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A study on the physical properties of 100% cellulosic woven fabrics

Abstract

The aim of this paper is to study the physical properties of three types of 100% cellulosic woven fabrics. These three types of fabrics are canvas, poplin and voile fabrics. These fabrics have the similar width of 60 inches. Physical properties of the fabrics like tear strength, tensile strength, weight (g/m^2), cover factor and shrinkage were investigated. The experimentations were carried out in accordance with the test standard provided by ASTM and AATCC as described underneath the paper. Canvas fabric expressed the higher value of weight and strength compared to poplin and voile. On the other hand, voile fabric expressed the better values of shrinkage compared to other two fabrics. Canvas fabrics expressed the higher values of air permeability. This research is practice based and the outcomes are advantageous to the textile professionals. This research opens possible ways for the scholars to further study in this field.

Keywords: woven fabrics, tear strength, tensile strength, cellulosic fiber, cover factor

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Shaharia Ahmed
College of Textiles, Zhongyuan University of Technology, China

Correspondence: Shaharia Ahmed, College of Textiles, Zhongyuan University of Technology, Zhengzhou, Henan, China, Email shaharia.ahmed.shahed@gmail.com

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Introduction

There is a great importance of this research in the field of cotton fabrics manufacturing industries. Different scholars worked regarding to this investigations at different times where literature review exposed different consequences. Some of them were similar and some of them were widely dissimilar. Cotton fibers are obtained from nature and fabrics made with cotton yarns are comfortable to wearer.[1] Fabrics can be made by weaving, knitting and braiding. Fabrics can also be made by nonwoven process where each fiber is joined with other fibers either by adhesive or by bonding agent.[2]

Woven fabrics are made by interlacement of two different sets of yarns. In these two sets one is called the warp and another is called the weft. Woven fabrics are made with the interlacement process of warp and weft at right angle. Generally, woven fabrics are manufactured in weaving loom, and made of yarns woven on a warp and a weft.[3] Woven fabrics are manufactured by both natural and synthetic fibers, and are frequently made from a combination of together.[4]

Woven fabrics are mainly three types such as plain, twill and satin. Plain weave fabrics are mainly manufactured by the two sets of yarns with the 1 up and 1 down process at right angles. Plain weave is a fabric that is strong and hard-wearing, and is applied for style and furnishing fabrics.[5] In this weave, the warp and weft yarns stay at right angles and create a durable fabric. Every weft yarn passes the warp yarn by moving above one and then below the following, and so on. The subsequent weft yarn goes below the warp yarn that its belonging passes over, and vice versa.[6]

Among plain weave fabrics, balanced clothes are prepared with the warp and weft yarns of same count and the similar quantity of picks and ends per inch of clothes. In the basket weave fabric, two or more yarns are laid together and then interlaced each other.[7] These yarns run parallel to its corresponding yarns. Muslin is a type of fabric that is made up of 100% cotton yarns with the interlacement ration of one up and one down. The yarn count of muslin clothes are very fine ranges from 200Ne to 300Ne.[8]

It is prepared in an inclusive variety of weights from elusive sheers to grainy sheet. It acquires its tag from the town of Mosul, Iraq, wherever it was first prepared. Initial muslin was hand-woven of especially subtle handspun yarn.[9] The yarns of muslin clothes were imported either from India or from Iran, turkey etc. Tearing strength is expressed as the energy needed to initiate or to endure to tear clothes, in whichever warp or weft way, in definite conditions. A tear in a cloth basically happens gradually along a line, and can be started by a stirring cloth being caught on shrill substances. Tensile strength of a thread or cloth is expressed as an extreme load that it would tolerate deprived of breaking when exposed to uniaxial tensile load.[10] This strength of a woven cloth is one of the most significant characteristics which make it bigger in many applications as related to nonwoven and knitted clothes.

The property of shrinkage is expressed as the change of measurement through the length and width of the clothes after washing, either in hot water or in cold water.[11] When cotton fabrics are submerged to water, they started to shrink in both warp and weft way to neutralize pressures obtained from processing/finishing department. Shrinkage values are both types like positive and negative. Positive shrinkage refers that a fabric will increase in length after washing. Wherein negative shrinkage fabrics started to shrink or reduce its length after washing.[12]

Cover factor is a technical dimension of the proportion area of the cloth enclosed by the yarns. Cover factor is dependent on the construction of the clothes and also in the type of yarns used. Plain weave fabrics expressed the best cover factor values compared to twill and satin weave fabrics.[13] Air permeability is a property that measures how effortlessly air passes through the clothes. It specifies the breathability of fabrics. The more the air permeability is, the better the breathability is. Air permeable clothes have a habit to have moderately high moisture vapor diffusion capacities.[14]

Materials and methods

Materials used

100% cellulosic woven fabrics were used in this research for investigation of the physical properties of fabrics as stated in Table 1. Three types of fabrics with different construction and width were used in this research. All the fabrics were of plain weave in pure

cotton yarns. Canvas fabrics are produced with coarser yarn count, poplin fabrics are produced with finer yarn count and voile fabrics are produced with very fine cotton yarns. Figure 1 shows the 100% cellulosic poplin fabric.

Table 1 Materials used in this research

S.N	Composition	Construction	Weave	Width (")
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	$Plain\left(\frac{1}{1}\right)$	60
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$		60
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$		60

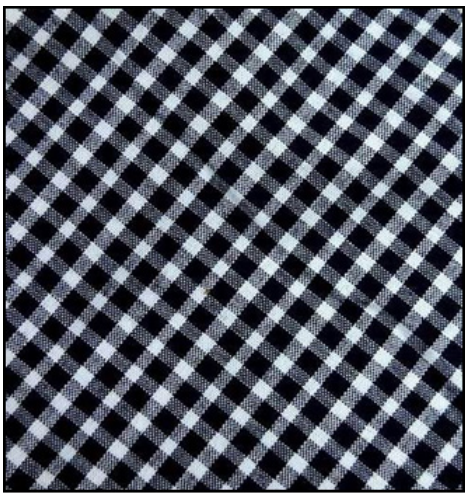

Figure 1 100% cotton poplin fabric.

Method used

All the fabrics were tested in accordance with the test method provided by ASTM Standard as mentioned underneath the paper. Weight measurement of the cloth was done followed by ASTM D3776 standard, tearing strength was measured in ASTM D1424 standard, tensile strength was measured in ASTM D5034 method, shrinkage was measured followed by AATCC 135 method and air permeability was measured in ASTM D737 standard.

The experimentation

Experiment of weight (g/m^2): The weight of the specimen was taken in ASTM D3776 Standard. The weight was taken in mass per unit area of clothes. A round GSM cutter was used to take the weight of the samples. At first the fabrics were conditioned properly after taking from the industry. Fabrics were cut with the round GSM cutter at 5 different places to get the average weight of the clothes. After cutting the clothes, it was placed in the measurement scale to get the results. The results were placed in Table 1. Figure 2 shows the weight (g/m^2) measurement of the fabric.

Experiment of tear strength

Tear strength of the fabric was measured in accordance with the test method provided by ASTM D1424 standard. It is a standard test method to test the tear strength of clothes by falling pendulum type apparatus. The name of the instrument is Elmendorf tearing tester. This instrument takes the sample loads effortlessly and firmly into the double bolt clamps. Here, the first tear in the cloth is made by dragging the lever devoted to the cutting edge. In this instrument the pendulum is set steadily in dwelling until the fabric is set and releases it with an impulsion of a finger. The fabric is set after cutting perpendicularly and locked the one part with a clip and another part is kept locked at the same way with another clip. Then the pendulum is released with finger push and found the results. The results are obtained and put in Table 3. Figure 3 shows the tear strength measurement process of fabrics.

Figure 2 Weight (g/m^2) measurement of the fabric.

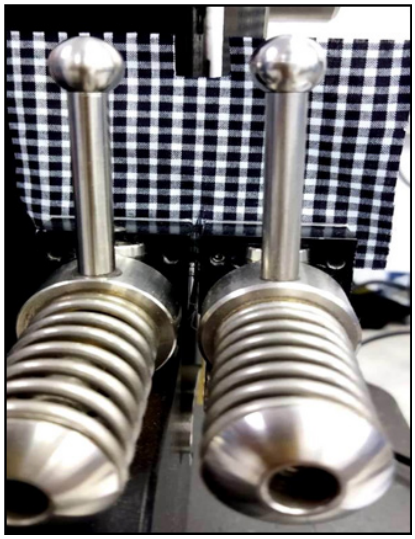

Figure 3 Tear strength measurement process of fabrics.

Table 2 Shrinkage report of cotton fabrics

S.N	Composition	Construction	Warp shrinkage%	Weft shrinkage%
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	-2	-3
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$	-1.5	-2
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$	-0.5	-1

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Table 3 Cover factor values of fabrics

S.N	Composition	Construction	Warp cover	Weft cover	Total cover
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	25	20	27.14
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$	19.45	15.91	24.31
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$	31.12	8.58	22.55

Experiment of tensile strength

Tensile strength of the fabric was measured in agreement with the test method provided by ASTM D1424 standard. This test method states a process to define the maximum force and the elongation at maximum force of clothes applying a grab method. Grab test is a type of tensile test where only the middle part of the sample is riveted in the jawline surfaces. 3 set of samples are made, one in the warp way and another in the weft way. The test samples should be allotted haphazardly in equivalent numbers to the instrument for experimentation. The two parts of the samples are clamped with 2 jaws and then started experimentation. The samples started to destroy due to pressure from hydraulic jaws and the values are shown in computer monitor and placed in Table 4. Figure 4 shows the tensile strength measurement process of fabrics.

Table 4 Air permeability values of fabrics

S.N	Composition	Construction	Air permeability (ft^3/min)
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	115
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$	90
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$	75

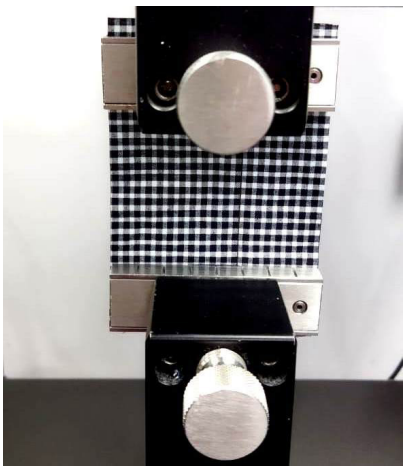

Figure 4 Tensile strength measurement process of fabrics.

Experiment of shrinkage

Shrinkage value of the cotton fabric was measured in agreement with the test method provided by AATCC 135 Standard of the specimen. At first the fabrics were collected from fabric mill as stated in Table 1. The fabrics were conditioned properly in testing laboratory before testing of shrinkage values. Fabrics were cut with scissors and then marked with permanent marker of black ink before testing. The fabrics were kept in normal water for 3 hours to shrink as much as possible in normal position. After that the measurement was taken again and shrinkage value was obtained. This value can be both positive and negative. If the fabric increases its length after submerge, then it is positive shrinkage and if the fabric decreases its length then it is negative shrinkage. Both types of shrinkages are obtained in cotton fabrics. The values of the shrinkage are obtained in placed in Table 5.

Table 5 Weight (g/m^2) measurement of fabrics

S.N	Composition	Construction	Weight (g/m^2)
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	273
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$	155
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$	110

Experiment of cover factor

Cover factor refers the rigidity or the density of clothes. Cover factor values of the samples were measured with equation 1 as stated below. 3 types of samples from the table 1 were taken and their cover factor was measured with this equation and placed the results in Table 6. This equation needs the values of EPI, PPI, warp count and weft count.

$$\left[\left\{\left(\frac{\text{EPI}}{\sqrt{\text{warp count}}}\right)+\left(\frac{\text{PPI}}{\sqrt{\text{weft count}}}\right)\right\}-\left[\frac{\left\{\left(\frac{\text{EPI}}{\sqrt{\text{warp count}}}\right)\times\left(\frac{\text{PPI}}{\sqrt{\text{weft count}}}\right)\right\}}{28}\right]\right]$$

Equation 1 Cover factor measurement formula

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Table 6 Tear strength values of fabrics

S.N	Composition	Construction	Warp tear (gram)	Weft tear (gram)
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	1260	870
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$	1090	710
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$	790	405

Experiment of air permeability

The air permeability of the clothes was measured in agreement with the test method provided by ASTM D737 Standard. The proportion of air movement passing vertically through an identified area of cloth is accustomed to get an agreed air pressure differential among the two cloth surfaces. By the passing proportion of air flow, the air permeability of the cloth is measured. The area of the test was 38cm^2 with air pressure 125Pa. 3 types of samples from the Table 1 was taken, prepared for investigation and finally obtained the test results and put in Table 7.

Experiment with microscope

Yarns were unplugged at first from the fabrics and kept them in the microscopic slide using glycerin. Adjusting the lenses of microscope, the yarns were visible. The photos of the scan samples were clearly visible in the computer screen as shown in Figure 6. Microscope has the capability to enlarge the view up to 800 times than its original size. Figure 5 shows the investigation of the yarn with microscope.

Table 7 Tensile strength values of fabrics

S.N	Composition	Construction	Warp tensile (lb)	Weft tensile (lb)	Warp extension (%)	Weft extension (%)
A	100% Cotton Canvas	$\frac{16\times16}{100\times80}$	78	57	23	27
B	100% Cotton Poplin	$\frac{32\times32}{110\times90}$	60	45	15	20
C	100% Cotton Voile	$\frac{50\times50}{120\times100}$	47	36	10	14

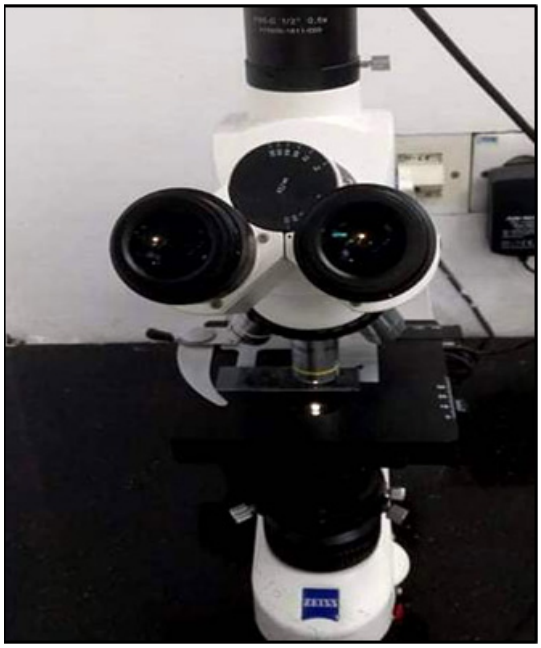

Figure 5 Microscopic view of the yarn.

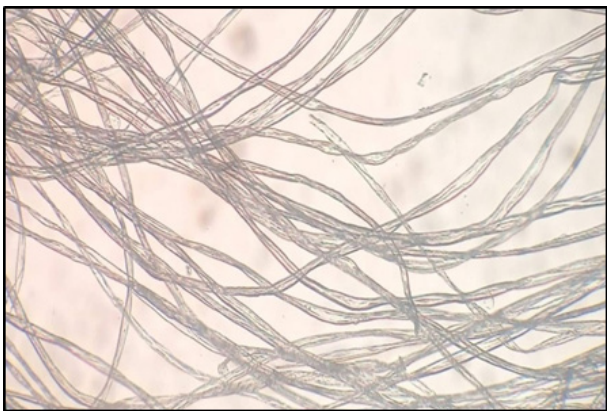

Figure 6 Investigation of the yarn with microscope.

Result and discussion

Results of weight

Weight in g/m^2 of the specimen was measured in accordance with the test method provided by ASTM D3776 Standard. The values are shown in Table 5. It is seen from the Table 5 that, the fabrics with courser yarn count expresses heavier weight than finer count. Canvas

fabrics always show heavier weight than poplin and voile fabrics. The weight was taken for 3 different places for each sample and then positioned in Table 5.

Results of tear strength

Tear strength of the specimen were conducted as standard specify by ASTM D 1424 Method. This method provides test report by falling pendulum apparatus. The strength values are shown in Table 6. It is shown that the coarser fabrics provide better tear strength than that of finer fabrics. This is because coarser yarns are stronger than finer yarns.

Results of tensile strength

Tensile strength of the specimen was conducted as standard specify by ASTM D 5034 Method. This method is applied to measure the breaking strength of fabrics. In this test the middle part of the sample is riveted in the jawline. This test was conducted in both warp and weft direction. Here also canvas fabric exposed the best tensile strength where poplin and voile fabrics exposed less strength. Table 7 shows the tensile report and extension% report.

Results of shrinkage

The dimensional stability of the fabrics was measured in agreement with the test method provided by AATCC 135. This test method provides the shrinkage report of cotton fabrics in both warp and weft way. Table 2 shows the shrinkage report of these fabrics.

Results of cover factor

Cover factor express the area of fabrics covered by the yarn. This value expresses the tightness and looseness of fabrics. Table 3 shows the cover factor of these fabrics. It is seen from the table that, 100% cotton canvas fabric has the highest cover factor value where in 100% cotton voile fabric has the least values of cover factor. Poplin fabric has the mid value of cover factor among these 3 samples.

Results of air permeability

Air permeability is the capability of a cloth to permit air to pass through it. The value of air permeability is less where the fabrics are more rigid. Air permeability values are higher where fabrics are loosely woven. Followed by ASTM D737 standard, air permeability values are tested and placed in Table 4. The values of air permeability were obtained in the unit of ft^3/min. it is seen from the table that 100% Cotton Canvas with construction $\frac{16\times16}{100\times80}$ exposed the maximum air permeability value. Alternately, 100% Cotton Voile with construction $\frac{50\times50}{120\times100}$ exposed the lowest air permeability value.

Microscopic observation

Yarns were unplugged from fabrics and microscopic views were taken. Figure 5 shows the microscopic views of the yarns. In this view we can see that the cell wall of a cotton fiber comprises of a primary and a secondary wall. The second that contains the bulk of the fiber, contains of numerous spirally sloping cellulose fibrils surrounded by a windy that creates a spiral, but in the contrary path from the previous.

Conclusion

It is seen throughout the research that, the physical properties of 100% cotton woven fabrics were investigated. These fabrics were woven with plain weave structure of different types like canvas, poplin and voile. Canvas fabrics have a heavier shape compared to poplin and voile fabrics. This fabric exposed the highest weight (g/m^2). It also exposed the maximum tear and tensile strength compared to other two fabrics like poplin and voile. Canvas fabrics also showed more shrinkage values compared to poplin and voile fabrics. Due to its heavier shape, it expressed maximum cover factor values. The microscopic views of the cotton yarns were also taken. Further study is possible in this field.

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Conflicts of interest

The authors have no conflict of interest regarding this paper.

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