Impact of Washing Stretchy Denim using Neutral and Acid Enzymes and Subsequent Softening Treatment on Physical, Mechanical and Sewing Properties

Dr. Nashwa Mostafa Hafez
Assistant Professor, Apparel Department, Faculty of Applied Arts, Helwan University, Egypt.
Dr. Eman Rafat Saad
Lecturer, Apparel Department, Faculty of Applied Arts, Helwan University, Egypt.

Abstract:
Comfort, versatility and durability continue to be stretchy denim's biggest assets, therefore it is known for its use in the manufacture of jeans; however, it can be used to make several apparels, depending on its mass. Even designers turn to it for inspiration occasionally. The main factors affecting consumers when selecting garments are aesthetic appearance and fashion. Denim garments are subjected in industrial washing to obtain specific appearance and handle. The washing and finishing processes are utilized for the purpose of fashion and different recipes are applied for different effects which are quite significant for marketing. Washing is a novel process to impart worn-out look, to modify the appearance and to improve the comfort ability of apparel. Enzyme wash is used to fade the color of denim as well as it has an effect on the physical, mechanical and sewing properties of the denim also. By this paper washing of tested denim with enzyme supplemented with softening were applied to preserve the quality and to create more distress worn-look fashionable denim. It presents the impact of enzyme wash type and subsequent softening treatment on stretchy denim dyed with indigo dye. Two different masses (380 & 320 gm/m2) of stretchy denim were sewed separately with lockstitch 301 by using two types of seams (lapped seam and flat felled seam) and washed using neutral and acid enzyme wash and then softened using silicone softener. The physical, mechanical and sewing properties were tested before washing, after washing and after softening. The properties that were analyzed include fabric mass, thickness, stiffness, tensile strength, seam strength, seam pucker and seam appearance. Neutral enzyme washed, acid enzyme washed and softened tested denim exhibit a clear difference in the tested properties than the unwashed denim. It's concluded that neutral enzyme wash supplemented with softening gives it the best value compared to all the tested denim washed properties

Keywords:
- ***Stretchy denim,***
- ***Enzyme wash,***
- ***Softening,***
- ***Sewing properties.***

Paper received 26th of August 2015, Accepted 14th of September 2015 Published 1st of October 2015

1. Introduction
Denim has a lot of demand in the market of regular garments as well as in the fashion market. People of all ages, especially the youth have a great interest on the denim. Different values by adding processes like industrial washing make denims not only look beautiful but also impart some functional properties to the garments. Denim has been used as clothing material for centuries due to its high durability. But today's fashion arena likes denim jeans due to its attractive shades, designs, attractive styles and various types of wash appeal, rather than for its robustness. [(1)] Denim is constructed in a twill weave with indigo and white yarns. The blue/indigo yarns are the lengthwise or "warp" threads (parallel to the selvage). The white yarns run across the fabric width (the weft threads). Denim is traditionally woven with 100% cotton yarn; however, today it's blended with polyester, to control shrinkage and wrinkles, and Lycra to add stretch. Traditionally, indigo denim fabric is deep blue in shade. [(2)] Today, denim has many faces. It can be printed, striped, brushed, napped washed with several types of washing, and the indigo blue yarns can be replaced with different colors to create colored denim. [(3)]

Denim washing: Technologically, denim washing is the most important fashion element for clothing industry. Usually the term 'washing' is most significantly applied in case of sewn apparels so it is very essential to observe the effects that have been made by particular washing on the fabrics to hold the qualities of sewn apparels. Washing is one of the most important finishing treatments applied on apparels that have great usage to create special outlooks and improve the fashion. There is huge demand of denim garments with distressed worn look. Various types of washing have been

used on completely sewn denim readymade garments to give this look and have the largest effect on finished garment. [4]

Denim washing types: Denim jeans in the past were worn in a raw, rigid and starch-finished form. But today's fashion requires various types of washing treatments. Normally denim washing is carried out in sewn garments. The denim jeans are subjected with different washing techniques, to achieve special outlook as well as to change the fashion. Responsible washing methods are stone wash, sand wash, bleach wash, rinse wash, enzyme wash, acid wash, moon wash, sun wash, over dyed/ tinted look, whisker-look, scrubbed-look, damaged and used look. However each of the washing techniques has their own advantages and limitations. [3]

Denim enzyme washing: In order to minimize the adverse effect of stonewash, denim garments are washed with enzymes. In the textile industry, enzymes are applied mainly to get a cleaner fabric surface. They played an important role to offer an aesthetic finish and enhanced the appeal in addition to reduce fuzz and pills, increase smoothness, softness, luster and brightness, improve fabric handle and drape ability and increase the wash down effects which meet the requirements of today's denim fashion trend. [5] During enzyme wash certain amount of indigo dye and cellulose fibers from the surface of the fabric are removed as shown in fig.1.

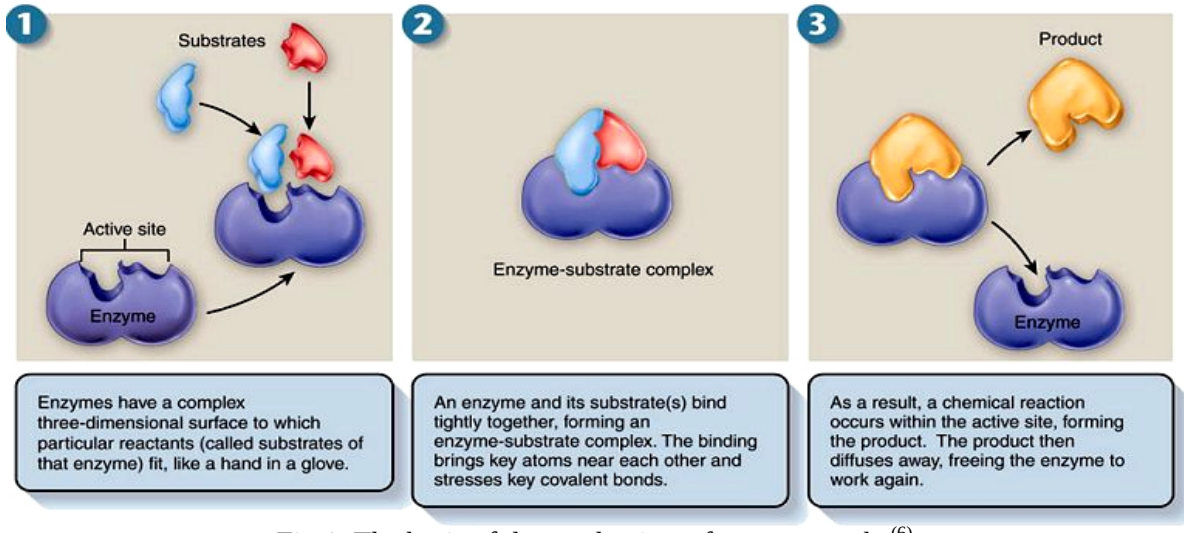


Fig.1: The basis of the mechanism of enzyme wash. [6]

Enzyme wash also known as "Bio-wash" which is a technique involving the use of enzyme to produce soft denim. It also has an effect on the color properties but the change is slight. The enzymes used in washing are "cellulases." Cellulase acts mainly on the surface of the fiber, but it leaves the inner intact. It removed by partially hydrolyzing the surface of the indigo dyed fiber of denim fabric. Cellulases are blends of selective enzymes that break down cellulose into glucose. [7] These enzymes are used under biological conditions of temperature and pH. They can be classified according to pH range in which they are more effective, such as acid, neutral and alkaline. However, the first two types are commonly used. [8] (This paper is concerned with these two types). The pH range of acid enzyme is 4.5 - 5.5 at 55°C. While pH ranges of neutral enzyme is 6 -7.0 at 60°C. Fig.2 illustrates a flow chart of denim enzyme washing process. [9] Generally, neutral enzyme is preferred to acid enzyme due to little or no back staining, less loss of strength and mass. However, acid enzyme are lower in costs and take shorter enzyme cycle time as compared to neutral enzyme. [8]

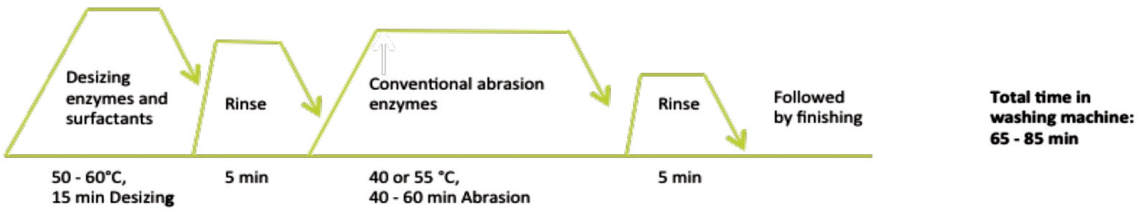


Fig.2: Denim enzyme washing process flow chart [9]

Denim enzyme washing advantages:

1) Now a days, enzyme treatment gained popularity in denim washing due to its low destructive nature on garments surface and eco-friendly nature compared to stone washing. [6] Enzyme wash is ecologically friendly due to the natural origins of enzymes and it is economical as compared to stonewash using pumice stones. The percentage of fabric damages has been reduced with this treatment. It ensures the same result by consuming less water and time, resulting less waste and damage to machines. The pollution, quality variability, and imperfections also reduced in enzymatic treatment.
2) The enzymes can be recycled.
3) The productivity of washing is increased due to the space formerly taken up by the pumice stones in the washing machines can be filled with more jeans.
4) The time consumption for removing stone fragments from the denim garments has been eliminated in enzyme wash.
5) The duration or number of rinse after enzyme wash is less than pumice stonewash.
6) A small quantity of enzyme can replace several kilograms of pumice stones during washing, which ultimately leads to less damage for garment, machine and less pumice dust.
7) Washed garment with soft handle and better appearance is achieved in enzyme wash. [10]

Denim enzyme washing disadvantages: During enzymatic treatment removed indigo dye can be redeposit on the white or un-dyed weft yarn of denim fabric which is known as back staining process and it can diminish the outlooks of the product. In order to remove the back staining, the garments are rigorously washed. However, this is added usage of water for the washing. So anti back staining agent is used to resist back staining then the garment has to be washed off for two times only. [8]

Denim softening: In the classical denim washing, softening is the last step before drying process. To improve fabric handle and other valuable properties, softeners are widely used in finishing operations. Specific drape and touch effect requested on the product is provided with it and various chemical materials are used to provide this. [10]

Denim sewing requirements: Selecting the proper mass of denim for the pattern is necessary. Since denim is a twill weave, it has a slight diagonal pattern; avoid patterns that aren't suitable for obvious diagonals. [11] Heavy denim (340 to 400 gm/m^2) tends to work best when made into jeans, jackets, overalls and work clothes. It's bulky, stiff and best suited to designs with straight lines and little or no gathering. Pants, jackets, skirts, work up well in medium mass denim (280 to 340 gm/m^2). Lighter denim can handle softer styling and some curved seams that require gathering. Skirts, shirts and dresses make up perfectly in light-mass denim (170 to 280 gm/m^2). This denim is the easiest to sew and handle. Denim dulls needles quickly. The heavier the denim, the larger the needle required. Sew heavy denim with a size 100/16 needle, medium mass denim with an 80/14 needle and light-masst denim with a size 75/11 needle. For the best sewing results a denim needle with a longer, sharper point, has to be used, so it can penetrate the close weave of the cloth easier. Its larger eye accommodates decorative topstitching thread. For standard sewing, polyester or cotton-wrapped polyester thread is used and decorative thread for topstitching. [12] Heavier fabrics need fewer stitches per inch than lighter mass versions. Heavy denim can be sewed with about 10 stitches per inch and lighter denim with about 12 stitches per inch. In addition to reduce the thread tension and the pressing of foot pressure slightly, it lets the fabric feeds evenly. The most popular denim seam is the flat felled seam; it's very durable and gives a nice, clean finish on the inside of the garment. [11]

Stretchy denim uses: Stretchy denim makes it possible to bridge the gap between jeans and active wear. It's a right a combination of well-worn jeans and the ever practical casual t-shirt or sweat shirt; it's also suitable to make fancy ladies top, tight pants, sportswear, sweater and kid's garments. Its production and the consumption have increased day by day. [13]

2. Experimental work

2.1. Tested denim specifications

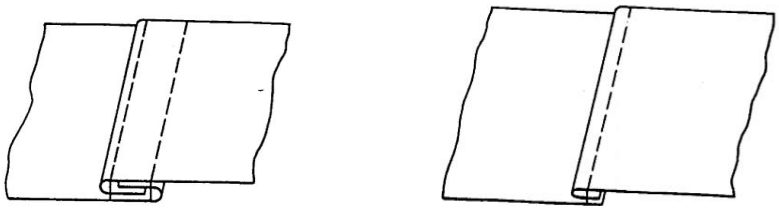
Two different masses of indigo dyed stretchy denim were tested. Detailed specifications of tested denim are mentioned in table1.

Table1 Specifications of tested denim

Denim no.	Denim structure	Fiber type	Warp/cm	Weft/ cm	Mass (gm/m^2)	Thickness (mm)
1	Twill3/1	95 % Cotton/ 5 % Lycra	40	35	380	0.78
2	Twill3/1	95 % Cotton/ 5 % Lycra	33	27	320	0.63

2.2. Sewing specifications

Each type of tested denim was sewed separately with lockstitch 301 by using two types of seams (lapped seam and flat felled seam) as shown in fig.3. Lapped seam is an overlap seam of two plies with one edge folded. While flat felled seam is made by placing one age inside a folded edge of fabric, then stitching the fold down. It includes a topstitched finish. It's useful for keeping seam allowances flat and covering raw edges. This strong seam is suitable for jeans, sportswear, menswear and children's clothes where added strength is required as seams come under pressure. It's ideal for reversible garments as it looks good from both sides. Table 2 illustrates sewing specifications. Table 3 illustrates enzyme washing specifications and table 4 illustrates softening specifications..



Lapped seam type LSb-1 Stitch A

Flat felled seam type LSc-2 Stitch B

Fig.3: Sewing stitches and seams of tested denim

Table 2 Sewing specifications

Stitch	Stitch type	Seam type	Thread type	Thread size	Needle size	Stitch density /cm
A	Single needle lockstitch 301	LSb-1	100% spun polyester	Ne 22/3	14	5
B	Double needle lockstitch 301	LSc-2	100% spun polyester	Ne 22/3	14	5

Table 3 Enzyme washing specifications

Enzyme type	Conc./dry denim mass	pH	Temp.	Water level	Time/min	Enzyme form
Neutral cellulase enzyme	1 - 2%	7	60°C	low	45 -90	White powder
Acid cellulase enzyme	0.5 - 0.8%	4.5 - 5	55°C	Very low	45 -90	Brown liquid

Table 4 Softening specifications

Softener type	Conc./dry denim mass	pH	Temp.	Time/min	Drying/temp.	Enzyme form
Silicone softener	1 – 4%	4.5	50°C	10-30	80°C	Transparent liquid

2.2. Experimental tests

The physical and sewing properties were tested before washing, after washing and after softening. All tests were done in conditioned atmosphere of 20ºC ± 2 and 65% ± 2 RH. Average of three readings has been obtained for each property. The properties that were analyzed include fabric mass obtained using digital sensitive scale according to

(ASTM D3776-96-2003). [14], thickness obtained using thickness tester according to (ASTM D1777-96-2003). [15], stiffness was carried out by using Shirley stiffness tester according to (ASTM D 1388) [16], tensile strength before and after sewing obtained using tensile tester according to (ASTM 1682-82). [17], seam pucker has been evaluated, according to (AATCC 88B-1978) [18] and seam appearance.

3. Results and Discussion

3.1. Tested denim physical properties before washing, after washing and after softening

3.1.1. Tested denim mass before washing, after washing and after softening

The following table5 & fig.4 illustrate tested denim mass before washing, after washing and after softening.

Table 5 Tested denim mass before washing, after washing and after softening

Treatment type	Denim1 mass (gm/m^2)	Denim2 mass (gm/m^2)
Before washing	380	320
Neutral enzyme wash	368	309
Neutral enzyme wash + softener	359	300
Acid enzyme wash	305	259
Acid enzyme wash + softener	292	245

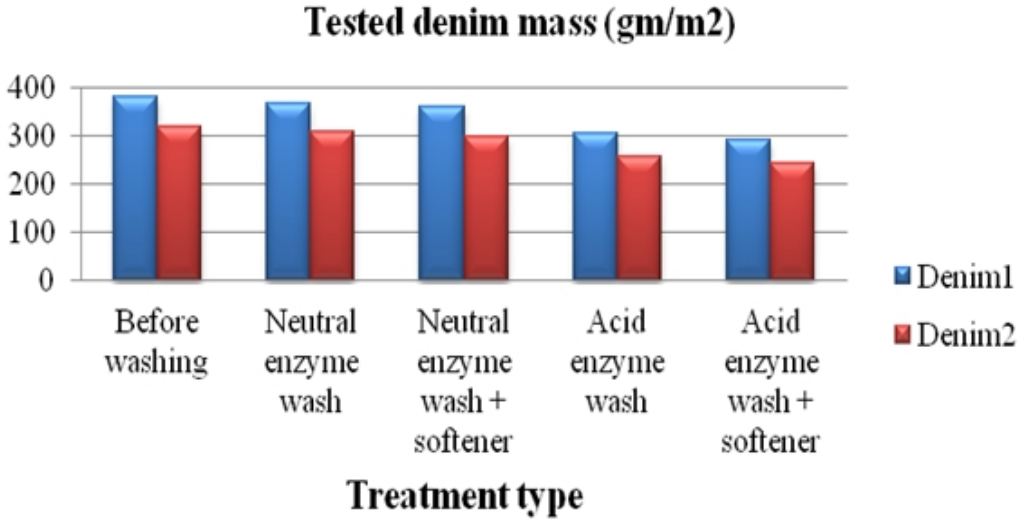


Fig.4: Tested denim mass before washing, after washing and after softening

There is no doubt that mass effects clearly on denim properties and according to table5 & fig4, it can be seen that all masses of tested denim after enzyme wash generally decreased. Acid enzyme wash has significant higher effect on decreasing the mass than neutral enzyme wash. According to the results, the silicone softening made an influence on the change of tested denim mass, whereas it decreased.

3.1.2. Tested denim thickness before washing, after washing and after softening

The following table6 &fig.5 illustrate tested denim thickness before washing, after washing and after softening.

Table 6 Tested denim thickness before washing, after washing and after softening

Treatment type	Denim1 thickness (mm)	Denim2 thickness (mm)
Before washing	0.78	0.63
Neutral enzyme wash	0.77	0.62
Neutral enzyme wash + softener	0.75	0.61
Acid enzyme wash	0.65	0.55
Acid enzyme wash + softener	0.62	0.53

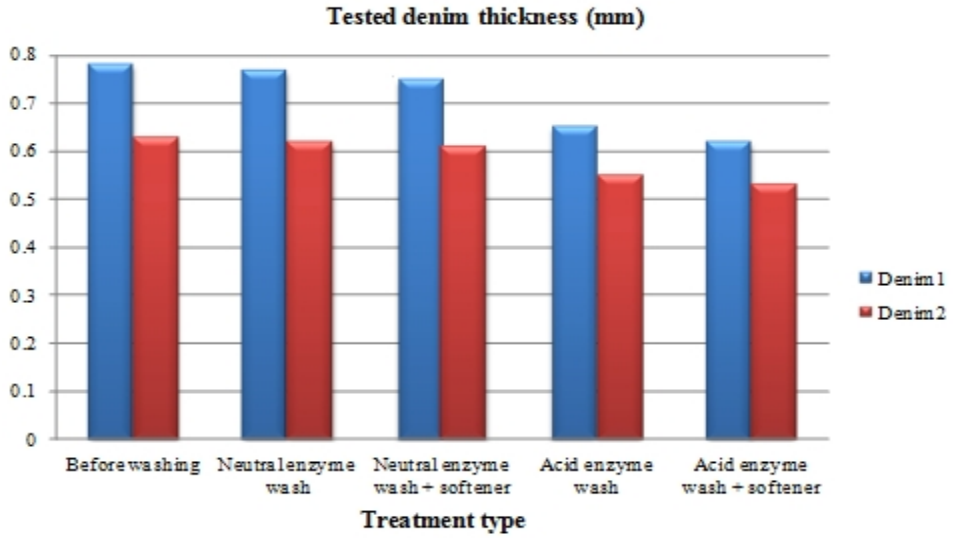


Fig.5: Tested denim thickness before washing, after washing and after softening

There is no doubt that heavier denim1 has a bigger thickness than medium mass denim2. It is clear that during enzyme wash the value of tested denim thickness decreased due to the removed amount of indigo dye and cellulose fibers from the surface of the fabric. As seen from table 6 & fig.5, acid enzyme wash affected on decreasing tested denim thickness more than neutral enzyme wash and after silicone softening more decreasing occurred.

3.2. Tested denim mechanical properties before washing, after washing and after softening

3.2.1. Tested denim tensile strength before washing, after washing and after softening

The following table7 & fig.6 illustrate tested denim tensile strength before washing, after washing and after softening.

Table7 Tested denim tensile strength before washing, after washing and after softening

Treatment type	Denim1 tensile strength (kg)	Denim2 tensile strength (kg)
Before washing	55	46
Neutral enzyme wash	53	43
Neutral enzyme wash + softener	50	41
Acid enzyme wash	48	39
Acid enzyme wash + softener	44	35

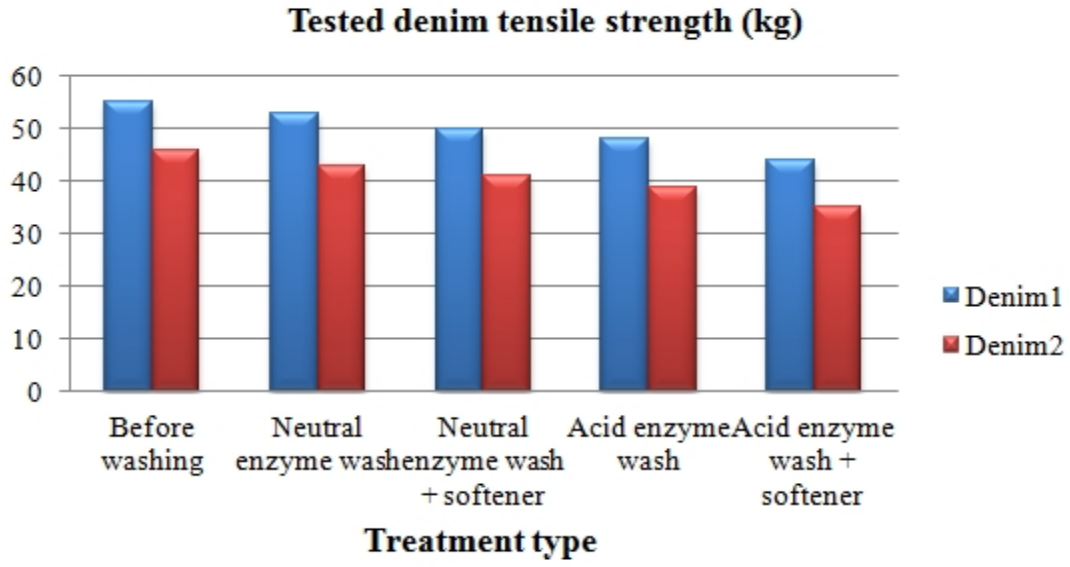


Fig.6: Tested denim tensile strength before washing, after washing and after softening

Tensile strength of a fabric is related with fiber, yarn, fabric properties and finishing process that treated the fabric. It's a necessary performance property especially on the denim fabrics that are used commonly. As shown in table 7 & fig.6, it's clear that heavier denim1 gives better tensile strength than medium mass denim2. Enzyme washing affects tensile strength values. As a result acid enzyme wash and softening were the application that decreases the tensile strength at most. Generally, neutral enzyme is preferred to acid enzyme due to its little loss of strength.

3.2.2. Tested denim stiffness before washing, after washing and after softening

The following table8 & fig.7 illustrate tested denim stiffness before washing, after washing and after softening.

Table 8 Tested denim stiffness before washing, after washing and after softening

Treatment type	Denim1 stiffness (mg.cm)	Denim2 stiffness (mg.cm)
Before washing	304	224
Neutral enzyme wash	221	154
Neutral enzyme wash + softener	208	150
Acid enzyme wash	199	139
Acid enzyme wash + softener	190	135

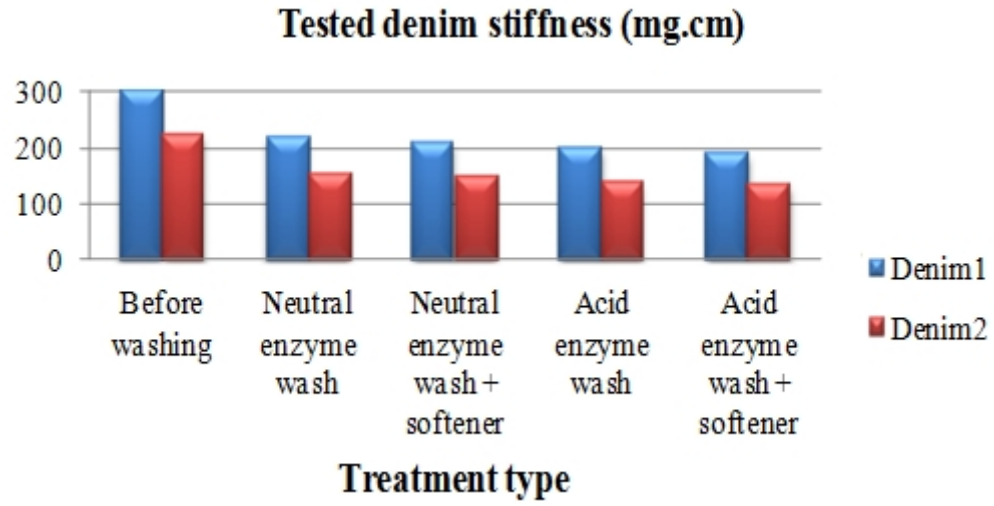


Fig.7: Tested denim stiffness before washing, after washing and after softening

The authors note that the hand feeling of the fabric improves a lot after performing the enzyme wash. Tested denims have before washing harsh feeling and rough surfaces. These sturdy and harsh hand feel were gone and a softer feeling was experienced when the enzyme washed denim was hold between the thumbs. That can be attributed to the cotton fibers which are loosened by enzymatic treatment as the fibrils are degraded and partly detached from the main fiber chain, and softness increased. Also the starch is removed from the warp yarns. Moreover the rubbing action between the denims during washing has a great influence on the increased softness of the denim fabrics. These enzyme washes provide softer and smooth surfaces specially after softening. According to table 8 & fig.7, it can be seen that heavier denim1 gives higher stiffness than medium mass denim2. Stiffness of tested denim has been decreased after enzyme washing which indicates the increase of tested denim softness. The type of enzyme has a significant effect on tested denim stiffness. From all the treatment methods applied to tested denim, the greatest influence on decreasing the stiffness was made by acid enzyme wash and softening.

3.3. Tested denim sewing properties before washing, after washing and after softening

Stitch A: single needle lockstitch 301 seamed with lapped seam type LSb-1, Stitch B: double needle lockstitch 301 seamed with flat felled seam type LSc-2.

3.3.1. Tested denim seam thickness before washing, after washing and after softening

The following table9 & fig.8 illustrate tested denim seam thickness before washing, after

washing and after softening.

Table 9 Tested denim seam thickness before washing, after washing and after softening

Treatment type	Denim1 seam thickness (mm)		Denim2 seam thickness (mm)	
	Stitch A	Stitch B	Stitch A	Stitch B
Before washing	0.81	0.83	0.64	0.66
Neutral enzyme wash	0.84	0.87	0.66	0.68
Neutral enzyme wash + softener	0.82	0.84	0.65	0.67
Acid enzyme wash	0.8	0.82	0.63	0.65
Acid enzyme wash + softener	0.79	0.81	0.57	0.58

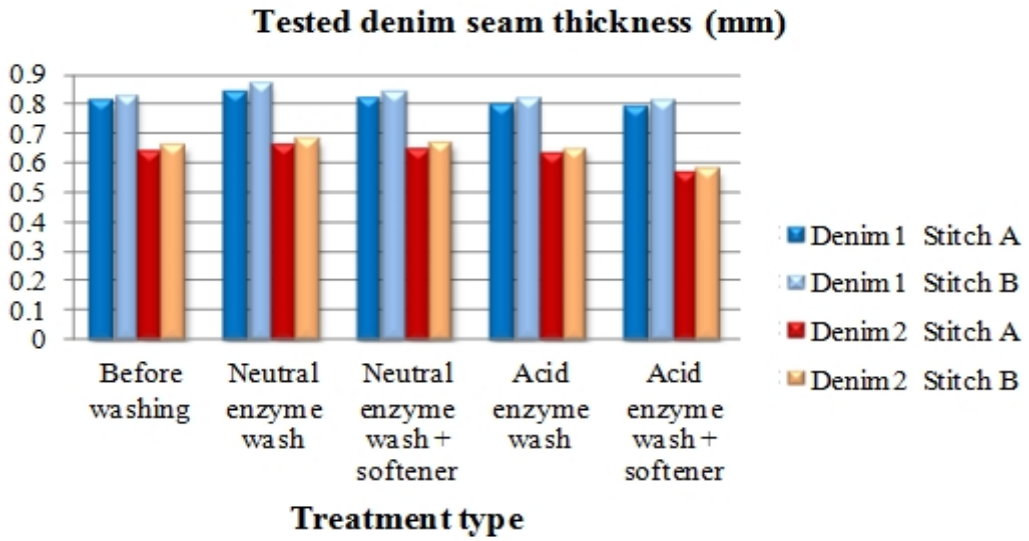


Fig.8: Tested denim seam thickness before washing, after washing and after softening

To hold the qualities of sewn apparel it is very necessary to observe the effects of enzyme wash on denim seams. From table9 & fig.8, it can be seen that heavier denim1 gives more seam thickness than medium mass denim2. And the tested denim seam thickness increased in enzyme washing than before washing which can be attributed to the occurred seam pucker after enzyme washing thus increases the seam thickness. This increase is decreased when washing was performed by acid enzyme wash and after softening due to the more loosening of surface fibers during this treatment. Stitch A has lower seam thickness than stitch B because of their seam construction, as lapped seam (stitch A) is an overlap seam of two plies with one edge folded. While flat felled seam (stitch B) is made by placing one age inside a folded edge of fabric, then stitching the fold down which makes it thicker.

3.3.2. Tested denim seam strength before washing, after washing and after softening

The following table10 & fig.9 illustrate tested denim seam strength before washing, after washing and after softening.

Table 10 Tested denim seam strength before washing, after washing and after softening

Treatment type	Denim1 seam strength (kg)		Denim2 seam strength (kg)	
	Stitch A	Stitch B	Stitch A	Stitch B
Before washing	65	70	50	58
Neutral enzyme wash	62	67	46	50
Neutral enzyme wash + softener	59	65	43	48
Acid enzyme wash	52	56	42	45
Acid enzyme wash + softener	49	59	40	43

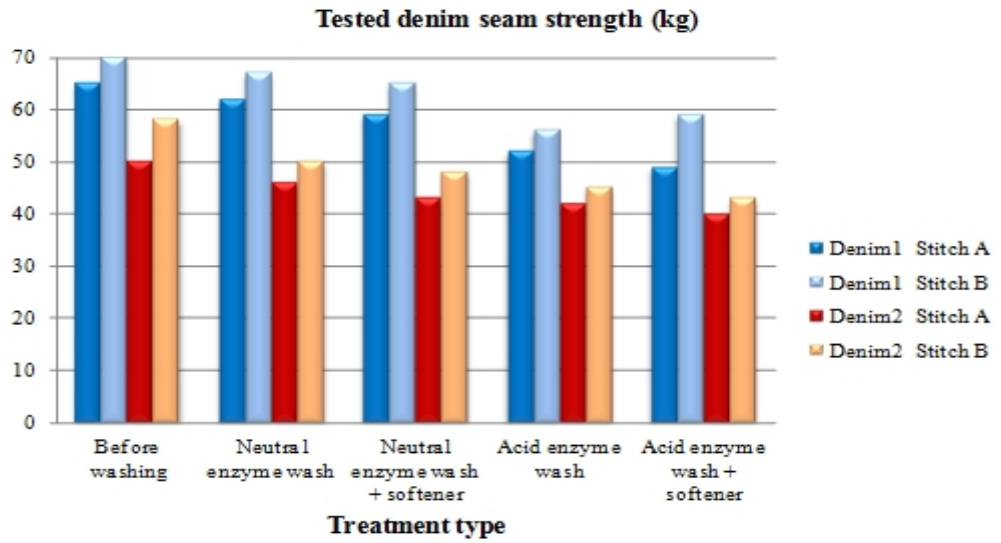


Fig.9: Tested denim seam strength before washing, after washing and after softening

From table10 & fig.9, it is obvious that, heavier denim1 provides higher seam strength than medium mass denim2. Enzyme wash has influence in the decrement of seam strength and the more significant decrement in the seam strength occurred after the softening treatment. As seam strength loss is higher in enzyme washing than before washing and this loss is increased when washing was performed by acid enzyme wash and after softening. The rubbing action between the enzyme, the softener and the seam area influences the reduction of the seam strength. This reduction in the seam strength is also been assisted by the friction between the machine cylinder and the seams of tested denim. Stitch A scored lower seam strength compared with stitch B due to their seam construction. This strong seam of stitch B is suitable for sewing jeans, sportswear, menswear and children's clothes where added strength is required as seams come under pressure.

3.3.3. Tested denim seam pucker before washing, after washing and after softening

The following table11 & fig.10 illustrate tested denim seam pucker before washing, after washing and after softening.

Table11 Tested denim seam pucker before washing, after washing and after softening

Treatment type	Denim1 seam pucker (level)		Denim2 seam pucker (level)	
	Stitch A	Stitch B	Stitch A	Stitch B
Before washing	5	5	5	5
Neutral enzyme wash	4.5	3.8	4.5	3.8
Neutral enzyme wash + softener	4.7	4.3	4.7	4.3
Acid enzyme wash	3.5	3	3.5	3
Acid enzyme wash + softener	4	3.5	4	3.5

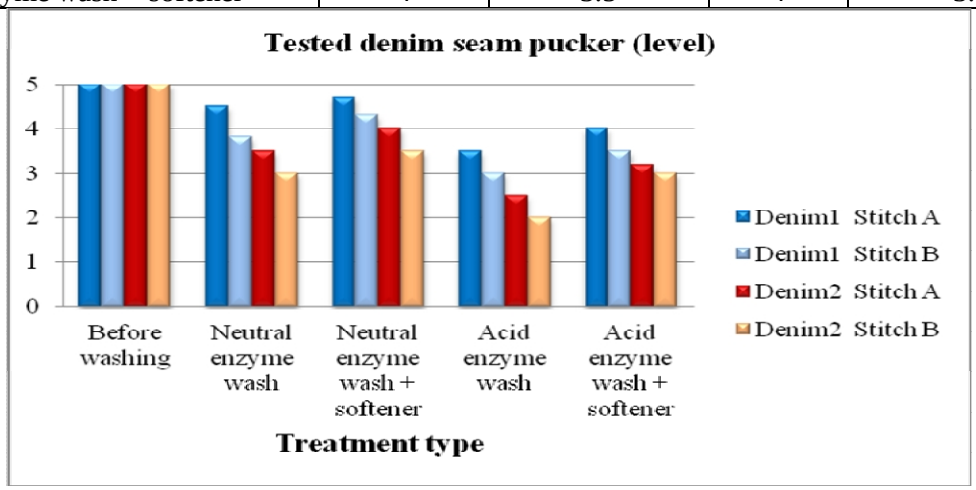


Fig.10: Tested denim seam pucker before washing, after washing and after softening

Seam pucker evaluated (from 1 to 5) where 5 means no pucker and 1 means severely pucker. Change in seam pucker of tested denim is presented in table11 & fig.10, as the level increases seam pucker decreases. It is clear that heavier denim1 gives less seam pucker than medium mass denim2 and the enzyme washing imparts significant change in the seam pucker. It has been found that acid enzyme wash has more influence on the increase of seam pucker than neutral enzyme wash and lowering of seam pucker occurs with the use of softening. Stitch A (single needle lockstitch 301) gives lower seam pucker compared with stitch B (double needle lockstitch 301).

3.3.4. Tested denim seam appearance before washing, after washing and after softening

The following table12& fig.11 illustrate tested denim seam appearance before washing, after washing and after softening.

Table 12 Tested denim seam appearance before washing, after washing and after softening

Treatment type	Denim1 seam appearance (level)		Denim2 seam appearance (level)	
	Stitch A	Stitch B	Stitch A	Stitch B
Before washing	8.8	9.6	8.6	9.2
Neutral enzyme wash	7.2	7.8	6.6	7.4
Neutral enzyme wash + softener	8.4	9.4	8.2	8.8
Acid enzyme wash	3.8	4.8	3.2	4
Acid enzyme wash + softener	5.4	6.4	5	5.6

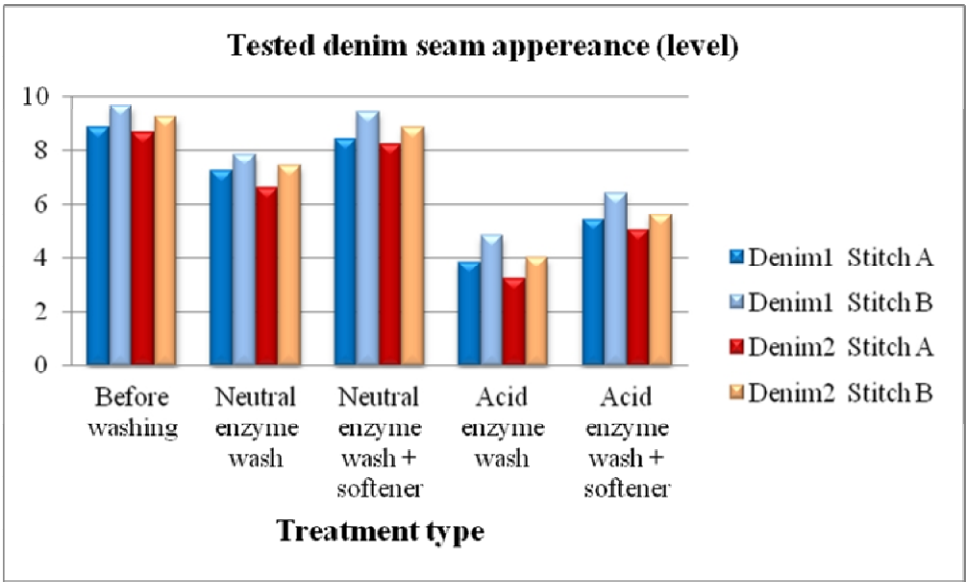


Fig.11: Tested denim seam appearance before washing, after washing and after softening

Appearance evaluated (from2 to10) where 10 means best appearance and 2 means worst appearance. Table12 & fig.11, as shown above depict that heavier denim1 gives better seam appearance than medium mass denim2. After enzyme wash tested denim seam appearance decreased and it's clear that acid enzyme wash has more effect in the decreasing of seam appearance than neutral enzyme wash and seam appearance improved by the use of softening. Despite stitch A gives lower seam pucker compared with stitch B, stitch B has a better seam appearance because it is made by placing one age inside a folded edge and it includes a topstitched finish. That's useful for keeping seam allowances flat and covering raw edges which is ideal for reversible garments as it looks good from both sides.

Conclusion

1- Garments washing are being used as a novel process to modify the appearance, to impart worn-out look and to improve the comfort ability of the garments, especially denim garments. Enzyme washing of denim garments helps in bio-polishing and to fade the color of the denim to a desired degree depending on the processing time and conditions.

2- It is clear that color fading effect can be

increased but that will reduce the serviceability of the garments. So an optimum enzyme wash should be chosen considering the required fading effect without compensating the important physical properties of denim.

3- By this paper it will be possible to know how denim apparel characteristics can be changed by industrial enzyme wash and softening.

4- It is further noted that tested denim before washed is almost heavier, thicker, durable, stiff and harder than the enzyme washed denim.

5- After the enzyme washing a significant change in stiffness was found in the tested denim and it can be said that, the softness of fabric increases after enzyme washing that gives distinctly soft denim which is more suitable for fashion garments.

6- The physical, mechanical and sewing properties of the tested denim are changed after washing and after softening compared within before washing. These properties are influenced by type of enzyme wash.

7- Acid enzyme wash actually reduces the mass, thickness, tensile strength and seam strength more than neutral enzyme wash, but the softness of the fabric increases more and the aesthetic appeal improves by using neutral enzyme wash.

8- Despite softening with silicone causes more loss in mass, thickness, tensile strength and seam strength, it has more positive effect on aesthetic properties whereas it causes more stiffness loss and more seam pucker loss which lets to reduce seam thickness and give better seam appearance.

9- Stitch A (lapped seam) scored lower seam thickness and pucker compared with stitch B (flat felled seam). While stitch B has higher seam strength and better appearance, therefore authors recommended using it.

10-Finally it is concluded that neutral enzyme wash supplemented with softening gives is the best value compared to all the tested denim washed properties.

References

1- Sarkar Joy, Elias Khalil, Effect of Industrial Bleach Wash and Softening on the Physical, Mechanical and Color Properties of Denim Garments, IOSR Journal of Polymer and Textile Engineering, Vol.1, Issue 3, May-Jun. 2014.

2- Khan M.M.R., M.I.H. Mondal, & M.Z.Uddin, Effect of Bleach Wash on the Physical and Mechanical Properties of Denim Garments, International Conference on Mechanical Engineering, 2011.

3- Abdul Hannan M. D., Shamsuzzaman Sheikh, S. M. Fijul Kabir, Md. Alamgir Hossain, Md. Abdur Rouf, Scope of Knit Denim Products Using Reactive Dye and Convenient Washing Effects, International Journal of Recent Development in Engineering and Technology, Vol.3, Issue 5, November 2014.

4- Rahman M. M., Effects of industrial enzyme wash on denim apparel characteristics, Daffodil International University, January 2011.

5- Khalil Elias, Joy Sarkar, Mostafizur Rahman, Md. Solaiman, Influence of Enzyme and Silicone Wash on the Physico- Mechanical Properties of Non Denim Twill Garments, International Journal of Scientific & Technology Research, Vol.3, Issue 10,October 2014.

6- Mir Suman, Milon Hossain, Palash Biswas, Alamgir Hossain, Mohammad Arafat Idris, Evaluation of Mechanical Properties of Denim Garments after Enzymatic Bio-Washing, World Applied Sciences Journal, 2014.

7- Vijayalakshmi D, T Ramachandran, Application of natural oil on light weight denim garment and analysis of its multi-functional performances, Indian Journal of Fibre & Textile Research, Vol.38, September 2013.

8- Khan M. Mashiur Rahman, M. Ibrahim H. Mondal, Bleach Washing Combined with Pumice Stone for the Modification of Denim Garments, Oriental Journal of Chemistry, Vol.28, No.3, 2012.

9- Nielsen Anne Merete, Senior Life Cycle Economist, Novozymes, Combined Denim Washing Process Save Time, Energy and Water without Sacrificing Quality, International Dyer, October 2012.

10- Mezarcioz Serin, Mutlu Toksoz, Investigation of Effect of Special Washing Processes on Denim Fabrics Properties, Tekstil ve Konfeksiyon, Vol.24, No.1, 2014.

11- Khedher Faouzi., Soufien. Dhouib, Slah. Msahli, Faousi. Sakli, The Influence of Industrial Finishing Treatments and their Succession on the Mechanical Properties of Denim Garment, AUTEX Research Journal, Vol.9, No.3, September 2009.

12- Bilisik K., Yolacan G.; Tensile and Tearing Properties of Newly Developed Structural Denim Fabrics after Abrasion, Fibers &

Textiles in Eastern Europe, Vol.19, No.5, 2011.
13- Sarkar Joy, Elias Khalil, Md. Solaiman, Effect of Enzyme Washing Combined With Pumice Stone on the Physical, Mechanical and Color Properties of Denim Garments, International Journal of Research in Advent Technology, Vol.2, No.9, September 2014.
14- ASTM D3776-96-2003: Method for determination of mass.
15- ASTM D1777-96-2003: Method for determination of thickness.
16- ASTM D 1388: Method for determination of stiffness.
17- ASTM 1682-82: Method for determination of tensile strength.
18- AATCC 88B-1978: Method for determination of seam pucker.

Acknowledgement
Deepest gratefulness and appreciation are due to Eng. Nabil Arslan the owner of "The Maestro" Company for washing denim, for his support and for providing all needed facilities. Also great thanks to Eng. Ahmed Bannan for his real support, during the practical part by providing the opportunity to treat the tested denim with enzyme washings and softening.