

**Study the Seam Stitch of Silk Garment Properties Dyed
With Natural dyes****N. M. Elghandour^a, Z. M. Abdel-Megied^a, L. K. El Gabry^{b*} and M. Y. Abdi El-Aziz^a**^a *Clothing and Knitting Industrial Research Department, Textile Research and Technology Institute National Research Centre, Dokki, 12622, Cairo, Egypt*^b *Proteinic and Man-Made Fibres Department, Textile Research and Technology Institute National Research Centre, Dokki, 12622, Cairo, Egypt*

DYEING silk fibers requires high heat, which damages the properties of the fibers. Today, the use of natural dyes is a solution to this problem. Dyeing, finishing and seam parameters are an important characteristic which affects the performance and durability of clothing during its usage life. Stitch density one of the most effect on the durability and appearance of garment, may be affect in opposite direction on the sewing machine speed. So it is important to study the better condition of sewing. Effect of two levels of seam stitch density are studied on the silk fabric garment properties which dyed with Eco-friendly Dyeing onion peel dye.

To analyze our results statistically, we used analysis of variance (ANOVA). The multiple linear regressions modeling is used to determine the influence of the different concentration onion natural dyeing, fabric parameters and stitch densities on silk garment properties.

Keywords: Silk, Stitch density, Onion dye, Seam efficiency, Seam slippage, ANOVA.

Introduction

Silk fibroin polymers consist of repetitive protein sequences [1, 2]. These silks are a group of unique fibrous proteins with high mechanical strength created in fiber form. The silk fibroin amino acid of *B. mori* is composed almost 43% of glycine (Gly), 30% of alanine (Ala), and around 12% of serine [3]. Silk fiber, known as the “Queen of Textiles”, consist of 97% protein - fibroin, with around 75% a filamentous protein and 25% sericin, a non-filamentous protein.

Degumming Silk Fibroin forms is obtained by boiling in hot water [4].

Recently, interest in dyeing silk fibers with natural dyes has increased. The silk was dyed with a dye extracted from onion peel using different mordant individually such as alum, stannous chloride, both Couper sulphate and ferrous sulphate, tartaric acid, and tannic acid [5- 7].

There are various methods for extracting colouring materials, such as ultrasonic extraction, Microwave assisted extraction, Aqueous extraction, Alkali or acid extraction, Enzymatic extraction, Solvent extraction, Fermentation, and Super critical fluid extraction [8]. The extracting dyes from the natural

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coloured material has been done in many ways. Natural dyes are distinguished by beautiful shades fluorescent, and colours from industrial dyes. Natural dyes characterized by being safe on the environment and easy to get rid of dyeing exhaust biologically, and can also be applied to some synthetic fibers [9, 10]. Altemimi et al has reported that using different solvents, such as ethanol, methanol and acetone is efficient in the extraction process [11].

Kumar et al focuses the application of onion peel and its extract solution as prospective functional ingredients [12]. Ultrasonic extraction of onion (*Allium cepa*) peel dye, its applications on silk fabric with bio-mordants and its antibacterial activity were investigation [13].

The sewing process is one of the critical processes in the determination of productivity and the quality of the finished garment in apparel production. To satisfy the customer sewing quality is essential if the apparel manufacturer [14]. The performance of the apparel in use is mainly depends on the quality of seam. The Seam's quality is assessed by means of its efficiency, elongation, bending, stiffness, abrasion resistance, seam slippage strength, puckering, tightness, boldness and seam damage [15]. Sewing threads have high effect on seam efficiency and appearance. In clothing industry is used a wide variety of sewing threads. Each one of sewing thread has distinct properties, which are employed according to end use [16].

Fabric stiffness is wanted to be reduced for a good drape in many apparel fabrics, and to optimize the sewing parameters such as stitch density, sewing thread type and size, and seam allowance in order to control the stiffness of the fabric on the garment [16, 17]. Seam slippage is one of the most important properties of seam especially in silk fabrics and it is a ratio between seam strength and fabric strength. Also, fabric strength and seam strength are the most important properties for the performance of the garment where it direct effect on its durability [18].

The purpose of this study to dyeing silk fabrics using easy technique with economy natural materials to save the advantages properties of these fibers. The garment performance affected by some properties like bending length, seam slippage, fabric tenacity, seam efficiency, and all these properties well affected by stitch density.

Experimental

Fabrics

Degummed plan silk fabric was supplied by ElKhatib for Spinning and Weaving Co., Akhmeem, Giza, Egypt. The weight of silk fabric is 80 g/m². The increase in the weight of silk fabric is due to the loading of sarin on it to withstand the weaving process, so the fabric was washed before the dyeing process. The description of fabrics shows in Table 1. Structural of silk.

TABLE 1. Fabric Specifications

Raw material	100% silk
Weave structure	Plain 1/1
Weight \ unit area (g/m ²)	72
Warp density (ends/cm)	31
Weft density (picks/cm)	28
Thickness (mm)	0.23
Tensile strength (kgf)	4.618 (warp direction), 2.141 (weft direction)
Elongation (%)	11.33 (warp direction), 10.33 (weft direction)

Scouring of fabrics

The silk fabrics were washed in a bath containing 5 g/l non-ionic detergent (Triton X-100), at 95°C for 60 min. The degummed silk fabrics were rinsed thoroughly in warm purified water to remove extra surface-associated sericin, the scoured fabrics were rinsed several times and then dried at room temperature.

Extraction the natural dyes

Onion peels were collected and ground. 5 grams of crushed onion peels were placed in a liter of water and the solution was heated to boiling for one hour. We obtained a brownish-reddish solution, and then left the solution to cool, then filtered the solution to get rid of the onion peel (onion dye solution). The solution is completed to a litre of water. This solution is used in dyeing silk fibres.

Dyeing with new coloured material

The dyed bath was prepared by different amount of the extracted solution (onion dye solution). The pH of the onion peel solution was between 4- 4.5. The dyed bath temperature was heated to be 80 ° C and the silk

fabric was added for 1 hr., at liquor ratio of 1:50. Then the dyed silk fabric was washed in warm water and air dried.

Methods

Color strength: Color strength of the dyed silk fabric (K/S) was measured at the wavelength of the maximum absorbance using a SF600+-CT Data colours spectrophotometer

Washing fastness property: The colour fastness to washing according to the AATCC test method (AATCC Technical Manual, Method 36, (1972), 68, 23, (1993) was determined.

Specimens

Sewing threads

Sewing thread specification was illustrated in table 2.

TABLE 2. Sewing thread Specifications

Structure	Ring spun
Raw material	100% PES
Thread (sewing yarn) count	40 /2 Ne
Breaking strength	0.9347 kgf
Breaking elongation	11%

Seams

The used Stitch type was lock stitch with two levels of stitch density (3, 6 stitches/cm). It was measured some seam properties as indication of the garment properties.

The procedure testing

The fiber type and fabric structure, in addition to the dyeing applied to it affect the fabric physical and mechanical properties. The tests were conducted on all silk fabrics after conditioning for 24 h under standard atmospheric conditions (20±2° C, 65± 2% RH) according to ASTM standard before testing. The mechanical and physical tests were performed on the undyeing and dyeing fabrics before washing.

The mass per unit area (Weight) test was conducted according to ASTM-D3776 using Electronic Balance.

Fabric thickness test was performed according to ASTM D1777-96 using thickness tester.

Bending length

Bending strength or flexural rigidity or bending rigidity is an indication of fabric stiffness, which measured by the bending length, test was conducted according to ASTM D1388 using Shirley tester. The results may lead to sewing and performance characteristic of garment controlled. The stiffness of dyeing silk fabrics is measured along the warp and weft direction also for face and back in woven fabrics. Also the Sewn seams stiffness has examined by the Shirley stiffness tester according to test methods BS3356 "Method for determination of flexural rigidity and bending length of silk fabrics" 1990 and according to researches.

Seam slippage

Seam slippage is one of the most important properties of seam especially in silk fabrics. It was tested according to ASTM D1683.

Seam efficiency

The seam efficiency is a ratio between fabric strength and seam strength according to equation (1).

$$\text{Seam Efficiency \%} = (\text{Seam Strength} / \text{Fabric Strength}) \times 100 \text{---- (1)}$$

To apply this equation; Fabric strength and seam tensile strengths were tested on INSTRON tensile tester in both directions warp and weft according to The (ASTM D1683-4).

Statistical analysis

The variance (ANOVA - two factors) used to analyzed the results. Table (3) provides the experimental design.

TABLE 3. Experimental design for the Parameters

Parameters	Levels		
	0	1	2
Dyeing time (x2)	0 hr (washing without dyeing)	1hr	2 hr
Stitch density (x3)	-----	3 stitches / cm	6 stitches / cm

TABLE 4. shows the results of testing seams properties

Sample no.	Dyeing time (hr)	Stitch density	Warp Seamed Bending length (cm)	Weft Seamed Bending length(cm)	Warp Seam slippage (N)	Weft Seam slippage (N)	warp Seam efficiency	weft Seam efficiency	Warp Seam strength (Kgf/mm2)	Weft Seam Strength (Kgf/mm2)	Warp Seam elongation (%)	Weft Seam elongation (%)
	X1	X2	y1	y2	y3	y4	y5	y6	y7	y8	y9	y10
1	0	1	4.2	4.2	176	174	56.3	29.4	1.2	1.4	12.1	8.17
2	1	1	4.1	5.8	170	165.7	56.1	32.1	1.6	1.3	11.5	9.2
3	2	1	3.9	7.9	151	152	62.7	40.5	1.5	1.6	11.8	15.1
4 (B)	0	2	5.6	4.5	200	198	103.7	67.3	2.2	3.1	13.2	15.8
5	1	2	5.4	5.5	188	184	37.7	37.3	1.1	1.5	14	13
6	2	2	5.1	7.6	181	176	58.3	55.8	1.3	2.2	13	20

*All dyed seamed fabrics where after washing

Results and Discussion

Colour strength

The colour strength and washing fastness of unwashed and washed silk fabrics dyed with extracted onion solution as a natural dyes shown in table (5). It was found that the dyeing washed silk fabrics give some increase in colour strength value than unwashed silk fabrics. The reason for this decrease may be attributed to the presence of some amount of sercein on the silk fibers, which absorbs part of the dyeing solution, and then part of it falls off the fabric. Also, it observed that the increase in the time of dyeing led to enhancement the colour intensity.

Also, the data of washing fastness for both unwashed and washed silk fabrics which dyed with natural dyes (onion peel solution) reported in table 5. In all dyeing times both fabrics showed results ranged from well to very well and very well to excellent.

TABLE 5. K/ S value of unwashed and washed silk fabrics dyed with (onion dye solution)

Cod of sample	Time of dyeing min.	K/S value	Alt	Washing fastness		
				St _s	St _w	St _p
Unwashed and dyed	60	7.0	4	4-5	4-5	4-5
Unwashed and dyed	120	7.7	4	4-5	4	4-5
Washed and dyed	60	7.2	4-5	4-5	4-5	4-5
Washed and dyed	120	8.0	4-5	4-5	4-5	4-5

Alt: Alteration the colour, St_s: Staining of silk fabrics, St_w: Staining of wool fabrics, St_p: Staining of polyamide fabrics.

Statistical Analysis of sewing measured seams

The analysis of variance (ANOVA - two factors) was carried on the results, table (6) shows p-values of the effect of testing parameters dyeing time (X1) and stitch density (X2) on the measured properties of the seams.

TABLE 6. P-values of the effect of dyeing time and stitch density on the measured properties.

Property	direction	p-value	
		Dyeing time	Stitch D
Bending length (cm)	Y1 - warp	0.06	0.002
	Y2 - weft	0.02	0.7
Seam Slippage (N)	Y3 - warp	0.07	0.02
	Y4 - weft	0.02	0.007
Seam Efficiency	Y5 - warp	0.5	0.7
	Y6 - weft	0.5	0.2
Seam Strength (Kgf/mm ²)	Y7 - warp	0.9	0.2
	Y8 - weft	0.4	0.2
Seam Elongation (%)	Y9 - warp	0.8	0.07
	Y10 - weft	0.07	0.04

- The stitch density on seam bending length

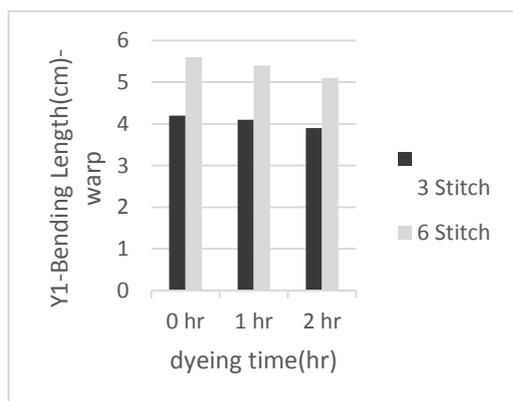


Fig. (1-a) Warp direction

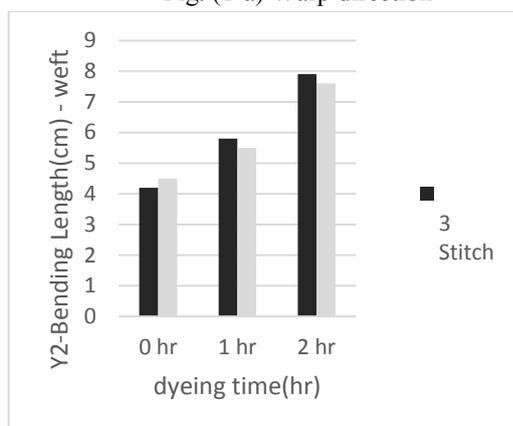


Fig. (1-b) weft direction

Fig. (1) Effect of dyeing time and stitch density on seam bending length

Table (6) clarifies that p-value of effect of dyeing time on the bending length in weft direction (0.002) and in warp direction (0.06), it is clear that dyeing time has significant effect on seam bending length in both weft and warp directions. Also it was found that p-value of effect of stitch density on bending length in warp direction (0.002) that is mean stitch density is effective on seam stiffness in warp direction, but is not significant in weft direction (p-value = 0.7).

From figure (1-a) clear that in warp direction the seam stiffness increases with increasing stitch density in warp direction, but decrease with increasing dyeing time. That is mean this property is improved with increasing dyeing time and decreasing the stitch density. From figure (1-b) clear that in weft direction the seam stiffness improved with decreasing dyeing time, but the stitch density has no effect on seam stiffness.

- The dyeing time and stitch density on seam slippage

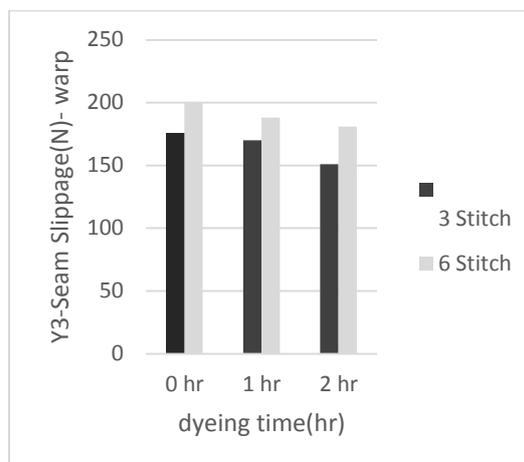


Fig. (2-a): Warp direction

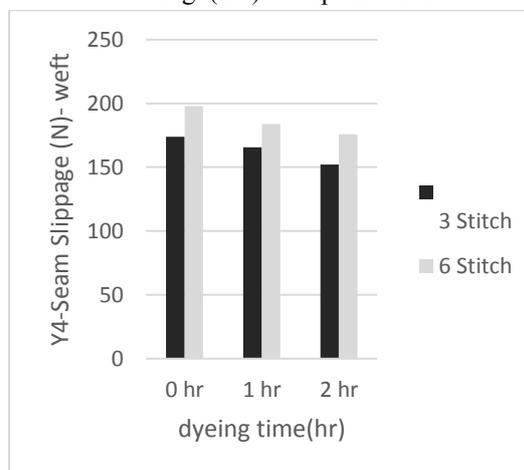


Fig. (2-b): weft direction

Fig. (2) Effect of dyeing time and stitch density on seam slippage in warp and weft direction

From table (6) we find that p-value of effect of dyeing time on seam slippage in warp direction (0.07), and in weft direction (0.02) it is clear that dyeing time has significant effect on seam slippage in warp and weft directions. Also we find that p-value of stitch density on seam slippage in warp direction (0.02), and in weft direction (0.007) it is clear that both of dyeing time and stitch density have significant effect on seam slippage in warp and weft direction.

From figure (2-a) clear that in warp direction the seam slippage is improved at decreasing of dyeing time as well as increasing the stitch density. From figure (2-b) clear that in weft direction the seam

slippage also improved at decreasing of dyeing time and increasing the stitch density.

- The dyeing time and stitch density on seam efficiency

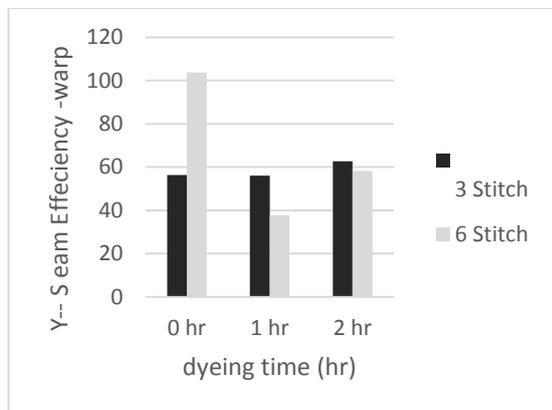


Fig. (3-a): Warp direction

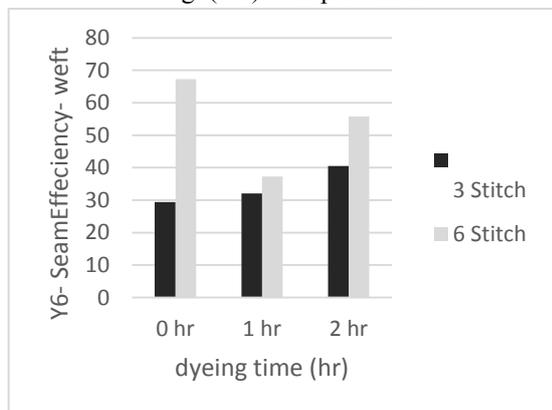


Fig. (3-b): weft direction

Figure (3) Effect of dyeing time and stitch density on seam efficiency in warp and weft direction

It was found that the p-value of the dyeing time on seam efficiency in warp direction (0.5), and in weft direction (0.5). The dyeing time in table (6) has significant effect in both of warp and weft directions. Also we found that p-value of effect of stitch density o seam efficiency in warp direction (0.7), and in weft direction (0. 2) it is clear that stitch density 1s insignificant effect on seam efficiency in warp, but significant weft direction.

Figure (3- a) clears that in the warp direction the seam efficiency is improved at increasing of dyeing time and increasing the stitch density. From figure (3-b) clear that in weft direction the seam efficiency is improved with increasing of dyeing time and increasing the stitch density.

- The effect of dyeing time and stitch density on seam strength

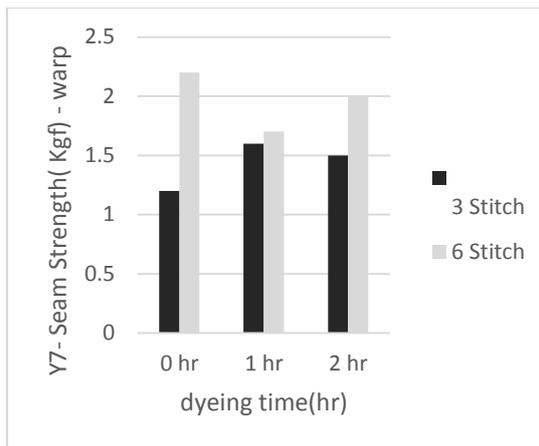


Fig (4-a): Warp direction

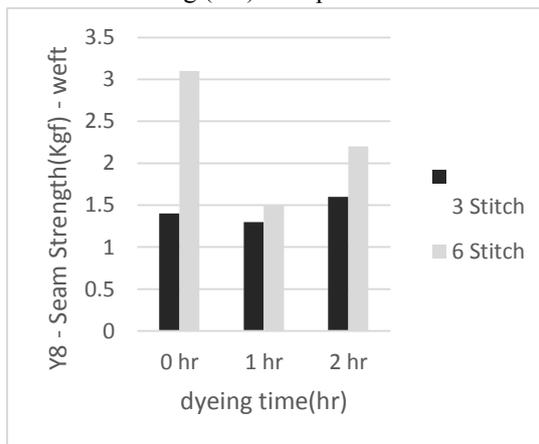


Fig (4-b): weft direction

Figure (4) Effect of dyeing time and stitch density on seam strength in warp and weft direction

From table (6) we find that p-value of effect of dyeing time on seam strength in warp direction (0.9), and in weft direction (0.4) it is clear that dyeing time is insignificant effect on seam strength in warp , but significant in weft direction. Also we find that p-value of effect of stitch density o seam strength in warp direction (0.2), and in weft direction (0. 2) it is clear that stitch density ifs significant effect on seam strength in warp and weft direction

From figure (4-a) it is clear that in warp direction high stitch density is better than lower one for seam strength and better dyeing time is 1 hr. From figure (4-b) clear that in weft direction high stitch density is better than lower one for seam strength, the higher values of seam strength at higher stitch density was at lower dyeing time.

- The effect of dyeing time and stitch density on seam elongation

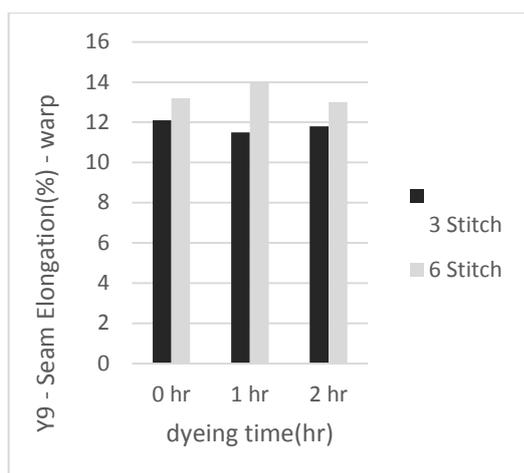


Fig. (5-a): Warp direction

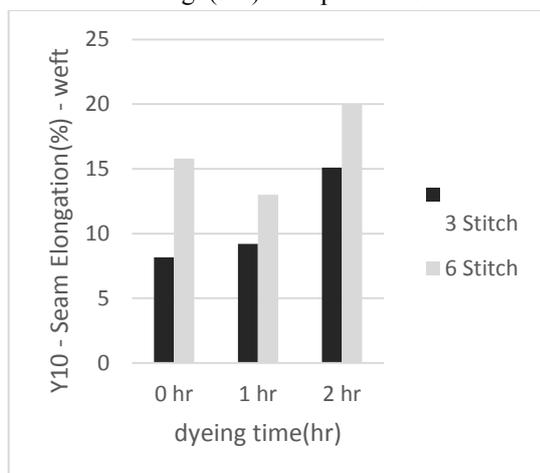


Fig. (5-b): weft direction

Figure (5) Effect of dyeing time and stitch density on seam elongation in warp and weft direction

From table (6) we find that p-value of effect of dyeing time on seam elongation in warp direction (0.8), and in weft direction (0.07) it is clear that dyeing time is insignificant effect on seam elongation in warp, but significant in weft direction. Also we find that p-value of effect of stitch density on seam elongation in warp direction (0.07), and in weft direction (0.04) it is clear that stitch density is significant effect on seam elongation in warp and weft direction.

From figure (5-a) it is clear that in warp direction high stitch density is better than lower one for seam elongation and better dyeing time is the lower. From figure (5-b) clear that in weft direction seam elongation is increasing with the increasing of dyeing time and stitch density.

Conclusions

- 1- The colour strength depended on the time of dyeing as well as washing led to enhancement the colour strength and fastness properties.
- 2- Seam stiffness is improved with decreasing dyeing time and stitch density in both warp and weft direction, the recommended condition at dyeing time hr. and stitch density 3 stitches/cm.
- 3- For seam slippage property the recommended condition at dyeing time 1 hr. and stitch density 6 stitches/cm.
- 4- For seam efficiency property the recommended condition at dyeing time hr. and stitch density 6 stitches/cm.
- 5- For seam strength higher stitch density is better, but Dyeing time not affected on seam strength in warp direction, and the higher values of seam strength in weft direction at higher stitch density was at lower dyeing time so we can dyed on 1 hr. So For seam strength property the recommended condition at dyeing time 1 hr. and stitch density 6 stitches/cm.
- 6- For seam elongation higher stitch density is better, but Dyeing time not affected on seam strength in warp direction, and in weft direction seam elongation is increasing with the increasing of dyeing time and stitch density. So For seam elongation property the recommended condition at dyeing time 2 hr. and stitch density 6 stitches/cm.

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Conflicts of interest

The authors declared that no conflict of interest with respect to the research, authorship and publication of this article.

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دراسة غرزة الحياكة على خصائص الملابس الحريرية المصبوغة بالأصباغ الطبيعية

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تتطلب صباغة ألياف الحرير حرارة عالية مما يضر بخصائص الألياف. يعد استخدام الأصباغ الطبيعية حلاً لهذه المشكلة. و تعتبر معاملات الصباغة والتجهيز والتماس من الخصائص المهمة التي تؤثر على أداء ومتانة الملابس خلال فترة استخدامها. قد تؤثر كثافة الغرز على متانة الملابس ومظهرها في الاتجاه المعاكس على سرعة ماكينة الخياطة. لذلك من المهم دراسة حالة الخياطة الأفضل.

تمت دراسة تأثير مستويين من كثافة غرزة التماس على خصائص الملابس الحريرية المصبوغة بصبغ قشر البصل الصديق للبيئة والمستخلصة بطرية سهلة و بثبات عالي مقاوم للغسيل.

و بتحليل النتائج إحصائيًا استخدمنا تحليل التباين (ANOVA). يتم استخدام نمذجة الانحدار الخطي المتعدد لتحديد تأثير التركيز المختلف للصباغة الطبيعية للبصل، ومعايير النسيج وكثافة الغرز على خصائص الملابس الحريرية.

الكلمات المفتاحية: الياف الحرير و صبغة قشر البصل وكثافة الغرز و تحليل التباين (ANOVA).