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Analysis of variance on Physical Properties of 100% Cotton 1acaaez1 Plain Woven Fabrics

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Abstract

This paper is to categorize the physical properties of three types of 100% cotton 1/1plain woven fabrics. These three types of fabrics are canvas, poplin, and voile fabrics. These fabrics have a similar width of 60 inches. Physical properties of the fabrics like tear strength, tensile strength, weight (g/m2), cover factor, shrinkage, and Air permeability, and Martindale pilling resistance were examined. The experimentations were performed with the test method provided by ASTM Standard as described underneath this paper. Canvas fabric expressed higher values of weight and strength associated with poplin and voile. On the other hand, voile fabric expressed a better value of shrinkage compared to the other two fabrics. Canvas fabrics expressed higher values of air permeability. This research is exercise-based and the outcomes are advantageous to the textile experts. This exploration opens possible ways for researchers to further study this ground.

Keywords

Cellulosic fiber• Construction• Strength• Construction• Cover factor

Introduction

There is prodigious importance of this research in the field of cotton fabrics manufacturing industries as well as retailers. Different scholars worked regarding this investigation at different times where literature review exposed different consequences. Some of them were parallel and some of them were widely different [1]. Cotton fibers are obtained from nature and fabrics made with cotton yarns are comfortable to the wearer. Strength is directly related to the polyester content percentage of the cotton-polyester blended woven fabrics. Woven fabrics are made by the 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 a right angle. Generally, woven fabrics are manufactured in weaving loom, and made of yarns woven on a warp and a weft. Woven fabrics are manufactured by both natural and synthetic fibers, and are frequently made from a combination of together [2].

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 elegance and furnishing fabrics. 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 [3]. Among plain weave fabrics, balanced clothes are prepared with the warp and weft yarns the same count and a similar measure of picks and ends per inch of clothes. In the basket-weave fabric, two or more yarns are laid together and then interlaced with each other. These yarns run parallel to their corresponding yarns [4].

Muslin is a type of fabric that is made up of 100% cotton yarns with the interlacement portion of one up and one down. The yarn count of muslin clothes is very fine ranges from 200Ne to 300Ne. The Thermal molding technique was applied to make the nonwoven composite by hot pressing. Nonwoven materials of different thickness were produced with two fibers were cheaper, stronger and lighter which were used in the interior part of the complex. Sustainable dyes are eco-friendly, biodegradable, economical, and easily attainable from natural sources [5]. Natural dyes have a reactive group that reacted with the cellulose of cotton fabrics in an alkaline condition to create a stable covalent bond between to dye and cellulose showing outstanding colorfastness properties of the plain weave. This strength of woven cloth is one of the most significant characteristics which make it bigger in many applications as related to nonwoven and knitted clothes [6].

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. When cotton fabrics are

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submerged in water, they started to shrink in both warp and weft ways to neutralize pressures obtained from the processing finishing department. Shrinkage values are both types like positive and negative. Positive shrinkage refers that a fabric that will increase in length after washing. Wherein negative shrinkage fabrics started to shrink or reduce their length after washing. The Cover factor is a technical dimension of the proportion area of the cloth enclosed by the yarns. The Cover factor is dependent on the construction of the clothes and also on the type of yarns used [7]. Plain weave fabrics expressed the best cover factor values compared to twill and satin weave fabrics. 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. Canvas fabric expressed a higher value of weight and strength compared to poplin and voile, on the other hand, voile fabric expressed a better value of shrinkage compared to the other two fabrics. Canvas shows the highest value of air transmission ability [8].

Materials and Method

100% cotton 1/1 plain woven fabrics were used in this research for the investigation of the physical properties of fabrics as stated in table 1. Three types of fabrics with different construction and the same width were used in this research. All the fabrics were of the plain weave in uncontaminated 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 [9].

S.N	Composition	Construction	Weave	Width (")
A	100% Cotton Canvas	$\frac{22 \times 22}{90 \times 75}$		60
B	100% Cotton Poplin	$\frac{32 \times 32}{102 \times 90}$	$Plain\left(\frac{1}{1}\right)$	60
C	100% Cotton Voile	$\frac{48 \times 48}{110 \times 100}$		60

Table 1. Materials used in this research.

Method Used

Specimen were experienced following the test method provided by ASTM Standard as mentioned underneath this paper. Allow the specimen to bring the equilibrium state in the standard atmosphere for test performance. Each specimen is directed in practice conditioning standard ASTM D1776. A 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 and Martindale pilling resistance was measured in ASTM D4970.

The Experimentation

The experiment of Weight (g/m2) the weight of the specimen was taken in ASTM D3776 Standard. Weight was taken in mass per unit area of fabric. A round GSM cutter was used to take the weight of the samples. First of all, the fabrics were conditioned as per standard ASTM D1776 after taking from the industry. Fabrics were cut with the round GSM cutter at 5 different places to avoid selvage to get the average weight of the clothes. After cutting the fabric, it was placed in the measuring balance to get the results. The results were placed in table 2. Figure 1 shows the weight (g/m2) measurement of the fabric [10].

Figure 1. Weight (g/m2) measurement of the fabric.

The experiment of Tear Strength

Tear strength was measured following the test method provided by ASTM D1424 standard using a pendulum apparatus. By the pendulum C in its original location, the two clamps were detached at a distance and associated in such a way that the clamped samples have stayed in a plane parallel to the axis. After cutting the samples at the middle using scissors, one part was clamped at the instrument and the other part was clamped at the pendulum in such a way that while splitting, the tear strength was recorded using the pendulum reading and positioned the results are obtained and put in table 3. Figure 2 shows the tear strength measurement process of fabrics [11].

Figure 2. Tear strength measurement observed by James heal tear tester machine (Elmendorf).

The experiment of Tensile Strength

Following ASTM D5034 the tensile strength was measured, which is a grab test system for the measurement of breaking force and elongation of the woven fabrics. The fabric samples were cut in a size of 4-inch square shape. Then the samples were mounted with their clamp and a force was applied to break the specimen 12 inches/min extension with jaw separation 3 inches between two jaw schemes. The upper part and lower part of the samples were clamped at the jaw. By the use of a computer, a signal was given to start the machine until the fabric is destroyed of its 60% Ruptured due to upward force from the device where the downward clam is static. In table 4, Figure 3 shows the tensile strength obtained process of fabrics.

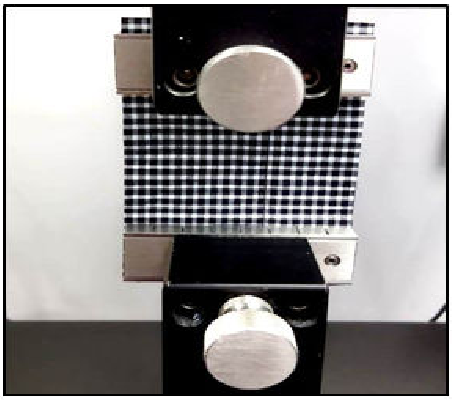

Figure 3. By Using Titan 5 Tensile strength measurement Observed.

Experiment of Shrinkage

Dimensional stability or shrinkage of fabric was measured using AATCC 135 standard. The fabric was cut in 40-inch square size and interlock stitched was given at the edge of the clothes so that the yarns could not be removed from the fabric due to heavy laundry in a washing machine. The fabric was marked by a 36-inch square shape for measurement with a permanent marker. The sample was loaded on the machine and started washing at 60°C temperature for 5 minutes. Then the sample was rinsed wash at normal room temperature. After that, the sample was dried in the machine for 3 minutes with hot air blow. At last, the samples were pulled out and dimension was measured using measurement tape and the shrinkage values were detected and positioned in table 5.

Experiment of Cover Factor

Cover factor specifies the extent to which the area of the cloth is covered by the yarns. It is the percentage of the area covered by the yarns to the total area of fabric. Cover factor also describes the compactness, solidity, and density of the fabric. Cover factor values of the samples were measured with equation 1 as stated below. 3 types of samples from 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. Yarn count checked through ASTM D1059 standards.

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

Figure 4. Equation Cover Factor calculation formula.

Experiment of Air Permeability

Air permeability is the rate of airflow passing perpendicularly through a fabric between the two surfaces following the ASTM D737 standard. The rate of airflow is measured in ft3/min/ft2. Air permeability is the competence of a material to permit air to pass through the clothes. The assessment of air permeability is less where the clothes are stiffer. The air permeability principle was complex where fabrics were slackly woven. The air pressure kept for this test was 125Pa across the samples keeping the laboratory temperature 20°C with a relative humidity of 65% and the values were positioned in table 7 and figure 4.

Figure 4. Air porousness transmission measurement process of fabrics.

Experiment of Martindale Pilling Resistance

The Pilling resistance of the clothes was measured in contract with the test method provided by ASTM D4970 Standard. Specimen test conducted in the standard atmosphere. The fabric was cut 3 pairs of specimens where 3 pieces are 5.5 inches in diameter other 3 pieces 1.5 inches diameter. Mount one 5.5 inches diameter of standard felt and one fabric specimen of diameter. Placing one 1.5 inches diameter disk of 3 mm polyurethane foam and a specimen of the same 1.5 diameters of fabric in each holder. Start machine without any load run for 100 movements. The rating was taken individually and record as its average result.

Result and Discussion

Weight in g/m2 of the specimen was measured following the test method provided by ASTM D3776 Standard. The values are shown in table 2. It is seen from Table 2 that, the fabrics with courser yarn count express 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 2.

S.N	Composition	Construction	Weight (g/m2)
A	100% Canvas Cotton	$\frac{22 \times 22}{90 \times 75}$	220
B	100% Poplin Cotton	$\frac{32 \times 32}{102 \times 90}$	146
C	100% Voile Cotton	$\frac{48 \times 48}{110 \times 100}$	110

Table 2. Weight (g/m2) measurement of fabrics.

Results of Tear Strength

The tear strength of the specimen was conducted as standard specified by ASTM D 1424 Method. This method provides a test report by falling pendulum apparatus. The strength values are shown in table 3. It is shown that coarser fabrics provide better tear strength than finer fabrics. This is because coarser yarns are stronger than finer yarns.

S.N	Composition	Construction	Warp Tear (gm)	Weft Tear (gm)
A	100% Cotton Canvas	$\frac{22 \times 22}{90 \times 75}$	2410	2276
B	100% Cotton Poplin	$\frac{32 \times 32}{102 \times 90}$	1650	1247
C	100% Cotton Voile	$\frac{48 \times 48}{110 \times 100}$	1032	975

Results of Tensile Strength

Tensile strength of the specimen was conducted as standard specified 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 directions. Here also canvas fabric exposed the best tensile strength where poplin and voile fabrics exposed less strength. Table 4 shows the tensile report and extension% report.

S.N	Composition	Construction	Warp Tensile (lbf)	Weft Tensile (lbf)	Warp Extension (%)	Weft Extension (%)
A	100% Cotton Canvas	$\frac{22 \times 22}{90 \times 75}$	78	67	25	30
B	100% Cotton Poplin	$\frac{48 \times 48}{110 \times 100}$	54	47	18	23
C	100% Cotton Voile	$Plain\left(\frac{1}{1}\right)$	45	39	13	17

Table 4. Tensile Strength values of fabrics.

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 ways. Table 5 shows the shrinkage report of these fabrics.

S.N	Composition	Construction	Warp Shrinkage%	Weft Shrinkage%
A	100% Cotton Canvas	$\frac{22 \times 22}{90 \times 75}$	-1.5	-2
B	100% Cotton Poplin	$\frac{32 \times 32}{102 \times 90}$	-1	-1.5
C	100% Cotton Voile	$\frac{48 \times 48}{110 \times 100}$	-0.5	-1

Table 5. Shrinkage Report of cotton fabrics.

Results of Cover Factor

Cover factors express the area of fabrics covered by the yarn. This value expresses the tightness and looseness of fabrics. Table 6 shows the cover factor of these fabrics. It is seen from the table that; 100% cotton canvas fabric has the highest cover factor value wherein 100% cotton voile fabric has the least value of the cover factor. Poplin fabric has the mid-value of a cover factor among these 3 samples.

S.N	Composition	Construction	Warp Cover	Weft Cover	Total Cover
A	100% Cotton Canvas	$\frac{22 \times 22}{90 \times 75}$	25.44	20.34	29.18
B	100% Cotton Poplin	$\frac{32 \times 32}{102 \times 90}$	19.45	15.91	26.5
C	100% Cotton Voile	$\frac{48 \times 48}{110 \times 100}$	31.12	8.58	24.08

Table 6. Cover factor values of fabrics.

Results of Air Permeability

Air permeability is the capability of cloth to transmit air to pass through it. The flow rate of air permeability is less where the fabrics are more rigid. Air permeability values are higher where fabrics are loosely woven. Followed by the ASTM D737 standard, air permeability values are verified and placed in table 7. The values of air permeability were obtained in the unit of ft3/min. it is seen from the table that 100% Cotton Canvas with construction (22×22)/(90×78) exposed the maximum air permeability value. Alternately, 100%Cotton Voile with construction (50×50)/(110×100) exposed the lowest air permeability value.

S.N	Composition	Construction	Air Permeability (ft3/min)
A	100% Canvas Cotton	$\frac{22 \times 22}{90 \times 75}$	110
B	100% Poplin Cotton	$\frac{32 \times 32}{102 \times 90}$	86
C	100% Voile Cotton	$\frac{48 \times 48}{110 \times 100}$	75

Table 7. Air permeability values of fabrics.

Result of Martindale pilling resistance

This method covers the determination of the resistance to the formation of pills and other related surface changes on fabrics using the Martindale tester. Followed by ASTM D4970 standard, pilling grades are verified and placed in table 8. The experimental resistance to pilling is reported on an arbitrary scale ranging from 5 to 1 (No pilling to severe pilling). It is understood from the table that 100% Cotton Canvas with construction (22×22)/(90×75) exposed the maximum pill resistance value. Alternately, 100% Cotton Voile with construction (48×48)/(110×100) exposed the lowest pill resistance against face to face rubbed.

S.N	Composition	Construction	Pilling Grading (5-1) photographic scale
A	100% Canvas Cotton	$\frac{22 \times 22}{90 \times 75}$	4.5
B	100% Poplin Cotton	$\frac{32 \times 32}{102 \times 90}$	4
C	100% Voile Cotton	$\frac{48 \times 48}{110 \times 100}$	3.5

Table 8. Martindale pilling grading of fabrics.

Microscopic Observation

Yarns were unplugged from fabrics and microscopic views were taken. Figure 4 shows the microscopic views of the yarns. In this view, we can see that the cell wall of a cotton fiber comprises a primary and a secondary wall. The second that contains the bulk of the fiber, contains numerous spirally sloping cellulose fibrils surrounded by a windy that creates a spiral but on the contrary path from the previous.

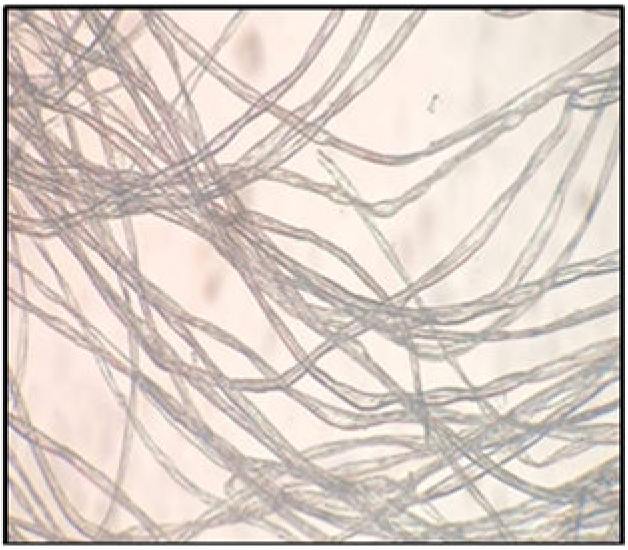

Figure 4. Microscopic view of the yarn.

Conclusion

It is realized throughout the research that, the physical properties of 100% cotton 1/1 plain woven fabrics were explored. These fabrics were woven with 1/1 plain weave structure of different types like canvas, poplin, and voile. Canvas fabrics have a heavier shape with thickness compared to poplin and voile fabrics. This fabric exposed the highest weight (g/m2). It also shows the maximum tear and tensile strength compared to the other two fabrics like poplin and voile. Canvas fabrics also exhibited more shrinkage values compared to poplin and voile fabrics because of compactness yarn and interlacement warp weft. Despite its heavier shape, it expressed maximum cover factor values. The conclusions of this research are beneficial to the personnel involved in textile industries who are in charge of manufacturing cotton-woven fabrics and controlling their physical properties as desired end products.

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