Comparison of the Physical and Colorfastness properties of 100% Cotton Knitted Fabric after Different Washes

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Abstract- ***Single jersey cotton knit fabric experiences significant changes in physical properties and color fastness when subjected to various washing treatments. This study evaluates the effects of four washing treatments—normal wash, enzyme wash, alkali wash, and bleach wash—on the physical and colorfastness properties of 100% cotton single jersey fabric (160 Grams per Square Meter-GSM). A series of tests, including assessments of fabric weight, bursting strength, pilling, and colorfastness, were conducted on fabric samples before and after washing, following standardized laboratory methods. Findings reveal that fabric weight increased by 2% to 8% after washing across all treatments. Bursting strength improved following normal and bleach washes but decreased with enzyme and alkali washes, suggesting differential impacts on fabric resilience based on wash type. Pilling resistance remained unchanged after washing, indicating consistent surface quality. Additionally, colorfastness assessments showed minimal variation before and after washing, with no significant color degradation observed across treatments. These results highlight that while certain washing techniques may enhance specific fabric properties, overall colorfastness remains stable, providing useful insights for fabric care recommendations in textile manufacturing and consumer use.***

Indexed Terms- ***Cotton, Knitted fabrics, Washing, Physical properties, Color fastness properties***

I. INTRODUCTION

Knitting is the technique of constructing fabric by creating a continuous length of yarn into columns of vertically interlocked loops. There are two primary knitting techniques: weft knitting and warp knitting [1]. In weft knitting, loops are formed from a single yarn running in the fabric's crosswise direction, while in warp knitting, all needles work together to form loops from an entire warp sheet, with the loops running lengthwise through the fabric [2]. Historically, knitting is believed to have originated in the Middle East in the 5th century. Early knitting in Egypt often used cotton fibers, and by the 16th century, knitting machines were used to produce hosiery for the elite. In the 20th century, knitting technology became integral to modern fashion, making garments like jersey dresses, cardigans, and jumpers for both men and women [3]. Fabric produced through knitting is known as knitted fabric, with single jersey knit being one of the most common types. Single jersey fabric is made on a circular knitting machine with one set of needles, called cylinder needles. This type of fabric has a distinct face and back, making it easy to identify, and is widely used for outerwear and undergarments, such as T-shirts and polo shirts, due to its comfort compared to woven fabrics.

Knitted fabric depends significantly on fine, strong, and consistently spun yarn. Cotton yarn, in particular, is frequently used in single jersey fabrics because it is soft, flexible, highly absorbent, and has a tendency to crease easily [4]. Nowadays a lot of knitted garments undergoes different washing process which is a growing sector in Bangladesh [5]. This washing process creates a unique look and feel that cannot be achieved by any other method. Additionally, washing removes starch from the garments. Today, alongside denim, knit garments like T-shirts, polo shirts, and trousers are washed using various techniques, including enzyme wash, softener wash, silicone wash, tie-dye wash, pigment wash, and caustic wash, to improve their physical properties and color fastness [6].

This project paper examines the effects of different washing methods—such as normal wash, bleach wash,

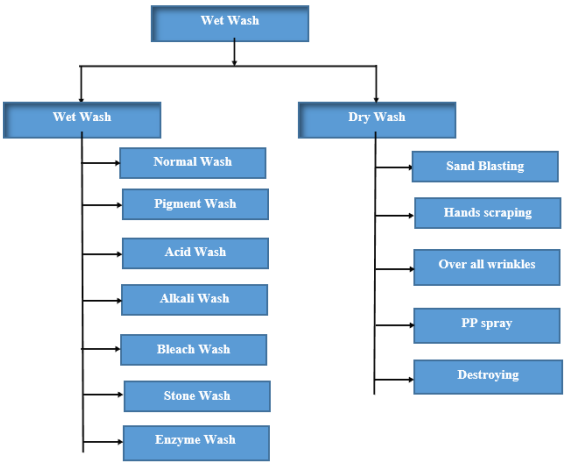
enzyme wash, and alkali wash—on the physical properties and color fastness of cotton knitted fabric, along with a comparative analysis of the outcomes post-wash.

1.1. What is washing?

Garments washing are an ongoing technology in garments production. Traditionally, washing means to clean something, but in the apparel sector, the only cleaning of garments is not the garments wash. Garment washing is a technology that is applied to change or modify the outlook, appearance, comfort ability, and design of garments. Garment washing is applied on solid dyed garments or solid printed fabric. Here, different types and objects of wash in the garment industry are addressed [7].

1.2. Types of garments washing

In the garments industry, there are mainly two types of washing processes for garment products. Those processes are the wet washing process and dry washing process. Here also wet washing process is divided into eight ways and the dry washing process is divided into five ways, according to the fabric quality and buyer requirements. However, the most common and applied wash in garments is normal wash, also known as detergent wash. In the wet washing process enzyme wash, stone wash and bleach wash are most popular with the buyer and the manufacturer. On the other hand, Potassium per magnet spray and hand scraping are common for dry washing process in the garments industry [7].



II. LITERATURE REVIEW

From the previous studies, there are several research works have been done about the effect of washing on denim fabric and knitted fabric to determine the generally physical and mechanical properties of the fabrics.

Solaiman et al. worked on Different Washing Effects on Physical and Mechanical Properties of Cotton Knitted Garments. They found that the application of enzymes on the knit garments improved all the tested properties of the garments, and it also reduced the hairy fibers from the fabric surface. Similar results are found in the case of Si- silicone and softener wash as well. The most important results are found for 100% cotton knit garments. Overall, the properties of knit garments improved after washing. Again with the increasingly important requirement for textile manufacturers to reduce pollution in textile production, the use of enzymes, softeners, and Silicones in the chemical processing of fibers and textiles is rapidly gaining wider recognition because of their non-toxic and eco-friendly characteristics [8].

E. Khalil et al. investigated the effect of acid washing (with thermocol balls and potassium permanganate) on different physical properties of three knitted garments (Single Jersey 100% Cotton T-shirt, Single Jersey 95% Cotton 5% Spandex T-Shirt and 1 × 1 Rib100% Cotton T-Shirt). Typical washing procedures and techniques were followed, and then physical properties were analyzed under standard conditions. It is observed that fabric weight, CPI, WPI, spirality, and shrinkage increase while bursting strength, and stitch length absorbency decrease after washing treatment. pH of all the samples is under control and lies between 7 to 8. There is no change in pilling, colorfastness to wash, water, and dry rubbing while there is a little bit decrease in wet rubbing [9].

Md. Mashiur Rahman Khan, Md. Ibrahim H. Mondal and Md. Zulhash Uddin investigated the effect of bleach wash on the physical and mechanical properties of denim fabric and found that the tensile strength, stiffness, fabric weight, and color shade decreased after hypochlorite bleach washing treatment. Examination of the bleach-treated fabrics by SEM shows more crack and decomposition on the surface,

as a result, fibers are loosened, weaker, and rough surface on denim fabrics. It is further noted that unwashed denim samples are almost smoother, stiffer, and harder and less water-absorbent than bleach-treated cotton denim garments [10].

Upama Nasrin Haq and Md. Mashiur Rahman Khan investigated the effect of acid wash and found that acid wash treatment is very effective for woven denim apparel to create an irregular fading effect. The properties of denim that were inspected contained breaking strength, stiffness, GSM, dimensional changes (shrinkage/growth %) count, EPI & PPI, and color change. The obtained results were compared and found that breaking strength, stiffness, GSM, dimensional stability, and color depths decreased. But count, EPI & PPI are increased for acid wash treatment on woven denim apparel [11].

In the literature, all the research work was done by investigating the physical and mechanical properties of single & double jersey cotton knitted fabric as well as cotton/spandex and denim apparel. As most of the studies mainly focus on specific was and the physical & mechanical properties of cotton knitted fabric and denim, this work analyzes the physical properties and color fastness of 100% cotton single jersey fabric with different washes. Consequently, this project tried to mitigate this gap by investigating the physical properties along with the colorfastness of 100% cotton single jersey fabrics with different washes.

III. METHODOLOGY

3.1. Materials

- Sample Fabric: 100% cotton knitted Fabric
- GSM: 160
- Dye Used: Reactive Green.

3.2. Chemicals Used

Wetting Agent, Sequestering Agent, Detergent, Softener, Acetic Acid, Hydrogen Peroxide, Stabilizer, Glauber's Salt, Soda Ash, Sodium Perborate and Enzyme.

3.3. Machineries

1. Machine Name: Electric Balance
Brand: AND-GULF
Origin: UAE
Capacity: 0.01gm to 620 gm
2. Machine Name: GSM Cutter
Brand: Halifax
Origin: UK
3. Machine Name: Sample Dyeing Machine
Brand Name: Mathis
Origin: China
Capacity: 24 pot
Steel pot capacity: 300 ml
Heating system: Infrared
4. Machine Name: Martindale Abrasion & Pilling Tester
Brand: Roaches
Origin: UK
5. Machine Name: Crock Meter
Brand: Paramount
Origin: India
6. Machine Name: OPTI-BURST (Bursting Strength Tester)
Brand: Roaches
Origin: UK
7. Machine Name: Gyrowash Machine
Brand: Halifax
Origin: UK
8. Machine Name: Perspirometer
Brand: SDL-Atlas
Origin: UK
9. Machine Name: Oven Dryer
Brand: SDL-Atlas
Origin: UK

3.4. Test Methods

List of the test:-

- Fabric weight (GSM)
- Bursting strength
- Pilling resistance
- Color fastness to wash
- Color fastness to perspiration
- Color fastness to light
- Color fastness to rubbing

Table 1. Method of the test and equipment

Serial	Test	Method	Equipment
1	Fabric Weight (GSM)	ASTM D3776	GSM Cutter, Electric Balance

2		Bursting Strength	ISO 13938-2	OPTI-BURST Machine
3		Pilling	ISO 12945-2	Martindale Pilling Tester
4		Color Fastness to Wash	ISO 105-C06	Gyrowash
5		Color Fastness to Rubbing	ISO-105-X12	Crock Meter
6		Color Fastness to Perspiration	ISO 105-104	Perspirometer & Oven dryer
7		Color Fastness to Light	ISO 105-B01	Daylight

IV. EXPERIMENTAL WORKS

4.1. Normal wash

Normal wash is used to remove size material, adhering dyes, and any dart or oil spot of the garments. It is also used to develop the wash look of garments and to improve the soft feeling of garments. Detergent is used in normal wash. We get soft feeling effect through normal wash [12].

4.2. Bleach wash

Bleach is a chemical which removes colors from the garments color garments are normally dyed with direct or reactive dyes. Due to the use of bleaching agent this wash is called bleach wash. Wetting Agent, Sequestering Agent, Stabilizer and H2O2 is used in bleach wash. Through bleach wash fading effect can be done on garments [12].

4.3. Enzyme wash

Enzyme washing is a laundering process which uses enzymes to soften and finish fabric; providing jeans and other garments with a worn-in look and feel. The use of enzymes comes with various benefits both economically and environmentally. Enzyme can be used for garment washing as well as fabric washing [12].

4.4. Alkali wash

High density alkali medium is used in alkali wash which remove the protruding fiber from the fabric surface and also fade the color of the fabric. Soda Ash is a chemical with corrosive nature, or strong cleaning power especially for oil spot. In this process all the dirt fine particles of cotton seeds & all foreign materials are cleaned up [13].

4.5. Fabric weight (GSM)

The samples were cut from the fabric by using GSM cutter and weighing on electrical balance. Then the rating was multiplied by 100. Each sample was tested 3 times and the average result was taken. The test was conducted according to ASTM D3776 standard.

4.6. Bursting strength

Bursting strength of samples was measured by an automatic bursting strength tester. Each sample was set on the machine and followed diaphragm bursting strength test method to test bursting strength. The specimen size was 15 cm in diameter. The test was conducted according to ISO 13938-2 standard.

4.7. Pilling resistance

For pilling test the sample fabrics were tested in Martindale pilling tester. The sample was cut from the fabric and mounted on the machine through holder. The sample size is 140mm in diameter. The pilling grading results were recorded after 500 cycles. The test was conducted according to ISO 12945-2 standard.

4.8. Color fastness to wash

The ability of a dyed fabric to retain its original shade against fade during washing is called color fastness to wash.

4.9. Color fastness to perspiration

This method is done for the determination of the resistance of the color of textiles of all kind and in all forms to perspiration from the human body which containing large quantities of salt, depending on the human metabolism. It can be either acidic or alkali.

4.10. Color fastness to rubbing

Fastness to rubbing is done to make sure that fabric doesn't transfer their color when rubbed against another of fabric or material. Rubbing fastness is done

with either a dry or wet cotton fabric that is rubbed against the surface of the dyed fabric to remove unfixed dye stuff .Rubbing fastness using a wet test fabric tends to show higher color transfer then when using a dry test fabric.

V. RESULTS

5.1. Fabric weight (GSM)

After cutting the fabric with GSM cutter the weight was taken by electric balance and the result is given below-

Table 2. Experimental results of GSM of the samples

Sample	Fabric Weight (gm/m^2)		Change in Percentage
	Individual reading	Mean	
After Normal Wash	157	158	
	158		7.48%
	158		
After Bleach wash	149	150	
	150		2.04%
	151		
After Enzyme Wash	157	157	
	157		6.80%
	157		
After Alkali Wash	153	154	
	154		4.70%
	154		

Figure 1. Bar Chart for change in fabric weight (before and after wash)

5.2. Bursting strength

After testing the strength the results are given below-

Table 3. Experimental results of bursting tests of the samples

Sample	Bursting Strength (kpa)	Mean Time (second)	Change in Percentage
After Normal Wash	166.1	19.3	2.29%
After Bleach wash	164.4	19.2	1.54%
After Enzyme Wash	158.3	18.5	-2.22%
After Alkali Wash	146.8	17.51	-9.32%

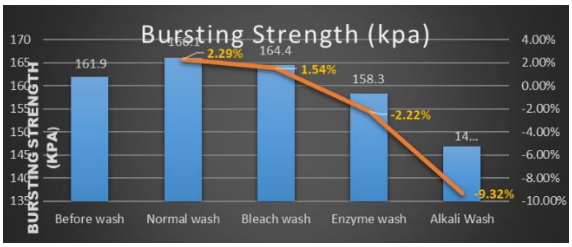


Figure 2. Bar Chart for change in bursting strength (before and after wash)

5.3. Pilling resistance

After the pilling resistance test on martindale abrasion and pilling tester the results are given below-

Table 4. Experimental results of pilling resistance tests

Sample	Reading (500 cycle)
Before Wash	3-4
After Normal Wash	3-4
After Bleach wash	3-4
After Enzyme Wash	3-4
After Alkali Wash	3-4

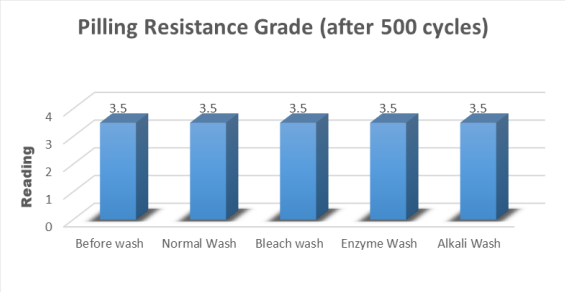


Figure 3. Bar chart shows the grade of Pilling test for 500 cycle among the samples

5.4. Color fastness to wash

This washing is done in gyrowash machine and the results are given below-

Table 5. Experimental results of color fastness to wash in staining scale

Sample	Reading					
	Wool	Acrylic	Polyester	Nylon	Cotton	Acetate
Before Wash	4-5	5	5	5	5	5
After Normal Wash	4-5	5	5	5	5	5
After Bleach wash	4-5	5	5	5	5	5
After Enzyme Wash	4-5	5	5	5	5	5
After Alkali Wash	4-5	5	5	5	5	5

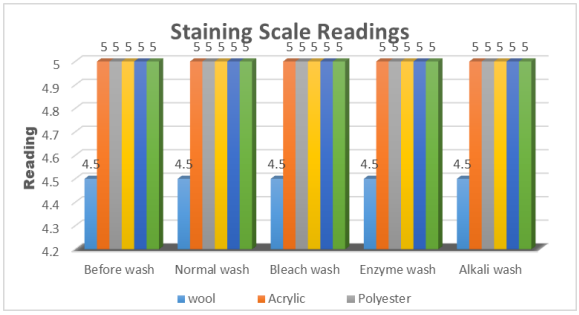


Figure 4. Bar chart shows the grade staining scale of the samples

5.5. Color fastness to perspiration

Perspiration test was done by perspirometer and oven dryer. The results are given in the table-

Table 6. Experimental results of color fastness to perspiration in staining scale

Sample	Reading					
	Wool	Acrylic	Polyester	Nylon	Cotton	Acetate
Before Wash	4-5	5	5	5	5	5
After Normal Wash	4-5	5	5	4-5	5	4-5
After Bleach wash	4-5	5	5	4-5	5	4-5
After Enzyme Wash	4-5	5	5	4-5	5	5
After Alkali Wash	4-5	5	5	5	5	5

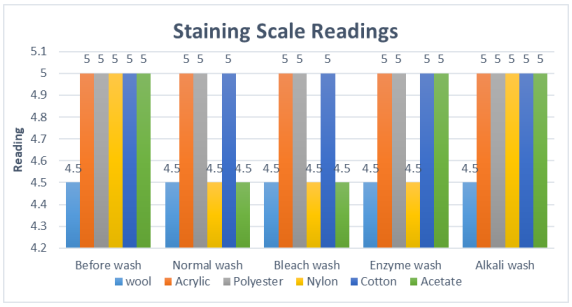


Figure 5. Bar chart shows the grade of staining scale of the samples

5.6. Color fastness to light

This test is done by exposing the sample in sunlight for 6 hours. The results are given in the table-

Table 7. Experimental results of color fastness to light in shade changing scale

Sample	Reading
Before Wash	4-5
After Normal Wash	4-5
After Bleach Wash	4
After Enzyme Wash	3-4
After Alkali Wash	3-4

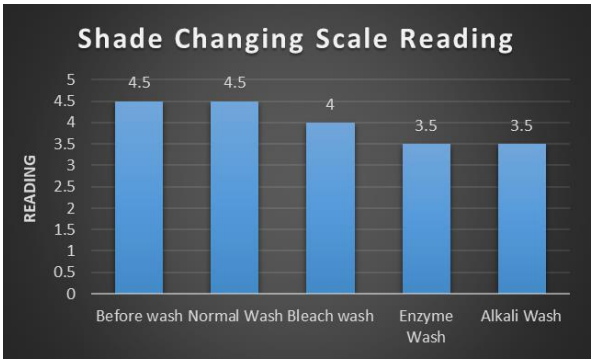


Figure 6. Bar chart shows the grade of shade change of the samples

5.7. Color fastness to rubbing

Rubbing test was done on paramount crock meter in dry and wet condition.

Table 8. Experimental results of color fastness to rubbing (dry rubbing)

Sample	Reading (Dry rubbing)
Before Wash	5
After Normal Wash	5
After Bleach Wash	5
After Enzyme Wash	5
After Alkali Wash	5

Table 9. Experimental results of color fastness to rubbing (wet rubbing)

Sample	Reading (Wet rubbing)
Before Wash	4-5
After Normal Wash	4-5
After Bleach Wash	4-5
After Enzyme Wash	4-5
After Alkali Wash	4-5

VI. FINDINGS & DISCUSSIONS

6.1. Change in fabric weight

The fabric's weight before washing was 147 gm/m². After various washing treatments (as shown in Fig. 1), an increase in weight per square meter was observed. The greatest change occurred after a normal wash, with a 7.48% increase, while the smallest change was after a bleach wash, with an increase of just 2.204%.

6.2. Change in bursting strength

The fabric's initial bursting strength was 161.9 kPa. After washing (as shown in Fig. 2), the bursting strength increased by 2.59% for normal wash and 1.54% for bleach wash. However, it decreased by 2.22% for enzyme wash and 9.32% for alkali wash.

6.3. Change in pilling resistance

After conducting the pilling resistance test using the Martindale abrasion and pilling tester, no change was observed in the fabric's pilling resistance before and after washing (Fig. 3). The rating remained the same, with a score of 3-4 both before and after normal, bleach, enzyme, and alkali washing.

6.4. Change in color fastness to wash

After washing, the samples were compared against the shade change scale, and it was found (Fig. 4) that no shade change occurred, which was rated as excellent. However, when the samples were compared against the staining scale, slight staining was observed on the wool fabric, with no other changes.

6.5. Change in color fastness to perspiration

After the perspiration test, similar results were observed in terms of shade change as those found in the color fastness to wash test (Fig. 5). However, regarding staining, noticeable changes were observed in every sample.

6.6. Change in color fastness to light

The test, which involved exposing the samples to sunlight for 8 hours, yielded results (Fig. 6) that varied significantly. When the samples were compared against the grey scale, it was found that the greatest

shade change occurred in the enzyme and alkali-washed fabrics, while the least shade change was observed in the normal washed fabric.

6.7. Change in color fastness to rubbing

The rubbing test was conducted under two conditions (dry and wet). In most cases, no color staining was observed during dry rubbing, so the results remained the same before and after washing (Table 8). However, slight staining was observed in each sample during wet rubbing, both before and after washing (Table 9).

CONCLUSION

This project studied the comparative analysis of single jersey cotton knitted fabric physical properties along with colorfastness when the fabric has undergone different washing processes. Among the various physical properties, GSM, bursting strength, and pilling resistance were examined. Additionally, the colorfastness to wash, perspiration, light, and rubbing were also analyzed after a series of washes such as normal wash, bleach wash, enzyme wash, and alkaline wash. The results obtained from the test indicated that washing improves all the physical and color fastness properties except the strength in terms of bleach, alkali, and enzyme wash. In bleaching, natural coloring matters are removed by the bleaching agent, and in enzyme wash enzyme breaks the surface cellulose fibers of the fabric and removes them during washing. Among the four types of washing has been done normal washing has proven almost in every test that it increases the fabric quality in both physical and color fastness properties. No adverse effect was found on the fabric after bleach, enzyme, and alkali wash as we know these wash is done for different purposes.

Like all other research works, this study has its limitations. There was the limitation of time and collection of the samples; if more samples were tested, then the results would be more accurate. We tried our best to get an accurate result, and for this reason, each fabric sample was tested three times for more accuracy. This project helped us to gain knowledge about the physical properties of s/j cotton knitted fabric after different washes. It also helps the knitting factory to get an idea about the physical properties and colorfastness of cotton knitted fabric in different washing stages. The researchers of the country who are interested in conducting such comparative work will also benefit in terms of ideas and data from this project work.

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