EFFECT OF MERCERIZATION TREATMENT ON DYENING EFFICIENCY OF EGYPTIAN COTTON FIBERS OF DIFFERENT MATURITY LEVELS

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Abstract

Six cotton cultivars represent the two Egyptian cotton categories, i.e. extra long staple length (Giza 45, Giza 70 and Giza 88) and long staple (Giza 80, Giza 83 and Giza 89) were used in this study. From each cultivar representative samples of fibers of four grades (maturity% levels) (FG, G, FGF and GF) were dyed with direct and reactive dyes before and after mercerization treatment. The results obtained revealed that differential response between different varieties to dyeing with the dyestuffs utilized in this study. The color strength (K/S) values were the highest when the reactive dyestuff was applied, and followed in descending order by direct dye. Regarding the grades, fully good grade (FG) showed the highest color strength (K/S) value followed by good grade (G), fully good fair grade (FGF) and good fair grade (GF) respectively for mercerized and un-mercerized samples. It is worthwhile to mention that, mercerization treatment increase the dye ability and improve the properties of the samples especially the low grades. The color strength (K/S) values of mercerized fully good faire grade (FGF) increased more than that of the color strength values of un-mercerized fully good grade (FG) of Giza 70, Giza 83 and Giza 89 and nearly equal to Giza 45, Giza 88 and Giza 80 cultivars.

INTRODUCTION

Mercerization is one of the most important processes of finishing cotton materials. It imparts luster to the fiber, increases its hydroscopicity and strength and improves its dye ability, Sadov *et al.* (1973).

Ahmed (1988) reported that, the material should be subjected to the following processes desizing, scouring, mercerizing, bleaching, dyeing and finishing. These processes cause some chemical and physical changes in the fibers which appear at the end as increased or decreased in their chemical and physical properties. Al-Ashwat (1974) reported that changes in the physical and chemical properties of the mercerized fibers are related to changes in structure of cotton fibers. Hatch (1993) reported that, mercerized fibers and fabrics are more absorbent and have greater

affinity for dyestuff. Mercerized fabrics are less expensive to dye because they require only 7/10 as much dyestuff as un-mercerized fabrics to achieve a given shade. Mohamed (2002) showed that, the value of color strength (K/S) for mercerized cotton fabrics which dyed with henna (as a natural dye) was increased compared with un-mercerized cotton fabrics. The same author (2003) studied the chemical composition of six commercial cotton varieties (G45, G70, G88, G80, G83 and G89) and four lint grades from each variety (FG, G, FGF and GF) and reported that, the decrease in micronaire reading was parallel to the decrease of lint grade and cellulose %. These results, however indicate the importance of micronaire reading in relation with chemical properties of cotton fibers. Abdel Aziz *et al.* (1996) reported that, as the micronaire reading increased the wax, soluble sugar and other non-cellulosic material contents of the fibers was decreased .

Gosh (1998) stated that, fiber dye uptake increased gradually with increasing maturity with micronaire values, and also Blanchard and Craves (1995) reported that dye sorption is dependent on the mature of the substrate concerned along with the quality of the cotton particular fiber maturity.

The CIE system is the one most frequently used to describe color in dyed textiles, Tyronel, (1997). L*, a*, and b* defined the viewing angle and other conditions for dyed textile. ΔE is the color difference of the dyed textile that can be calculated according to the following equation:

$$\Delta Ea^*b^* = [(\Delta L^*)^{-2} + (\Delta a^*)^{-2} + (\Delta b^*)^{-2}]^{1/2}$$

Arthur (1998) reported that direct and reactive dyes in aqueous solutions and on cotton were much more sensitive and reactive dyes being much more stable on the fiber. In general, most of the direct dyes were less stable than the reactive dyes, and there was a rough linear correlation between (K/S), and A (regression coefficient = 0.78).

Gulrjani et al. (1993) studied the color components of natural dyes on cotton in terms of L*, a*, b* and ΔE values to give different authentic effects.

The microscopic examination concept defines the empty pore structure on the cotton fiber and the filled one by the dyes used. This method is claimed to be very useful and give excellent shade sorting results, Mclaren (1987).

MATERIALS AND METHODS

The materials in the present study included six commercial Egyptian cotton varieties (Giza 45, Giza 70, Giza 88, Giza 80, Giza 83 and Giza 89) and four lint grades

secured from each variety (four maturity % levels), in descending order fully good (FG), good (G), fully good fair (FGF) and good fair (GF). These samples were taken from yield of season 2002-2003. The maturity % and micronaire readings of these materials shown in Table (1) were measured according to ASTM D: 1448-97 (1998).

Table 1. Maturity % and micronaire reading of six commercial cotton cultivars.

Samples	Giza 45		Giza 70		Giza 88		Giza 80		Giza 83		Giza 89	
Lint grad	M.R	M%	M.R	M%	M.R	M%	M.R	M%	M.R	M%	M.R	M%
Fully Good	3.08	95.5	4.12	94.0	4.08	93.6	4.61	98.4	3.86	95.9	4.25	95.8
Good	2.65	87.2	3.26	93.5	3.24	89.0	3.44	89.3	3.41	92.4	4.00	93.5
Fully good fair	2.48	83.1	3.12	90.9	3.12	87.3	3.12	88.1	2.53	85.6	2.46	91.0
Good fair	2.00	70.9	2.48	89.9	2.95	82.7	2.72	84.0	2.39	81.7	2.53	90.5

M. R= micronaire reading, M% = maturity percent

The lint of each sample was divided into two parts, the first part was scoured by using 3% NaOH, and the second part was scoured also and then subjected to slack mercerization according to Al-Ashwat (1974). Each of mercerized and un-mercerized fibers was dyed with (Sirius Yellow K-GRL, CI 58) and (Remazol Yellow) as direct and reactive dyes respectively according to Tortman (1988).

The color strength (K/S), and the color parameters (L*, a*, b* and Δ E), were measured by using the Win lab Software of the Perkin Elmer, Lambda 35 Spectrophotometer using integrated sphere, according to ASTM (1993) D: 2288.

Fiber cross- sections were used to study the differential response between different varieties and different grades to dyeing with the dyestuffs used in this study and effect of mercerized treatment by using a light microscope with photo camera under 800X magnifications, according to AATCC, 20-(1976).

RESULTS AND DISCUSSION

Color strength

As shown in Tables 2 ,3 and Figure 1 it is quite obvious that, generally in all cases the color strength (K/S) values of mercerized fibers were higher than the color strength of un-mercerized fibers of either direct or reactive dyes utilized in this study. This result is in agreement with Sadov *et al.* (1973), Hatch (1993) and Mohamed (2002). However, generally color strength (K/S) values were the highest when the reactive dyestuff was applied and followed in descending order by direct dye. This result is in accordance with that reported by Arthur, (1993).

Regarding the four grades (four maturity % and micronaire reading levels) fully good grade (FG) showed the highest color strength value, followed by good grade (G), fully good fair grade (FGF) and good fair grade (GF). This may be due to decrease in maturity % and micronaire reading which parallel with decrease of lint grades and cellulose %, so the dye ability was change from grade to other, this result was in agrees with Ghosh (1998), Blanchard and Craves (1995) and Mohamed (2003). However it is worthwhile to mention that, mercerization treatments increase the dye ability of low grades. These results were confirmed by the microscopic examination of the fiber cross sections as shown in (Fig.3) .

Nevertheless, it is rather interesting to mention in this concern that there were differential response between different varieties to dyeing with the dyestuffs utilized in this study that may be dependent on the chemical characteristics and the structure of fibers. The values of K/S has the highest for Giza 89 than that Giza 80 this is due to the increase in maturity % and micronaire reading with the increase of lint grade and cellulose content %. The highest K/S values for the reactive dye is much more than that of the direct dye. Bonding direct dye with cellulose fiber is mainly dependent on the primary hydroxyl groups of cellulose, but in reactive dye the fixation of dye dependent on chemical combination with the fiber forming cellulose ethers (remazoles), and it is due to specific structure of reactive group carriers.

Figure 1. showed that the color strength (K/S) value of the of mercerized fully good fair grade (FGF), increased more than that of the color strength (K/S) value of

the un- mercerized fully good grade (FG), of Giza 70, Giza 83, and Giza 89, and nearly equal to Giza 45, Giza 88, and Giza 80 cotton fibers which used in this investigation.

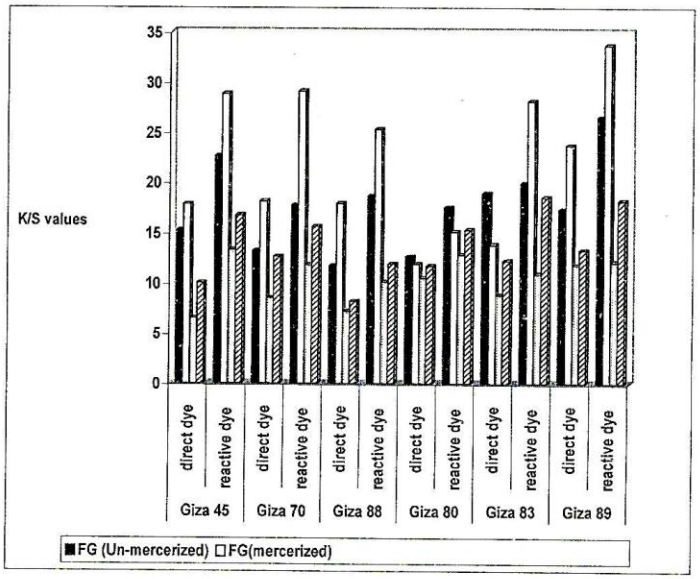


Figure 1. Effect of the mercerization treatments on the dyeing response of Egyptian cultivars grades

Table 2. The color strength (K/S) values of un-mercerized and mercerized fibers dyed with direct and reactive dyestuff.

Varieties	Giza 45				Giza 70				Giza 88				Giza 80				Giza 83				Giza 89			
dyes	Direct dye		Reactive dye		Direct dye		Reactive dye		Direct dye		Reactive dye		Direct dye		Reactive dye		Direct dye		Reactive dye		Direct dye		Reactive dye	
Lint grades	K/S*	K/S**	K/S*	K/S**	K/S *	K/S**	K/S*	K/S**	K/S*	K/S**	K/S*	K/S **	K/S*	K/S **	K/S*	K/S**	K/S *	K/S**	K/S*	K/S**	K/S *	K/S**	K/S*	K/S**
FG	15.2	17.8	22.6	28.8	12.6	18.1	15.6	29.1	11.7	17.9	18.6	25.3	12.6	17.5	18.9	23.8	12.2	18.7	18.5	28.1	13.3	23.7	18.2	33.7
G	10.7	16.9	20.1	21.2	11.3	17.3	18.5	27.3	9.8	13.2	12.9	19.8	11.9	15.1	13.7	18.1	11.1	17.6	18.1	28.6	13.1	21.3	13.8	31.6
FGF	6.5	10	13.3	16.7	8.5	13.2	11.8	17.7	7.2	8.2	10.1	11.9	10.5	11.7	12.8	15.3	8.8	13.5	10.9	19.9	11.8	17.3	12.1	26.5
GF	7.8	12.1	16.5	19.6	10.9	15.8	13.1	19.8	7.7	9.7	10.8	13.1	11	14.3	13.1	16.9	10.3	16.9	13.8	21.7	11.8	19.9	12.9	29.9

K/S*, ** = Color strength for un-mercerized and mercerized samples respectively

Table 3. Percentage change in color strength (K/S) values after mercerized fibers which dyed with direct and reactive dyestuff.

Varieties	Giza 45		Giza 70		Giza 88		Giza 80		Giza 83		Giza 89	
Type of dye	Direct dye	Reactive dye	Direct dye	Reactive dye	Direct dye	Reactive dye	Direct dye	Reactive dye	Direct dye	Reactive dye	Direct dye	Reactive dye
Retention	±%	±%	±%	±%	±%	±%	±%	±%	±%	±%	±%	±%
FG grade	17.10	27.43	37.12	86.53	52.99	36.02	38.88	25.92	38.50	41.20	36.99	27.17
G grade	57.94	5.47	53.09	47.56	34.69	53.48	26.89	32.11	58.55	58.01	62.59	128.98
FGF grade	55.12	18.78	44.95	51.14	25.97	21.29	30.00	29.00	64.07	57.24	68.64	131.78
GF grade	53.84	25.56	48.20	50.00	13.88	17.82	11.42	19.53	38.60	69.70	12.70	50.41

Color components

According to the uniform color scale (CIELAB), Fig 2. Represents the color components (L*= lightness-darkness, a* = redness-greenness and b* = yellowness-blueness) value.

From Tables 4, 5 regarding the four grades, fully good grade (FG), showed the lowest L* value followed in descending order by good grade (G), fully good fair grade (FGF) and good fair grade (GF) respectively. This may be due to the high absorption of the dye on the fiber, decreasing the whiteness of the fiber and increase the darkness (the color) of that fiber. These results were confirmed by the uniform color scale (CIELAB). The L* value decreased in the following order after the mercerization treatment FG < G < FGF < GF. These results are in agreement with the results obtained by Ghosh (1998), and followed the uniform color scale (CIELAB).

The minimum values of a* of Tables 4, 5 are due to the use of the yellow color of either the direct or the reactive dye, which lie in the opposite angle of the b* axis as shown in Figure 3. The results obtained show that a* value was nearly the same for the four grades in both un-mercerized and mercerized treatments of all cultivars used in this study.

The maximum values of b* of Tables 4, 5 are due to the use of the yellow color of either the direct or the reactive dye, which lie in the yellowness axis as shown in Figure 3. The results obtained show that b* value was increased for the four grades in both un-mercerized and mercerization treatments of all cultivars used in this study.

The values of ΔE (the color difference of the dyed textile), from Table 4, and Table 5 indicated that the mercerization treatment improves the dyeing efficiency for the grades of the cultivars used in this study.

Table 4. The color components L*, a*, b* and ΔE of un-mercerized and mercerized fibers after dyed with direct dyestuff.

Cotton variety	Giza 45				Giza 70				Giza 88				Giza 80				Giza 83				Giza 89			
Grades	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF
L*	69.8	78.7	75.6	78.6	67.9	71.3	73	77.3	67.6	76.6	79.1	76.3	73.8	78.9	79.2	77.6	73.8	79.7	88.2	82.5	67.1	71.8	78.8	76.2
L**	67.5	70.7	73.1	72.9	63.8	70.9	69	72.6	67.7	75.7	76.5	75.8	73.1	72.1	78.6	78.3	70.3	72.6	78.9	72.8	62.1	66	69.8	67.1
a*	10.8	10.1	8.63	8.78	9.09	8.71	7.78	6.98	10.8	9.23	5.78	6.28	10.2	9.85	7.01	8.56	9.58	9.55	9.21	9.55	9.66	9.13	8.66	5.89
a**	12.2	11.9	9	9.1	10.2	9.8	8.8	7.1	11.1	9.8	6	6.7	12	10.1	8.8	9.7	10.1	10	10	10	10	9.5	7.8	8.5
b*	92.5	92.3	90	91.1	93	92.7	92	91.6	92.6	92.8	93.8	92.1	85.6	85.8	88.1	88.7	98.3	93.1	92	92.7	95.6	98.8	93	93.7
b**	93.	93.1	93	98.1	92.8	92	93	93.1	93.8	93.2	93	92.3	91.2	90.2	90.1	90.5	87	86.1	88.9	85	97.8	96.9	95.8	96.1
ΔE*	16.9	17	16.9	17.4	17.1	16.8	16.9	17	17.2	16.9	16.9	17.1	16.6	16.5	16.4	16.5	15.7	15.6	15.8	15.3	17.3	17.2	17.4	17.2
ΔE**	16.7	16.8	16.2	16.5	15.8	16.3	16.7	16.6	17.6	16.8	16.7	16.8	16.1	16	16.4	16.4	15.7	15.4	15. 5	15.1	17.2	17	17.1	17

L* = Lightness value for un-mercerized (*) and mercerized (**)samples respectively
a* = (redness-greenness) value for un-mercerized (*) and mercerized (**) samples respectively
b* = (yellowness-blueness) value for un-mercerized (*) and mercerized (**)samples respectively
ΔE* = Color difference for un-mercerized (*) and mercerized (**)samples respectively

Table 5. The color components, L*, a*, b* and ΔE of un-mercerized and mercerized fibers after dyed with reactive dyestuff.

Cotton variety	Giza 45				Giza 70				Giza 88				Giza 80				Giza 83				Giza 89			
Grades	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF	FG	G	FGF	GF
L*	60	61.8	66.2	63.5	59.8	61.5	66.3	68.2	61.2	63.5	66.9	65.1	60.8	62.7	67.7	68.2	61.5	63.2	67.7	66.8	88.7	50.1	53.8	53.2
L**	50.3	52.6	58.9	52.8	53.8	60.9	62.6	59	52.6	56	59.9	57.8	57.1	55.7	56.5	55.8	53.1	52.1	58.6	58.3	87.5	50.7	53.1	52.9
a*	2.75	2.59	2.85	2.86	3.12	2.98	2.63	2.73	2.72	2.61	2.81	2..5	10.8	9.23	9.78	9.28	2.95	2.78	2.61	2.65	3.0	2.85	2.66	2.71
a**	2.1	2.1	2.8	2.8	2.2	2.8	2.1	2.8	1.8	2.5	2.8	2.5	11.1	9.1	9	9.7	2	2.1	2.8	2.7	2.2	2.9	2	2.1
b*	93.8	89.7	82.3	82.5	93.3	87.9	88.5	87.3	96.7	93.8	91.8	91.6	87.1	76.6	72.1	79.3	83.8	82.9	78.1	88.2	93.9	93.7	88.8	89.8
b**	87	86.1	88.9	85	92.8	92	93.1	93	98.7	99.6	97.8	97.1	93.8	93.2	93	92.3	91.2	90.2	90.1	90.5	93.	93.1	93	98.1
ΔE*	17.7	17.6	17.4	17.3	17.6	17.5	17.7	17.8	17.9	17.8	18	17.8	17.8	17.2	17.3	17.7	17.2	17.3	17.2	17.8	17.9	17.1	17	17.1
ΔE**	16.7	16.8	16.8	16.8	17.8	17.3	17.6	17.7	17.5	17.8	18	17.7	18	17.8	17.7	17.8	17.1	17	17.4	17.4	17.7	17.8	17.2	17.5

L* = Lightness value for un-mercerized (*) and mercerized (**) samples respectively

a* = (redness-greenness) value for un-mercerized (*) and mercerized (**) samples respectively

b* = (yellowness-blueness) value for un-mercerized (*) and mercerized (**)samples respectively

ΔE* = Color difference for un-mercerized (*) and mercerized (**)samples respectively

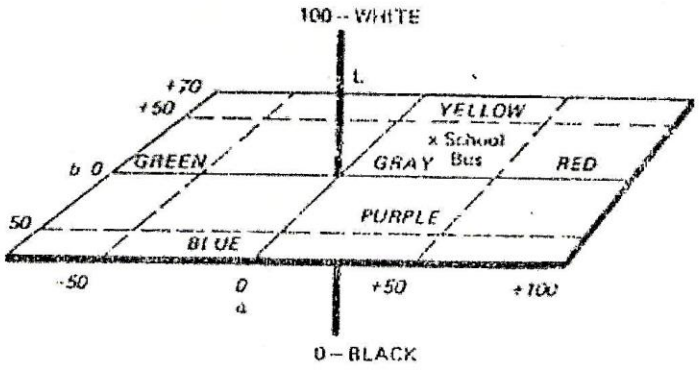
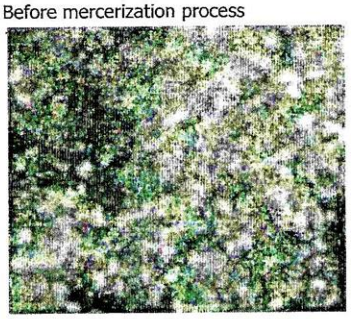


Figure 2. The uniform color scale (CIELAB)

Fiber cross-section

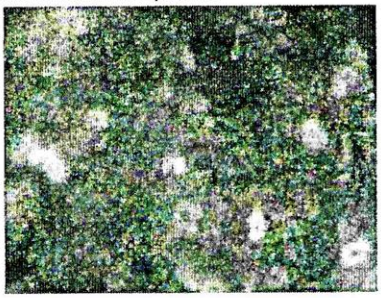
Microscopic examinations (cross section) illustrates the differential response between different varieties of the cotton samples used (grade Good), to dyeing with reactive dyestuff as shown in Fig. (3). We found that the mercerized Giza 89 fibers showed more response to dyeing followed by Giza 83, 70, 45, 88, and 80 respectively, this differential response is due to the genetic structure of varieties. It is worthwhile to mention that, the mercerized dyed samples were more deep in color than un-mercerized samples. The is due to the main object of mercerization is rearrangements of the units in the cellulose macromolecule interacting with water and increase the pores size 50-80% (swelling effect) Sadov *et al.* (1973) and improves the dye ability of mercerized cotton fibers. Hatch (1993).

Before mercerization process



G45 Good

After mercerization process



G45 Good

Figure 3. The cross section of mercerized and un-mercerized cotton fibers dyed with reactive dyestuff.

CONCLUSION

The results of our study showed differential response between different varieties to dyeing with the dyestuffs utilized. The color strength (K/S) values were the highest when the reactive dyestuff applied, and followed in descending order by direct dye. Regarding the maturity % levels (four grades) fully good grade (FG) showed the highest color strength (K/S) value and followed by good grade (G), fully good fair grade (FGF) and good fair grade (GF) respectively for mercerized and un-mercerized samples. It is worthwhile to mention that, mercerization treatment increases the dye ability of the samples especially the low grades. K/S value of the un-mercerized samples with the direct dye has the following order Giza 45 > Giza 89 > Giza 80 > Giza 83 > Giza 70> Giza 88, the mercerized samples has the following order Giza 89> Giza 83 > Giza 80 > Giza 70 > Giza 85> Giza 88. K/S values of the un-mercerized samples with the reactive dye have the following order Giza 45 > Giza 70 > Giza 88 > Giza 80 > Giza 83> Giza 89, the mercerized samples have the following order Giza 89> Giza 70> Giza 45 > Giza 83 > Giza 88> Giza 80. Giza 89 has the highest K/S value after mercerization process dyed with either direct or reactive dye. Microscopic examinations showed that the coloring of mercerized fiber is more uniform and deeper than that of the un-mercerized samples. the color strength (K/S) values of the of mercerized fully good fair grade (FGF), increased more than that of the color strength (K/S) values of the un- mercerized fully good grade (FG), of Giza 70, Giza 83, and Giza 89, and nearly equal to Giza 45, Giza 88, and Giza 80 cotton fibers used in this investigation.

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تأثير معاملة المرسرة على كفاءة صباغة بعض أصناف القطن المصري ذات مستويات النضج المختلفة

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معهد بحوث القطن – مركز البحوث الزراعية – جيزة – مصر

يهدف هذا البحث إلى دراسة تأثير معاملة بعض أصناف القطن المصري ذات مستويات النضج المختلفة بهيدروكسيد الصوديوم (عملية المرسرة) وتأثير ذلك على القابلية للصبغ بالصبغات المباشرة (صبغة الريمازول الصفراء) والنشطة (صبغة سيريز الصفراء). وقد استخدمت ستة أصناف من الأقطان المصرية " ثلاث أصناف فائقة الطول (جـ٤٥، جـ٧٠ ، جـ٨٨) و ثلاث أصناف طويلة التيله (جـ٨٠، جـ٨٣، جـ٨٩) " . حيث استخدم من كل صنف أربع رتب هي بالترتيب (فولى جود ــ جود ــ فولى جود فير ــ جود فير) . وقد تم قياس درجة عمق اللون للصبغة للعينات المعالجة بالصودا الكاوية، وكذلك قياسات اللون المختلفة (L, a, b, ΔE). وكما أجرى الفحص الميكروسكوبي للقطاعات العرضية للألياف المصبوغة قبل وبعد المرسرة.

وتتلخص النتائج التي امكن التوصل اليها فيما يلى :

١. كان الترتيب التنازلى لدرجة عمق اللون (شدة الصبغ) لعينات الاصناف القطنية المصبوغة بالصبغة المباشرة قبل المرسره كالاتى : جيزة ٤٥ – جيزة ٨٩ – جيزة ٨٠ – جيزة ٨٣ – جيزة ٧٠ – جيزة ٨٨. وللعينات المصبوغة بعد المرسرة جيزة ٨٩– جيزة ٨٣ – جيزة ٨٠ – جيزة ٧٠ – جيزة ٤٥ – جيزة ٨٨

٢. اتضح ان كان الترتيب التنازلى لدرجة عمق اللون (شدة الصبغ) لعينات الاصناف القطنية المصبوغة بالصبغة النشطة قبل المرسره كالاتى : جيزة ٤٥ – جيزة ٧٠ – جيزة ٨٨ – جيزة ٨٠ – جيزة ٨٣ – جيزة ٨٩. وللعينات المصبوغة بعد المرسرة جيزة ٨٩– جيزة ٧٠ – جيزة ٤٥ – جيزة ٨٣ – جيزة ٨٨ – جيزة ٨٠.

٣. وجد من القحص الميكرسكوبى للقطاعات العرضية للالياف الفطنية موضع الدراسه ان امتصاص الصبغات قد ازداد بعد عملسة المرسرة ووجد ان الصنف جيزة ٨٩ من اكثر الاصناف استجابة للصباغة سواء بالصبغة المباشرة او الصبغة النشطة بعد عملية المرسرة . ووجد أن استجابة الالياف القطنية للصبغة النشطة اعلى بكثير من استجابتها للصبغة المباشرة سواء قبل او بعد المرسرة.

٤. خلصت هذة الدراسة الى وجود اختلافات صنفية بالنسبة للاستجابة للصبغ بالصبغتين موضع الدراسة المباشرة (صبغة الريمازول الصفراء) والنشطة (صبغة سيريز الصفراء) قبل و بعد عملية المرسرة . وادت معاملة

الالياف القطنية بالصودا الكاوية (عملية المرسرة) عموما الى رفع كفاءة امتصاص الالياف القطنية للصبغات وقد تحسنت ايضا بدرجة جيدة قابلية الالياف ذات مستويات النضج المنخفضة مثل رتبة فولى جود فير والجود فير للصبغ مما يرفع من العائد الاقتصادى لها .