

Alternative Washing of Cotton Denim Fabrics by Natural Agents

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Abstract: Nowadays denim garments are phenomenally popular among the people of all ages especially to the youth. To get the soft and comfortable feeling along with fading effect, different kinds of denim washing techniques are used which is most of cases synthetic chemical based. This paper practically throws the light towards the washing of 100% cotton indigo dyed denim garments using natural substances like soapnut, lemon juice, tamarind, and sunlight. Cotton denim ready-made garments were taken through washing with lemon juice and tamarind at 60°C and carried out for 30 minutes. Different properties of the washed samples were investigated like Weight loss%, Shrinkage, GSM, Strength, Whiteness Index, Color Difference, Reflectance Value and Color strength in the washed fabric. Weight losses of the samples washed by natural reagents were almost three times less than synthetic chemical washed samples. Natural washed samples had less amount of shrinkage as well. Moreover, the samples which were naturally washed contained greater strength and less color difference values than the samples washed by synthetic chemicals. Hence, the results have introduced a new concept of pollution-free washing system of denim fabrics.

Keywords: Denim Washing, Lemon Juice, Tamarind, Natural Agents

1. Introduction

Traditionally denim is defined as hard wearing fabric having high mass per unit area which turns it into a high density fabric. In the current world, denim is being produced more than any other types of fabric [1]. In Denims, Garment Washing is done to produce effects like color fading with or without patchiness, crinkles, seam puckering, hairiness, Depiling, softened-hand feel, stabilized dimensions etc. Various industrial washings are used to produce faded and old-look denim, including rinse washing, bleaching, sand blasting, moon washing, stone washing, scrubbed look washing, damaged look washing, plasma treatment, ultrasonic treatment and over-dyed-look washing [2-4]. Washing of

denim fabric follows two main objects- denim garment discoloration and making it soft handle [5]. However, these fading processes not only change the aesthetic appearances of denim products but also cause deterioration in their structural and mechanical properties, especially their strength and durability [23]. The most commonly used chemicals in washing plant of Denim are Enzyme, Detergent, Acetic Acid, Anti-stain, Bleaching powder, Sodium hyposulfite, Caustic Soda, Soda Ash, Sodium Bicarbonate, potassium Permanganate, cationic/nonionic Flax softener, Micro Emulsion Silicon, Salt (sodium chloride), Buffer, Hydrogen peroxide, Stabilizer, Fixing, Optical Brightener, Resin, Sodium Metabisulphite, Desizing agent etc [6]. For the washing purpose of denim, the abrasive action is carried out

using the pumice stone in a rotary drum washing machine, with or without any oxidant agent, such as potassium permanganate, hydrogen peroxide etc. These discolor as well as reduce the strength of the fabric to an acceptable limit. To avoid this problem, researchers also tried bio washing i.e., using acid or neutral cellulase, alone or along with pumice stone, laccase or a combination of cellulase and laccase. They found that increasing the amount of cellulase leads to higher lightness and color change. Using cellulase is one of the eco friendly techniques for washing denim as well as cotton fabrics. But till date in case of enzymatic washing of denim, neutral cellulase (*Humicola insolens*) and acid cellulase (*Trichoderma reesei*) are involved which has a drawback of backstaining onto the fabric. [7-13]. To eliminate the problem of backstaining, immobilized form of cellulase on pumice stone was also examined in lieu of soluble form. Desirable softness and degradation of color was found using immobilized acid cellulases. [14]. Though chemicals play a very significant role by giving various effects, colorful prints to soft handle, from easy care to nanotechnology finish and so on, the use of chemicals in finishing has created harmful effects on the environment as a whole [24]. Again waste water containing these synthetic chemical negatively affect the aquatic environment [25]. Let's be honest: denim is an awfully dirty industry! To make jeans is like to make sausages. That's why denim fabric manufacturing and washing is usually done in undeveloped countries where the environmental regulations are not defined clearly. Despite the ecological facts denim still keeps to be growing part of the fashion market. Especially important is to face with the aspect that denim washing is one of the most environment polluting technologies. Facts were considered around 2010 [15]. All the processes involved in denim washing can be polluting. That's why it needs to understand the importance of more eco-friendly alternatives. Different natural reducing agents such as; pineapple barks, edible root, dubbed sloughs, emblica, lemon, tomatoes, tamarind, sugarcane, cucumber, palm cabbage, sloughs, grape, lotkon, carambola were also examined in case of denim washing as an eco-friendly method. In that case, the different natural fading effect was done on denim fabric by rubbing (20-30 times) with these natural reducing agents [16]. Researchers also used dry wood and wood composite as a medium of denim washing where they have found desirable fading effect with the cost of strength loss of the fabric [17]. Washing on denim was also done by organo-montmorillonite without prior desizing and post chemical softening. After washing with different amount of organo- montmorillonite, best result was found in 30% organo-montmorillonite in per kg denim garments [18]. By this process to get old look soft fabric it needs sky high amount of organo- montmorillonite along with exorbitant liquor ratio. In this work Lemon juice and tamarind used as bleaching agent and soapnut used as a natural detergent. And as the sunlight has also the power of bleaching many things [19], for that reason sunlight also used for bleaching. The aim of this paper is to find out the suitability for denim desizing using soapnut and denim bleaching by natural substances like

lemon juice or tamarind along with sunlight. Moreover this work underscores the practice of sustainable textile processing for denim washing which will help the readers to opt an optimum eco-friendly method for denim washing.

2. Experimental

2.1. Fabric and Chemicals

100% cotton woven denim fabrics were used in the current experiment. These comprised of indigo dyed denim fabric, GSM (Grams /Meter²) 365, 3/1 warp faced twill, construction (66 x 44 / 7 x 9) x56 collected randomly from local market. *Sapindus Trifolatus*, also known as Soapnut cultivated in Bangladesh collected from local market was used as a de-sizing agent. Moreover, DYNOTEX MH-40 which is an anionic chemical of pH 6-7 and assist the quick penetration of liquor into the fiber, and MASQUOL P210N (hydroxyethylideneDiphosphonic Acid) were used besides soapnut in de-sizing as wetting agent and sequestering agent respectively. For washing, Lemon juice extracted from natural lemon, Tamarind powder made manually and tamarind collected from natural source, Calcium hypochlorite and Enzyme (Cellzyme mxl-200, Dysin) were used separately and compared.

2.2. De-sizing and Washing

The fabrics were de-sized using Soapnut (4 g/l), Wetting agent (1 g/l), Sequestering agent (2 g/l) and material to liquor ratio of 1:20 in Rota Wash machine (SDLM228B, SDL Textile Machine Co. England). This treatment was carried out at temperature 70°C for 10 minutes. After desirable time the liquor was dropped out. The denim fabrics were then washed with hot water at 100°C for 5 minutes. Then the samples were washed twice with cold water for 10 minutes each. Then the samples were taken into the Hydro-extractor for hydro-extraction and hydro-extracting was continued for 2-3 minutes. Then the samples were taken into Tumble Dryer for 40 minutes. Then the samples were released from Tumble Dryer.

De-sized denim fabrics were treated using lemon juice (20 g/l), sequestering agent (2 g/l), Wetting agent (1 g/l) and material to liquor ratio of 1:20 in the Rota Wash machine (SDLM228B, SDL Textile Machine Co. England). Temperature was kept 60°C and treatment time 30 minutes. Keeping the same recipe, same amount of de-sized fabrics were also washed by using tamarind powder, Enzyme and Calcium hypochlorite instead of lemon juice. Then the samples were taken into the Hydro extractor (NH-EX10, Singapore) and hydro-extracting was continued for 2 minutes. Then the samples were kept for 30 minutes at room temperature. After that the samples were kept under sunlight for 2 hours. Then the samples were washed with hot water at 80°C for 10 minutes. Having finished the hot wash, all the samples were taken into another bath for cold wash for 2 minutes (2 times). Then the samples were again hydro-extracted for 2 minutes. And for the drying of all the samples

we followed tumble drying techniques. Atlast, the samples were taken into an Oven Dryer to dry at 60°C for 40 minutes.

2.3. Testing Methods

The treated denim fabrics were conditioned in 65% RH and 20°C for 24 hours before testing according to ASTM D1776 [20]. Tensile strength (breaking force) was determined by a strength tester (Testo Metric M250-3CT, England) through the US Standard Grab test method according to ASTM D 5034 [21]. Dimensional changes / shrinkage (%) was calculated from the difference in fabric length before and after washed garment according to AATCC test methods 135. Weight change (%) in fabric was calculated from the difference in fabric weight before and after the treatment. Mass per unit surface area/ GSM was calculated according to ASTM D 3776 [22]. A spectrophotometer (datacolor 650, USA) was used to measure the CIE Whiteness indexes, Color differences and reflectance values of the samples in D₆₅-10 degree illuminant. Color strengths of the samples were calculated from Kubelka Munk equation:

$$\frac{K}{S} = \frac{(1 - R)^2}{2R}$$

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

3. Results and Discussion

3.1. Comparison of Weight Loss Among Samples

Loss of weight of the washed samples is an important factor of washing as it is related to profit and quality, durability, comfort ability and other properties of washed fabrics. The weight loss which is determined after washing is shown in Table 1. The results show that the weight loss of sample by tamarind is comparatively less and by Calcium hypochlorite is high. The weight loss is more in case of Calcium hypochlorite may be for the destruction of fiber more by it than other reagents.

Table 1. Loss of weight among samples washed by different reagents.

Washing reagent	Weight before washing (gm)	Weight after washing (gm)	Weight loss %
Lemon	95.6	89.4	6.48
Tamarind	95.6	90.4	5.44
Cellzyme	95.6	90.2	5.65
Calcium hypochlorite	95.6	81.6	14.64

3.2. Finding Out the Shrinkage Among the Samples

Shrinkage is related to the dimension of the washed sample. From Figure 1 it is seen that the shrinkage% of samples at warp direction by lemon and tamarind are same which are less than bleaching powder and more than enzyme and in case of weft, shrinkage of samples by lemon, tamarind and bleaching powder are same but by enzyme is less.

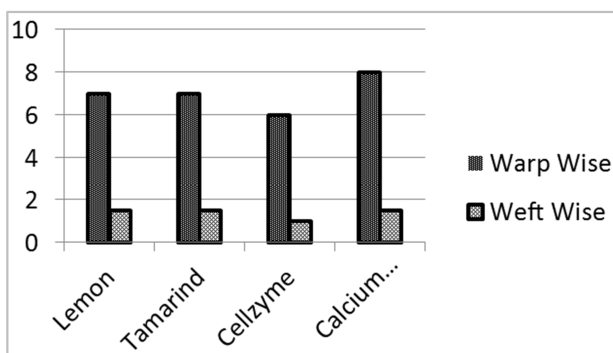


Figure 1. Shrinkage of samples washed by different reagents.

3.3. GSM of Different Washed Samples

GSM of all the samples has been increased after washing with reagents. From the Figure 2 it is shown that 5.48% GSM has been increased in case of washing with Lemon. GSM increase after washing from original sample is nearly same in case of washing with Tamarind and Cellzyme and it is 6.85% and 6.30% respectively. GSM increased more while washing

with Calcium hypochlorite which is 11.78%. Though weight loss% is more in case of washing with Calcium hypochlorite, may be due to more shrinkage the value is high.

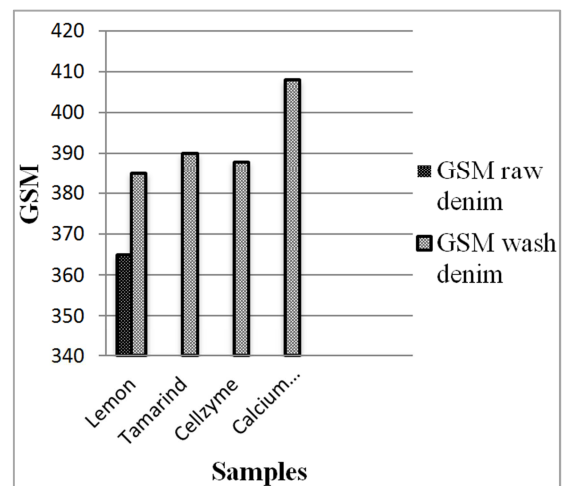


Figure 2. GSM of wash samples washed by different reagents.

3.4. Strength of Washed Samples

After washing by these reagents strength increased both in warp and weft direction of the fabric. From the Tab. 2 it is seen that elongation at break is more for all the samples than original except the sample washed by Calcium Hypochlorite. Among the natural reagents, best elongation at break was found in case of washing with tamarind. May be less fiber has been hampered by tamarind washing, so more strength has been found. Strength

increased less in weft direction after washing may be due to low inherent characteristics of the weft yarn.

Table 2. Strength of washed samples.

Samples	Force at peak (N)		Elongation at break (mm)	
	Warp	Weft	Warp	Weft
Original	896.27	795.78	23.25	20.2405
Lemon Washed	915.71	800.44	33.93	22.381
Tamarind Wash	948.17	820.39	36.59	23.720
Cellzyme wash	940.80	815.51	35.80	22.916
Calcium Hypochlorite wash	890.54	799.23	21.89	19.546

3.5. Whiteness Values of Different Washed Samples

The values of whiteness of different washed samples are depicted in Tab. 3. It is found that the whiteness of original sample is less. It has been increased highly by calcium hypochlorite. May be more dye molecules and portion of fibers were abraded by Chemical reagents then natural reagents and that's why whiteness index value of Calcium Hypochlorite washed sample is comparatively more high.

Table 3. Value of Whiteness Index (CIE).

Samples	Whiteness Index (CIE)
Original	40.76
Lemon	65.2
Tamarind	70.52
Cellzyme	78.58
Calcium hypochlorite	90.18

3.6. Color Difference Values of the Samples

The washed fabric samples along with the original one is shown in Figure 3. The color difference values which describe how far closes the trail closed to standard sample are listed in Table 4. It has been found that the color difference values of washed sample are more for Calcium hypochlorite than cellzyme, lemon and tamarind. In case of lemon and tamarind almost similar effect has been found.

Table 4. Color difference values of all samples.

Samples	L	c	h	a	b	ΔE
Original	23.746	6.269	276.228	0.680	-6.231	-
Lemon	19.736	8.852	277.237	1.115	-8.781	3.90
Tamarind	19.954	8.979	276.259	0.979	-8.925	3.86
Cellzyme	19.903	9.171	278.085	1.289	-9.079	4.04
Calcium hypochlorite	21.061	10.138	275.480	0.968	-10.091	4.31

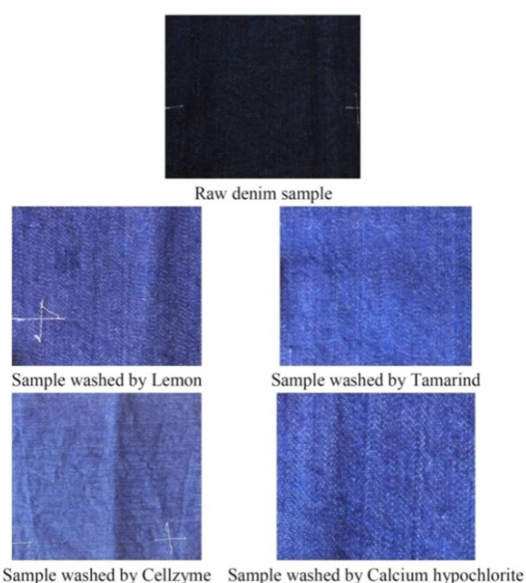


Figure 3. Fabric samples washed by natural and synthetic reagents.

3.7. Reflectance and Color Strength Among the Samples

The reflectance value describes the reflection of a particular dye by a particular fiber. The reflectance values of the tested specimens are shown in Table. 5. It has been found that little bit less color has been damaged by the natural reagents as the reflectance values are little bit less and color strength values are higher than that of synthetic reagents.

Table 5. Reflectance and color strength of washed samples.

Samples	Reflectance % ($\lambda=612$ nm)	Color Strength (K/S)
Original	3.7	0.9851
Lemon	2.6	0.4923
Tamarind	2.6	0.4923
Cellzyme	2.7	0.5351
Calcium hypochlorite	2.8	0.5785

4. Conclusion

There are different types of garments washing like bleach

wash, enzyme wash, stone wash, acid wash, etc. All of them are chemical based and they have adverse effects on nature. Therefore, it is the time to introduce natural resources for industrial garments washing. In this research, soapnut was used as de-sizing agent for its detergency power. Tamarind and Lemon were used as bleaching agents under sunlight. In respected to all the tests performed, the denim fabrics washed by lemon as well as tamarind were better than the sample washed by calcium hypochlorite and nearly similar to the sample washed by the enzyme. Hence it can be concluded that lemon and tamarind hold worthy potential in denim wash as natural reagents.

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