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The Impact of Neutral Enzyme on Jute-Cotton Blended Denim Fabric

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***Abstract*—** Garments washing is the process of altering the aesthetic look, luxury, fashion, and comfortability of a garment after it has been manufactured. Most garments nowadays go through many washing processes before being sold in retail outlets. As denim is one of the most adaptable fabrics available today, the aesthetics may be reinvented in an infinite number of ways through garments washing techniques. Because of the rough and stiff nature of jute fiber, it is not currently used as a popular material for garments manufacturing. A sustainable option may be possible by using jute and cotton blended fabric in manufacturing. Moreover, enzyme is a naturally occurring product. Therefore, the product is environmentally friendly. In a washing bath, the enzyme functions as a catalyst to hydrolyze fiber, soften the fiber surface, and decrease pilling. The experiment was conducted on a 70 percent cotton, 30 percent jute blended fabric with a weave construction of 2/1 twill. The goal of this study is to observe how an industrial enzyme wash affects a jute-cotton blended denim fabric. For this investigation, neutral enzyme was used. Finally, the raw and washed samples was compared in terms of physical parameters such as EPI, PPI, GSM, warp strength, and weft strength. This research may unlock a way for enzymatic treatment on jute cotton blended denim fabric.

***Index Terms*—**Scouring, Garments Wash, Neutral Enzyme, Denim, Jute-cotton Blended Denim, Eco-Friendly, Sustainability

I. Introduction

AMONG all the natural fibers, jute is one of the cheapest one. Primarily jute fiber is composed of cellulose (58~63%), hemi-cellulose (20~24%) and lignin (12~15%). Jute falls in the category of bast fibers as it is extracted from the skin of the jute plant.

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The lignin and hemicellulose units surround the cellulose units and acts as a cementing material for the fiber structure. Though jute is popular for its variety of usage but introducing it as a clothing material is very far from implementation. The main drawbacks of jute are rough hand feel, stiffness, poor drapability, coarseness etc. However, when incorporated with cotton, jute shows good considerable properties like better drapability, good crease recovery, air permeability, good pilling performance and abrasion resistance [1]. Nevertheless, some problem remains; for example, its thickness. It is very difficult to produce finer yarns with jute, which is an important factor that suggests that it cannot be used as a clothing material. That is why modification of the fiber is a necessary process. It is possible that jute cotton blended fibers can be treated with various chemicals to modify its overall physical characteristics [2]. Enzyme is one of such chemicals. Enzyme is a bio catalyst. Jute and cotton both are cellulose based fiber, and cellulose is the most abundant natural polymer on earth. Cellulose polymers can be degraded by appropriate enzymatic action [3]. Typically, the blended fiber of jute and cotton feels a bit sturdy but the protruding surface of jute fiber made the fabric prickly. Enzyme can help in this scenario. If the blended sample fabric is treated with commercial cellulases, pectinases and xylanases individually and in combination at various concentrations, then the smoothness of the fabric surface significantly improves and it becomes soft [4]. Various cellulose-degrading enzymes are available nowadays and these can be produced commercially. Therefore, these are very much affordable. Jute cotton blended denim treated with neutral enzyme in a washing bath can give the fabric its intended performance. For this study, 2/1 twill weave is used for the fabric construction. Blend ratio is 70% cotton, 30% jute. The characteristics of jute cotton blended denim fabric is very much similar to cotton fabric in many aspects [5]. The coarseness of the jute yarn is its inherent property. Producing finer yarn with jute will require a vigorous amount of processing. Therefore, producing heavy consumable fabric will be a sustainable solution. Heavy clothing materials like denim can easily be produced from this blend [6]. Treating this sample fabric with pumice stone and enzyme can further improve the softness. But it will produce a sample with variable physical and mechanical properties [7]. However, washing time is also a significant factor in changing the physical and chemical properties. More time in the washing bath will have a more effect on fabric [8]. It has been observed that the curtain made from 100% cotton performed similar to the curtain

made of jute-cotton blended (50:50) yarn. Furthermore, the blended sample was not only 33% cheaper but better too by serviceability. The only exception was found in case of repeated washability [9]. Both 100% cotton and mixed denim fabrics have good abrasion resistance. After desizing, blended denim has a lower weft-wise strength than 100% cotton denim. However, every other property is found to be closer. The strength of mixed denim does not significantly decrease when subjected to enzyme, stone wash, or bleach. At various stages of treatment, blended denim fabric (50:50) has produced results that are remarkably similar to those of 100% cotton denim [10].

Therefore, it is clear that repeated wash is a problem for this kind of blended fabric. However, garments wash may pose a solution to this problem. Using enzyme is the best choice for this kind of scenario where sustainability is one of the prime objectives. The aim of this research is to evaluate some physical properties (GSM, EPI, PPI, warp strength, weft strength) change of the jute cotton blended denim fabric after scouring and a sustainable enzyme wash.

II. Materials and Methods

A. Materials

Jute-cotton blended denim fabric was collected from the Bangladesh Jute Research Institute (BJRI), Dhaka. The fabric construction of the sample fabric was 2/1 Twill & the blend ratio is 70% Cotton and 30% Jute. Due to this blend constituents this category of fabric is popularly known as "Jutton". The GSM (Grams per Square Meter) of the sample fabric was 344 (Average of 3 sample).

The samples were enzyme washed by using these following chemicals: wetting agent, detergent, sequestering agent, caustic soda, neutral enzyme, acetic acid. The machineries that were used to perform the experiment was garments washing machine, hydro extractor, drying machine, pH meter. The testing apparatus for the required tests are GSM cutter, counting glass, electric balance, universal tensile strength tester.

B. Methods

Operation Sequence: The study was conducted according to this following flow chart.

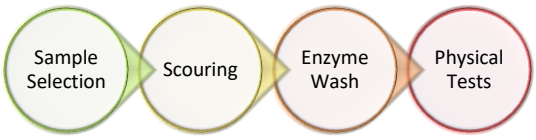

Fig I. Methodology of the study

The sample fabric of 12 gram was selected for the intended purpose. Then the sample were scoured using wetting agent (1.0 g/L), detergent (2.0 g/L), sequestering agent (3.0 g/L), caustic soda (4.0 g/L) and material to liquor ratio of 1:10 in a laboratory scale sample washing machine at 95-100 °C for 15-20 minutes. The garments were then washed with hot water (70°C) followed by cold water wash.

Scoured samples were treated by using neutral enzyme. This process was conducted in liquor containing acetic acid (2.0 g/L), wetting agent (1.0 g/L) at pH 6-7 and material to liquor ratio of 1:10 for 30 minutes at a temperature of 50°C. A hot wash (80°C) was performed after the enzyme treatment for 10 min to kill the enzymes from the washing bath.

C. Physical Tests

GSM Test:

- Testing Standard: ASTM D3776
- GSM cutter and cutting board is used to perform this test.

Equipment Specification:

TABLE I.

Specification of GSM cutter

Cutting area	100 cm^2
Cutting thickness	5 mm
Cutting diameter	112.8 mm
Dimension	17*17*13 cm
Weight	2 kg

Fabric Density Test:

- Counting glass is used to perform this test.

Equipment Specification:

TABLE II.

Specification of Counting glass

Material	Fabric
Magnification Power	3.5-6x
Weight	200-300 g
Thickness	2-5 mm
Lens Diameter	75 mm

Tensile Strength Test:

- Apparatus: Universal Tensile Strength Tester
- Machine origin: USA
- Method: Strip Test according to ASTM D5035
- Dimension of sample – 8" x 2"
- Gauge length – 75 mm
- Test speed: 300 mm/min

III. RESULTS AND DISCUSSION

GSM Test:

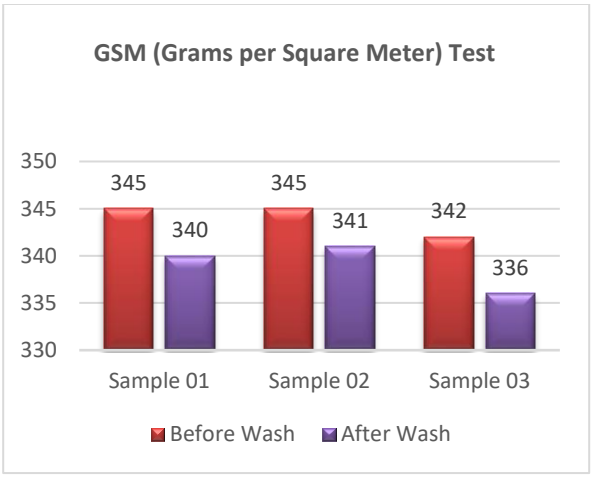

Fig II. GSM Test

From Fig II, it is observed that the GSM of each sample is reduced. The reason behind it is the hydrolysis of cellulosic fiber in the sample, the elimination of size materials, dust, dirt & foreign materials. The elimination of protruding stiff fiber makes the sample soft and reduction in weight. GSM is a very important parameter in determining how the sample is behaving when subjected to various washing treatments. Too much variation in GSM value indicate an inferior fabric construction type, which is not advisable to be used as clothing materials. Here, the variation of GSM among the samples are very little. Therefore, it can be said that the samples have a good structural properties i.e. even blend ratio, good shrinkage properties, desirable fabric crimp percentage etc.

Fabric Density Test:

Warp Density (EPI – Ends per inch):

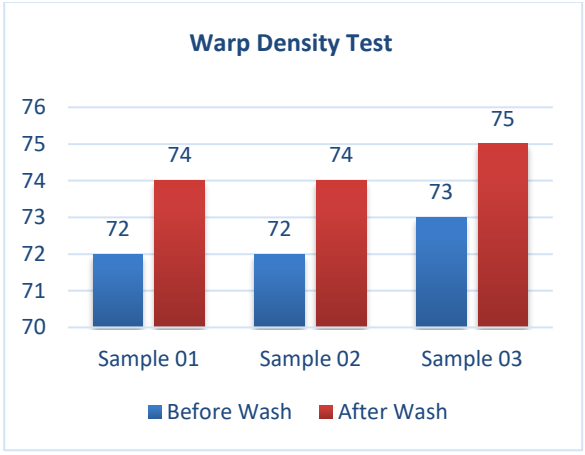

Fig III. Warp Density Test

Weft Density (PPI – Picks per inch):

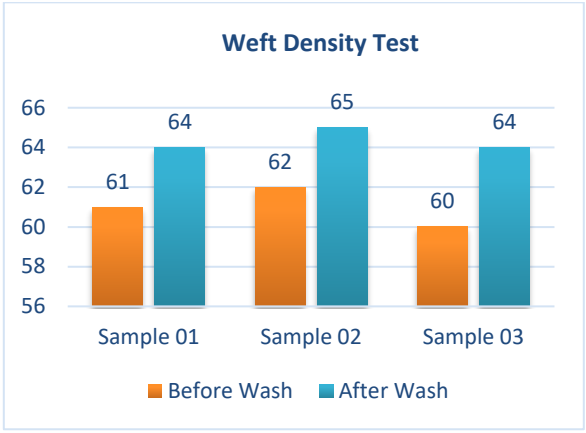

Fig IV. Weft Density Test

Fabric density is a significant factor to determine the property of a fabric sample. Generally, woven fabric specification is expressed by EPI, PPI, warp count, weft count & fabric width. As this sample is a woven fabric, evaluation of EPI & PPI is very important to determine the fabric quality. From Fig III & IV, it is clear that the EPI & PPI of each sample is increased. The cellulosic fibers prefer the alkaline medium. The effect of caustic soda during the scouring process and the fiber swelling process is the main reason for fabric shrinkage. Increase in EPI & PPI is a clear indication of fabric shrinkage. From the data, it is obvious that the weft shrinkage is comparatively higher in every sample. It is also evident that the warp and weft density do not vary too much. This indicates that the fabric is not susceptible to too much dimensional change when treated with different chemicals and this is a good sign for any fabric sample.

Tensile Strength Test:

i. Warp Strength:

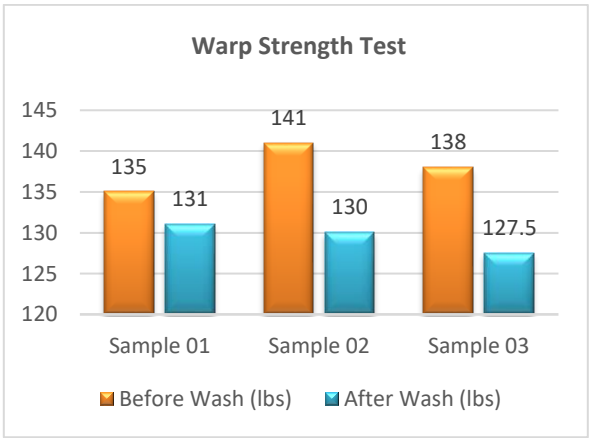

Fig V. Warp Strength Test

ii. Weft Strength:

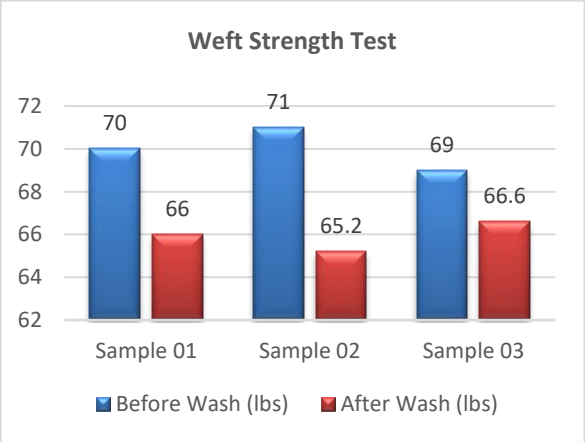

Fig VI. Weft Strength Test

From Fig V & VI, it is evident that the strength on both warp & weft yarn reduces. The enzyme acts as a catalyst to attack the fiber surface and hydrolyze it. This reduces the fiber strength eventually. However, time is critical factor in this respect. The effect of enzyme on fiber will be more prominent if the time increases. Strength is a very vital aspect of denim fabric. Denim fabric is known for its strength. The warp strength of regular denim fabric made from 100% cotton is around 140/150 (lbs) & weft strength is around 80/90 (lbs). From the chart given above, it is clear that the sample strength is slightly less than expected.

IV. CONCLUSION

The research is mainly focused on evaluating some basic physical aspects of jute cotton blended denim fabric before and after some finishing treatment. Though the sample fabric is not advisable to be used in apparel manufacturing, proper processing & finishing treatment can make it possible to have a good handle and some desirable end properties. Treating the sample with enzyme is a very good approach, as the enzyme hydrolyses the stiff fiber from the fabric surface that resulting in a good & soft handle. Further, the process is also environment friendly because enzyme is an environment-friendly substance. From this study, it is quite clear that this blended fiber can be processed in enzymatic finishing treatments as the enzyme is bringing out the desirable properties from the sample fabric. However, some limitations should be stated regarding this study. Softening treatment was necessary to further assess the handle and drape of the sample. The work was done on a prepared sample. As a result, modification of fabric parameters according to the need was not an option. Various comfortability tests, serviceability tests should be done on the sample to assess the acceptability. There lies a huge opportunity for various sustainable products to be manufactured from jute cotton blended fabric if the fabric-making process gets proper attention and funds from the competent authority. The most critical factor for this type of fabric is its price. If this fabric becomes more affordable then the manufacturer will surely go for it. Therefore, cost-effective fabric manufacturing is necessary for the widespread application of jute cotton blended denim fabric.

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