

Comparison study of the Effects of Bleaching and Enzyme Concentration on the Physical and Mechanical Properties for Denim wash

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Abstract— As vintage denim look is the attraction to the present fashionable young generation, different types of chemical finishing is done to meet this demand. For getting various faded effect, different concentration of enzyme and bleaching powder is applied and so the physical and mechanical properties of denim apparel is changed. In this research work, modification of denim apparel due to applying different concentration of bleaching powder and enzymes has been observed. For the experiment Indigo dyed cotton denim apparels were chosen and processed by enzyme with the concentration of 0.5% to 3.5%, temperature 55°C. In another work, for same fabric construction, bleaching powder is used with the concentration of 5.0g/L up to 15.0g/l (owl) with 30% pumic stone (owg) at temperature 40°C and pH 10.5 for 20min. The effect on the properties like tensile strength, elongation at break, weight loss, stiffness and shade loss were examined and compared.

Index Terms— Denim, washing, Cellulase enzyme, desizing, bleach, stone, tensile strength, shade.

1. Introduction

Garments' washing is an important part of garments manufacturing. By which outlook, comfort ability and fashion of garments is changed or modified and old garments effect can be produced (International Organization for Standardization (ISO) 1993).

Denim garment (Jeans) is produced from very strong and stiff fabric. Denim is basically cotton and twill-weave fabric that uses coloured warps and white/grey weft yarn. Popularity of garments was specially on denim garments in the World market have been increasing day by day [1,2]. To meet up the quick change of current demands of customers, technologists are trying to introduce new designs and fashion on denim garments by using different washing methods. The most commonly denim washing methods are enzyme wash, bleach wash, acid wash, normal wash, stone wash, etc. Among the washing methods, enzymatic method is widely used method in industry [3,4].

To minimize the unwanted strength losses and to provide distressed worn out fashion look to the denim garment, stone-bleach washing is carried out with the aid of fixed amount of pumice stone mixed with various concentrations of bleaching powder to achieve the specific washing effects by the customers.[5] However, enzyme treatment of cellulosic garments degrades cellulose at the ends or in the middle of the cellulose chains, yielding shorter chain cellulose polymers, and reduces its mechanical strength. But Cellulase treatments have been successful at improving fiber flexibility, desirable appearance and soft handle of cotton denim garments [6].

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This research work involves the treatment of denim apparels with different concentration (conc.) of bleaching powder and enzyme. The major objective is to determine the effects of washing on some significant fabric properties like strength, weight, stiffness, elongation and color and to compare between them in case of different concentration of bleaching and enzymatic treatment.

2. Experimental

2.1 Materials

2.1.1 Fabric

(For both enzyme and stone bleach wash) 100% cotton, twill, weave 3/1, construction 70 × 42 / 10 × 9, indigo dyed denim fabric is used in this work. Denim garments (trousers) were manufactured using the stated denim fabric.

2.1.2 Stone

Fresh pumice stones (Turkey) of size (2-3 cm) were used for bleach wash only.

2.1.3 Chemicals

Detergent (Hostapur, BASF, Germany), desizing agent (Luzyne, BASF, Germany), anti-staining agent (India), acetic acid (China), softener (Text-soft, BASF, Germany) the experiment. A bleaching powder (Bleach KCl, India) (35% available chlorine) was used for washing denim garments. In addition, soda ash (Na₂CO₃, China) was used as buffer to control pH 10.5 in the washing bath [1, 2]. Genzyme SL, (Cellulase enzyme, Sri Lanka); detergent (Kohinoor, BD);

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Bio.D. (Biological detergent as desizing agent, Germany); soda ash (China), acetic acid (China) and textsoft softener (Germany).

2.2 Testing and Analysis

Treated all denim trousers were conditioned at 65% RH and at 20°C for 24 h before testing according to BS EN ISO 139:2005 and ASTM D1776. Weight loss (%) in fabric was calculated from the difference in fabric weight (GSM) before and after the treatment according to ASTM D 3776. Stiffness was measured from the bending stiffness in fabric by Shirley stiffness tester according to BS 3356-1990. Tensile strength and elongation at break was determined by the US Standard Grab test method according to ASTM D 5034 and ASTM D 1682. Change in the original color shade of the fabric was rated using gray scale for color change according to AATCC evaluation procedure 1.

2.3 Methods

2.3.1 Pumice Stone-Bleaching Powder Treatment

At first denim garments were desized in liquor containing detergent (1.0 g/L) and desizing agent (1.5 g/L) in a laboratory scale sample washing machine at 60°C for 20 min in material to liquor ratio of 1:30. After desizing, the garments were treated using bleaching powder mixed with pumice stone in the same sample washing machine at different concentrations of bleaching powder (5.0 - 15.0 g/L) with fixed amount of pumice stone (30%, owg), fixed at 40°C for 20 min. All treatments were involved in the rotary cylindrical sample washing machine at 30 rpm. The washed denim garments were squeezed in a laboratory scale hydro-extractor machine (Zanussi, Roaches, England) at 200 rpm for 4 min to remove excess water and then dried in a steam drier (Opti-Dry, Roaches, England) at 75°C for 40 min.

2.3.2 Enzymatic Treatment

2.3.3 Desizing

Denim trousers were desized using detergent, desizing agent and soda ash. This treatment was conducted in liquor containing soda ash (1.2 g/l), detergent (0.6 g/l), and desizing agent (0.6 g/l) and material to liquor ratio of 1:30 in a laboratory scale sample washing machine at 60°C for 20 min. The garments were then washed with hot water (70°C) followed by cold water wash.

2.3.4 Cellulase Treatment

Desized trousers were treated using Cellulase enzyme. This process was conducted in liquor containing acetic acid (1g/l) at pH 5.5 and material to liquor ratio of 1:30. The enzyme treatment was carried out at different concentrations of Genzyme SL (0.5 - 3.5%), temperatures 55°C and treatment time 40 min. After desired time the temperature was raised to 90°C for 1 min to stop enzyme action. The denim garments were then washed with hot water then washed with cold water. Finally, garments were softened with Textsoft softener (1 g/l) at 40°C for 10 min.

2.3.4 Hydro-Extracting and Drying Processes

After treatment, the washed denim trousers were squeezed in a laboratory scale hydro-extractor machine (Zanussi, Roaches, England) at 200 rpm for 3-4 min to remove excess water and then dried in a steam drier (Opti-Dry, Roaches, England) at 75°C for 35-40 min. These are done firstly for stone bleach washed samples and then for enzyme washed samples.

3. Result and discussion

The conc. of bleaching powder and enzyme have significant effects on different properties of fabric like tensile strength, fabric weight, stiffness, elongation at break and shade. Most of the properties were affected by the gradual increase of the conc. of the bleaching powder and enzyme, which were shown in table 1.

Table (1) Effect of fabric properties for using washing materials in different conc.

Name of washing materials	Concentration of washing materials (g/L)	Loss in Tensile strength (%)		Weight loss of fabric (%)	Loss of Stiffness (%)	Elongation at break (%)		Loss of colour shade (%)
		Warp	Weft			Warp	Weft	
Bleaching Powder	0.0	0	0	0	0	21	16	0
	5.0	15.85	5.88	3.41	20.00	12.95	3.45	40
	7.5	18.29	9.56	4.46	22.22	12.12	2.29	50
	10.0	21.14	11.76	6.04	24.44	9.64	2.01	60
	12.5	23.58	12.50	6.82	26.67	7.71	1.44	70
	15	28.46	13.97	7.61	26.67	6.89	1.15	80
Cellulase Enzyme	0.0	0	0	0	0	21	16	0
	1.0	9	6	-2.5	28	36	20	(4/5)20
	1.5	12	10	-3.0	31	37	22	(4)20
	2.0	22	16	-5.0	42	37	22	(3/4)40

	2.5	29	22	-5.0	45	34	20	(3)40
	3.0	33	22	-3.7	45	34	20	(3)40

3.1 Effect of conc. of bleaching powder and enzyme on tensile strength

The tensile strength of denim fabric is decreased with the increasing concentration of bleaching and Cellulase enzyme (Fig 1). Both the figure shows upward trend i.e greater loss in strength during the gradual increase of the conc. of enzyme and bleaching powder. But this loss of strength is higher in case of enzyme wash rather than stone-bleach wash For both case degradation in warp way is higher than weft way. In case of stone bleach wash, the highest 29% degradation in strength in warp way occurred for using 15 g/l of bleaching powder and for enzyme wash, the highest 33% degradation was

observed for using only 1.5 g/l of enzyme. The tensile strength affected mostly for both bleach and enzyme but the amount of bleaching powder was used almost 5 times more than the enzyme. Therefore drastically loss in strength occurred by enzyme. Cellulase enzyme degraded cotton under the conditions used. Cellulase enzyme first attacked on projecting fibers (micro-fibrils) having fabric surface, then attacked on yarn portion, hydrolyzed them slowly. After that it attacked on secondary wall. As a result, cotton fiber loosened and broken down quicker with the frictional forces of rotating cylinder of the washing machine.

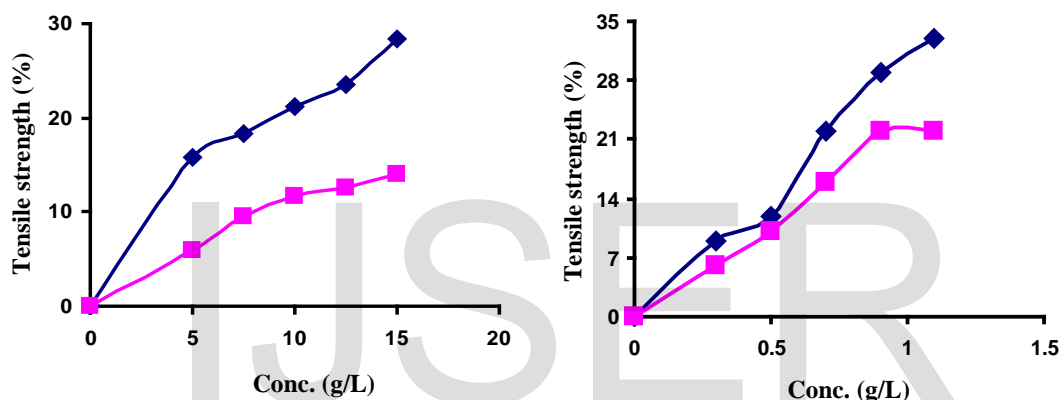


Fig. (1) Concentration Vs Tensile strength (a) Bleaching and (b) enzyme washing

3.2 Effect of conc. of bleaching powder and enzyme on weight loss of fabric

A different trend is found with gradual increase of the concentration of bleaching powder and enzyme (Fig 2). Fabric weight is increased when samples are treated with Cellulase enzyme but a significant loss in weight occurs during bleaching action along with pumic stone. The highest loss of GSM was 8% when 15g/l bleaching powder was used that is almost double from the loss when 5 g/l was used. But in case of enzyme the GSM of fabric is increased up to using 2.5g/l of enzyme. 0.5% enzyme concentration causes significant rise in the GSM (fabric weight) of the garment. The increasing rate of weight was unchanged at the concentration 2 to 2.5 g/l. After that the fabric is begin to loss there weight with

increasing concentration. During weaving cotton fabrics were subjected to considerable tensions. In subsequent finishing processes such as calendaring this stretch was increased and temporarily set in the fabric. The fabric is then in a state of dimensional instability [9]. This effect is usually greater in the warp direction. This is known as relaxation shrinkage. Due to relaxation shrinkage fabric GSM is increased. Thus, 2.5% Cellulase wash is optimal and this exhibited 5% increase in fabric weight and maximum shrinkage; As fading effect continues at 3.0% conc., fabric weight is decreased than the previous condition.

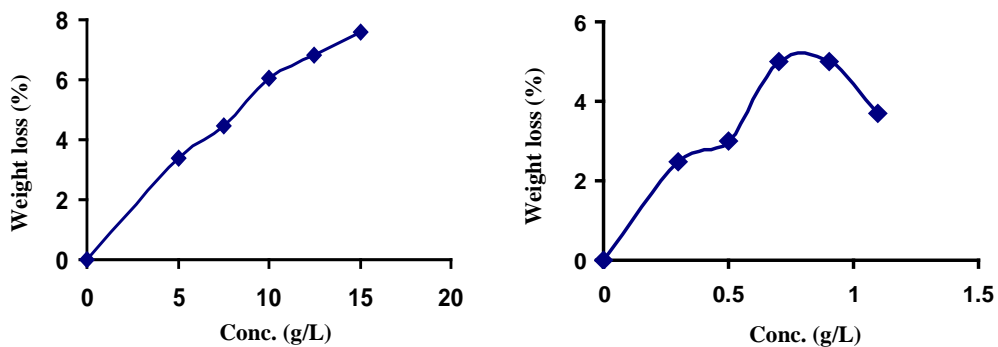


Fig. (2) Concentration Vs Weight loss (a) Bleaching and (b) enzyme washing

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3.3 Effect of conc. of bleaching powder and enzyme on stiffness

The effect on stiffness for enzyme wash is very high than the bleach washing with stone i.e enzyme makes the fabric softer than the bleaching powder. There is a noticeable amount of decrease in stiffness when sample apparels were treated with 5.0g/l of bleaching powder

with pumic stone and this loss of stiffness is increased up to 26% when 7.5, 10.0, 12.5 and 15 g/l conc. of bleaching powder were used. In case of enzymatic action, with the slow rise of the conc. of enzyme from 1.0g/l to 3.0g/l, the softness of the apparels was increased starting from 28% upto 45%.

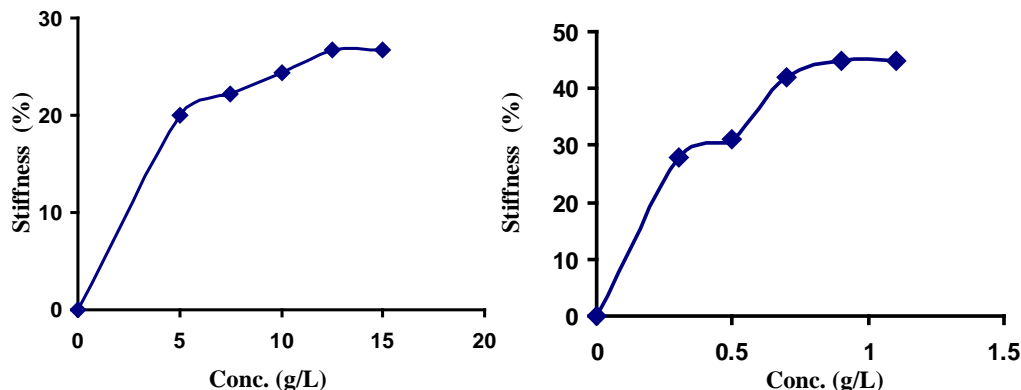


Fig. (3) Concentration Vs stiffness (a) Bleaching and (b) enzyme washing

3.4 Effect of conc. of bleaching powder and enzyme on elongation at break

When samples are treated with enzyme the change in elongation at break is very little and with the higher value of conc. it decreases in warp direction. When 1.0 g/L enzyme is used then the change of elongation at break is 36%, the change is 37% and 34% for both 1.5 and 2.0 g/l conc. and both 2.5 and 3.0 g/l respectively in warp way. But in weft way this change is almost same at 20%

although the conc. is changed accordingly. When bleaching powder with 30% pumic stone is used for washing, then the change in elongation at break is less than the enzymatic action. The change in elongation at break is decreased in both warp and weft way while the conc. of bleaching powder is increased.

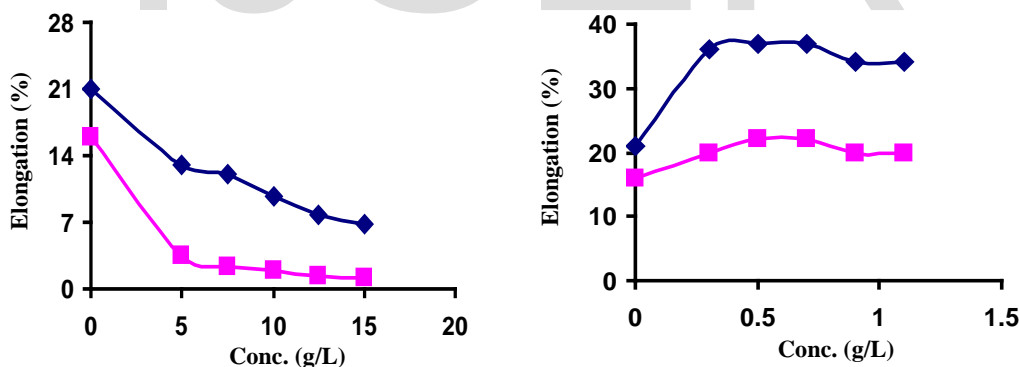


Fig. 4: Concentration Vs Elongation at break (a) Bleaching and (b) enzyme washing

3.5 Effect of conc. of bleaching powder and enzyme on Colour Shade

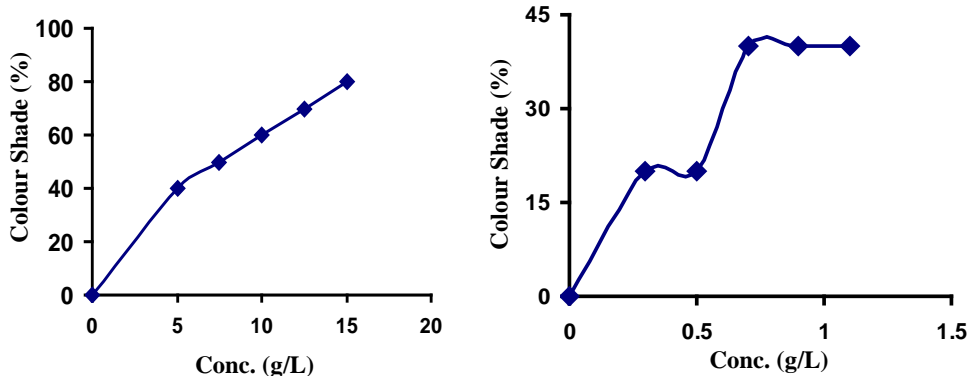


Fig. 5: Concentration Vs colour shade (a) Bleaching and (b) enzyme washing

Washing with bleaching powder along with pumic stone causes more change in the shade of the sample than the enzyme wash. The change in Shade is significant when 15g/L conc. of bleaching powder is used and it is 80% variation than the original sample. The fading effect found high at high conc. of bleaching powder used. When Cellulase enzyme was used, 1.0, 1.5 and 2.0g/l conc. causes 20% variation and 2.5, and 3.0 g/l brought about 40% faded effect in the newly washed sample.

4. Conclusion

The enzymatic wash has more effect on different properties of denim garments than the bleach wash. The tensile strength and elongation at break is highly affected by Cellulase enzyme than bleaching powder. Softness is dramatically increased by this sustainable treatment on denim garments. But weight of fabric is increased where bleach causes loss in fabric weight. Enzyme also accelerates more colour fading than stone bleach and has more positive effect on creating new look faded fashion denim garments.

5. References

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