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An Investigation of Physico-Mechanical Properties of Knit and Woven Fabric Using Different Washing Effects

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Abstract
Industrial washing is now becoming popular as it increases the value of the fabric properties and appearance. So, the aim of this study is to evaluate the physio-mechanical properties of the sample fabrics after doing enzyme and bleach wash. For this experiment, three different sample fabrics were used: 98/2% cotton/spandex woven fabric, 100% cotton knit fabric, and 95/2% cotton/spandex knit fabric. To observe the physical and mechanical properties of the samples several tests were done viz. color fastness to wash, rubbing, light, color strength, tensile strength, shrinkage, and surface density. After performing all the tests, significant improvement has been achieved. Almost no change occurred for enzyme and bleach wash against color fastness to wash. Bleach wash showed better results for rubbing fastness and enzyme wash for light fastness.

Keywords
Bleach wash, Color fastness, Enzyme wash, Knitted fabric, Woven fabric

INTRODUCTION

In this modern epoch, males and females are both very fashion-conscious about their dresses. This fashion trend is increasing daily and depends on the types of washed denim garments, which are now extremely popular worldwide. Passing with the time, tastes of fashion are also mutating day by day. Few types of research were done on denim garments and various kinds of effects were produced by treating with some schemes [1]. Bleaching treatment, enzymatic treatment, silicon treatments are among them [2, 3]. The demand for denim garments is increasing dramatically as consumers can purchase any washed garments as their required size. Because size is varied for the shrinkage properties of washed garments [4, 5]. But we can release this pressure from this sector by using these washing techniques on knit fabrics. But it is a matter of joy that few textile industries are producing knit wash garments like a polo shirt, t-shirt, trousers etc. by using different washing techniques i.e., enzyme wash, softener wash, silicone wash, tie-dye wash, pigment wash, and caustic wash [6, 7]. Among them, Enzyme wash and bleach wash are prominent. The enzyme acts as a catalyst as it can accelerate the chemical reaction. For this kind of behaviour, Enzymes have wonderful use in industry and medical applications [8, 9]. An enzyme is a diversified group of proteins which is the greatest group among all proteins [10]. It plays a key role in the textile industry to remove the fuzz from the surface of the fibre and it gives an excellent smooth hand feel to the fibre [11]. On the other hand, bleaching is used for removing the color and to give a faded look to the fabric. Moreover, it can be used for cleaning purposes and can kill the virus, bacteria etc. [12, 13]. There is no other such way in the garments industry that can bring a higher degree of fading color without bleaching [14]. Bleaching is normally done by two major chemicals. One is Sodium Hypochlorite, and another one is Hydrogen peroxide [15]. But strong bleach can damage the fabrics and turn the fabric yellowish. For that reason, it needs to be neutralized by using different steps and it adds extra charge economically. Bleach wash has some advantages. For instance, it can be used both for knit and woven fabrics. Moreover, a uniform appearance can be produced by using bleach wash [1]. So, despite having some drawbacks of bleach wash, Enzyme wash is more responsible to reduce the strength of fabrics [16].

The effect of enzymes and bleach wash on the physical and mechanical properties of knit fabrics is investigated in this paper since these properties decide how the wearer feels, how fashionable the finished product is, and how long it lasts. The efficient usage of the enzyme with a defined proportion of pumice stones is also explored in the paper.

MATERIALS AND METHODS

Materials

Fabric

In this study, 3 types of fabric samples were used where one was woven structured and another 2 fabrics were single jersey (S/J) knitted fabrics. The fabric weight per unit area of knitted fabric was 160 g/m^2.

Table 1 Sample Identifications

Sample No.	Sample Name	Sample Code
1	98% cotton 2% elastane twill fabrics	CWF1
2	100% cotton knitted S/J fabrics	CKF1
3	95% cotton 5% elastane knitted S/J fabrics	CKF2

Chemicals

Here 500 g bleaching powder [$Ca(OCl)_2$], same amount of soda ash (Na_2CO_3), 300 g sodium meta sulphate ($Na_2S_2O_5$), 300 g anti-back stain agent, 500 g acid enzyme and 100 g pumic stone were bought from Millennium supplier Dhaka who procued these items from following countries having different brand : Bleaching powder's brand was HTH from USA, Soda ash's brand was SODA SOLVAY from Belgium, Sodium Metabisulphite's brand was Antichlor from India, Anti-Back Stain agent's brand was Sequestrant from Germany, Acid Enzyme's brand was Biolase from Denmark, and Pumice Stone's brand was Pumie from USA.

Equipment

The sample fabrics were washed by using a laboratory sample washing machine (Model: H-24P X450ml).

Methods

Table 2 Methods of sample preparation

Types of fabrics →	CWF1	CKF1	CKF2
Steps of fabric processing	Enzyme Wash Bleach Wash	Enzyme Wash Bleach Wash	Enzyme Wash Bleach Wash

The enzyme wash was done in a sophisticated way. At first, 400 g of acid enzyme, 250 g of acetic acid and 200 g anti back staining agent were taken into the machine where 1:10 liquor ratio was maintained [17-19]. The solution was then kept at a temperature of 50-55°C for 20 minutes [20]. The fabrics were washed with hot water to kill the enzyme. Finally, the samples were rinsed for 2 minutes [16].

The bleach wash was conducted in liquor containing KCI bleach (10 g/L), soda ash (5 g/L) at pH 10.5, and material to liquor ratio of 1:10 in the washing machine. The temperature was kept at 50°C and treatment time was 30 min [1, 21]. The fabrics were then neutral washed in same liquor ratio with Hypo (2 g/L), acetic acid (40 g/L) to maintain the pH of the bath 5.5 for 7 min at room temperature [22, 23]. Then the leg panels were rinsed with only water for 2 minutes.

Testing and Analysis

Color Fastness to Wash

This test (ISO 105 C04) measures the extent to which a fabric retains its color and resists transferring its color to other materials after washing [24, 25]. The procedure for this involves washing a fabric swatch multiple times using varying washing conditions, from temperatures, times, several types of soaps. After washing the fabric samples, the samples are compared to other unwashed dry samples of fabric. Typically, a gray scale is used to compare the change in color [26-28]. The comparison yields a neuter connoting shade in which is used for assessment. This gray scale is numbered from 1 to 5, with 1 indicating poor color fastness, and 5 attesting to the excellent color fastness. Thus, this implies that a higher rating means the fabric maintains its color after being washed, leading to better results [29, 30].

Color Fastness to Rubbing

The test (ISO 105 X12) shows the extent to which the fabric color can transfer to another fabric during wear [31-33]. The test procedure involves rubbing a color fabric sample against a white fabric swatch [34]. The amount of color transferred is then viewed as the extent to which a fabric's color can shift when put under friction wear. This is then done by comparing the results to the results of samples swatches that the same the first sample swatch. The results are measured using the 1 to 5 gray scale. Like color fastness to washing, here 1 also indicates poor color fastness, and 5 attests to the excellent color fastness [35, 36]. Thus, a higher rating indicates that the fabric retains its color more effectively after rubbing, resulting in better performance [29, 30].

Color Fastness to Light

This test (ISO 105 B02) measures the extent to which a fabric will lose its color to exposure [32, 37, 38]. As such, a fabric sample is put under light, usually natural light from the sun, under a unit light intensity. The change in color is then measured using the instrumental process. This result is then gauged using the numbers ranging from 1 to 8 [39, 40]. Rating 8 connotes excellent color fastness value, and 1 represents the poorest color value of all [41].

Color Difference Value

The test for showing minimal color change is known as the color difference value [42-44]. The color change is measured in units such that 0.05 is the least value change which a human eye will not see. The purpose of the test is to find the differences in color that the human eye can see from one fabric swatch to the other [45]. The test is crucial during dyeing process in order to ensure textile uniformity on both fabrics. The lower the value, the negligible color difference will exist from one fabric to the another [46].

RESULTS AND DISCUSSION

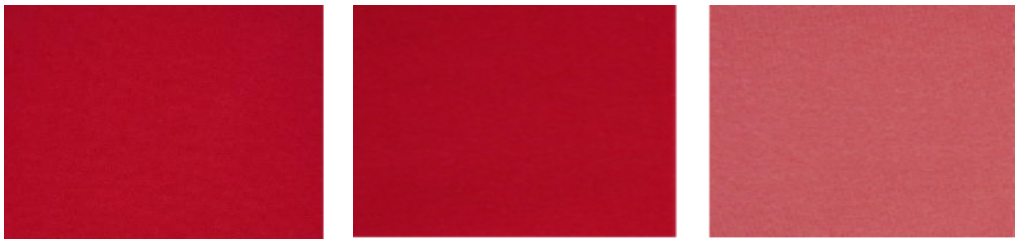
Physical Appearance of Treated Samples

(a) Before wash (b) Enzyme wash (c) Bleach wash

Fig. 1 Visual appearance of CWF1

(a) Before wash (b) Enzyme wash (c) Bleach wash

Fig. 2 Visual appearance of CKF1



(a) Before wash (b) Enzyme wash (c) Bleach wash

Fig. 3 Visual appearance of CKF2

From the photograph of the samples (see **Fig. 1-3**), it can be concluded that there is a very subtle difference among all the samples. The twill fabric (CWF1) among them was very lustrous and the 100% cotton knitted S/J fabric (CKF1) appeared to be the least lustrous as luster increases with the compactness of the fabric [47]. Since elastane enhances the compactness of the fabric, more loops could be in contact due to the ability of fabrics to take a perfect shape if they are compact [48]. This would also enhance the flow of charge, hence, higher luster of that fabric. Even though the fabric samples went through enzyme and bleach washes, luster is always determined by the structural parameters and fabrics' comfort properties. It is known that a soft fabric is a quality fabric, hence, higher luster because that came with the softness after treatments. In conclusion, CWF1 showed brighter shade before CKF2 and CKF1. Again, CKF1 showed lower brightness than CKF2 as CKF2 contains 5% elastane where CKF1 is zero.

Assessment of Color Fastness to Rubbing

Table 3 Color fastness to rubbing

Status		**CWF1**		
		Control	**Bleached**	**Enzyme**
Rubbing	Dry	4-5	4-5	4
	Wet	3	4	2-3
Status		**CKF1**		
		Control	**Bleached**	**Enzyme**
Rubbing	Dry	4-5	4-5	4
	Wet	2-3	4	2-3
Status		**CKF2**		
		Control	**Bleached**	**Enzyme**
Rubbing	Dry	4-5	4-5	4
	Wet	2-3	4	2-3

From Table 3, Wet rubbing of all samples show better fastness for bleach wash than enzyme wash. Bleach wash rating is 4 and enzyme wash rating is 2-3. Wet rubbing fastness has improved after bleach wash but decreases in the case of enzyme wash [49, 50].

Assessment of Color Fastness to Wash

Table 4 Color fastness to wash (CWF1)

Status			**Control**	**Bleached**	**Enzyme**
	Change in color		**4**	**4**	**4**
Color fastness to wash	Color staining	Diacetate	4-5	4-5	4-5
		Cotton	4	4	4-5
		Polyamide	4-5	4-5	4-5
		Polyester	4-5	4-5	4-5
		Polyacrylic	4-5	4-5	4-5
		Wool	4-5	4-5	4-5

Table 5 Color fastness to wash (CKF1)

Status			Control	Bleached	Enzyme
	Change in color		4	4	4
Color fastness to wash	Color staining	Diacetate	4-5	4-5	4-5
		Cotton	4	4	4-5
		Polyamide	4-5	4-5	4-5
		Polyester	4-5	4-5	4-5
		Polyacrylic	4-5	4-5	4-5
		Wool	4-5	4-5	4-5

Table 6 Color fastness to wash (CKF2)

Status			Control	Bleached	Enzyme
	Change in color		4-5	4	4
Color fastness to wash	Color staining	Diacetate	4-5	4-5	4-5
		Cotton	4	4	4-5
		Polyamide	4-5	4-5	4-5
		Polyester	4-5	4-5	4-5
		Polyacrylic	4-5	4-5	4-5
		Wool	4-5	4-5	4-5

Table 4 shows that bleach washed, and enzyme washed sample having no change in color rating due to washing except the CKF2 fabric sample. Again, the entire sample having the color staining of different multi-fibre is like the control sample [11]. But enzyme wash improves the color staining properties against the cotton [51]. No notable change in color due to washing (see **Table 4-6**).

Assessment of Color Fastness to Light

Table 7 Color fastness to light

Status	CWF1		
	Control	Bleached	Enzyme
Color fastness to light	4	2-3	3-4
Status	**CKF1**		
	Control	**Bleached**	**Enzyme**
Color fastness to light	4	2-3	3-4
Status	**CKF2**		
	Control	**Bleached**	**Enzyme**
Color fastness to light	4	2-3	3-4

From Table 7, the enzyme washed sample shows better light fastness properties than bleach washed sample. Bleach wash sample rating is 2-3 and enzyme washed sample rating is 3-4.

Measurement of Color Difference Value

The light source D65 and TL84 are used for the spectro-photometric evaluation. The lightness (DL*), Saturation (DC*), Tone (DH*), CIE lab values difference (Da*, Db*), Total color deviation (DE*) are measured for bleached washed and enzyme washed samples [42]. Here, Individual control samples were treated as standard samples.

Table 8 CMC test for CWF1

Standard	Sample Batches	Illuminant/ Observer	DL*	Da*	Db*	DC*	DH*	DE	Metamerism Index
CWF1 (Before Wash)	CWF1 (Bleach)	D65/10 Deg	20.93	-14.07	-2.92	-14.14	2.54	12.86	2.59
		TL84/10 Deg	20.30	-11.6	-3.42	-11.8	2.69	11.66	
	CWF1 (Enzyme)	D65/10 Deg	-0.53	0.61	0.30	0.68	0.06	0.39	0.21
		TL84/10 Deg	-0.53	0.40	0.28	0.49	0.06	0.34	

From Table 8, Bleach washed sample gives a lighter and dull shade whereas enzyme washed sample gives a darker and brighter shade. The shade difference of bleached samples is remarkable.

Table 9 CMC Test for CKF1

Standard	Sample Batches	Illuminant/ Observer	DL*	Da*	Db*	DC*	DH*	DE	Metamerism Index
CKF1 (Before Wash)	CKF1 (Bleach)	D65/10 Deg	23.14	-13.38	-2.62	-13.36	2.74	14.19	2.84
		TL84/10 Deg	22.79	-10.57	-2.72	-10.51	2.92	13.01	
	CKF1 (Enzyme)	D65/10 Deg	-0.86	0.24	0.18	0.29	0.08	0.50	0.33
		TL84/10 Deg	-0.88	-0.07	0.29	0.07	0.29	0.51	

From Table 9, Bleach washed sample gives a lighter and dull shade whereas enzyme washed sample gives a darker and brighter shade. The shade difference of the bleached sample is remarkable.

Table 10 CMC Test for CKF2

Standard	Sample Batches	Illuminant/ Observer	DL*	Da*	Db*	DC*	DH*	DE	Metamerism Index
CKF2 (Before Wash)	CKF2 (Bleach)	D65/10 Deg	22.95	-14.08	-2.98	-14.15	2.65	14.11	2.81
		TL84/10 Deg	22.45	-11.33	-3.27	-11.45	2.81	12.85	
	CKF2 (Enzyme)	D65/10 Deg	-0.93	-0.59	-0.99	-0.9	-0.72	0.77	0.44
		TL84/10 Deg	-1.13	-0.77	-1.34	-1.31	-0.82	0.97	

From Table 10, Bleach washed sample gives a lighter and dull shade whereas enzyme washed sample gives a darker and brighter shade. The shade difference of bleached samples is remarkable [53]. The spectrophotometric values under different light sources of CMC are seen that DE* value is out of range i.e., more than 1 for all three-bleach washed sample (as shown in Table 7-9). DE* values recognize the color difference between washed fabric samples and respective Control samples. Again, DE* value is in the range i.e., less than 1 for all three enzymes washed sample. So, as per the colorimetric observation, bleach wash provides the effective shade variation rather than enzyme washed samples.

CONCLUSIONS

Innovation is required in the garment-washing industry. A washed product could bring in 100 times the benefit of an unwashed product. Before marketing of a garments or cloth, manufacturer wants to produce a wide range of unique styles on that cloth by various methods or processes. Washing process is one of them. It makes the fabric soften as well as produce fashionable patterns by worn or faded look. The effect of various washing methods, such as enzyme and bleach wash, on three distinct types of fabrics, is investigated in this project. Bleach-washed samples fade more effectively than enzyme-washed samples. Except for light fastness, average fastness properties increased in both bleach and enzyme washes. The use of enzymes in the chemical manufacturing of fabrics and textiles is gradually gaining broader acceptance due to their non-toxic and eco-friendly characteristics, which is becoming increasingly necessary for textile factories to mitigate emissions in textile production. It can be easily used in a variety of textile processes.

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