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Research Article

Scope of Dry Wood & Wood Composite Alternate to Stone in Case of Acid Wash on Denim Fabric

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Abstract

For the betterment of comfort ability, to impart decent fading effect and to make more exquisite, denim fabric is examined with different washing techniques. Usually, Acid wash is used to fade the color of denim to a higher degree and therefore this wash has a significant effect on the physical and mechanical properties of the denim. In this paper, we worked on to find out the comparison among stone, waste wood and wood composite in case of acid wash on denim fabric dyed with indigo dye. Denim garments were processed using some parameters such as temperature 30 °C, time 30 min as well as acid concentration (H_3PO_4) 1 ml/L, ($KMnO_4$) 4 gm/l. This study was focused on the physical & mechanical properties like strength, weight loss, shrinkage, EPI & PPI, absorbency, color fading, GSM, wash, rubbing and perspiration fastness test and monitored the comparison of each treated and untreated fabric samples. It was noticeable that, a significant difference was found in case of Waste wood washed and wood composite washed garments in almost all properties than stone washed garments but the desired fading effects were achieved by acid washing with wood composite on denim fabric.

Keywords:*Denim washing, Acid wash, stone, dry wood, wood composite.*

1. Introduction

No other fabric has received such a wide acceptance just like as denim among all the textile products. It has been used extensively by people of all ages, classes, and genders (Paul, R. 2015). Now, denim jeans can be considered as the most widely used garment in the fashion business. From their inauguration, they have had a major influence on the lives of consumers (Khalil, E., 2015). Denim is very strong, stiff and hard wearing woven fabric (Kashem, M. A., 2008). The exceptional criteria of denim like versatile appearance, high strength has made it widely acceptable especially among the young people (Maryan *et al.* 2013). By the application of different washing techniques fashionable effect brought out in the fabric which makes the product exceptional and trendy as well (Mazumder, S. 2010). Along with making the fabric soft, Industrial washing also removes dust, dirt and infection materials from the garments (Mondal *et al.* 2014). Experts are trying to new possible effects of fabric appearance, such as mill wash or rinse wash, stone wash, moon wash, sand wash, bleach, over dyed-look, damaged-look, scrubbed-look (Jucienė *et al.* 2006). Without washing the newly combined denim garment is uncomfortable to wear due to its weaving and dyeing effect, hence it can be finished/modified by washing and introduces new look design and fashion (Khan *et al.* 2013). The most commonly used denim washing methods are enzyme wash, bleach wash, acid wash, normal wash, stone wash, etc. (Lamya *et al.* 2015). Traditionally, in case of denim washing pumice (P) stones are mainly used to achieve a soft handle as well as a desirable worn look (Pazarlioğlu *et al.* 2005).

According to Md. Khan and Mondal, pumice stone in bleach washing accelerates more color fading which affects on the fabric properties and has a more positive effect on producing new look faded fashion denim garment (Khan *et al.* 2014). Though pumice stone widely used during washing process, it has some disadvantages such as damage to washing machinery and garment due to stone to machine and machine to stone abrasion, stiffness of garments reduced, then dimensional stability also reduced, difficulty of removing residual pumice stone from processing clothing items, obstacle machine drainage passages and drain and sewer line at the machine site , increase in labor to remove dust from finished garments, water pollution during disposal of used liquor, back staining and re deposition (Arjun *et al.* 2013; Mir *et al.* 2014). Because of the problems of pumice, alternative methods of stone washing denim fabrics have been

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developed. For that, Cellulase has been used for the past ten years (Heikinheimo *et al.* 2000). But, hydrolysis of cotton denim due to cellulase treatment decreased tensile strength, stiffness and color shade. Moreover, SEM shows more cracked cellulose on the surface leads to fiber loosening which creates the rougher surface on denim fabric (Mondal *et al.* 2014).In a research paper,Sarkar and Khalil refer that, it is very difficult without bleach wash, to fade the color from all over the garments at one wash in such a higher degree (Sarkar *et al.* 2014). Having said that, chlorine is the harsh chemical not only harmful to human health but also causes corrosion to the washing machine including during bleaching, many decomposed products are produced which pass into the effluents are harmful to the environment (Khan *et al.* 2011). In that case, hydrogen peroxide in denim washing is fairly effective because it is applied to boiling condition (Mashiur *et al.* 2012). But Nematianaraki *et al.* noticed that bleaching directs to higher energy consumption and it bears longer time to present desired effects (Nematianaraki *et al.* 2015). In recent years, noticeable interest has been moved upward in the use of environmentally friendly, non-toxic, fully biodegradable enzymes in the modern textile technology during the finishing process. Enzymatic treatment can replace a number of mechanical and chemical operations, which have been applied to improve the comfort and quality of fabrics (Anon, 2018; maps enzymes, 2018). Notably, during enzymatic treatment with bleaching powder and pumice stone in light wash showed poor color fastness to ozone due to back staining occurred as well as it was economically unfriendly.

In addition, tear strength toward warp and weftwise were smaller than the original sample and showed downward trend during processing time 10 to 90 minutes (Hasan *et al.* 2017; El-Dessouki *et al.* 2015). In another researcher Hossain *et al.* mentioned that natural reducing agent can be applied to get color fading effect of denim fabric which is eco-friendly (Hossain *et al.* 2016). Tarhan, and Sariisik tried to find out an alternative method to get the similar result as like stone wash. So they used laser and sand-blasting but when laser intensity was highest approximately 60% strength, 11% weight and a great amount of color decreased. On the other hand in case of sand-blasting when the pressure was highest 50% strength, 11% weight, and a considerable amount of color decreased (Tarhan *et al.* 2009). In this perspective, we have chosen the acid wash with waste wood and wood composite. To overcome such difficulties, we have used the waste wood and wood composite instead of pumice stone to explore a time-saving method of acid wash. We also find out the effects of the acid wash with waste wood and wood composite on denim properties by comparing to the properties of the acid wash with pumice stone treated and untreated jeans.

2. Experimental

2.1 Fabric and chemicals

During the experiment, 100% indigo dyed cotton denim was used having GSM (Grams /Meter2) 340. The fabric construction was 83 x 55 / 10 x 12 with a width of 56 inches bearing 3/1 warp-faced twill design. The fabric was collected from a local market of Chittagong, Bangladesh and then desized by using an enzyme (Cellzyme mxl-200, Dysin) and detergent (Ferrol IPC, Srilanka). During Desizing, DYNOTEX MH-40 and MASQUOL P210N were used along with cellzyme as wetting and sequestering agent respectively. For the washing Pumice Stone (Nevsehir, Turkey) of varying from 5 to 8 gm having 1 to 7 cm diameter, Wood (Gamari Wood, GMELINA ARBOREA) having the weight of 4 to 8 gm, volume was 12.95 cm3 having length, width and thickness 2.9 cm, 2.46 cm and1.81 cm respectively and Wood composite (covered with 3/1 twill 100% cotton denim fabric) were used and compared.

2.2 De-sizing of Denim Fabric

Denim fabrics were desized using detergent and desizing agent. The liquor ratio containing desizing agent, Cellzyme (2gm/l), srilancan (1gm/l), sequestering agent(2.5gm/l), wetting agent(1gm/l) and material to liquor ratio of 1:12. The process was accomplished in a sample stone washing machine (NISHO, Model-NH-WH-25, Singapore) at 60°C for 20 min. Desizing treatment was carried out to remove the sizing material from the yarn dyed denim. After that, a hot wash was conducted at 70°C for 10 min following a cold wash (2 times) for 3 minutes each. After that, a hot wash was conducted at 70°C for 10 min following a cold wash (2 times) for 3 min. Then samples were taken into the Hydro-extractor machine (Model-NH-EX-10, Singapore) for 3 min to remove excess water from the apparels. Then the samples were dried at 60°C for 25 min in an oven dryer (Mel-HX-30, England).

2.3 Washing by Pumice Stone

The desized samples were released from tumble dryer and treated using the soaked pumice stone. To make the soaked pumice stone, The fresh stone were soaked at room temperature for 30 min by shuffling using potassium permanganate (4gm/l, $KMnO_4$) and phosphoric acid (1ml/ l, H_3PO_4 containing the liquor ratio 1:2. After the desired soaking of stone, the completely dried desized fabrics were treated with them (damp stone) at room temperature for 15 min at the same sample washing machine without additional water followed by the standard washing procedure. After the treatment, the stone was unloaded from the machine. The acid washed apparels were conducted by a neutralization process. The neutralization process was carried out by sodium meta bisulfite (4gm/l),

detergent wash (2gm/l) at 50°C for 10 min to remove the breaking stone dust and adhering chemicals. The acid washed fabrics were squeezed and dried in the same hydro-extractor machine and oven respectively following the same time and temperature. Then the treated fabrics were assessed to find out the changes of properties of denim fabric due to acid wash treatment. The denim which has been treated with stone has been named as sample 1 in this paper

2.4 Washing by Wood

The fresh wood was soaked at room temperature for 30 min by shuffling using potassium permanganate (4gm/l, KMnO4) and phosphoric acid (1ml/l, H3PO4containing the liquor ratio 1:2. After the desired soaking of wood, the completely dried desized fabrics were treated with them (damp wood) at room temperature for 15 min at the same sample washing machine without additional water followed by the standard washing procedure. After the treatment, the wood was unloaded from the machine. The acid washed apparels were conducted by a neutralization process. The neutralization process was carried out by sodium meta bisulfite (4gm/l), detergent wash (2gm/l)at 50°C for 10 min to remove the breaking wood dust and adhering chemicals. The acid washed fabrics were squeezed and dried in the same hydro-extractor machine and oven respectively following the same time and temperature. Then the treated fabrics were assessed to find out the changes of properties of denim fabric due to acid wash treatment. The denim which has been treated with wood has been named as sample 3 in this paper

2.5 Washing by Wood Composite

By covering the wood with 100% cotton denim fabric we made the wood composite. The fresh wood composite was then soaked at room temperature for 30 min by shuffling using potassium permanganate (4gm/l, KMnO4) and phosphoric acid (1ml/ l, H3PO4 containing the liquor ratio 1:2. After the desired soaking of composite wood, the completely dried desized fabrics were treated with them (damp wastage wood) at room temperature for 15 min at the same sample washing machine without additional water followed by the standard washing procedure. After the treatment, the stone was unloaded from the machine. The acid washed apparels were conducted by a neutralization process. The neutralization process was carried out by sodium meta bisulfite (4gm/l), detergent wash (2gm/l) at 50°C for 10 min to remove the breaking composite wood dust and adhering chemicals. The acid washed fabrics were squeezed and dried in the same hydro-extractor machine and oven respectively following the same time and temperature. Then the treated fabrics were assessed to find out the changes of properties of denim fabric due to acid wash treatment. The denim which has been treated with wood composite has been named as sample 2 in this paper.

2.6 Testing methods

All washed denim fabrics were conditioned in 65% RH and 20°C for 24 hours before testing according to BS EN 20139 and ASTM D1776 (ASTM D 1776. 2008). A strength tester (Testo Metric M250-3CT, England) was used to measure tensile strength (breaking force) through the US Standard Grab test method according to ASTM D 5034 (ASTM D5034. 2009). According to ASTM D 3776, Weight change (%) in fabric / GSM was calculated from the difference in fabric weight before and after the treatment (ASTM D 3776. 1996). According to AATCC test methods 135 and 150, ASTM D 2724, BS4931we determined the dimensional Changes / Shrinkage (%) of treated denim fabrics. It was calculated from the difference in fabric length before and after washed garment. GSM of the treated denim fabrics was calculated from the differences in denim fabric weight between before and after washed treated denim according to ASTM D 3776 (ASTM D 3776. 1996). EPI and PPI were counted through counting glass. For absorbency test, 1% direct red (Congo red) was taken in a pipette and droplet of solution put on the different places of the fabric. Then the shape of the absorption area on the fabric was observed. For testing the rubbing fastness we followed AATCC Test Method 8, Colorfastness to Crocking: AATCC Crock-meter Method (AATCC 8-2007 RA38. 2010). Color fastness to washing was tested according to ISO 105-C06:2010. According to AATCC 15:2002 method, color fastness to Perspiration was determined (AATCC 15-2009 RA52. 2010). To measure the CIE Whiteness indexes, Color differences and reflectance values of the samples we used a spectrophotometer (data color 650, USA) in D65-10 degree illuminant. Color strengths of the samples were calculated from Kubelka Munk equation:

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

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

3. Result and Discussion

3.1 Comparison of strength among the sample

Table 1: Strength among the samples

Sample No.	Warp		Weft	
	Breaking Strength (N)	Elongation at break (mm)	Breaking Strength (N)	Elongation at break (mm)
original	1044.45	34.3085	341.25	16.068
1	952.2	35.746	315.8	16.6695
2	910.55	42.454	324.43	18.5085
3	517.65	37.9915	343.55	18.26

Here, sample 1, 2 & 3 are respectively treated by stone wash, wood composite & waste wood. The presented table is shown data about the comparison of strength among the sample. According to the table, Sample 1 treated with stone wash represents higher strength than that of the sample (2) & (3) respectively treated by wood composite and waste wood. On the other hand, through the weft direction sample, (3) by waste wood showed a better result in the comparison of the sample (1) by stone wash and sample (2) by the wood composite. This may be happened due to the frictional action (mechanical force) of rotating cylinder in the washing machine which leads to loosening and breaks down the primary cell wall of the cotton fabric that's why strength towards the warp direction declined (Khan *et al.* 2011). Again Elongation at break moves upward all the cases both warp and weft direction among them the sample (2) shows the better result.

3.2 Comparison of Weight Loss among the Samples

Table 2: Weight loss among samples

Sample no.	Weight Before - Washing (gm)	Weight After Washing (gm)	Weight Loss %
1	83.74	76.44	8.71
2	82.73	75.32	8.95
3	82.94	74.64	10.01

The following table illustrates that weight loss of sample (1) by stone wash is comparatively less, samples (3) by wood wash is high and sample (2) by wood composite wash is comparatively medium. Because, the outer surface of stone comparatively smoother than the wood and wood composite, whereas the sides of wood are comparatively pointier than wood composite. Hence, friction is less than that of wood and wood composite fabric will be better in case of the acid wash with stone.

3.3 Comparison of Shrinkage among the Samples

Table 3: Shrinkage of different washed samples

Sample no.	Shrinkage %	
	Warp	Weft
1	-1.5	-0.25
2	0.05	-1.75
3	-2.8	-0.45

The presented table shows that weft shrinkage of samples (1) & (3) by stone and wood wash are almost same but by the wood composite is little high. Because of getting higher shrinkage by the wood composite wash in the fabric, the fabric density increases. That's why, after making garments by this fabric it will not give or will give less shrinkage after further washing.

3.4 GSM of Different Washed Samples

Table 4:GSM of washed samples

Sample no.	GSM of raw denim	GSM of wash denim
1	340	321
2	340	324
3	340	321

From the above table, it has seen that GSM decreases after each wash. But at sample, no (2) i.e. in case of wood composite wash its decreasing rate is less than stone wash and waste wood wash. In case of wood composite, shrinkage is comparatively higher than wood composite & stone. Due to this shrinkage, EPI & PPI went up which moved upward GSM. So, GSM of wood composite wash Denim is comparatively high.

3.5 Comparison of EPI & PPI among the Samples

Table 5: EPI & PPI among washed samples

Sample no.	EPI		PPI	
	Before Wash	After Wash	Before Wash	After Wash
1	84	85	55	55
2		88		58
3		86		57

According to Cookson, after washing denim fabric has a tendency to bring the fabric back to its static dimensions which show wrinkle of the yarn. Usually, this effect is greater in the warp direction. This is called relaxation shrinkage. Due to this relaxation shrinkage, EPI and PPI rose than untreated denim garments (Cookson *et al* 1992). Although, in all cases, EPI and PPI increased sample (2) treated with wood composite presented higher result.

3.6 Comparison of Absorbency among the Samples

Table 6: Absorbency of washed samples

Sample No.	Absorbing Time(Sec)	Absorbing Spot
1	13	
2	6	
3	14	

According to Kissa, the sorption of a drop indicates the wettability of a textile material either by the time of its sorption by the fabric or by the area of the wet spot formed by the liquid (Kissa 1991). From the above graph, it has seen that stone and wood washed samples (1,3) take more time than composite sample(2) during absorbency. As the wastage fabric used over the wood has more absorption capability than stone & waste wood that's why sample (2) shows more absorbency.

3.7 Comparison of Color fastness to Perspiration among the Samples

Table 7: Perspiration of different washed samples

Sample No.	Degree Of Staining						Gray Scale Rating
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
1	4	4/5	4	4/5	4/5	3/4	4/5
2	4	4/5	4/5	4/5	4/5	3	5
3	4/5	5	4	4/5	5	3	4

From the above table, it has seen that wood waste sample (3) shows the highest rating which gives good fastness in case of acrylic but wood composite and stone washed samples show almost same rating.

3.8 Color fastness to Rubbing among the Samples

Table 8: Rubbing Fastness of different washed samples

Sample No	Gray Scale Rating	
	Wet	Dry
1	2/3	3
2	2/3	3
3	1	3

The presented table illustrated that, in dry condition stone, wood and composite samples (1,2,3) show the same rating but in wet condition waste wood washed sample (3) shows the lowest rating i.e. worst rubbing fastness. Because of the surface of the waste wood is harsh.

3.9 Color fastness to Wash among the Samples

Table 9: Wash Fastness of different washed samples

Sample No.	Degree of Staining						Gray Scale Rating
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
1	1/2	4	2/3	4/5	4/5	3	4
2	2	4/5	3	4/5	4/5	4	4
3	1/2	3/4	2/3	4	4/5	4	4

As stone, waste wood & wood composite treated with potassium per manganite which oxidizes the cellulose and color is removed from the surface of the fabric. From the above table, it is seen that wood waste sample (3) shows the highest rating which gives good fastness in case of acrylic but wood and stone washed samples show almost same rating.

3.10 Data color report

Table 10: Data color report of washed samples

Sample	Test			
	L	C	H	CMC
Original	22.222	3.726	284.452	
1	19.871	7.175	282.048	4.39
2	18.843	6.801	284.049	4.39
3	18.804	6.678	282.376	4.30

From the above graph, it is seen that the CMC value of the sample (1, 2) are same and sample (3) is slightly less. Higher CMC value means more color difference between two colors i.e. more fading effect. So, the stone and wood composite washed fabric has the more fading effect than waste wood washed fabric. This may be happened due to acid reacts with the indigo dye which removes dye from the fabric. Moreover, friction among the fabric stone, wood, and wood composite may also play a role in case of this fading effect.

3.11 Whiteness Test

Table 11: Whiteness test report of washed samples

Sample No	Whiteness Index
Original	50.62
1	99.21
2	95.79
3	94.94

According to Md. Kamrul Hasan Munna, samples treated with natural reducing agents which contain acid shows higher CIE whiteness index in comparison to the whiteness of the unfaded sample (Hossain *et al.* 2016). It has clearly seen from the table that whiteness index is almost similar in all the samples but sample 1 shows slight higher.

3.12 K/S Value

Table 12: K/S vale of different washed samples

Sample No.	K/S Value
Original	13
1	38
2	70
3	42

K/s value is closely related to the concentration of the colorant in the medium and also the reflectance percentage. Dark shade shows low reflectance value that means low K/s value (Kan *et al.* 2011). At a glance at the table, it reveals that the k/s value of sample (1)

of stone washed and sample (3) of wood washed fabric is almost same but the value is higher in case of wood composite washed fabric (2) at a definite wavelength. More k/s value means more dye molecule concentration i.e. less fading effect. The value is less in the sample (1) and sample (3) due to more reaction of stone and waste wood respectively with the fabric which causes the more fading effect.

Conclusion

After completing investigation we can reach the following conclusion:

1) Tensile strength declined and Elongation at break increased all the cases, it's natural as after washing fabric become weaker but Stone wash shows the better result comparatively than others.
2) GSM changes and weight loss happened after each wash having said that whereas Shrinkage, EPI and PPI increased in case of the wood composite shows a better result.
3) Stunning result was found in case of absorbency. Wood composite washed sample took a little amount of time to absorb the liquid.
4) Color fastness properties show almost similar result all the experiments but when the question is about fading, waste wood shows a significant result.

It can be assumed that the sample which was treated with waste wood didn't show optimum result except for the test result of fastness properties. However, Wood composite and wood waste from various kinds of trees can be used for future research. Different sizes wood can be used. Waste foam or cork sheet can be used as a composite with wood through the process. The process can be done on different types of denim fabric also.

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