

An Experimental Study to Assess the Washing Effect on Physical Properties of Plain Cotton Fabric

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Abstract

In this study, effect of normal and enzyme wash on the physical properties of indigo dyed 2/1 plain rib cotton fabric was examined. ISO and ASTM standard were followed separately for testing tensile strength, tearing strength, pilling resistance, color fastness to light, color fastness to rubbing, color strength and fabric weight. The fabric samples were subjected to neutral and acid enzyme wash, then the test results were compared with the normal washed samples. Enzyme wash reduced the tensile strength (13% in warp and 16.04% in weft), tearing strength (35.4% in warp and 29.6% in weft), GSM (1.8%), color strength (0.91% lighter) and improved color fastness to rubbing (rating for dry rub 5 and wet rub 1-2) of the sample. On the other hand, normal wash showed lower pilling resistance (grade2). The results are comparable with the results found from similar wash effect on cotton twill fabric.

Key words: Washing, Enzyme wash, Plain fabric, Physical properties, Color fastness.

Introduction

Clothing is the basic need of a human being. Although, generally it is important only for satisfying the basic need, with the lapse of time it becomes an integral part of fashion. Fashion represents the lifestyle of a human. It is a distinctive and changing trend of style in which people present themselves (Davis, 1994).

Among the current fashion trends, one of the prominent style is worn out or faded denim. This worn out or faded look is created by garment washing process (Khan, Mondal, & Uddin, 2012). Washing technology is used to modify the appearance, comfort ability and fashion of any garments (Ali, Hossain, & Shahid, 2018). There are various types of washing method available for washing like enzyme wash, acid wash, bleach wash, normal wash, stone wash etc. Among these, enzyme washing method is more preferable for this study due to its biodegradable nature, cost effectiveness, lesser residue (Hafez & Saad, 2015). Commonly, washing is done on denim that is made by twill woven fabric (Khan et al., 2012). Most common woven structure is plain (Gokarneshan, 2004). The purpose of this study was to analyze the effect of washing on the physical properties of plain cotton fabric as it is the most used fabric in daily life.

Methodology

Materials

A woven plain fabric was used in the washing processes to determine the changes of it's physical properties. The structural properties of this fabric are given below in table-1. Industrial type machines were used for washing and drying.

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Table-1 Specification of subject material

Fabric type	Woven
Weave construction	2/1 Plain Rib
Fiber type	100% Cotton
Warp density (inch-1)	88 ends/inch
Weft density (inch-1)	46 picks/inch
Color	Blue
Type of dyestuff	Indigo
GSM (before wash)	220

The list of machines is given on Table-2 that were used for this experiment.

Table-2 List of Machines

Sl no.	Machine Name	Brand / Model No.
1.	Washing Machine	New Horizon
2.	Tumble Dryer	P.M.W
3.	GSM Cutter	James H. Heal GSM Cutter
4.	Electric Balance	DY
5.	Wi-Fi Microscope	DCX-205-ILED
6.	Tensile Strength Tester	ADMET
7.	Color Spectrophotometer	KEJIE
8.	Crock Meter (rubbing tester)	GT-D45A
9.	ICI Pilling Box Tester	Para Mound
10.	Tearing Strength Tester	VTR-01
11.	Color Fastness to Light Tester	ASK28v

Experimental work

Washing Method

Normal, enzyme and acid enzyme washing process were applied on the fabric sample separately. After washing they were dried in the Tumble dryer.

Normal Wash

Fabric sample was washed with material to liquor ratio of 1:30 in the sample washing machine. Here, 0.05 % detergent (WBL), 0.07% softener (Softycell IPS) were used for normal wash. The temperature for desizing was 40°C and for softening it was 25°C. The whole process took 30 minutes to complete (Rouf, Rassel, & Khalil, 2015).

Enzyme wash

Fabric sample was washed with material to liquor ratio of 1:30 in the sample washing machine for enzyme wash.

For neutral enzyme wash, neutral cellulosic enzyme (0.6% Ecozyme 400 NP) was used maintaining pH 6.5. The whole process took 40 minutes and the temperature was 55°C. For acid enzyme wash, acid cellulosic enzyme (0.5% Ezysoft XCL) was used. Acetic acid was used for maintaining pH 5.5. The whole process took 30 minutes and the temperature was 45°C.

White MRC anti-redepositing agent was used for both type enzyme wash (Rouf et al., 2015).

Testing Method

The washed and dried samples were subjected to different types of testing process to determine the effect of different washing on their physical and color properties. The following tests were carried out according to their standards.

Table 3: Testing methods and standards

Sl no.	Name of Test	Standard
1.	Microscopic image	
2.	Tensile strength testing (grab test)	ASTM D5034 ("Identifying Color Differences Using L*a*b* or L*C*H* Coordinates," 2019)
3.	Tearing strength	ISO13937-1 ("Textiles -- Tear properties of fabrics ", 2017)
4.	Pilling test	ISO12945-1 ("Textiles -- Determination of fabric propensity to surface fuzzing and to pilling -- Part 1: Pilling box method," 2013)
5.	Color Strength Test	ASTM D387 ("Standard Test Method for Color ", 2017)
6.	Color fastness to rubbing test	ISO 105-X12 ("Textiles -- Tests for colour fastness -- Part X12," 2016)
7.	Color fastness to light	ISO105-B02 ("Textiles -- Tests for colour fastness -- Part B02," 2014)
8.	GSM	ASTM D3776 ("Standard Test Methods for Mass Per Unit Area (Weight) of Fabric," 2017)

Findings and Discussion

Microscopic image

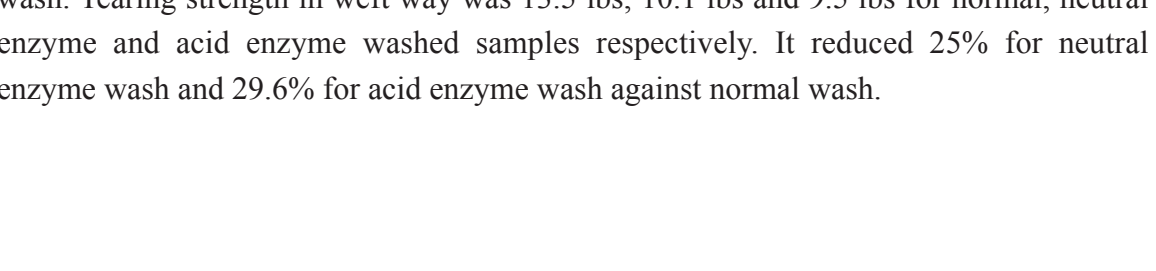


Figure 1:(a) Normal wash; (b) Neutral enzyme wash; (c) Acid enzyme wash

Figure 1 represents normal, neutral enzyme and acid enzyme washed samples. These images were captured by using Wi-Fi microscope and no visible difference noticed among them.

Tensile strength testing

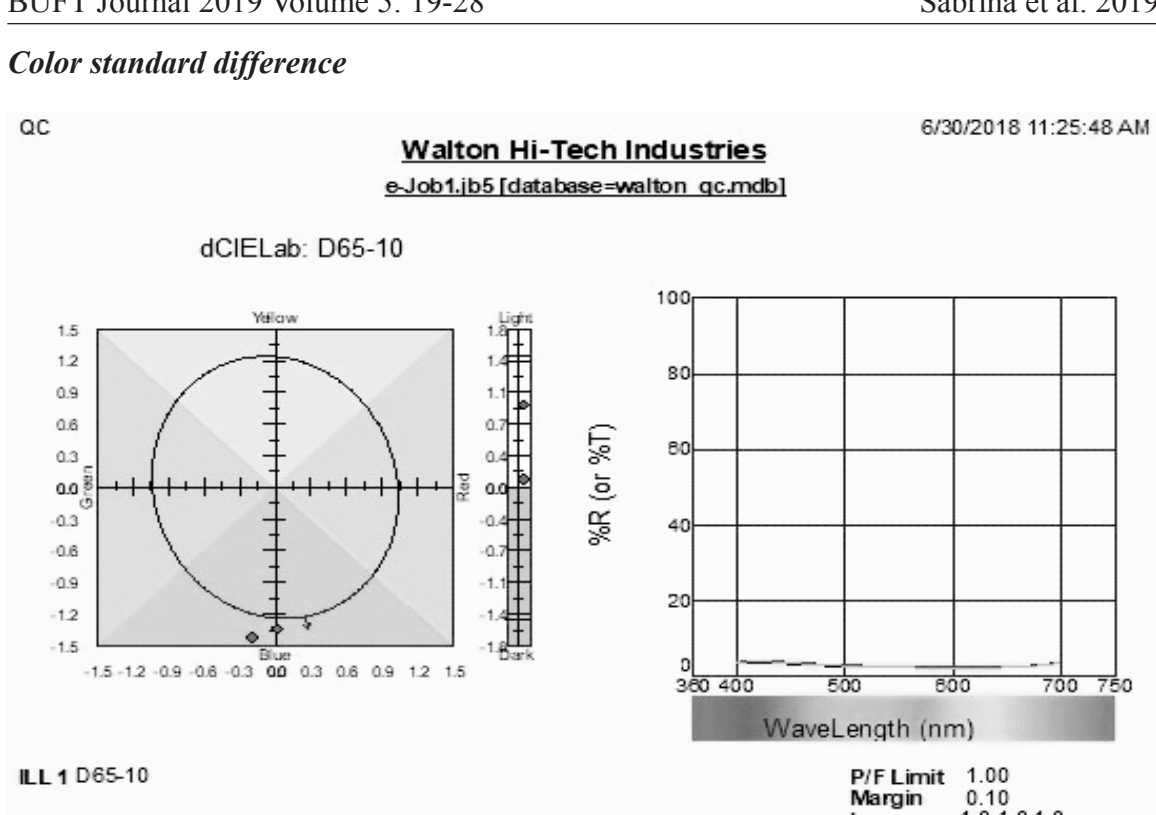


Figure 2: Tensile strength test result

Figure 2 represents tensile strength test results of normal and enzyme washed plain fabric in both warp and weft way. Tensile strength in warp way was 87.4 kgF for normal, 81.7 kg F for neutral enzyme and 75.4 kgF for acid enzyme washed samples. It reduced 6% for neutral enzyme wash and 13% for acid enzyme wash compared to the normal wash fabric sample. Tensile strength in weft way was 48 kgF for normal, 43.2 kgF for neutral enzyme and 40.3 kgF for acid enzyme washed samples. It reduced 10% for neutral enzyme wash and 16.04% for acid enzyme wash against normal wash. The strength of cotton fiber depends on the alignment of polymeric chain. The higher percentage of the

straight alignment of the polymeric chains provides more strength to the fiber. During enzyme wash, it weakens the bond between the polymeric chains in the straight aligned region of the fiber surface. This resulted in the reduction of strength of the fabric (Hafez & Saad, 2015).

Tearing strength

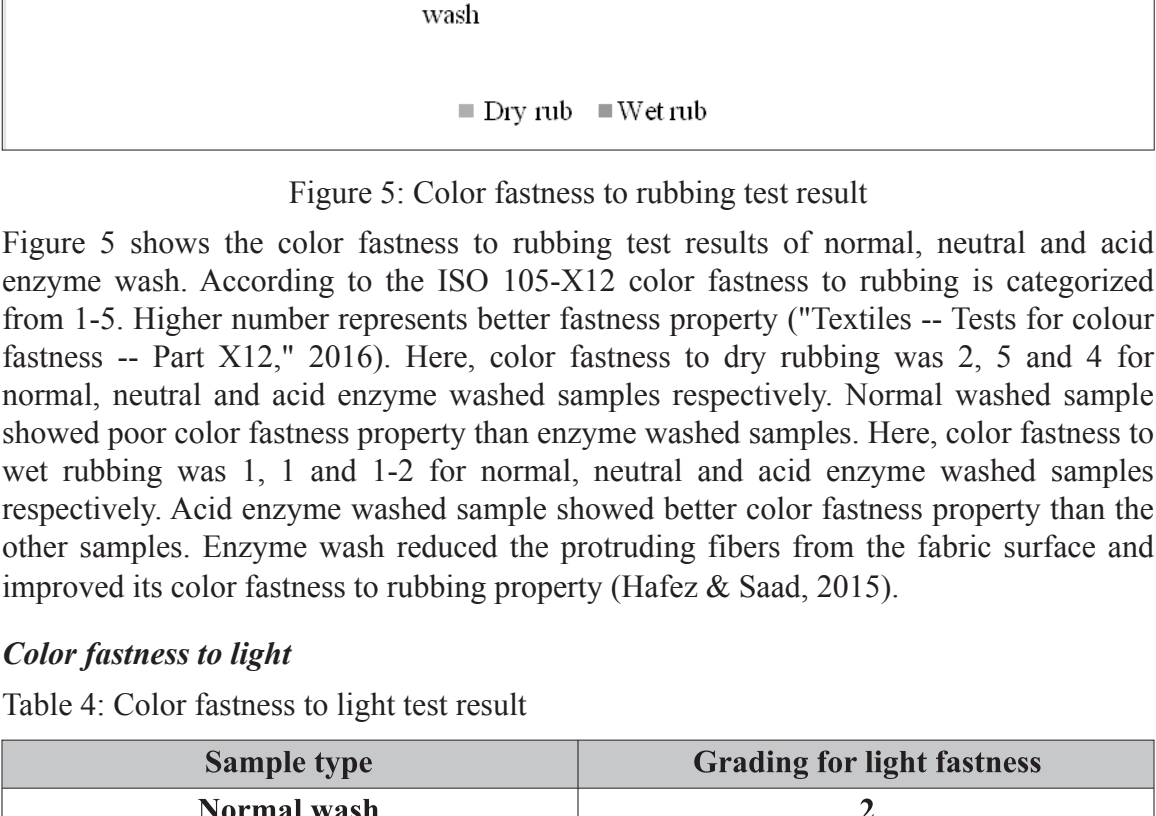


Figure 3: Tearing strength test result

Figure 3 represents tearing strength test results of normal and enzyme washed plain fabric in both warp and weft way. Tearing strength in warp way was 17.5 lbs, 12.6 lbs and 11.3 lbs for normal, neutral enzyme and acid enzyme washed samples respectively. Compared to normal wash, it reduced 28% for neutral enzyme wash and 35.4% for acid enzyme wash. Tearing strength in weft way was 13.5 lbs, 10.1 lbs and 9.5 lbs for normal, neutral enzyme and acid enzyme washed samples respectively. It reduced 25% for neutral enzyme wash and 29.6% for acid enzyme wash against normal wash.

Color standard difference

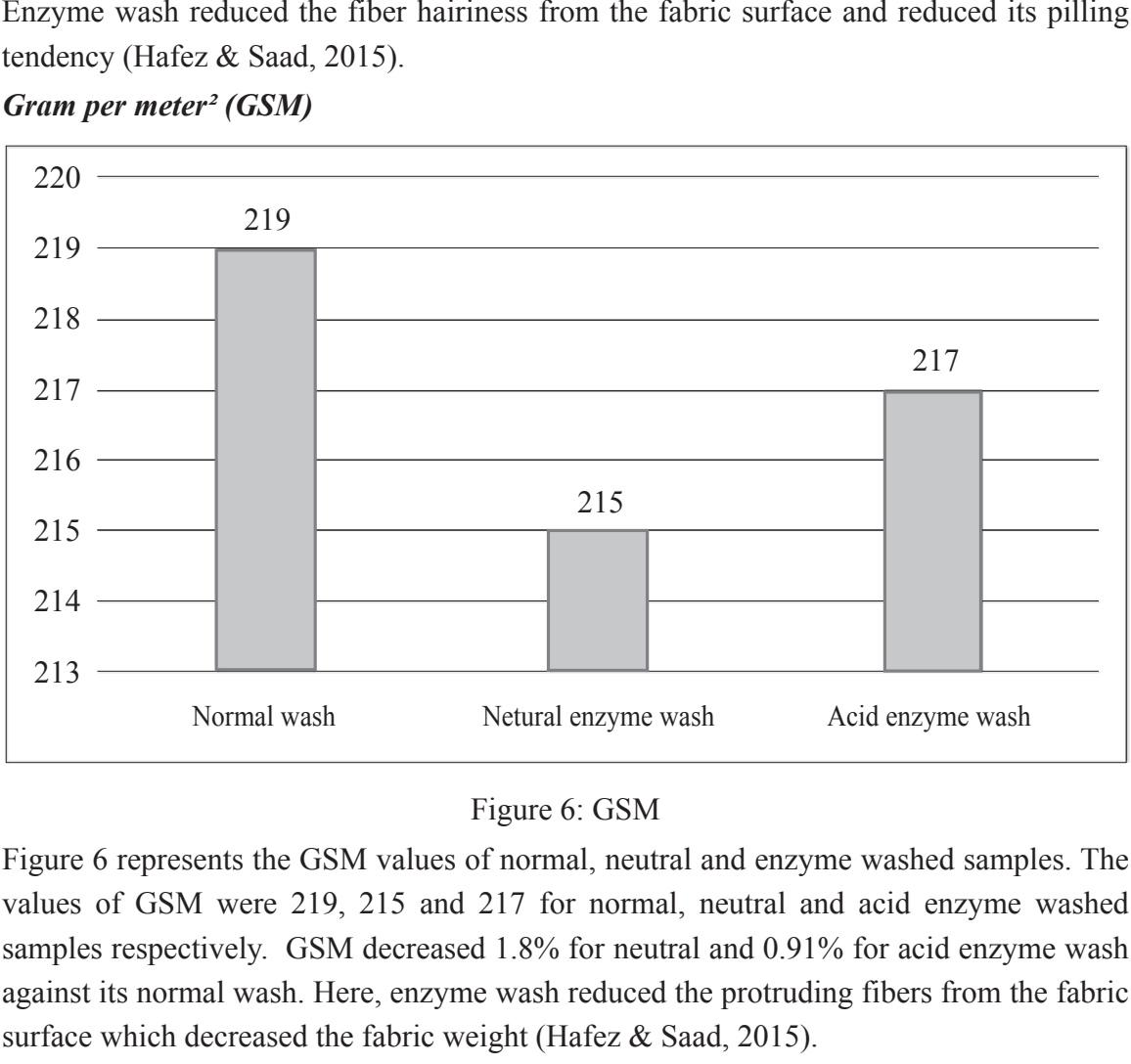


Figure 6: Color strength difference

Figure 6 represents the color strength difference values in terms of L*a*b* co-ordinates. Standard value for color strength was found from normal washed sample and the values were 17.18, 1.12, -5.36 for lightness (L*), red/green co-ordinate (a*) and yellow/blue co-ordinate (b*) respectively.

Here, neutral and acid enzyme washed samples showed the lightness (L*) 0.91 and 0.08 lighter than standard values. The value of a* were -0.19 and 0.03 for neutral and acid enzyme washed and the value of b* were -1.43 and -1.35 for neutral and acid enzyme washed samples accordingly.

Neutral enzyme washed sample was less green and less blue in appearance than the standard whereas acid enzyme washed sample showed redder and less blue in appearance ("Identifying Color Differences Using L*a*b* or L*C*H* Coordinates," 2019).

Color fastness to rubbing

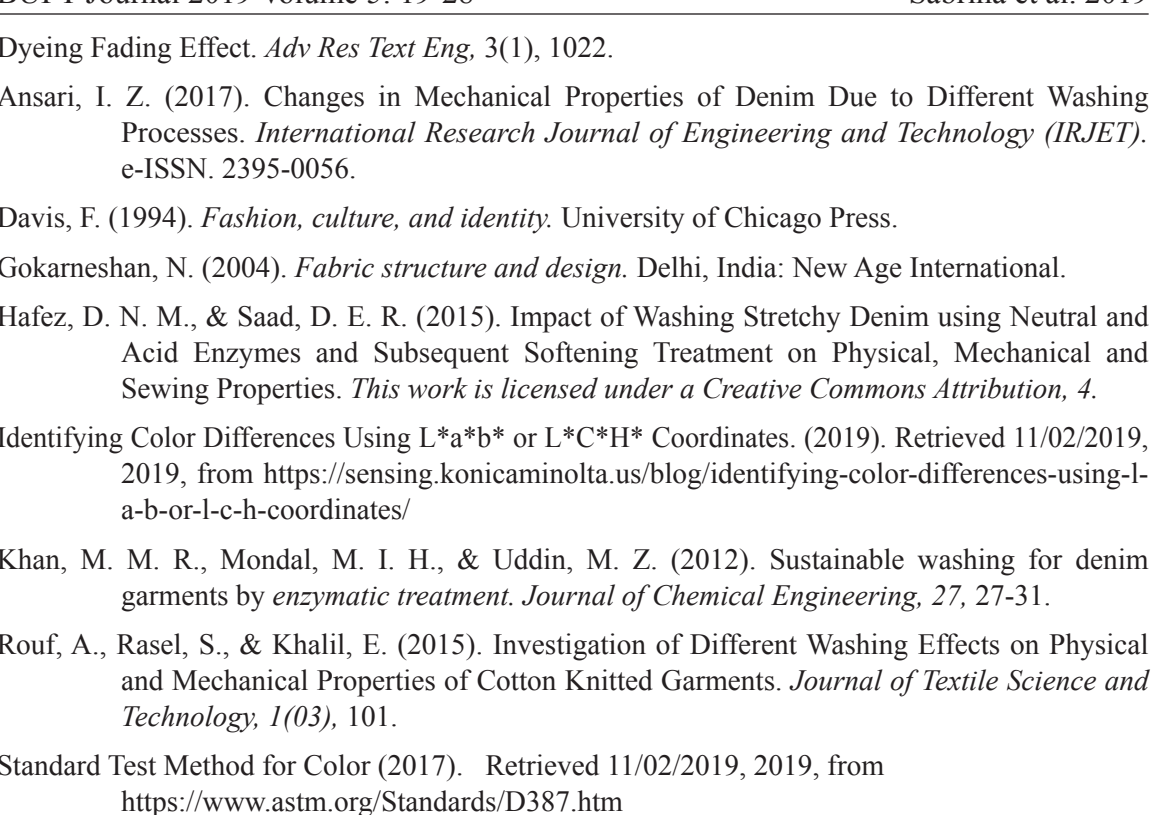


Figure 5: Color fastness to rubbing test result

Figure 5 shows the color fastness to rubbing test results of normal, neutral and acid enzyme wash. According to the ISO 105-X12 color fastness to rubbing is categorized from 1-5. Higher number represents better fastness property ("Textiles -- Tests for colour fastness -- Part X12," 2016). Here, color fastness to dry rubbing was 2, 5 and 4 for normal, neutral and acid enzyme washed samples respectively. Normal washed sample showed poor color fastness property than enzyme washed samples. Here, color fastness to wet rubbing was 1, 1 and 1-2 for normal, neutral and acid enzyme washed samples respectively. Acid enzyme washed sample showed better color fastness property than the other samples. Enzyme wash reduced the protruding fibers from the fabric surface and improved its color fastness to rubbing (Hafez & Saad, 2015).

Color fastness to light

Table 4: Color fastness to light test result

Sample type	Grading for light fastness
Normal wash	2
Neutral enzyme wash	2
Acid enzyme wash	2

Table 4 indicates the color fastness to light properties of normal, neutral and acid enzyme washed samples. All three samples resulted in grade 2 out of 8 according to ISO 105-B02. There was no significant change among the samples and all showed poor light fastness property ("Textiles -- Tests for colour fastness -- Part B02," 2014).

Pilling test

Table 5: Pilling test Result

Sample type	Grading for pilling test
Normal wash	2
Neutral enzyme wash	3
Acid enzyme wash	4

Table 5 represents the pilling test results of the normal, neutral and enzyme washed samples. The pilling test results were 2, 3 and 4 for normal, neutral and acid enzyme washed samples respectively according to ISO 12945-1 ("Textiles -- Determination of fabric propensity to surface fuzzing and to pilling -- Part 1: Pilling box method," 2013). Enzyme wash reduced the fiber hairiness from the fabric surface and reduced its pilling tendency (Hafez & Saad, 2015).

Gram per meter² (GSM)

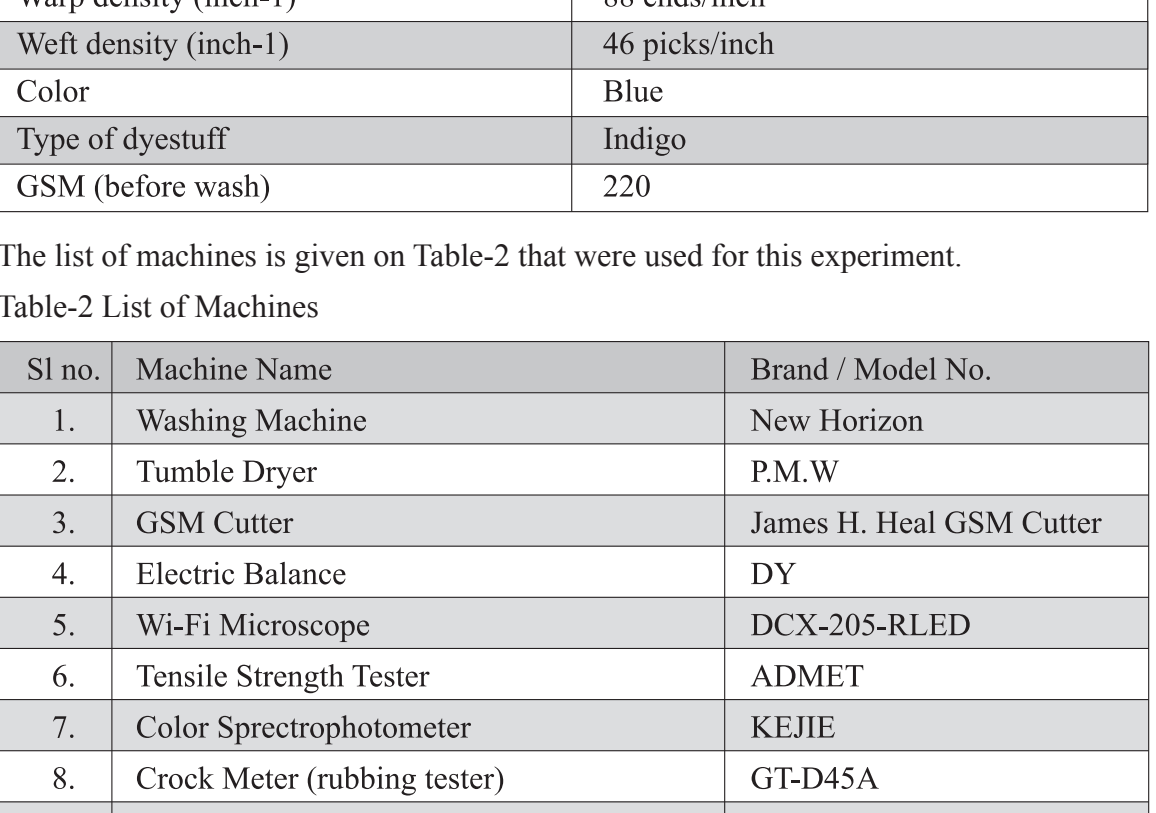


Figure 6: GSM

Figure 6 represents the GSM values of normal, neutral and enzyme washed samples. The values of GSM were 219, 215 and 217 for normal, neutral and acid enzyme washed samples respectively. GSM decreased 1.8% for neutral and 0.91% for acid enzyme wash against its normal wash. Here, enzyme wash reduced the protruding fibers from the fabric surface which decreased the fabric weight (Hafez & Saad, 2015).

Comparison with other reported results

Table 6: Comparison of physical properties between plain & twill fabric after enzyme wash

Properties/Fabric Weave Type	GSM	Tensile Strength		Tearing Strength		Color Fastness to Rubbing (rating)		Pilling (Rating)
		Warp way	Weft way	Warp way	Weft way	Dry rub	Wet rub	
Plain (Present work)	1.8%	13%	16.04%	35.4%	29.6%	5	1-2	4
Twill (Reported work)	10%	23.9%	32.2%	81.6%	30.9%	4-5	2	4-5

It can be seen from Table 6 that enzyme wash had moderate effect on physical properties of plain fabric compared to similar test results of twill fabric. Therefore, cotton plain fabric can be subjected to enzyme wash for various applications.

Conclusion

In this study, 2/1 plain rib fabric was treated with normal wash, neutral enzyme wash and acid enzyme wash to check their effect on physical and color properties. The results indicated that normal washed sample had comparatively better tensile and tearing strength than enzyme washed samples. On the other hand, better color strength and pilling resistance were observed in the acid enzyme washed sample. Neutral enzyme wash showed better color fastness to dry rubbing than wet rubbing. Due to unavailability of electron microscope, higher magnified images could not be captured to compare their surface structures. All three washed samples did not show any significant changes in appearance but some changes were found on their physical and color properties. Moreover, effects of enzyme wash on plain cotton fabric in terms of GSM, tensile and tearing strength are significantly lower than the results found for enzyme wash effects on twill weave. Therefore, the enzyme washing process can be used on plain weave for different look.

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