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Dyeing of cotton yarns using natural dyes for carpets and rugs

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Abstract

THE objective of this study was to produce carpets and rugs from 100% Egyptian cotton yarns as a natural fiber and sustainable inexpensive alternative to other textile fibers, such as wool, dyed with natural dyes extracted from Henna and Tea leaves. Pre-mordanting was done using different mordents namely; Alum, Iron (III) Chloride, Iron (II) Sulphate, Copper (II) Sulphate and Iron (II) Sulphate/Zinc Chloride ($ZnCl_2$). Different color shades of these natural dyes were represented by using different kinds of mordants, even for the same natural dye used. The effect of different mordants on dyeing performance in terms of color measurements; L*, a*, b*, C*, h° and K/S as well as color fastness to wash, perspiration and light were evaluated. The results obtained showed satisfactory fastness properties and an improvement of the cotton dyed properties.These results were very important in industrial applications for the production of carpets and rugs from eco-cotton yarns dyed with natural dyes at a low cost.

Keywords: Natural dyes; cotton yarns; mordant; Carpets, Rugs.

Introduction

Textiles are used for wear and also for many other applications, as carpets and rugs which add style and comfort to our houses. [1] Carpet is a type of textile floor covering that is soft to walk on, easy to maintain, and has a sumptuous appearance composed of natural and synthetic fibers with a top layer of pile. The type of fiber used to form surface yarns is commonly used to classify carpets. [2, 3]

Cotton is a natural eco-friendly material; its fibers are soft, and strong. Exhibit excellent hydrophilic character and has a great affinity for dyeing due to the presence of a large amount of OH^- groups. [4] Cotton has always been a popular choice for textiles. Nowadays, cotton rugs remain popular, Cotton is a natural fiber, inexpensive alternative to wool. Cotton rugs are sturdy yet soft and some can even be cleaned in the washing machine, making them very easy to clean. So, cotton rugs are commonly used in high traffic areas such as doorways, kitchens, and bathrooms. Cotton fibers are soft, strong and effectively dyed. Cotton rugs are hypoallergenic, making them an excellent choice for households with allergy sufferers these characteristics make cotton a popular choice for rugs and carpets. [5]

Generally, cotton mats, rugs, and carpets are inexpensive, but compared to the mass produced, they are a little bit more expensive. Cotton returned to the carpet trade in the region. Demand has increased in the past few years mainly due to yarn developments that have made cotton fiber in yarn form more resilient and reduced surface shedding when made into rugs.

The use of dye stuffs is as old as textiles, which are obtained from two main sources: natural dyes and synthetic dyes. Natural dyes are sustainable, biodegradable and environmentally friendly. These dyes both were obtained from plants, animals, and minerals. Most of these dyes are substantive and therefore do not require mordant to fix the molecules on fibers but mordant are sometimes used to increase the strength of color and change the shade range of the natural dye. The addition of mordants acts as a link between the dye molecules and the amorphous parts of the fiber [5-8]. [6-10]

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Compared to natural dyes, synthetic dyes have become commonly used due to cheaper costs and a wide variety of vibrant colors with dramatically enhanced color fastness properties. However, all the natural dyes were suitable for humans, and these dyes did not harm the skin. Furthermore, they aren't toxic compared to synthetic dyes. Needless to say, many synthetic dyes have been forbidden since they induce allergy or carcinogenicity-like symptoms. [11] However, natural dyes are less toxic, non-pollutant, less of a health hazard, very brilliant, a rare color idea, and cause allergic reactions [10,11]. [12-17]

Another major contributing factor is in dyeing and finishing maintaining color fastness, better cleaning, and flame retardancy. However, in recent years, Cotton Incorporated has worked with textile and carpet companies to develop rugs and broadloom carpets made of 100% cotton yarns. The technology of dyeing rugs and carpets can be adapted successfully from pastel to very bright colors and many dyestuffs have affinity for the cellulosic fibers. Generally, the dyeing process is applied in an aqueous solution with mordant to improve the dye fastness. [18] At the beginning of the new millennium, many changes came into the lives of mankind. One of them is going to be the shift towards natural dyes mainly due to the consequences of increased international awareness of environmental and ecological preservation, in addition the color fastness which is important for all textiles. [19] Recently, more interests have been devoted to the use of natural dyes and a limited number of commercial organic and natural dyes have been produced. Some studies have been done to evaluate the possibilities of using natural dyes for dyeing and printing of textiles. [20]

Henna (Lawsonia inermis) is a flowering plant used traditionally to dye skin, hair, fingernails, leather and wool. Henna leaves are the most commonly used for dye extraction. Henna produces a brown color tending to red-orange on protein fibers, while on cellulosic fibers henna yields light yellow greens. Studies were carried out on both extraction and application of henna dye in textile fibers along with the standardization and simplification of dyeing techniques. [21] The dye component was extracted and handling on silk fibre for the sake of clarity of the dyeing characteristics, e.g., dyeability, fastness etc. It has been shown that the amount of dye absorbed by silk fibers decreases with increasing dye concentration. Similarly the absorption of dye was increased with the decrease of dye concentration. [7] The application of henna dye in the coloration of textiles is conducted for both natural and man-made textile fibers. [22] Dutta et al, explored the dyeing possibility and the fastness qualities of dye extracted from henna leaves on cotton fabric compared to reactive dyeing. [6] The coloration of polyester fiber with natural dye henna at a high temperature and pressure with the prospect of a mordant-free dyeing has been extensively investigated. [23] Alkaline hydrolysis of polyester fabric and dyeing with natural colorants extracted from Henna leaves was investigated. [24] The alkaline conditions for extraction of natural dye from Henna leaves were optimized and the resulting extract was used to further optimize its dyeing conditions on cotton by exhaust method. [25] A comparison was made between dyeing without using mordants and dyeing with pre-mordanting and post-mordanting with alum and iron. It was found that dyeing produced with alkaline extracts of Henna leaves have better colour strength than dye extracts obtained in distilled water.

Tea natural dye extracted from tea leaves is a kind of polyphenols and flavonoids as catechins make up to 27% of the composition of unoxidized green tea; reduced in black tea to around 4% after oxidation process. Tea leaves extract being an important natural dye which has almost such potent metabolic compounds that have strong antimicrobial, anticancer, antioxidant and antifungal activity and is widely used as medicine for the treatment of various diseases. [26] Its leaves are rich in polyphenolic compounds including flavonoids, Catechin, quercetin, Kaempherol, rutin, gallic acid, and phenolic acid, where catechin is the main coloring pigment that impart brown color onto fabrics. The oxidation products of catechins in black tea are polyphenols, which provide the tea both color and flavour. They are considered the main component of tea extract and has many health benefits and functionalities, such as antibacterial activity and UV protection. [26] Previous studies have reported that the pH value of the tea extract dye bath had a strong effect on apparent color and color strength and possessed good rubbing and washing fastness. [27, 28] Hosseinnezhad et al. (2023) investigate the eco-friendly dyeing of cotton fabric using extracts from used tea bags, and the intricate relationship between pH levels and fabric cationisation, exploring their combined impact on the functional properties of naturally dyed cotton samples. [5] The polyphenols in black tea are divided into two categories: aflavins and arubigens, which are a large group of polymeric polyphenols. Both of these groups contribute towards the orange-red coloration of tea as well as to the taste. [29]

The purpose of this investigation aims to use 100% Egyptian cotton yarns to produce carpets and rugs with natural dyes from Henna, and Tea. Premordanting technique with different mordants was used for the production in low-cost dyeing conditions without harming the physical properties of yarns or the fastness properties of dyes.

Experimental

Materials

A long-staple Egyptian cotton variety of Giza 95 was used in this study. The cotton was spun into coarse combed ring yarn to suit its use in carpet performance. TPM for spinning: 500, TPM for Twist: 300, Spinning machine model; Zinser 350, Twist machine model: MoraticDoubling machine model: Moratic. Cotton spinning and yarn physical and mechanical tests was carried out at Misr Shebin El-Kom Textile Company.

Fiber upper half mean (UHML) (mm), fiber uniformity index (UI), Fiber SFI %, micronaire value, fiber maturity ratio, fiber strength (g/tex), the percentage of fiber elongation, fiber reflectance degree (brightness) (Rd %) , and fiber yellowness degree (+b) and fiber trash (count, Area %) were measured using HVI instrument under standard conditions of relative humidity (65%±2) and room temperature (21°C±2) in the laboratory of the Cotton Research Institute, Giza, Egypt according to the American Society for Testing and Materials (ASTM., 2012). The data of fiber and yarn tests are illustrated in Appendix 1: A, B, and C.

Chemicals

All chemicals used in this study were of analytical grade. Sodium hydroxide, Sodium silicate, Sodium carbonate, Magnesium sulphate, acetic acid, hydrogen peroxide, Chloroform**,** Triton X100 (wetting agent), Mordants**;** Alum, Iron (III) Chloride, Iron (II) Sulphate, Copper (II) Sulphate and mixture of Iron (II) Sulphate /Zinc Chloride ($ZnCl_2$).

Natural Dyes

Henna leaves are harvested from the shrub *Lawsonia inermis*. The leaves were dried and ground into a powder. The main dyeing component is Lawsone, or 2-hydroxy-1,4-naphthoquinone (HNQ). [30] The chemical structure was represented as shown in Fig.1.

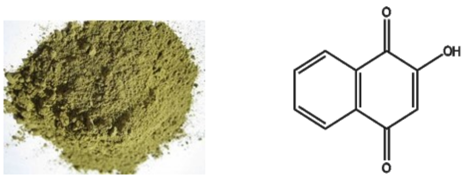


Fig 1. Chemical structure of Henna

Tea leaves are the commonly used for the pigment extraction. The chemical structure was representing as shown in Fig. 2

Scouring and bleaching treatments

Cotton yarns was scoured with a solution containing 3% sodium hydroxide and 0.5 cm^3/l wetting agent, the L: R was 1:50 for 90 min at boiling degree, For caustic scouring pH value was 10.5 .then the scoured yarns were bleached with a solution containing 1.5 g/l sodium hydroxide,0.4 g/l sodium silicate, 0.2 g/l Magnesium sulphate, 0.2 g/l sodium carbonate and 1 ml/l wetting agent with L: R was 1:50 after boiling H_2O_2 was added for 1 hour in closed condition. Bleaching with hydrogen peroxide (H_2O_2) carried out under alkaline conditions (pH 11–12). After treatment, the bleached samples were taken out, washed and dried.

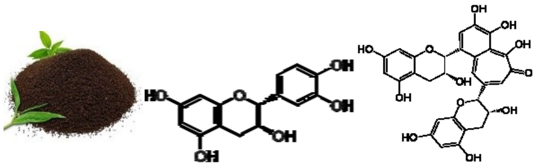


Fig 2. Chemical structure of Tea

Henna dye extraction process

Henna powder (50 gram) was taken in NaOH solution with a liquor ratio 1: 50 for 24 hours in ambient temperature with the pH level of 8-9. The henna solution was reddish orange color. Alkaline reddish orange color solution of henna was mixed with acetic acid to make the pH neutral. Chloroform (5ml) was added to the solution to protect it. The solution was kept in air till chloroform was evaporated. The color bearing extract was used to dye the cotton yarn samples.

Tea dye extraction process

Tea powder (50 gram) was taken in acetic acid solution for 12 hrs. The solution with a liquor ratio 1: 50 was boiled for 60 minutes to provide a high color extract. The tea solution was adjusted to pH level of 7-8. The color obtained extract was used to dye the cotton yarn samples.

pre-Mordanting

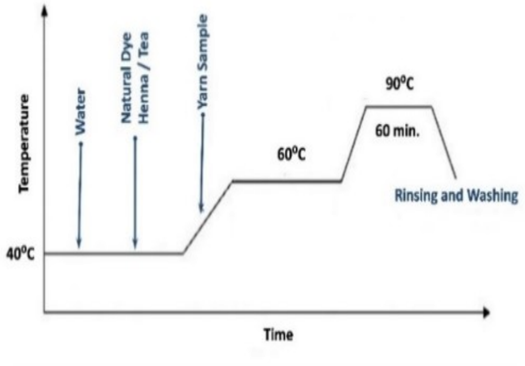
Pre-mordanting method was carried out using 0.2% (w/w) concentration of mordant solutions (alum, ferric sulphate, ferrous sulphate, copper sulphate and zinc chloride with ferrous sulphate) carried out at 90^{o}C for 60 minutes at a liquor ratio of 1:40. The cotton yarn samples were then dried in the oven at 130°C, for 5 min.

Dyeing processes

A common procedure is used for dyeing each sample of pre-mordanted cotton yarns as shown in the dyeing chart. Then, all dyed yarns were washed with 2 g/L of soap for 15 minutes at 50^{o}C, rinsed with tap water and dried at room temperature. All the dyeing process of the two kinds of extracted natural dye using different mordant carried out according to the dyeing curve shown in Schematic 1. For comparison, all the cotton yarns were dyed also without mordant.

Color measurements of the dyed cotton yarns:

Color measurements of the dyed samples such as; CIE L*, a*, b*, c*, h and K/S values were conducted with Perkin Elmer spectrophotometer, using the reflectance data in a visible spectrum between 400 and 700nm wavelengths with 20nm interval under an illuminant D65/10° standard observer with the specular component included In CIE L*a*b* and CIE L*C*h color systems.



Schematic 1. Chart of dyeing processes

The color strength expressed as K/S 'K' and 'S' are absorption and scattering coefficients of dyed sample. Relative color strength (%) is calculated from reflectance, R using Kubelka-Munk equation as follows: [31, 32]

$$K/S = (1-R)^2/ 2R.$$

Fastness measurements

The color fastness which is determined by grey-scale testing, either by removing the color from the original sample or by staining adjacent white material. Wash fastness testing of the dyed samples was done by the standard method ISO-105-C10: (2015). [33] Light fastness of the dyed samples was tested on Q-Sun Xenon Test Chamber by the standard method ISO 105 B02: (2014) [34]. Perspiration fastness of the dyed samples was measured on respirometer by the standard method ISO 105 E04: (2013). [35]

Statistical procedure

The analysis of Variance (ANOVA) statistic was performed by SPSS software version 16. P value less than 0.05 was considered significant.

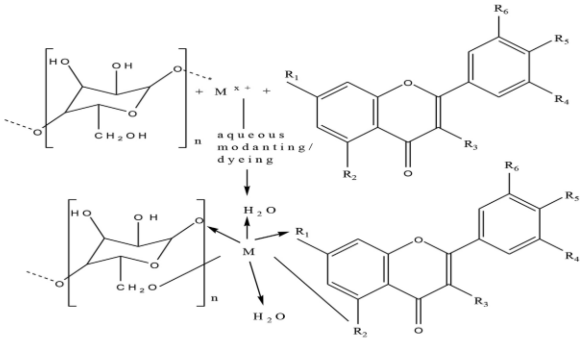
Results and discussion

Effect of mordants on dye uptake of cotton yarns

Most natural dyes usually require chemicals called mordants to produce color fastness on textiles. Mordants, as some metal salts help the fixation of dyes to the fiber by forming a chemical bond between the fiber and the dye has a direct effect on the amount of color strength and fastness.

Metal pre-mordanting of cotton yarns improved their color strength through the formation of fiber–metal–dye coordination complex as described in schematic 2, [36]

All dyed cotton samples have different color shades from light to dark shade with different mordants as shown in Figure 3. As cotton fibers can be dyed by coordination bonding of cellulose molecules to natural dyes with the aid of various metal ions [33], it was of interest to determine whether this process could also be used to apply mordant dyes to cotton.



Schematic 2. Reaction mechanism of cotton fibers with inorganic metals

Fig. 3: Shades obtained with natural dye extract (Henna & Tea) on cotton yarns

Color strength values (K/S) of the samples are given in Figures 4, and 5. It was seen that the samples without mordant gave the lowest K/S value 0.8, where the maximum value of K/S was given by using Iron (II) sulphate 4.8, and 4.6 for Hanna, and Tea extract dye respectively.

The color strength (K/S) results for the both extracted dyes indicate that Iron (II) sulphate gave a greater depth of shade followed by Copper (II) sulphate, then mixture of Iron (II) sulphate/zinc chloride and finally, and Iron (III) Chloride. The lowest K/S value was with Al^{3+}. Although Al^{3+} gave brighter shades, the depths K/S values, were low in each case, suggesting a weaker interaction between the natural dye and this mordant which is consistent with results reported elsewhere. [17]

These results might be due to that cotton fiber contained –OH groups with free electron pairs on the oxygen atoms, which could fill the free orbital of the metal ions, forming metal–dye coordination complexes. This complex formation led to improvements in the dye affinity. As a transition metal, Fe^{2+} and Cu^{2} have empty orbitals capable of participating in back bonding, which enhances the photo stability of the natural dyes, unlike Group III metals such as Al, and Fe^{3+}.

Effect of mordants on color measurements of cotton yarns

Table 1, and Table 2 represented the changes in color shades on cotton yarn samples with respect to different mordants for both Henna and Tea respectively. Merigold, and orange colors were obtained by using Henna and Tea dyes extract respectively without using any mordant. The color of the cotton yarn becomes darker with the presence of mordents. Table 1 showed that Dijon, Umber, Ochre, Artichoke, Green Olive, and Brownish Gray colors represented on the cotton yarn samples when using Alum, Iron (III) chloride, Iron (II) sulphate, copper (II) sulphate, and Iron (II) sulphate/zinc chloride as a mordants using Henna extract dye respectively.

Finding of orange, ochre, hazelnut, clay, walnut, and graphite colors were originated in the presence of Alum, Iron (III) chloride, Iron (II) sulphate, copper (II) sulphate, and Iron (II) sulphate/zinc chloride as a mordants using Henna extract dye respectively as shown in Table 2.

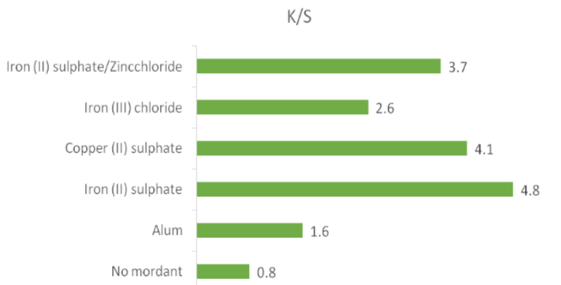


Fig. 4. Color strength (K/S) for cotton yarns dyed with Henna using different mordants

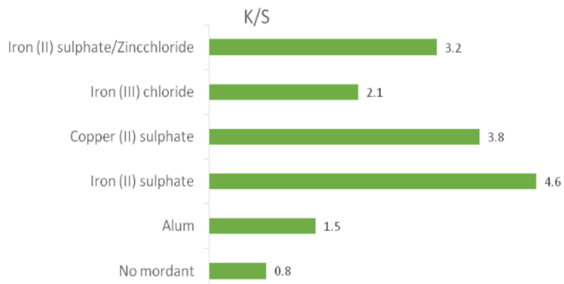


Fig. 5. Color strength (K/S) for cotton yarns dyed with Tea using different mordants

Table 1. Color measurements of cotton yarns dyed with Henna extract

Mordant	Color	L*	a*	b*	C*	h
Without	Merigold	92.74	-3.01	17.15	91	49
		92.77	-3.4	17.11	90.48	49.06
		93.51	-3.7	17.31	91.5	48.39
Mean		**93.01**	**-3.37**	**17.19**	**90.99**	**48.82**
SD		**0.44**	**0.35**	**0.11**	**0.51**	**0.37**
Alum	Dijon	75.44	-4.24	14.22	12.25	114.85
		76.31	-4.02	14.07	12.01	114.29
		76.11	-4.84	15.41	12.39	115.42
Mean		**75.95**	**-4.37**	**14.57**	**12.22**	**114.85**
SD		**0.46**	**0.42**	**0.73**	**0.19**	**0.57**
Iron (III) chloride	Umber	55.76	11.05	18.86	28.66	56.12
		55.41	10.64	19.77	28.54	57.26
		54.95	11.32	18.46	28.79	56.43
Mean		**55.37**	**11.00**	**19.03**	**28.66**	**56.60**
SD		**0.41**	**0.34**	**0.67**	**0.13**	**0.59**
Ferrous sulphate	Artichoke	55.57	-0.14	13.53	15.13	122.21
		55.71	-0.18	14.68	14.73	122.21
		55.12	-0.15	13.79	15.38	122.25
Mean		**55.47**	**-0.16**	**14.00**	**15.08**	**122.22**
SD		**0.31**	**0.02**	**0.60**	**0.33**	**0.02**
Copper (II)sulphate	Green Olive	44.04	-7.72	7.9	10.71	131.54
		44.73	-7.33	7.42	10.06	131.50
		43.86	- 7.95	7.65	10.68	131.08
Mean		**44.21**	**-7.67**	**7.66**	**10.48**	**131.37**
SD		**0.46**	**0.31**	**0.24**	**0.37**	**0.25**
Iron (II) sulphate /Zinc chloride	Brownish Gray	34.76	-0.11	4.14	4.19	94.78
		35.45	-0.19	4.69	4.85	94.93
		34.82	-0.21	4.11	4.93	95.25
Mean		**35.01**	**-0.17**	**4.31**	**4.66**	**94.99**
SD		**0.38**	**0.05**	**0.33**	**0.41**	**0.24**
P value		**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***

The results obtained revealed that there were drastic changes of L*, a*, b*, C, and Hue. The lightness (L*) values indicate that the higher (L*) of the sample, the higher is its luminosity. L* values indicate the difference in luminosity between samples. The (a*) value in the presence of different mordents were more brownish in compared with the cotton yarn samples without mordents. The (b*) values indicated that the cotton yarn samples tend to more yellowish color. The results showed that there was a highly significant difference in the hueangle (H), saturation (C), and all color parameters for both Henna and tea dyes. These results were very important in industrial application for the production of cotton carpets and rugs.

Effect of mordants on Fastness properties of the dyed cotton yarns

Results represented in Tables 3 and 4 demonstrated the color fastness to wash, perspiration and light for the cotton yarn samples dyed with henna and tea extract respectively. The complex formation between the cotton yarns and the metal led to improvements in the color fastness. It was seen from Table 3 that Wash fastness values (cotton 4/5, wool 4) of the cotton yarns dyed with Henna dye was the highest with Iron (II) sulphate and Copper (II) sulphate mordants. Wash fastness values (cotton 4, wool 3/4) of the cotton yarns with Alum, Iron (III) chloride, and Iron (II) sulphate /Zinc chloride was the second. The lowest value (cotton 3/4, wool 3) of the cotton yarns was obtained without mordant used. The results obtained revealed that, Henna dye reacted with cellulose of cotton in alkaline condition to form a permanent covalent bond between the dye and the cellulose, which would not be removed by frequent washing treatment with steaming water in neutral conditions and exposed excellent color.

Light fastness values (5) of the cotton yarns dyed with Henna dye was the highest with Iron (II) sulphate and copper (II) sulphate mordants. Light fastness values (4/5) of the cotton yarns with Alum, Iron (III) chloride, and Iron (II) sulphate/ zinc chloride was the second.

Table 2. Color measurements of cotton yarns dyed with Tea extract

Mordant	Color	L*	a*	b*	C*	h
Without	Orange	71.78	0.72	28.49	36.07	82.13
		71.39	0.78	28.71	36.11	82.10
		71.99	0.73	28.18	36.17	82.19
Mean		**71.72**	**0.74**	**28.46**	**36.12**	**82.14**
SD		**0.30**	**0.03**	**0.27**	**0.05**	**0.05**
Alum	Ochre	77.49	1.98	22.69	24.87	74.97
		77.27	2.05	22.17	24.58	74.69
		77.69	1.83	22.93	24.99	75.15
Mean		**77.48**	**1.95**	**22.60**	**24.81**	**74.94**
SD		**0.21**	**0.11**	**0.39**	**0.21**	**0.23**
Ferric chloride	Hazelnut	43.86	17.86	21.37	43.06	56.02
		43.99	17.06	21.74	43.64	56.19
		43.36	17.81	22.06	44.58	56.64
Mean		**43.74**	**17.58**	**21.72**	**43.76**	**56.28**
SD		**0.33**	**0.45**	**0.35**	**0.77**	**0.32**
Ferrous sulphate	Clay	32.48	6.1	15.01	28.83	68.21
		32.68	5.70	15.11	29.59	68.68
		32.08	5.97	15.16	28.48	67.59
Mean		**32.41**	**5.92**	**15.09**	**28.97**	**68.16**
SD		**0.31**	**0.20**	**0.08**	**0.57**	**0.55**
Copper sulphate	walnut	42.05	0.73	18.87	30.55	82.75
		42.17	0.79	19.82	30. 74	82.91
		42.26	0.84	19.74	31.33	81.40
Mean		**42.16**	**0.79**	**19.48**	**30.94**	**82.35**
SD		**0.11**	**0.06**	**0.53**	**0.55**	**0.83**
Iron (II) sulphate /Zinc chloride	Graphite	42.1	0.85	8.61	10.3	67.15
		43.69	0.89	8.85	10.71	67.47
		42.55	0.88	8.17	10.81	68.55
Mean		**42.78**	**0.87**	**8.54**	**10.61**	**67.72**
SD		**0.82**	**0.02**	**0.34**	**0.27**	**0.73**
P value		**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***

The lowest value (4) of the cotton yarns was obtained without mordant used.It was seen from Table 3 that perspiration fastness values (acidic 4-5, alkaline 4-5) of the cotton yarns dyed with Henna dye was the highest with Iron (II) sulphate and Cupric (II) sulphate mordants. Perspiration fastness of the cotton yarns values (acidic 4, alkaline 4) with Alum, Iron (III) chloride, and Iron (II) sulphate/ zinc chloride was the second. The lowest value (acidic 3/4, alkaline 4) of the cotton yarns was obtained without mordant used.

Results in Table 4 showed that the highest values of wash fastness for the cotton yarns dyed with Tea dye with Iron (II) sulphate and Copper (II) sulphate mordants was (cotton 5, wool 4/5). Wash fastness values (cotton 4/5, wool 4/5) of the cotton yarns when using Iron (III) chloride was the second. The fastness values were (cotton 4, wool 4/5) when using Iron (II) sulphate/ Zinc chloride, and recorded (cotton 4, wool 4) when using alum. The lowest value (cotton 3/4, wool 3/4) of the cotton yarns was obtained without using mordant.

Light fastness values (4/5) of the cotton yarns dyed with Tea dye was the highest with Iron (II) sulphate and Copper (II) sulphate mordants. Light fastness values (4) of the cotton yarns with Iron (III) chloride, and Iron (II) sulphate/ Zinc chloride was the second, and (3/4) with Alum. The lowest value (2/3) of the cotton yarns was obtained without mordant used.

It was seen from Table 4 that perspiration fastness values (acidic 5, alkaline 4-5) of the cotton yarns dyed with tea dye was the highest with Iron (II) sulphate and Copper (II) sulphate mordants. perspiration fastness of the cotton yarn values (acidic 4/5, alkaline 4/5) with Iron (III) chloride, and Iron (II) sulphate/ Zinc chloride was the second and recorded (acidic 4, alkaline 3/4) with Alum. The lowest value (acidic 3/4, alkaline 3/4) of the cotton yarns was obtained without mordant used.

Table 3. Color fastness of cotton yarns dyed with Henna dye extract

Dye	Mordant	Washing fastness		Perspiration fastness		Light fastness
		Cotton	wool	Acid	Alkaline	
Henna	Without	3/4	3	3/4	4	4
	Alum	4	3/4	4	4	4/5
	Ferric chloride	4	3/4	4	4/5	4/5
	Ferrous sulphate	4/5	4	4/5	4/5	5
	Copper sulphate	4/5	4	4/5	4/5	5
	Zinc chloride + Ferrous sulphate	4	4	4	4	4/5

Table 4. Color fastness of cotton yarns dyed with Tea dye extract

Dye	Mordant	Washing fastness		Perspiration fastness		Light fastness
		Cotton	wool	Acid	Alkaline	
Tea	Without	3/4	3/4	3/4	3/4	2/3
	Alum	4	4	4	4	3/4
	Ferric chloride	4/5	4/5	4/5	4/5	4
	Ferrous sulphate	5	4/5	5	4/5	4/5
	Copper sulphate	5	4/5	5	4/5	4/5
	Zinc chloride + Ferrous sulphate	4	4/5	4/5	4/5	4

Appendix 1-A; Fiber physical and Mechanical Properties

Sample	Mic	Mat. %	UHML mm	UI %	SFI %	T.Sg/Tex	E %	Rd%	b+	Trash count	Trash area %
Mean	4.4	0.865	29.95	84.4	8.0	36.5	7.0	67.1	11.3	43	0.5
CV	0.5	1.2	0.2	0.5	1.9	1.0	1.4	1.6	4.4	21.6	27
Max	4.3	0.87	30.1	84.8	8.1	36.8	7.1	67.5	11.5	53	0.68
Min	4.5	0.86	29.8	84.0	7.8	36.1	6.9	66.8	11.1	33	0.41
Std	0.02	0.01	0.07	0.4	0.15	0.35	0.1	1.1	0.5	9.3	0.135
Number of tests 6 single tests											

Where T.S is Tensile strength, E% is Elongation%

Appendix 1-B; Yarn physical properties

Nr	U%	CVm %	T1	T2	T3	T4	N1	N2	N3	Rel.Cnt ± %	sh	H
1	**3.96**	**5.05**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.13**	**9.36**
Mean	**3.96**	**5.05**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.13**	**9.36**
Max	**3.96**	**5.05**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.13**	**9.36**
Min	**3.96**	**5.05**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.13**	**9.36**
Std	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Number of tests 10 single tests												

Where; T1, T2, T3, T4 are Thin -50%/km, Thic +50%/km, Thick +35%/km, Thin -40%/km, respectively, and N1, N2, N3 are Neps +200% /km, Neps +140%/k, Nep +280%/km respectively.

Appendix 1-C; Yarn mechanical properties

Nr	Time to breakage	B-force	Elongation %	R/km	B- work
Mean	1.5	7176.8	19.97	19.77	38914.6
cv	-	5.3	23.81	5.38	36.45
Number of tests 25 single tests					

From the above results, it is understood that natural Henna extracted dye are not intended for only decorating or cosmetic products, but can also be used in textile dyeing of cotton with different shades. The relative color strength of the Henna extracts obtained at alkaline solution gets better than color strength of dye extracts obtained in distilled water. This effect may be due to the acidic hydroxylated structure of coloring component (a-hydroxy-naphtha-quinone). The color strength value is decline due to the high reactivity of lawsone in alkaline medium. For cotton yarns dyed with Henna extract, the higher the lightness value represented lower the color yield with different mordants compared with un-mordanted sample. Also,negative values of a* represented greener tone with different mordants except Iron (III) chloride which gave positive value represented redder tone which gave hue degree (56.12). For cotton yarns dyed with Tea extract, it can also be observed that there were positive values of a* and b* represented redder and yellowness tones with different mordants used. There was no huge change in hue and the hue degree ranged from 82.12 to 67.15.

Conclusions

These experiments would introduce a rising need for organic and eco-friendly carpets and rugs. we can use the Egyptian cotton yarns dyed with natural dyes extracted from Henna or Tea. These dyes showed satisfactory dye uptake and fastness properties by using mordants which can enhance the dye shade and fastness of natural dye, which ultimately results in showing eco-friendly dyeing. This study is useful for the workers in the textile industries and costumers who have been accountable for the eco-textile materials dyed with natural dyes.

Conflicts of interest

The authors have no conflicts of interest to declare

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صباغة خيوط القطن باستخدام الصبغات الطبيعية للسجاد والمعلقات

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المستخلص:

ان الهدف من هذة الدراسة هو الحصول علي سجاد ومعلقات مصنوعة من القطن المصري كخامة طبيعية، باستخدام خيوط مصبوغة بصبغات طبيعية تم استخلاصها من مصدرين : الحناء والشاي، وتمت المعالجة بالـمثبتات المعدنية ثم الصباغة ، واستخدم العديد من الـمثبتات المعدنية والهدف من ذلك الاجراء هو الحصول علي عدة الوان ودرجات لونية مختلفة من صبغة نباتية واحدة. وتم قياس الخواص الطبيعية واللونية للخيوط المصبوغة والتي تشمل قياس كلا من L^*, a^*, b^*, C^*, h^o وايضا K/S هذا بالاضافة الي قياس ثبات الصبغة للغسيل والعرق والضوء وكانت النتائج ذات قيمة ثبات عالية.وتعد هذة النتائج مهمة جدا في المجال الصناعي الخاص بانتاج السجاد والمعلقات حيث اننا نقوم باستخدام خامة طبيعية وتم صباغتها بصبغات طبيعية صديقة للبيئة.

الكلمات المفتاحية: الصبغات الطبيعية، خيوط القطن، الـمثبتات المعدنية، السجاد، المعلقات.