a pulley and a metallic rod. The pulley was driven by an electric motor. As the fabric revolved, electrostatic charge was generated on the fabric by friction which was collected in a condenser of known value through the metallic rod. The voltage across the condenser was measured by a precision digital milli volt meter. As the capacitance of the whole system was known, the value of the voltage generated across the condenser gives a measure of the overall

charge generated on the fabric. Thus, if the voltage across the condenser was V, the capacitance of the whole system was C and the total charge generated on the fabric was Q, then by using the formula Q = CV, the charge generated on the fabric could be determined in coulomb/meter$^2$.

*(e) Microbiological test.* The mycotoxin producing fungi and allergy producing fungi were characterized following the procedure described by Gilman [22], Barnet [23] and Raper [24].

**Results and Discussion**

Thermal conductivity of a fabric depends on its density which in turn depends on its construction. Higher value of thermal conductivity of a fabric means that the fabric is more compact and more air can pass through it. From the comfort point of view higher thermal conductivity is desirable as heat generated in the body can very easily and quickly dissipate. It appears from Table 1 that Jeans C has the highest thermal conductivity (116.57 mW/m°C) amongst all the samples while Diamond has the highest thermal conductivity (89.83 mW/m°C) among the union fabrics.

Table 1. Thermal Conductivity of Jute-Cotton Union and Cotton Fabrics

| Fabrics Name | Thickness mm | Apparent fabric density gm/cc | Thermal conductivity mW/m°C |
|---|---|---|---|
| Diamond | 0.04x10$^{-2}$ | 0.6038 | 89.83 |
| Twill | 0.034x10$^{-2}$ | 0.7632 | 62.33 |
| Ribbon | 0.031x10$^{-2}$ | 0.8262 | 81.67 |
| DW plain | 0.032x10$^{-2}$ | 0.8211 | 71.33 |
| Jeans A | 0.027x10$^{-2}$ | 0.8574 | 87.00 |
| Jeans B | 0.0268x10$^{-2}$ | 1.001 | 67.54 |
| Gueberdine | 0.02x10$^{-2}$ | 0.96 | 87.00 |
| Poplin | 0.014x10$^{-2}$ | 0.891 | 71.21 |
| Jeans C | 0.043x10$^{-2}$ | 0.933 | 116.57 |
| Khaddar | 0.013x10$^{-2}$ | 0.917 | 51.11 |
| Drill | 0.019x10$^{-2}$ | 1.053 | 84.00 |

Table 2. Water Absorbency of Jute-Cotton Union and Cotton Fabrics

| Fabrics Name | Cloth Cover | Time of absorption of water |
|---|---|---|
| Diamond | 19.84 | 18 min. 17 secs. |
| Twill | 20.48 | 3 min. 16 secs. |
| Ribbon | 19.65 | 3 min. 2 secs. |
| Plain | 20.02 | 2 min. 18 secs. |
| Jeans A | 23.72 | 1 min. 33 secs. |
| Jeans B | 23.21 | 2 min. 49 secs. |
| Gueberdine | 26.08 | 8 min. 39 secs. |
| Poplin | 22.38 | 6 in. 25 secs. |
| Jeans C | 26.97 | 4 min. 14 secs. |
| Khaddar | 21.36 | 4 min. 55 secs. |
| Drill | 24.54 | 0 min. 2 secs. |

Gueberdine has the second highest thermal conductivity (87 mW/m°C) among the cotton samples which is equal to the value of Jeans A and nearly equal to the value of Diamond. Thermal conductivity (84 mW/m°C) of Drill fabric is slightly lower than that of Gueberdine. It is also observed that differences among the thermal conductivity values of union fabrics are not so high as to differentiate one fabric from the other in respect of comfort properties.

It is found (Table 2) that cloth cover of Jeans C is the highest (26.97) followed by Gueberdine (26.08) and Drill (24.54). Among the union fabrics, Jeans A has the highest cloth cover (23.72) followed by Jeans B (23.21) and Twill (20.48). In respect of water absorbency, Drill has the lowest time of absorption which makes it most suitable among all the fabrics. In union fabrics Jeans A has the lowest time of absorption indicating its better comfort properties.

It is observed (Table 3) that polyester (100%) fabric has the highest static charge (29.2 x 10$^{-9}$ Coulomb) followed by Polyester; Cotton (80:20), Tetron : Cotton (80:20) and union fabrics. Novotex fabrics (treated jute) and jute-cotton union fabrics show almost similar results. It is also observed that static charge developed on jute fabrics is higher than the one on cotton fabrics. Tetron has the same value as that of the jute-cotton union fabrics. There is also some difference in the static charge of cotton fabrics which may be due to different pattern of weaves.

Among all the jute-cotton fabrics Diamond has the highest thermal conductivity and lowest absorbency followed by Ribbon. Thermal conductivity as well as absorbency of DW

Table 3. Static Charge of Jute-Cotton Union and Cotton Fabrics

| Fabrics Name | Voltage produced | Static charge |
|---|---|---|
| Jute-cotton union fabric (Jute 60% + Cotton 40%) | 8 mv | 19.5x10$^{-2}$ coulomb/m$^2$ |
| Novotex fabrics (Jute 60% + Cotton 40%) | 9 mv | 21.9x10$^{-9}$ coulomb/m$^2$ |
| Jeans A&B (Jute 60% cotton 40%) | 3 mv | 7.3x10$^{-9}$ coulomb/m$^{-2}$ |
| Polyester (100%) | 18 mv | 29.2x10$^{-9}$ coulomb/m$^2$ |
| Polyester : cotton 80% 20% | 12 mv | 23.9x10$^{-9}$ coulomb/m$^2$ |
| Tetron : cotton 80% 20% | 8 mv | 19.5x10$^{-9}$ coulomb/m$^2$ |
| Poplin (cotton) | 3 mv | 7.3x10$^{-9}$ coulomb/m$^2$ |
| Drill (cotton) | 3 mv | 7.3x10$^{-9}$ coulomb/m$^2$ |
| Jeans C (Cotton) | 2 mv | 4.8x10$^{-9}$ coulomb/m$^2$ |
| Markin (cotton) | 2 mv | 4.8x10$^{-9}$ coulomb/m$^2$ |
| Mattress cover (cotton) | 2 mv | 4.8x10$^{-9}$ coulomb/m$^2$ |

Table 4. Microbiological Examinations on all Jute and Jute-cotton union Fabrics

| Sample | Total mould count per 100 cm$^2$ | Mycotoxin producing fungi per 100 cm$^2$ | Allergy producing fungi per 100 cm$^2$ |
|---|---|---|---|
| All jute (prepared in 1994) | 8.0 x $10^2$ | Not found | Not found |
| Jeans B (Jute-cotton) (Prepared in 1986) | 1.0 x $10^2$ | Not found | Not found |

plain fabric is higher than that of Twill. Cloth cover of Diamond fabric shows that it is more or less a compact fabric. Twill, Ribbon and DW plain fabrics are also compact but they have higher absorbency. This may be due to the nature of weave. Jeans A and Jeans B have lower cloth cover than Jeans C. On the other hand, density of Jeans B is higher than Jeans A and Jeans C. Jeans A takes less time to absorb water than Jeans B and Jeans C. Higher absorbency and higher thermal conductivity are desirable from the comfort view point. Absorbency of Jeans C is slightly lower than Jeans A and Jeans B, which may be due to the combined effect of higher cloth cover and surface tension of water drop. If the systematic considerations (appearance and handle) are taken into account the three Jeans can be arranged in the following order: (1) Jeans C, (2) Jeans A and (3) Jeans B. Considering all these points, it can be concluded that Jeans C is a better fabric followed by Jeans A and Jeans B.

Gueberdine is the softest of all the cotton fabrics. Khaddar has almost the same absorbency as that of Jeans C but has very low thermal conductivity. In respect of static charge, jute-cotton union fabrics appears to be more comfortable than polyester fabrics.

Comfort also depends on the utility of the fabric i.e. by whom it is worn. Hard fabric is desired by some people whereas soft fabric by others. A factory worker prefers a fabric which is oil and water repellent with less protruding fibers so that dust coming in contact with the fabric can be dusted off very easily. In this respect, Jeans C is better than Jeans B. However, considering all these points, Jeans A and Jeans B can also be recommended for use. As regards comfort, cotton fabric is the best and more hygienic than polyester. Jute-cotton union fabrics rank between cotton and polyester fabrics.

Since the discovery of the existence of microorganism by Leeuwenhoek in 1676, investigators have proved that microorganisms may be found practically everywhere [25]. Some microorganisms are beneficial to mankind while some are harmful. Microbiological examinations show that microorganisms are present in jute fabrics. Results from Table 4 show that microbial load is higher in all jute fabrics (3 years old fabric) than that of Jeans B (10 years old jute-cotton union fabric). But the most important observation is that no mycotoxin producing fungi and allergy producing fungi have been found in the jute fabrics. So it may be concluded that jute fabrics are not hazardous to health and are not supposed to produce any allergic effect.

## Conclusion

This study would enable the consumers to compare comfort and physiological properties of jute-cotton union fabrics with cotton and synthetic fabrics. Jute-cotton union fabrics may be introduced in the apparel or outer garments market. Attempts should also be made to improve the quality of such fabrics and make them more attractive and comfortable for wider acceptability by the consumers.

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