Influence of cellulase enzyme on some properties of knitted children's wear

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Abstract:
This paper studied the influence of cellulase enzyme on some physical and mechanical properties of two kinds of cotton knitted children's wear (single jersey 100% cotton T-shirt, interlock 100% cotton T-shirt). Samples of garments were dyed with reactive dyes, then treated with acid cellulase enzyme according to standard conditions. Some physical and mechanical properties were measured, then compared these properties before and after cellulase treatments. Cellulase enzyme treatment improve some mechanical properties of cotton knitted wear such as pilling resistance and water absorbency. Cellulase enzyme treatment decrease some properties of cotton knitted wear in acceptable rate such as fabric weight, fabric thickness, fabric burst resistance, and seam tensile strength of T-shirt side seam. The influence of cellulase enzyme treatment on the most physical and mechanical properties of interlock 100% cotton children's T-shirt is better than its influence on the same properties of single jersey 100% cotton children's T-shirt.

Keywords:
Cellulase enzyme
Reactive dyes
Cotton Knitted fabrics
Children's wear
Interlock
Single jersey

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Introduction

Recently, cellulase enzyme attract the attention in textile industry due to its role in removing fuzz-fibers of cotton fabrics. [1,2,3]. Cellulase is used in knitted fabric to enhance softness. [4]. The surface alteration of cellulosic textures presents cooler and smoother feel, and brighter shading using cellulases. [5]. Chemical composition of cotton is cellulose chains, consisting of crystalline region and amorphous region. The amorphous region is responsible for the fuzz and pilling on textile surface. [6,7]. Bio-polishing of cotton fabrics can be done by the actions of three cellulase components including endo-glucanase، exo-glucanase and β-glucosidases. This system hydrolysis the cotton substrate to release final products. [3,8]. Denim washing techniques have been developed to create a range of designs for trendy denim garments and jeans. [9]. Nowadays along with denim treatments, knitted garments such as T-shirt and Polo shirt are treated using different techniques as follows: cellulase treatment, softener, and pigment dyeing, etc. are used to enhance the physical and mechanical properties of knitted clothing, and to give to knitted wear a fashionable look. [9, 10, 11].

Knitting is the process of forming fabric by interloping yarn in a series of connected loops using needles. Knitted fabrics provide comfort and use in many kinds of clothing. [12]. To make environmentally friendly garments more noticeable to customers, very important to understand what factors impact customers' purchasing decisions with regard to environmentally friendly garments. Children may be the most sensitive to environmental risks, based on their concerns for their children's health. [13]. Enzymatic treatment of garments is one of the most important processes environmentally friendly in the textile sector in. For improving fashionable look on garments, some enzymatic treatments techniques can be followed. [14].

This paper studied the effect of cellulase enzyme on some physical and mechanical properties of two kinds of children's T-shirt fabrics. This paper investigated the application of enzymatic treatments techniques of denim wear on knitted children's T-shirt. This cellulase treatment gives children's T-shirts a fashionable look, softness and good properties without harming children's skin because enzymes are environmentally friendly.

In the present paper, two kinds of knitted children's T-shirts fabrics (single jersey 100% cotton, interlock 100% cotton) were dyed with reactive dyes then treated with acid cellulase enzyme according to standard conditions. Weight of fabrics, fabric thickness, seam tensile strength, burst resistance, pilling resistance, water repellency, and water absorbency of T-shirts were measured then compared these properties before and after enzymatic treatments.

Materials and Methods

Materials

Garments samples
Following two kinds of knitted children's T-shirts

were used in this study:

a) Three samples of single jersey 100% cotton T-shirt,
b) Three samples of interlock 100% cotton T-shirt.

The specification of the fabric used is shown in Table 1.

Table 1. Description of knitted T-shirt fabrics.

No.	Fabric type	Fabric weight (g/m^2)	Fabric thickness (mm)	Water repellency %	Burst resistance (kPa)	Seam tensile strength (kg)	Pilling resistance
1	Single jersey 100% cotton	194	0.59	90	11.4	28	B
2	Interlock 100% cotton	199	0.78	90	10.6	26	C

Where pilling degrees are A: excellent, B: good, and C: bad

Chemicals

- Acid cellulase enzyme (Producto EAPS 55), Asutex, Spain.
- Acetic acid CH3 COOH, Russia.
- Sodium hydroxide (Caustic soda) Na OH, China
- Sodium carbonate (Soda ash) Na2 Co3, Egypt.
- Sodium chloride (Common salt) Na Cl, Egypt.
- Wetting agent (Wettex SE 130), Egypt.
- Sequestering agent, Egypt.
- Reactive dyes (synozol blue HFG), kisco, korea.

Washing machine

- Brand name: Yilmak;
- Capacity: 5 kg;
- RPM (Revolution per minute)—30 - 33 rpm;
- Origin: Turkey.

Reactive dyeing

Samples of T-Shirt were dyed with reactive dyes. Firstly, samples were scoured in the following scouring bath by: Sodium hydroxide (caustic soda) 2 g/l, and wetting agent 1g/l at temperature 90 ^{0}C, Time 30 min., pH 10-11.

Then neutralization after scouring by Acetic acid 1g/l, Temperature
50^{0}C, Time 10 min.

Dyeing curve

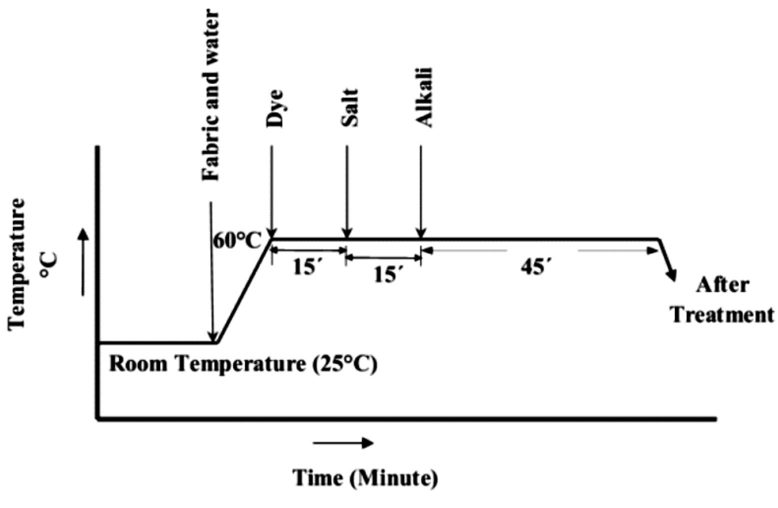

Figure 1. Reactive dyeing curve.

Dyeing bath

Secondly, all the samples were dyed with the following: 1% reactive dyes (synozol blue HFG), 75g/L glauber salt or common salt (electrolyte), 7.5g/l soda ash (Alkali), 1 g/l sequestering agent, liquor ratio 1:20, and temperature 60°C

After dyeing

After treatment of those dyed samples were done according to the following: cold wash (50°C, 10 minutes), neutralization (0.5 g/L acetic acid), and hot wash (95°C, 15 minutes).

Acid cellulase treatment

One sample of each kinds of T-shirt has been untreated. Other samples of T-shirt were treated with acid cellulase enzyme in following standard conditions cellulase of enzyme bath: acid cellulase enzyme 1 %, and acetic acid 1 g/l at pH 4.5, temperature 50^{o}C, time 20 min., and liquor ratio 1: 10.

After the treatment was finished, the samples were raised up to 70-80^o C for 10 min. to stop the enzyme activity. Then samples were rinsed by cold water in a bath for 10 minutes.

Measurements

All measurements were carried out at national researches center in Egypt according to standard procedure.

Fabric weight

This test is intended for determination the weight per Cm^2 of samples. This test was carried out according to ASTM D 3776 Test Method for measuring Mass per Unit Area (Weight) of fabric.

Fabric thickness

This test is intended for determination the thickness of samples. This test was carried out according to ASTM D 1777 Test Method for measuring thickness of fabric.

Water repellency and absorbency

This test which called spray test is intended for determination the water repellency of samples. This test was carried out according to AATCC 22 Test Method for measuring water repellency of fabric.

Burst resistance

This test is intended for determination the Burst resistance of samples. This test was carried out according to ASTM D 3786 Test Method for measuring Burst resistance of fabric.

Seam tensile strength

This test is intended for determination the Seam tensile strength of side seam of samples. This test was carried out according to ASTM D 4632 Test Method for measuring Seam tensile strength of garment.

Pilling resistance

This test is intended for determination the pilling resistance of samples. This test was carried out according to BS 5811, ICI Box Test Method for measuring pilling resistance of fabric.

Results and discussion

Effects of cellulase on fabric weight

The results were obtained from measurement of the fabric weight of cotton knitted T-shirts were shown in Table 2. Results of the loss of weight in interlock 100% cotton fabric (2.4%) was slightly more than the loss of weight in single jersey 100% cotton fabric (0.46%) after enzymatic treatment. This loss of weight is a result of enzymatic hydrolysis of the cellulosic fibers, especially on the fabric surface to soluble products such as glucose. [15]. Commercially, a weight loss of 3-6% is considered acceptable. [16]. So, the loss of weight of two kinds of fabrics is acceptable.

Table 2. Effects of cellulase enzyme on fabric weight of different knit T-shirts.

Fabric type	**Single jersey 100% cotton T-shirt (g/m^2)**	**Interlock 100% cotton T-shirt (g/m^2)**
Samples before treatment	217	245
Samples after treatment	216`	239

Effects of cellulase on fabric thickness

The results obtained from measurement of the fabric thickness of cotton knitted T-shirts were shown in Table 3. Results of the loss of thickness in both fabrics was very little, and no significant difference in the loss of thickness between two fabrics after enzymatic treatment.

Table 3. Effects of cellulase enzyme on fabric thickness of different knitted T-shirts.

Fabric type	Single jersey 100% cotton T-shirt (mm)	Interlock 100% cotton T-shirt (mm)
Samples before treatment	0.65	0.91
Samples after treatment	0.64	0.89

Effects of enzymatic treatment on water repellency and absorbency

The results obtained from measurement of the fabric water repellency of cotton knitted T-shirts were shown in Table 4. Results of the water repellency of both fabrics was decreased 20%, and the water absorbency of both fabrics was improved 20% after enzymatic treatment. This is due to biodegradation of cellulosic protruding fibers from fabric surface which results in improving the water absorbency of knitted fabrics. [5].

Table 4. Effects of cellulase enzyme on water repellency of different knitted T-shirts fabrics.

Fabric type	Single jersey 100% cotton T-shirt (%)	Interlock 100% cotton T-shirt (%)
Samples before treatment	70	70
Samples after treatment	50	50

Effects of enzymatic treatment on burst resistance

The results obtained from measurement of the fabric burst resistance of cotton knitted T-shirts were shown in Figure 2. The burst resistance of single jersey decreased 7.4%, while the burst resistance of interlock decreased 4% after enzymatic treatment. Testing the bursting strength, which is the strength against multi directional forces, becomes very important for knitted fabrics. [17]. The pilling tendency of interlock is high. So, the loss of burst resistance of interlock fabric was less than single jersey after cellulase enzyme treatment. That is due to the action of enzyme hydrolyzes the pills, fuzz, and protruding fibers with less effect on the burst resistance of the fabric. The pilling tendency of single jersey is not high. [11]. So, the action of enzyme hydrolyzes the pills, fuzz, and protruding cellulose fibers caused more effect on the burst strength of the fabric. The loss of burst strength about 10% is considered acceptable. [18]. So, the loss of burst resistance of single jersey and interlock is acceptable. But the loss of burst resistance of interlock is less than single jersey.

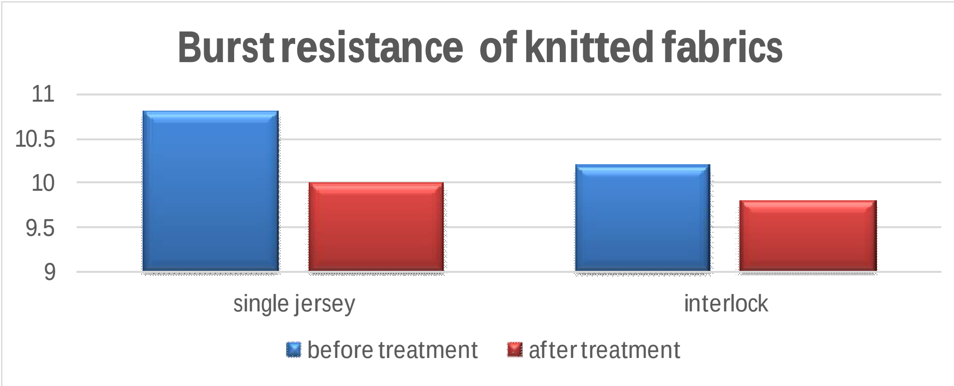

Figure 2. Effects of cellulase enzyme on burst resistance of different knitted T-shirts fabrics.

Effects of cellulase on seam tensile strength

The results obtained from measurement of the seam tensile strength of cotton knitted T-shirts side seam were shown in Figure 3. The seam tensile strength of single jersey T-shirt side seam decreased 10.7%, while the seam tensile strength of interlock T-shirt side seam decreased 3.7% after enzymatic treatment. The pilling tendency of interlock is high. So, the loss of seam tensile strength of interlock garment was less than single jersey after cellulase enzyme treatment. That is due to the action of enzyme hydrolyzes the pills, fuzz, and protruding fibers with less effect on the seam tensile of the interlock garment. The pilling tendency of single jersey is not high. [11]. So, the action of enzyme hydrolyzes the pills, fuzz, and protruding cellulose fibers caused more effect on the seam tensile strength of the single jersey garment.

The loss of seam tensile strength of interlock is less than single jersey after cellulase enzyme treatment. So, the treatment of interlock garments with cellulase enzyme is better than the treatment of single jersey garments with the same enzyme.

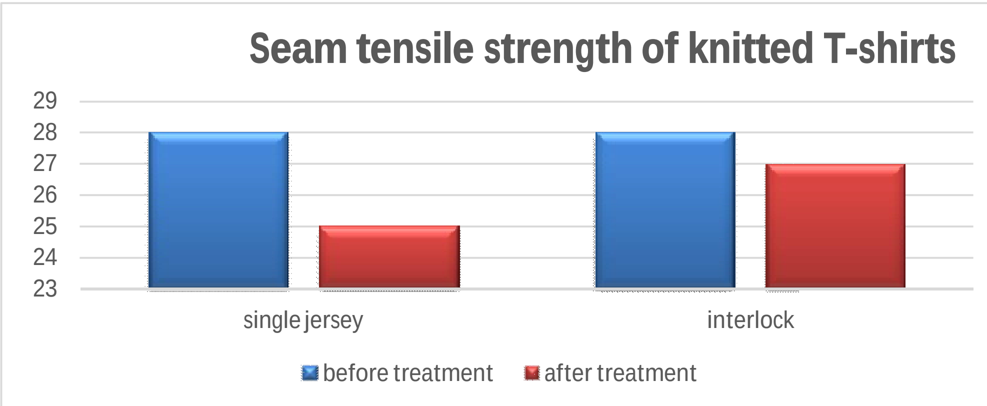

Figure 3. Effects of cellulase enzyme on seam tensile strength of side seam of different knitted T-shirts.

Effects of enzymatic treatment on pilling resistance

The results obtained from measurement of the fabric pilling resistance of cotton knitted T-shirts are shown in Table 5.

Before treatment the pilling resistance of single jersey better than interlock. After treatment, the pilling resistance of both T-shirts fabrics was improved. The cellulase enzyme remove fuzz, pills and protruding fibers from fabrics surface. So, the pilling resistance of both fabrics was improved.

Table 5. Effects of enzymatic treatment on pilling resistance of different knitted T-shirts fabrics.

Fabric type	Single jersey 100% cotton T-shirt	Interlock 100% cotton T-shirt
Samples before treatment	B	C
Samples after treatment	A	A

Where pilling degrees are A: excellent, B: good, and C: bad

Conclusion

The loss of burst resistance and seam tensile strength of interlock 100% cotton T-shirt were less than single jersey 100% cotton T-shirt after cellulase enzyme treatment. The pilling tendency of interlock is high. So, the loss of seam tensile strength of interlock garment and burst resistance of interlock fabric were less than single jersey after cellulase enzyme treatment. That is due to the action of enzyme hydrolyzes the pills, fuzz, and protruding fibers with less effect on the seam tensile of the interlock garment and burst resistance of interlock fabric. The pilling resistance and water absorbency of both types of fabrics were improved after cellulase enzyme treatment. That is due to the action of cellulase enzyme on hydrolyze protruding cellulose fibers from fabrics surface. The loss of weight of interlock 100% cotton T-shirt fabrics was slightly more than the loss of weight in single jersey 100% cotton fabric after cellulase enzyme treatment. So, we conclude that the influence of cellulase enzyme treatment on the most properties of interlock 100% cotton T-shirt is better than its influence on the same properties single jersey 100% cotton T-shirt. We recommend to use cellulase enzyme treatment on interlock 100% cotton children's wear to improve some properties of knitted wear, give T-shits fashionable look like denim garments, don’t damage knitted fabrics, and don’t harm children's skin.

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