



Effect of Enzyme Wash with Stone on Different Properties of Stretch Denim Fabric

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Abstract

Denim washing is an aesthetic finish that improves the surface of fabric with softness and comfort. In this work the effects of enzyme wash were investigated with stone on 3/1 twill stretch denim (cotton-98%, lycra-2%) fabric. The changes in Grams per square meter (GSM), mechanical strength, spectrophotometric evaluation, color fastness to wash, rubbing and perspiration after wash with the increment of time 10, 20 and 30 minutes are evaluated. Leg panels were produced for this experiment. The findings stated as: the GSM and Tearing strength were decreased, while the wash, rubbing, perspiration fastness of the fabric samples were improved with the increment of wash time. The overall color differences (DE) for ten, twenty and thirty minutes wash samples were 1.89, 2.72 and 3.22 on D65 light source and 1.88, 2.69 and 3.19 for A-10 light source when compared with desized samples for indigo dyed samples (sample 1). Color differences (DE) for ten, twenty and thirty minutes wash samples were 3.76, 4.75 and 6.20 on D65 light source and 4.65, 5.89 and 7.65 for A-10 light source when compared with desized samples for direct dyed samples (sample 2). The Metamerism index (MI) increases with time of washing; ten, twenty and thirty minutes wash samples were 0.08, 0.20 and 0.25 for sample-1 and 1.33, 1.69 and 2.26 for sample-2. Color strength (K/S) values of the washed fabric samples on different wave lengths (400-700nm) as compared to the desized samples (11.350-12.522, 10.514-13.228) were decreased on ten minutes (9.072-10.336, 9.063-15.409), twenty minutes (7.541-8.84, 7.226-13.273) and thirty minutes (7.612-8.978, 7.675-16.126) wash samples.

Key words: Enzyme, Denim, Stone wash.

I. Introduction

Weaving and dyeing effects make denim garments uncomfortable to wear. The manufacturing process of denim involved dyeing of the surface of the warp yarn and the core stays white. Denim fabrics are with high density and high mass per unit area also hard to wear (S. A. Belal, 2009; M. Z. Hasan et al. 2017). That's why uncomfortable denim garments need a finishing treatment to make it soft and smooth which increases wearer's comfort. One of the most widely used finishing treatments is washing due to its effects on appearance and comfort (M. Hossain et al. 2017; S. Li et al. 2008; H. C. Yang et al. 2010). Various attempts are made to use chemicals in denim garment washing, such as enzyme wash, bleach wash, acid wash, stone wash etc (M. Z. Hasan et al. 2017). To reduce the hardness of fabric, pumice stones are also used in washing of denim fabric. To produce better distressed look during washing, the denim and pumice stones are put together in the washing

machine (M.M.R. Khan et al. 2012). Hand feel property is increased with increasing time of garment washing (M. M. Khatun et al. 2017), where tensile strength is decreased, stone and enzyme wash of garments increase color fading, softness and water absorption. Cracked and hairy fiber surface are visible on scanning electron micrograph and fluorescence microscopy analysis which results strength losses and soft-hand feel of denim garments (M. I. H. Mondal et al. 2016; M. M. R. Khan et al. 2012).

Enzyme washing is a process involving the use of enzyme to produce soft, comfort, luster and fade effect on denim fabric. The surface cellulose fibers of the denim fabric are broken down by enzymes and removed during washing. During enzyme washing, certain amount of indigo dye and cellulose fibers from the surface of the fabric are removed (H. A. El-Dessouki, 2015; D. Arjun et al. 2013). Enzymatic method is also eco-friendly but it decays cellulose chains, forming

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shorter chain cellulose polymers and lower its mechanical strength severely (M. Z. Hasan et al. 2017). Enzyme has difficulties to achieve different irregular effect on the garments which can be obtained easily by using stone. Garments and machine may be harmed by using only stone, so using enzyme with the stone can reduce harm to the garments and machine and bring the desired effect quickly (J. Sarkar et al. 2014). Tensile strength, seam strength and weight loss of fabric influenced by increasing time, temperature and stones of all washing treatments (M. Hafeezullah et al. 2014). Concentration of pumice stone effects durability in denim garment washing (M. I. H. Mondal et al. 2016). Strength loss increased with the use of pumice stone in denim washing with bleaching powder (M. M. R. Khan et al. 2013). To meet the desire of customer

and changing trends washing process are suitable to open new market.

In this work, two raw (unwashed) denim fabric samples of which the warp yarns of the 1st sample is dyed with indigo and the 2nd sample is dyed with royal blue and black shade are enzyme washed with stone at three different times interval (10, 20 and 30 minutes). The aim of this work is to investigate the effect of enzyme wash with stone over time on physical, mechanical, chemical and optical properties.

II. Materials and Methods

II.A. Description of Materials:

Two samples of fabrics are collected from Mahmud denim of below specifications.

Table 1: Description of the fabric samples

Features	Sample 1	Sample 2
Composition	Cotton-98% , lycra-2%	Cotton-98% , lycra-2%
Weave	3/1 twill	3/1 twill
Type	Bi-stretch twill denim	Bi-stretch twill denim
GSM	337	396
Color	Indigo	Indosol royal blue and Black(Direct dye)

Leg panels are produced for this experiment.

II.B. Desizing (1st step)

In this pretreatment stage, denim leg panels were desized with soda ash 5g/L, anti-back staining agent 1g/L, lycra protector 2g/ L keeping liquor ration 1:20. The treatment was carried out at room temperature in Industrial Belly washing machine for 10minutes. After desizing, a subsequent clearing process was conducted with detergent 1g/L in room temperature for 5minutes.

II.C. Enzyme wash with stone (2nd step)

Denim leg panels were loaded into the washing machine and then enzyme wash was carried out in the same washing machine by maintaining following recipe; 1.5kg pumice stone, 10g/L powder enzyme, 1g/L anti-back staining agent, 2g/L lycra protector, 1:60 M:L, Temperature was room temperature and time increased gradually 10, 20 & 30 minutes.

II.D. Testing Methods

- The Grams per Square Meter (GSM) was measured by cutting the fabric sample with GSM Cutter (Model No.-GTC75; Brand : Gester; Country of origin: China). Then the weight of cut sample was measured by electronic balance. After that the weight was multiplied with 100 and the result was found.
- Universal testing machine (Model No.-GTK03, Brand: Gester; Country of Origin :China) was used to determine tearing strength or breaking force of the fabric samples. Strip methods (ASTM D5035-11) were used. The strip test method is used to determine the breaking force and elongation of textile fabrics and geotextiles.
- To determine the color fastness to Rubbing, James Heals Crock Master was used (Origin:UK) Color Fastness to Rubbing was followed according to test standard ISO 105 X 12; 1993.
- Color fastness to perspiration was determined by ISO 105 E04: 1994 method.

v. X-rite (Color i Match 9.4.10) is used for measuring DL^* , Da^* , Db^* , DC^* , DH^* , DE and Metamerism Index and K/S value is measured Kubelka - Munk equation,

$$K/S = (1 - (0.01 \times R)) / (2 \times 0.01 \times R)$$

Where, K/S is the color strength and R represents reflectance of the sample.

III. Results and discussion

III. A. Effect on GSM

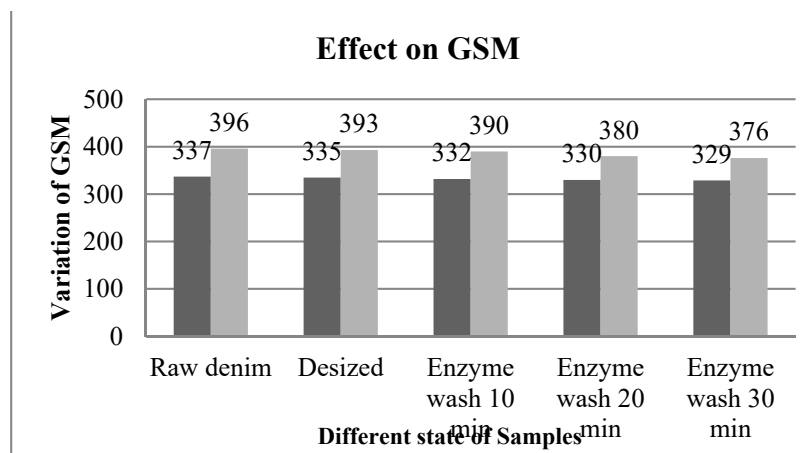


Fig. 1: Effect of Enzyme wash with stone on GSM of fabric samples

Figure 1 shows that enzyme wash with pumice stone plays a significant role on fabric weight. Where raw denim GSM was 337 and 396, desized sample has 335 and 393 GSM, 10 minutes wash sample has 332 and 390 GSM, 20 minutes wash sample has 330 and 380 GSM and 30 minutes wash sample has 329 and 376 GSM. That means GSM decreases slightly for both samples with the increment of time during

washing. Enzyme can reduce the fabric weight by abrading the fabric surface and removing the protruding fibres from the surface. Stone hits the fabric and brings out the dyes, thus GSM decreases slightly (H. A. El-Dessouki, 2015; D. Arjun et al. 2013).

III.B. Effect on Tearing strength

Table 2: Effect of stone enzyme wash on tearing strength

Process	Sample 1		Sample 2	
	warp way (N)	weft way (N)	warp way (N)	weft way (N)
Raw denim	29	23	61	54
Desized	27	22	48	42
Enzyme wash 10'	24	21	40	40
Enzyme wash 20'	20	20	38	39
Enzyme wash 30'	18	19	35	34

Table 2 shows that tear strength is also changed with the increment of time, decreases for both samples in both way (warp & weft). For sample 1 highest value was 29N on warp way for raw denim and lowest value is 18N in warp way for thirty minutes wash sample; in weft way highest and lowest value is 23N & 19N correspondingly. In case of sample 2 highest values are 61N & 54N in both warp and weft

direction and the lowest values are 35N and 34N in both directions. Enzymes are responsible for hydrolyzing the cotton, that's why tearing strength reduced (M. Z. Hasan et al. 2017).

III.C. Effect on colorfastness to wash, rubbing and perspiration

Table 3: Effect of stone enzyme wash on colorfastness to rubbing& Perspiration

Process	Rubbing fastness rating				Perspiration fastness rating			
	Sample 1		Sample 2		Sample 1		Sample 2	
	Dry	Wet	Dry	Wet	Acid solution	Alkali solution	Acid solution	Alkali solution
Raw denim	4/5	3	3/4	3	4/5	4/5	3/4	3
Desized	4/5	4/5	4	3	4/5	4/5	4	3
Enzyme wash 10min	4/5	4	4/5	3/4	4/5	4/5	4/5	3/4
Enzyme wash 20min	4/5	4/5	4/5	3/4	4/5	4/5	4/5	4
Enzyme wash 30 min	4/5	4	4/5	4	4	4/5	4/5	4

From table 3 it can be seen that rubbing fastness result of sample 1 in dry state is same for all samples which are 4/5 but in wet state it improves (rating was 3 of raw denim but it becomes 4/5 for desized denim, 4 for 10 minutes stone enzyme washed denim, 4/5 for 20 minutes stone enzyme washed denim and 4 for 30 minutes stone enzyme washed denim). In case of sample 2 which is dyed by indosol royal blue and black, Colorfastness to rubbing test result in dry state is changed slightly (rating was 3/4 of raw denim but it becomes 4 for desized denim, 4/5 for 10 minutes, 20 minutes 30 minutes stone enzyme washed denim). For wet state rubbing test result is 3 of raw denim and desized denim, 3/4 for 10 minutes and, 20 minutes wash and 4 on 30 minutes stone enzyme washed denim. So color fastness to rubbing improves with time of wash (M. M. Khatun et al.2017)

Table 3 also shows colorfastness to perspiration test result is exactly same for sample 1 in alkaline solution. In acidic solution, raw sample, desized sample, 10 & 20 minutes washed samples rating is same; 4/5. Only 30 minutes stone enzyme washed samples has a very minor difference in rating which is 4 but it's satisfactory. For sample 2, in acidic solution rating was 3/4 for raw denim and it changes to 4 on desized denim. But for 10, 20, 30 minutes washed samples rating is 4/5. In alkaline solution the highest value is 4 which come out after 20 and 30 minutes stone enzymatic wash whereas the rating was 3 for raw sample and desized sample and 3/4 for 10 minutes wash sample. Perspiration can't further fade the color of the sample because maximum color already came out on washing.

III.D. Spectrophotometric evaluation

Table 4: Spectrophotometric evaluation of enzyme washed samples as compared to desized wash

	Enzyme wash (minutes)	Light source	DL*	Da*	Db*	DC*	DH*	DE	MI
Sample 1	10	D65	2.41	0.37	-0.33	0.35	0.35	1.89	0.08
		A-10	2.43	0.34	-0.26	0.22	0.36	1.88	
	20	D 65	3.32	0.17	-0.90	0.90	0.16	2.72	0.20
		A-10	3.27	-0.02	-0.92	0.91	0.12	2.69	
	30	D 65	3.94	0.19	-1.05	1.05	0.18	3.22	0.25
		A-10	3.89	-0.04	-1.07	1.06	0.12	3.19	
Sample 2	10	D 65	-0.78	-0.45	-3.45	3.33	-1.01	3.76	1.33
		A-10	-1.14	-1.65	-3.90	4.04	-1.26	4.65	
	20	D 65	1.30	-0.91	-4.21	4.05	-1.45	4.75	1.69
		A-10	0.81	-2.38	-4.86	5.13	-1.72	5.89	
	30	D 65	1.48	-0.92	-5.65	5.49	-1.62	6.20	2.26
		A-10	0.84	-2.93	-6.47	6.82	-1.97	7.65	

Table 4 shows the spectrophotometric evaluation of the enzyme washed Sample 1 and Sample 2. Desized sample is taken as standard and DL^* , Da^* , Db^* , DC^* , DH^* , DE , MI are observed for 10, 20 and 30 minutes washed samples. Here the Metamerism index is less (0.08, 0.20, 0.25) than 1 for sample 1 and greater (1.33, 1.69, 2.26) than 1 for sample 2. Metamerism index is increasing with increment of time of wash. For sample 1 the overall color differences (DE) for ten, twenty and thirty minutes wash samples were 1.89, 2.72 and 3.22 on D65 light source and 1.88, 2.69 and 3.19 for A-10 light source when compared with desized samples. It means very small difference on ten and twenty minutes wash samples but thirty minutes wash sample shows medium difference with desized sample. For sample 2, color differences (DE) for ten, twenty and thirty minutes wash samples were 3.76, 4.75 and 6.20 on D65 light source and 4.65, 5.89 and 7.65 for A-10 light source when compared with desized samples. (font size 10) It means obvious differences between desized and wash samples. Color differences (font size 10) (DE) is increasing with increment of time of wash (M. Bhattacharjee et al. 2019).

The lightness DL^* for sample 1 is also increasing with time for both D65 (2.14, 3.32, 3.94) and

A10 (2.43, 3.27, 3.89) light source which means samples are being more lighter with washing treatments. For sample 2 lightness DL^* is also increasing (-0.78, 1.30, 1.48) on D65 and (-1.14, 0.81, 0.84) on A10 light source.

The chroma difference DC^* value for sample 1 shows 0.35, 0.90, 1.05 on D65 and 0.22, 0.91, 1.06 on A10 light source for 10, 20 and 30 minutes wash samples. The chroma difference DC^* value for sample 2 shows 3.33, 4.05, 5.49 on D65 and 4.04, 5.13, 6.82 on A10 light source for 10, 20 and 30 minutes wash samples. It indicates slightly brighter samples means more saturated with wash treatments (M. Bhattacharjee et al. 2019).

DH^* is 0.35, 0.16, 0.18 on D65 and 0.36, 0.12, 0.12 on A10 light source for sample 1 on 10, 20 and 30 minutes wash. So, DH^* is decreasing with increasing time of wash treatments. DH^* is -1.01, -1.45, -1.62 on D65 and -1.26, -1.72, -1.97 on A10 light source for sample 2 on 10, 20 and 30 minutes wash. Here DH^* is also decreasing with increment of time of wash.

These are the signs of good washed fabric and fading effect is increasing with time of washing.

III.E. Color strength K/S values

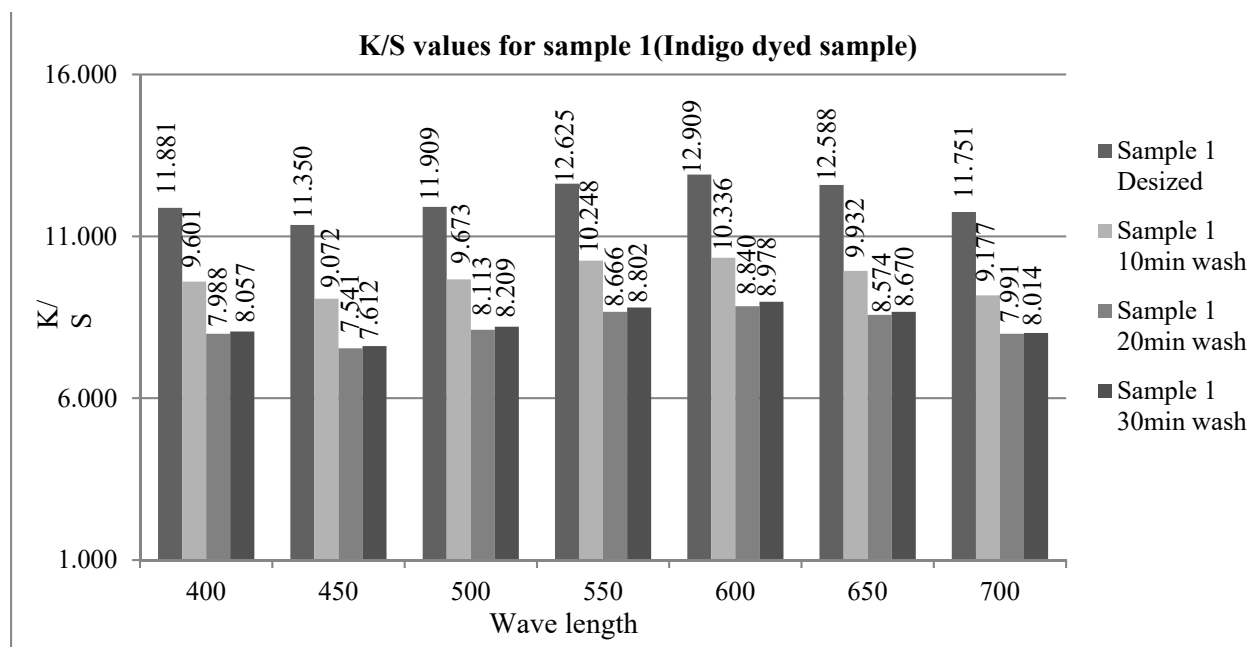


Fig. 2: Comparison on K/S values of Sample 1 with the increment of wash time

It is visible from figure 2 that K/S value is highest on 600 nm wave lengths which is 12.909 for desized sample, 10.336 for 10 minutes washed sample, 8.840 for 20 minutes washed sample and 8.670 for 30 minutes washed sample . From 400-700nm wavelengths desized sample without wash has higher K/S (11.35-12.909) than 10 minutes (9.072-10.336),20 minutes (7.541-

8.84)and 30 minutes (7.612-8.978) washed samples on same wavelengths.

It was observed that color strength of denim fabric decreased after they were exposed enzyme treatment with stone wash. (M. Bhattacharjee et al. 2019). For thirty minutes wash sample most of the dyes already washed out, so color strength value is slightly decreased compared to twenty minutes wash sample which is negligible.

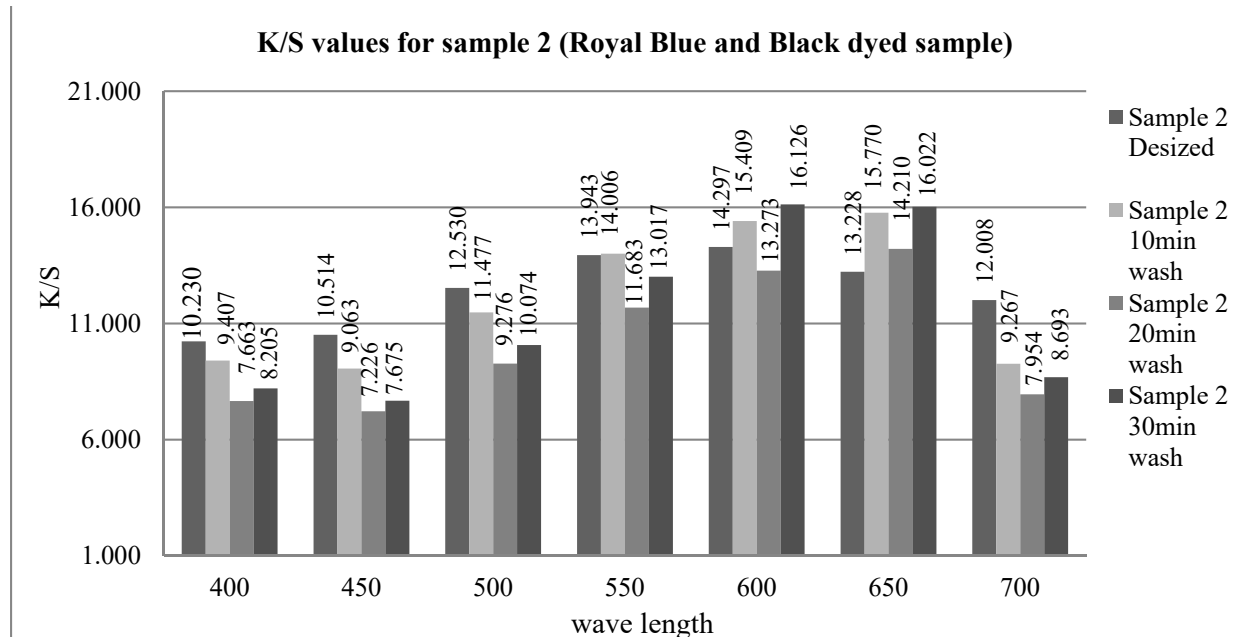


Fig. 3: Comparison on K/S values of Sample 2 with the increment of wash time

From figure 3, it is visible from figure 2 that K/S value is highest on 600 nm wave lengths which is 14.297 for desized sample, 15.409 for 10 minutes washed sample, 13.273 for 20 minutes washed sample and 16.126 for 30 minutes washed sample . From 400-700nm wavelengths desized sample without wash has higher K/S(10.514-14.297) than 10 minutes (9.063-15.409),20 minutes (7.226-13.273)and 30 minutes (7.675-16.126) washed samples on same wavelengths.

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IV. Conclusion

Now-a-days washing of denim garments with different chemicals and other mechanical actions

is the most demanding and popular finishing process all over the world. Apart from fancy looks, it's also responsible to bring many aesthetic and functional properties on denim fabric like softness, comfort and others. From this point of view this research work is conducted. In the concluding part: the overall findings can be mentioned in some points:

- Prolonged wash are responsible to decrease the physical strength of both samples. GSM decrease with increase time of wash while washing with enzyme and pumice stone. Tear strength is also decreases with the time for both samples in both way (warp & weft).Some variations in chemical test results (i.e. colorfastness to rubbing & perspiration) are found for sample 2. Washing treatments make the rating lower than that of sample 1.
- As mentioned that sample 2 is dyed with direct dye (Indosol royal blue and black). Direct dyed

sample (sample-2) shows less color fastness rating on rubbing & perspiration than indigo dyed sample (sample-1). But the overall result is good.

- Metamerism index is greater for sample 2 than sample 1. Color difference between samples increases with time of washing.
- The color strength K/s values for both sample, desized sample without wash show higher K/s on 400-700nm wave length rather than ten, twenty and thirty minutes wash sample. Consequently, enzyme washed with pumice stone denim become duller and color is faded than the original one.

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