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Effect of preparatory processes on physical properties of cotton fabric

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Abstract
Cotton is a natural fibre. Natural fibres generally have some primary and secondary impurities which are present naturally or are added during the course of spinning, knitting, weaving and some after treatments like starching, etc. These impurities need to be eliminated, therefore the fabrics are subjected to preparatory treatments including desizing and scouring. The present study was planned to check the effect of preparatory processes on physical properties of cotton fabric. After desizing and scouring, physical properties of fabric were tested using standard test methods. The results of the study indicated that all geometrical properties i.e. fabric count, weight per unit area and thickness of cotton fabric increased non-significantly after desizing and scouring. The results also showed that the tensile strength decreased while the elongation increased non- significantly. It was also found that there was increase in bending length and flexural rigidity whereas air permeability and moisture regain decreased after desizing and scouring of the cotton fabric.

Keywords: preparatory process, cotton fabric, desizing, scouring, physical property

Introduction
Cotton is a natural fibre of great economic importance as a raw material for cloth. It is nearly pure cellulose, which is the most abundant organic polymer with the formula (C6H10O5)n on earth and it is a polysaccharide consisting of a linear chain of several hundred to over ten thousand β (1→4) linked D glucose units (Saleemuddin 2013; Tania 2018) [11, 12]. Cotton fibre is mainly compiled with cellulose and some non-cellulosic constituents surrounding the cellulose core (Chung 2004) [1]. The cotton fibre is a single biological cell with a multilayer structure. These layers are structurally and chemically different, and contain approximately 10% by weight of non-cellulosic substances such as lipids, waxes, pectic substances, organic acids, proteins/nitrogenous substances, non-cellulosic polysaccharides, and other unidentified compounds included within the outer layer of the fibre (Karmakar 1999; Li and Hardin 1997; Li and Hardin 1998; Lin and Hsieh 2001; Karapinar and Sariisik 2004; Mojsov 2012) [3, 4, 5, 6, 2, 7]. Various preparatory processes such as desizing are done to remove sizing material and scouring are done to remove these impurities from the fabric without causing any damage to physical and chemical properties of fabric. Physical properties of fabric are vital because these properties decide the functionality of the fabric. There were various physical properties such as geometrical, mechanical and comfort properties. The geometrical properties of the cotton fabric comprised of fabric count, weight and thickness etc. Fabric count is the number of warp yarns (ends) and weft yarns (picks) per square inch in the cotton fabric. Weight of the fabric is defined as weight of a known area of the material and then computing the weight per unit area. Fabric thickness is defined as the perpendicular distance through the fabric which is determined with a thickness gauge (Poonia 2018) [8]. Mechanical properties includes tensile strength and elongation. Tensile strength is the ability of material to withstand a pulling (tensile) force that it can take before failure such as breaking or permanent disruption. It is a measurement of force per unit cross- sectional area. Elongation of fabric corresponding to tensile strength is the original length of the sample at breaking point. Comfort properties includes bending length, flexural rigidity, moisture regain and air permeability of fabric. Moisture regain is defined as the weight of water in a material expressed as a percentage of the oven dry weight (Sushila 2018) [9]. Flexural rigidity is defined as the force required to bend a non-rigid structure in one unit of curvature or it can be defined as the resistance offered by a structure while undergoing bending. Air permeability of a fabric is the volume of air measured in cubic cm passed per second through 1 square cm of the fabric at a pressure of 1 cm head of water. Thus, the work has been planned to find the “Effect of preparatory processes on physical properties of cotton fabric”.

Methodology

Selection of raw materials

Grey cotton fabric samples were collected from the local market of Hisar city. The collected samples were screened visually and through physical and chemical tests. The collected samples were analysed by physical, burning and solubility tests to determine hundred per cent purity of cotton. Among the screened cotton fabrics, medium weight grey cotton fabric was selected.

Desizing of the fabric

The textile fabric after weaving has sizing material on the warp yarn, which makes the yarn less porous, thus it is very important to remove it. The fabric was weighed and pre wetted in normal tap water before immersing in the desizing bath. The fabric was squeezed thoroughly and was desized in a solution containing one per cent sulphuric acid (H_2SO_4) with an MLR 1:40 at 50^0 C for 60 minutes. The fabric was then taken out and rinsed thoroughly to get rid of starch and other residues (Singh *et al.* 2017) [10].

Scouring of the fabric

Woven fabric has natural as well as added impurities like oils, wax, dirt and non-cellulosic material (in case of cotton fabric). Scouring, a wetting process is used to remove these impurities without any damage to the physical and chemical properties of the fabric. In the present study, the fabric was weighed and soaked in normal tap water prior to introducing into the scouring bath. The fabric was squeezed scrupulously and was put in an aqueous solution containing 1 per cent soap, 3 per cent soda ash (Na_2CO_3) and 0.5 per cent sodium sulphite with MLR 1:40 at boiling temperature (100^0 C) for 60 minutes. The fabric was further washed thoroughly until free from any residues and dried on a flat surface (Singh *et al.* 2017) [10].

Testing of physical properties after preparatory processes

The fabric's physical properties are vital because these properties decide the functionality of the fabric. In the study, the physical properties of the grey cotton fabric and desized and scoured samples were tested and compared to analyse the effect of the preparatory processes on the fabric.

Geometrical properties

The geometrical properties of the desized and scoured cotton fabric comprising of fabric count, weight and thickness were tested to determine the effect of the preparatory processes on the fabric. The geometrical properties of the samples were studied as per the standard test methods described below.

Fabric count: To determine the fabric count of the cotton fabric, Paramount Pick Glass with pointer was employed using ASTM–D123 test method. An average of five readings was taken as the fabric count.

Fabric weight: Samples were cut at random from the fabric samples with the help of round cutter of GSM. The individual samples were suspended on the clamp of the pointer beam of the Paramount Precision Scale for GSM using ASTM D3776-90 test method. The weight per unit area was read directly from the Quadrant scale from 0-250 GSM. An average of five readings was calculated as fabric weight.

Fabric thickness: In order to determine the thickness of the samples, Paramount Fabric Thickness Gauge was employed using BS 2544: 1967 test method. A specimen of 5"x5" was taken. An average of five readings was calculated as the fabric thickness.

Mechanical properties

Mechanical properties i.e. tensile strength and elongation were tested to analyse the effect of preparatory processes on mechanical properties of fabric. These properties of fabric samples were studied as per the standard test methods described below.

Tensile strength: Tensile strength of fabric was calculated employing Paramount Tensile Tester using IS 4169 test method. Template sized conditioned samples were cut from warp and weft directions of the fabric. An average of five readings from both directions (warp and weft) was taken.

Elongation: Paramount Tensile Tester was employed to determine the elongation of fabric using IS 4169 test method. The percentage elongation at breaking point was calculated from the following formula:

$$\text{Elongation at break (\%)} = \text{Lf} - \frac{\text{Li}}{\text{Li}}\text{x}100$$

Where,
L_i= initial reading
L_f= Final reading

Comfort properties

Properties, i.e. bending length, flexural rigidity, moisture regain and air permeability were tested to find out the effect of preparatory processes on comfort properties of fabric. The comfort properties of fabric samples were studied as per the standard test methods described below.

Moisture regain: Moisture regain was determined using BS 1051:1964 test method. The samples of the required size were cut. The oven was preheated for 10-15 minutes to reach the controlled temperature and the samples were weighted and placed in dry oven at 105±30 ^{0}C for 3 hours. The closed container was transferred to desiccators when the container and the specimen were cooled at room temperature. The samples were weighed and an average mean was calculated.
The percentage of moisture regain was calculated using the following formula:

$$\text{Moisture regain (\%)} = \frac{\text{Original weight} - \text{Oven dry weight}}{\text{Oven dry weight}} \times 100$$

Fabric bending length: Paramount Stiffness Tester was employed to determine the bending length of the fabric samples using BS 3356: 1961 test method. Template sized samples were cut from the warp as well as weft direction and conditioned to standard testing conditions. A total of five samples were observed and each sample was tested four times i.e. at each edge. An average of 20 readings in warp and 20 in weft direction was calculated.

$$C = l \text{ x } f(o)$$

Where,

C= bending length
f(o)= 0.5

l= length reading on the bending meter

Flexural rigidity: "Flexural rigidity is defined as the force required to bend a non-rigid structure in one unit of curvature or it can be defined as the resistance offered by a structure while undergoing bending". The area and weight was determined for calculating the flexural rigidity.

Flexural rigidity (G) = W x C^3 x 9.81 x 10^{-6} mN.mm

Where,
W= weight per unit area of fabric in g/m^2
C= the bending length in mm
Overall flexural rigidity

$G_o = G_w \times G_f$

Where
G_w- warp way flexural rigidity, and
G_f- weft way flexural rigidity

Air permeability: The air permeability test of the samples was tested by using JIS L 1903 test method. Air permeability was measured by KES-FB-AP1 instrument, in which a constant rate of air flow is generated and passed through the specimen. This leads to the development of pressure difference across the specimen. The instrument had a digital panel meter from which air resistance of the specimen was read directly. The air resistance was directly recorded from the digital panel meter. The inverse of this value gives air permeability in CFM.

Results and Discussion

The present study was undertaken to check the effect of preparatory processes on physical properties of cotton fabric. The physical properties of cotton fabric were studied by using standard test methods. The results are presented as follows:

Preliminary properties of the cotton fabric

Medium weight grey cotton fabric was selected for the study. Three parameters i.e. fabric count, weight and thickness of selected fabric were evaluated. The data in Table 1 showed that the fabric count of grey cotton fabric was 53.40×46.40 picks/sq. inch with 0.26 mm thickness and 137.40 g/m^2 weight.

Table 1: Preliminary properties of the cotton fabric

Fabric Properties	Fabric count (ends and picks/sq. inch)	Fabric weight (g/m^2)	Fabric thickness (mm)
Cotton fabric	53.40×46.40	137.40	0.26

Effect of preparatory processes on physical properties of grey cotton fabric

The selected cotton fabric underwent preparatory processes like desizing and scouring which involves the removal of impurities and starch from the fabric and makes it more absorbent for further textile processing. Scouring was done after desizing to remove all the impurities and starch from the fabric. The pre-treated grey cotton fabric was further studied with respect to change in physical properties i.e. geometric, mechanical and comfort properties.

Geometrical properties of cotton fabric

Geometrical properties viz. fabric count, weight and thickness were tested to explore the effect of preparatory processes on the geometrical properties of grey cotton fabric. The Table 2 revealed that the fabric count of grey fabric was 53.40±0.68 × 46.40±0.51 ends and picks per sq. inch. The results highlighted that after desizing and scouring, the fabric count increased to 60.00±0.89×49.20±0.58 ends and picks per sq. inch. There was +12.4 and +6.0 per cent change in fabric count in both warp and weft direction with 4.56 and 3.50 t-values, respectively. The increase in fabric count in both warp and weft direction was found to be non-significant.
The thickness and weight of the grey fabric was also found to increase after desizing and scouring. The thickness of grey fabric was 0.26±0.005 mm which increased to 0.28±0.002mm and the weight was initially 137.40±0.75 g/m^2 which increased to 150.60±1.17 g/m^2. There was 6.9 and 9.6 per cent change in thickness and weight of the fabric with 3.09 and 9.73 t-values, respectively. The increase in fabric weight and thickness of desized and scoured fabric was found to be non-significant.
Hence, it is clear from the data presented in Table 2 that after desizing and scouring, all the geometrical properties of grey cotton fabric increased non-significantly.

Table 2: Effect of preparatory processes on geometrical properties of cotton fabric

Fabric Physical Parameters		Grey fabric Mean ± S.E	Desized and scoured fabric Mean ± S.E	Percent Change	t-value
Fabric count (ends and picks per square inch)	Warp	53.40±0.68	60.00±0.89	+12.4	4.56
	Weft	46.40±0.51	49.20±0.58	+6.0	3.50
Weight per unit area (g/m^2)		137.40±0.75	150.60±1.17	+9.6	9.73
Thickness (mm)		0.26±0.005	0.28±0.002	+6.9	3.09

**Significant at 1% level of significance, *Significant at 5% level of significance

Mechanical properties of cotton fabric

The data in Table 3 highlighted that the tensile strength in warp and weft directions of grey cotton fabric was 16.02±0.75 and 10.58±0.07 kg respectively, which after desizing and scouring decreased to 15.04±0.29 and 10.10±0.23 kg. It was found that there was a decrease of 6.1 and 4.5 per cent in warp and weft directions with 1.73 and 1.94 t-values, respectively. The results showed that the decrease in tensile strength of desized and scoured cotton fabric in warp and weft directions was found to be non-significant.
Elongation in both warp and weft directions of grey cotton fabric increased after desizing and scouring. It was 9.24±0.09 and 15.70±0.21 per cent respectively, which increased to 9.88±0.20 and 17.04±0.27 per cent. An increase of 6.9 and 8.5 per cent was noticed in elongation of desized and scoured grey cotton fabric in both warp and weft directions with 2.90

and 2.97 t-values, respectively. The increase in elongation in both warp and weft directions of desized and scoured grey cotton fabric was found to be non-significant.

Thus, results showed non- significant decrease in tensile strength and non-significant increase in elongation of desized and scoured grey cotton fabric.

Table 3: Effect of preparatory processes on mechanical properties of cotton fabric

Fabric Physical Parameters		Grey fabric Mean ± S.E	Desized and scoured fabric Mean ± S.E	Per cent Change	t-value
Tensile strength (kg)	Warp	16.02±0.75	15.04±0.29	-6.1	1.73
	Weft	10.58±0.07	10.10±0.23	-4.5	1.94
Elongation (%)	Warp	9.24±0.09	9.88±0.20	+6.9	2.90
	Weft	15.70±0.21	17.04±0.27	+8.5	2.97

**Significant at 1% level of significance, *Significant at 5% level of significance

Comfort properties of cotton fabric

Comfort properties, i.e. bending length, flexural rigidity, moisture regain and air permeability were tested to study the effect of preparatory processes on these properties of cotton fabric.

Data in Table 4 revealed that the bending length of grey cotton fabric in both warp and weft directions was 2.28±0.07 cm and 1.67±0.01 cm respectively. It was found that after desizing and scouring, the bending length in both warp and weft directions increased to 2.42±0.01 cm and 1.86±0.02cm with 6.1 and 11.4 percent increase with 1.83 and 10.15 t-values, respectively. The increase in bending length (weft direction) of desized and scoured cotton fabric was found to be significant at 1% level of significance.

The flexural rigidity of grey cotton fabric also increased. It was recorded as 177.71±18.09 mN.mm initially, which after desizing and scouring increased to 187.49±4.69 mN.mm with an increase of 5.5 per cent and 0.56 t-value. The results showed that the increase in flexural rigidity of desized and scoured grey cotton fabric was found to be non-significant.

The air permeability of grey cotton fabric was found to be 152±2.19 CFM. After desizing and scouring, the air permeability of grey cotton fabric decreased to 140±0.71 CFM with per cent reduction of 7.9 and 5.26 t-value. The results showed non-significant decrease in air permeability of desized and scoured grey cotton fabric.

Moisture regain of grey cotton fabric was 5.81±1.04 per cent. It was found that the moisture regain decreased to 5.59±0.08 per cent after desizing and scouring and the per cent reduction was 3.9 per cent with 2.09 t-value. Thus, there was non-significant decrease in moisture regain of desized and scoured grey cotton fabric.

Table 4: Effect of preparatory processes on comfort properties of cotton fabric

Fabric Physical Parameters		Grey fabric Mean ± S.E	Desized and scoured fabric Mean ± S.E	Per cent Change	t-value
Bending length (cm)	Warp	2.28±0.07	2.42±0.01	+6.1	1.83
	Weft	1.67±0.01	1.86±0.02	+11.4	10.15**
Flexural rigidity (mN.mm)		177.71±18.09	187.49±4.69	+5.5	0.56
Air permeability (CFM)		152±2.19	140±0.71	-7.9	5.26
Moisture regain (%)		5.81±1.04	5.59±0.08	-3.9	2.09

**Significant at 1% level of significance, *Significant at 5% level of significance

Conclusion

Pre treatment processes such as desizing and scouring were performed for removal of the impurities and starch present in cotton fabric. The geometric properties of pre-treated fabric increased after process. The fabric count in warp (12.4%) and weft (6.0%) directions, weight (+9.6) and thickness (+6.9) increased non-significantly after desizing and scouring. Tensile strength decreased by (6.1%) in warp and (4.5%) in weft direction while elongation increased in warp (6.9%) and weft (8.5%) direction and the changes were found to be non-significant. The bending length increased in warp (6.1%) and weft direction (11.4%) and flexural rigidity increased by (5.5%). Change in bending length (weft direction) was significant. Air permeability and moisture regain decreased by (7.9%) and (3.9%), respectively. Changes were found to be non- significant. Therefore, in the test results, it was found that preparatory processes had an effect on physical properties of cotton fabric.

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