Research Article

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Effects of Different Mordanting Methods of Dye from Reseda Luteola Plants on Cotton, Viscose Rayon Knitted Fabrics Coloration

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Abstract

Cotton and viscose fibers are the most common fibers that used in textile industry. They have also a crucial potential for sustainability. As environmentalist approaches have gained importance to endure sustainable fashion, textile products have started to be produced by sustainable processes like ecological dyeing methods. Considering this approach, natural dye is preferred by producers and consumers with an environmentally friendly approach as a dye that is frequently used in textile coloring such as cotton and viscose rayon products.

*In this study, Reseda Luteola plant, which grows in the Mediterranean region of Turkey, was used as a natural dye source. For this purpose, natural dye was extracted from the dried and ground leaves of the Reseda Luteola plant. 100% cotton, 100% viscose rayon and (50% -50%) blended cotton/viscose rayon knitted surfaces were used in the study. Prior to the dyeing process, copper sulfate, aluminum potassium sulfate and iron sulfate were used as mordant material and pre-mordanting method was used in applications. The color strength (K/S) and CIE Lab (L *, a *, b *, C *) values of the samples dyed with the different mordanting agents were analyzed and their effects on fastness properties were investigated.*

*As a result, the color efficiency (K/S) and fastness properties of 100% cotton, 100% viscose rayon and (50% -50%) blended cotton/viscose rayon knitted fabrics colored with natural dye that is obtained from Reseda Luteola plant, were obtained by determining CIE Lab (*L, *a, *b and *C) values. It has been figures out that their fastnesses meet the coloring properties and high results are evaluated especially in light fastness values.*

Keywords: Natural Dye, Reseda Luteola L, Cotton Knitted Fabric, Viscose Rayon Knitted Fabric ,Colour Properties

Introductıon

Since the last century, synthetic dyestuffs are frequently preferred in textile coloring. However, it is known that synthetic dyestuffs have harmful effects to the human health and environment. Therefore, there is a serious need for researching natural dyestuffs for the textile industry. The search for ecologically and economically efficient natural colorant resources is a requirement for sustainable textile dyeing [1-3]. Since the day when mankind became aware of the existence of thousands of plant species, these natural wealth have been less investigated for textile dyeing processes, while the pharmaceutical industry has extensively used compounds extracted from plants [3-6]. The plants, which are an important and abundant source of colorant, have been used for dyeing textile products since ancient times. Reseda Lutea L. (Resedaceae) known as Reseda vulgaris was found by the Egyptians and used to cure diseases. At the same time, it is used in the dyeing of goods due to the its own yellow color [7]. However, yellow dyes are flavonoids that are unstable to UV radiation and also the dyed fabric has very poor fastness to washing and light. In figure 1, Reseda luteola L. dye flavonoids, luteolin, apigenin, luteolin 7-O-glukozit, apigenin 7-O-glukozit, luteolin 3; 7-O-diglucoside ve luteolin 4'-O-glucoside1 are shown in the data obtained from the HPLC device [8].

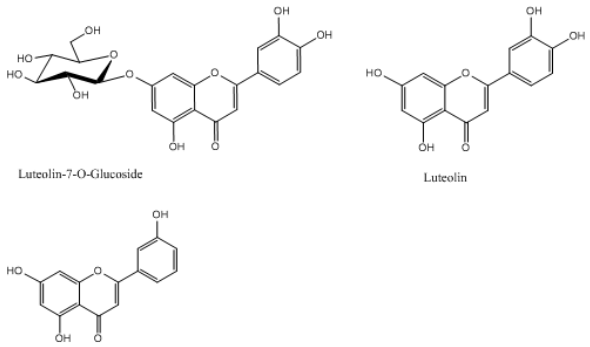


Figure 1: Reseda luteola L. (weld) dye flavonoids, luteolin, apigenin, luteolin 7-O-glucoside [8].

Poor extraction of colorant from plants is one of the main obstacles to their use in modern textiles due to the small amount of natural coloring compounds can be extracted in water. Therefore, the extraction of coloring compounds is done by breaking down the plant cellwand. To improve dye extraction and color fastness characterization, scientists used different technologies such as suitable extraction medium [9-10].

Mordant substances are used to increase the permanence of natural dyestuffs on surfaces. Studies have shown improvements in fastness values in textile colorings with natural dyestuffs made with metal-containing mordant substances [11,13]. In this study, copper sulfate, aluminum potassium sulfate and iron sulfate were used as natural dyestuff and mordant obtained from Reseda Luteola plant in the coloring of 100% cotton, 100% viscose rayon and (50% -50%) blended cotton/viscose rayon knitted surfaces. Color efficiency (K/S), CIE L*a*b*,C* values of the samples dyed with mordanting agents were analyzed, and the fastness of the samples were also examined.

Materıals and Methods

Materials

In this study, The 100% cotton, 100% viscose rayon and (50% -50%) blended cotton/viscose rayon knitted surfaces with 190 g / m2 weight are used in this research was obtained from the Merit Textile Company (Turkey). Reseda Luteola L plant extract collected from the Mediterian Sea Region is another natural pigment used in the study. (Figure 2.) The aluminium sulfate, copper sulfate and iron sulfate (purity 99.9% -sigma Aldrich Germany) are used as mordans obtained from Merit Textile Company (Turkey).

Figure 2: Reseda Luteola L. Bitkisi ve Edilen Doğal Boya

Methods

Laboratory-type dyeing machine (Thermal) is used in dyeing and mordant processing. At the end of the processes, 100% cotton, 100% viscose rayon and (50% -50%) blended cotton/viscose rayon knitted surfaces samples were dried in an oven at 105 ° C for 2 minutes.

Extraction

The 10 g/L solution of the dye obtained from Reseda Luteola L. Plant was first dissolved by boiling for 15 minutes, the evaporated amount was completed to litter with distilled water and used in dyeing. Reseda Luteola L plant was dried in an oven (40 ° C ± 2 ° C) for 8 hours after washing, and was extracted by boiling in 750 ml of distilled water for 1 hour and made ready for dyeing by filtration. The filtered (Whatman, 595/1/2, 110 mm diameter) product then was dried in a laboratory oven at 60 C for at least 6 h, and weighted (Figure 2).

Mordanting and Dyeing

Since the textile materials do not have much affinity to the natural dyes, the mordant process is performed. Metal mordants are the most preferred materials for dyeing textile materials with natural dyes. In this study, metal mordant method was used for pre-mordant different percentage 100% cotton, 100% viscose rayon and (50% -50%) blended cotton/viscose rayon knitted fabric samples. In both dyestuff applications, potassium aluminium sulfate, copper sulfate and iron sulfate at 1% concentration were used as mordant substances (according to material weight). The samples were mordant at boiling temperature for 1 hour in flotte with a ratio of 1/40, and the dyeing process was applied without rinsing by removing the excess flotte. The mordant solution was prepared by use of 10 grams of in both dyestuff applications, potassium aluminum sulfate, iron sulfate and copper sulfate in 1000 ml of distilled water. Then the samples were treated in a liquor ratio of 1:50 for one hour at the boiling temperature of about 98°C.

Dyeings were done according to the exhaustion method and the dye extracts obtained were used without dilution. According to the temperature-time diagram given in Figure 3, The different knitted surface samples, were dyed in a float with a flotte ratio of 1/40. Then, cold overflow washing (250 ml), 60 °C hot washing (100 ml), boiling soaping (1g/l nonionic detergent 100 ml) and cold rinsing (100 ml) were applied to the samples.

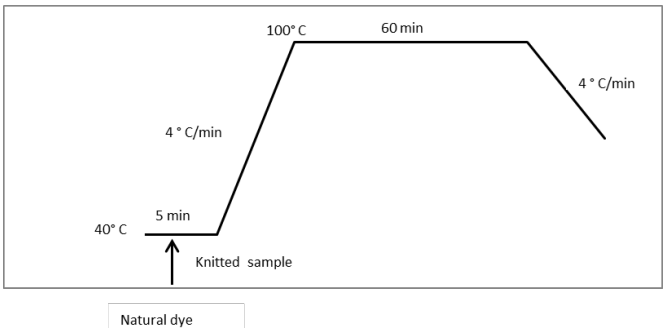


Figure 3: Dyeing Process

Color Measurements

Machbeth 2 180 V color measurement device and Coloroffice

Textile computer program were used for color measurements. According to the CIELab system, in the measurements made under D65 illuminat using a 10 ° standard observer, the samples were painted with natural dye after blending with potassium aluminum sulphate,iron sulfate, copper sulfate and these samples were accepted as standard. The colors of dyed fabrics were calculated according to CIELab color coordinates (L *, a *, b *, C * and h) Formula 1, and color strength values (K / S) were calculated using Formula 2 from Kubelka-Munk equation [14]. $K/S = (1-R)^2/2R$ (2) Here, *k* absorption coefficient , *s* scattering coefficient, *R* reflectance value of the fiber at wavelength at maximum absorption ve *K/S* color strength.

Color Fastness Measurements

The washing fastnesses of the dyed samples were made in the washing fastness tester (Gyrowash-James H. Heal) in accordance with ISO 105-C06 standards. The dyed samples were treated with a solution of 4 g / l ECE detergent at a ratio of 1/100 flotte at 40 ° C for 30 minutes in Gyrowash Washer Tester and evaluated with gray scale. The rubbing fastness tests of dyed different containing knitted surfaces were tested in the Crockmeter Test device according to ISO 105-X12: 2016, then the wet and dry staining fastness values were determined with gray scale.. The light fastness of the dyeings was carried out in a light fastness tester (Atlas Alfa 150 S) according to the EN ISO 105 - B02-1994 standard and the color change was evaluated with a blue scale [15-17].

Results and Discussion

CIE-Lab sonuç değerlendirilmesi

In this section, the results obtained from the research results are evaluated. According to the CIELab system, the measurements is made under D65 illuminat using a 10 ° standard observer. The CIELab values of the samples are given in Table 1.

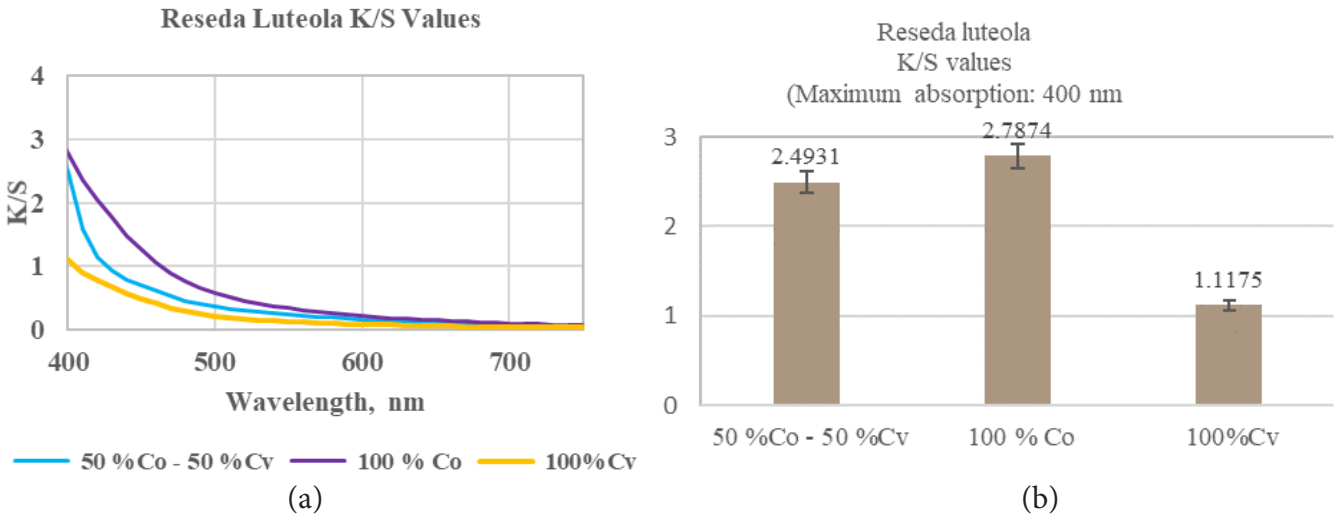
Table 1: CIELab Values of the dyed and mordants samples

Source of light D65 - 10°D65 - 10°												Colours
Material	**Mordans**	**L***	**a***	**b***	**C***	**h°**	**X**	**Y**	**Z**	**x**	**y**	
100% Viscose rayon(Cv)	Copper sulfate	79,80	0,08	25,63	25,63	89,81	53,44	56,33	36, 44	0,37	0,39	
100% Cotton (Co)		71,62	1,12	31,51	31,53	87,96	41,23	43,10	22, 93	0,38	0,40	
50 %-50 % (Co/Cv)		74,92	1,44	23,10	23,14	86,44	46,16	48,15	32, 03	0,37	0,38	
100% Viscose rayon(Cv)	Potassium aluminium sulfate	81,80	0,68	21,70	21,71	88,22	57,10	59,93	42,54	0,36	0,38	
100% Cotton (Co)		72,37	3,06	27,70	27,86	83,69	42,93	44,21	25,98	0,38	0,39	
50 %-50 % (Co/Cv)		76,45	1,67	21,31	21,37	85,53	48,60	50,62	35,32	0,36	0,38	
100% Viscose rayon(Cv)	Iron sulfate	66,91	3,88	14,63	15,14	75,15	35,75	36,51	28,34	0,36	0,36	
100% Cotton (Co)		63,53	4,17	14,26	14,86	73,70	31,68	32,22	24,87	0,36	0,36	
50 %-50 % (Co/Cv)		67,98	4,15	13,61	14,23	73,04	37,23	37,95	30,28	0,35	0,36	

Since the sample dyed with natural dye obtained from Reseda Luteola plant and copper sulfate, potassium aluminum sulfate and iron sulfate mordants are considered the standard for color measurement. It has been determined that for the lightness-darkness (L*) axis, the color is light in all dyeings, as the results are evaluated according to the CIELab axis. However, 100% cotton knitted surfaces are darker than other surfaces. The best results of the lightness-darkness values in the study were obtained with iron sulfate mordant [18]. The red nuance is more acoording to evaluation of the green-red axis (a*) and the highest redness value is obtained with cotton 100%. The red nuance of the dyeing is higher in mordanting with iron sulfate. In dyeings made of viscose 100% and its mixtures, the green nuance is more than the others in all three mordants. The yellow nuance is high in staining as the blue-yellow (b*) axis is evaluated and the most yellow nuance is seen for 100% cotton knitted surfaces. The effect of the copper sulfate mordanting process on the increase in yellow nuance is more effective than the others. When the saturation values (C*) of the dyeings is examined, bright and saturated values are obtained for all dyeings. The copper sulfate mordanting has the brightest value on 100% cotton knitted surfaces. The most opaque value is obtained in the mordanting process in ferrous sulfate. When the saturation (C*) was evaluated in all studies, the lowest value was obtained on cotton/viscose rayon (50% -50%) blended surfaces.

Color Strenght (K/S) Values

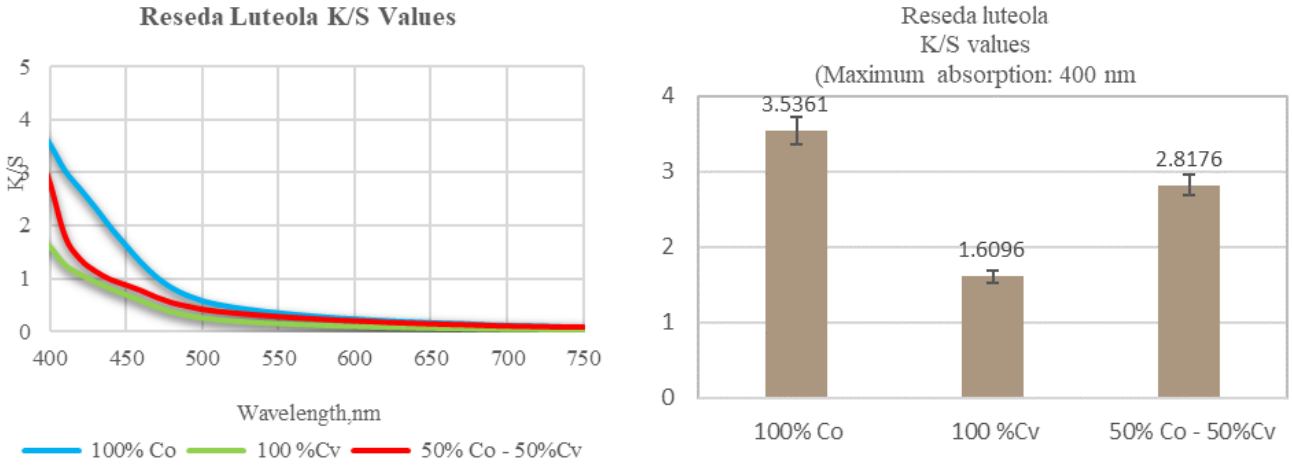
K/S (color strength) results were evaluated according to the dyeing of knitted surfaces in three different structures using natural dyestuff obtained from the Reseda Luteola plant with three different mordanting. The highest K/S value for all dyeings is obtained at the wavelength at the maximum absorption (400nm.)



(a) (b)

Figure 4: K / S Curves of Reseda Luteola Dyed and Copper Sulfate Mordant Samples (a: K / S values in the 400-700 nm wavelength range; b: K/S value obtained at maximum absorption wavelength (400nm)).

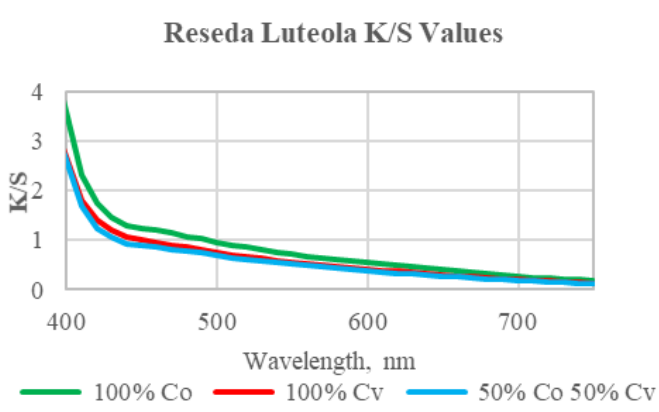
In Figure 4, when the K/S curves of the surfaces colored with copper sulfate mordant are evaluated at 400-700 nm wavelength, it is seen that there are curves with a similar structure. The highest K/S value was (2,7874) in the mordants made with copper sulfate, which is obtained in 100% cotton knitted surface samples.



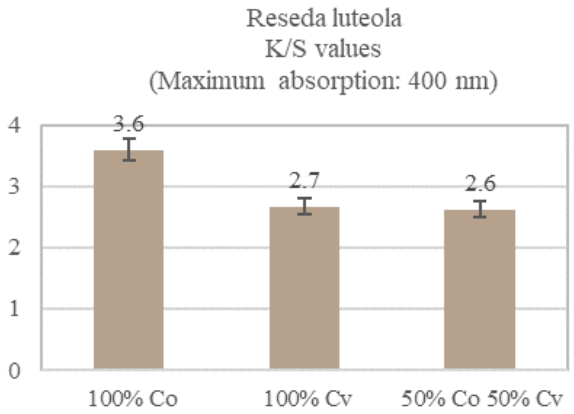
(a) (b)

Figure 5: K / S Curves of Reseda Luteola Dyed and Potassium Aluminum Sulfate Mordant Samples (a: K / S values at 400-700 nm wavelength range; b: K/S value obtained at maximum absorption wavelength (400nm))

In Figure 5, the K/S curve structures of the surfaces colored with potassium aluminum sulfate at a wavelength of 400-700 nm are similar. The highest K/S value (3.5361) is determined in mordanting with potassium aluminum sulfate obtained from 100% cotton knitted surface samples.



(a)



(b)

Figure 6: K / S Curves of Reseda Luteola Dyed and Iron Sulfate Mordant Samples (a: K / S values at 400-700 nm wavelength range; b: K/S value obtained at maximum absorption wavelength (400nm))

In Figure 6, the K / S curve structures of the surfaces colored with iron sulfate at a wavelength of 400-700 nm are similar. The highest K/S value is determined as (3,6) which is mordanting with iron sulphate of 100% cotton knitted surface samples.

It was observed that the mordanting agents used in all dyeing samples are very effective. The highest color strength values (K/S) at 400nm were obtained on 100% cotton knitted surface [19-21].

Determination of the Fastness Values

The fastness evaluations of the samples colored with three different mordants from the Reseda Luteola plant are given in Table 1 to Table 4.

Table 2: Washing, Rubbing and Light Fastness of the natural dyed copper sulfate samples

Material	Washing							Rubbing Fastnesss		Light Fastness
	Color Change	Staining								
		CA	CO	PA	PET	PAN	WO	Dry	Wet	
100% Viscose rayon(Cv)	3-4	4	4	3	3	3-4	2-3	4/5	4/5	4/5
100% Cotton (Co)	3	4	4	4	5	4-5	4-5	3	3-4	3-4
50 %Cotton - 50 %Viscose(Co/Cv)	3	4	4	3-4	4	4	3-4	4	4	4

Table 3: Washing, Rubbing and Light Fastness of the natural dyed Potassium Aluminum Sulphate samples

Material	Washing							Rubbing Fastnesss		Light Fastness
	Color Change	Staining								
		CA	CO	PA	PET	PAN	WO	Dry	Wet	
100% Viscose rayon(Cv)	4	5	5	5	5	5	5	5	5	5
100% Cotton (Co)	3	4	4	4	4	3-4	3	3	4	4
50 %Cotton - 50 %Viscose(Co/Cv)	4	4	4	4	4	4	4	4	4	4

Table 4: Washing, Rubbing and Light Fastness of the natural dyed iron sulfate samples

Material	Washing							Rubbing Fastnesss		Light Fastness
	Color Change	Staining								
		CA	CO	PA	PET	PAN	WO	Dry	Wet	
100% Viscose rayon(Cv)	4	5	5	5	5	5	5	5	5	5
100% Cotton (Co)	3	4	4	4-5	4-5	4	4	4	4	4
50 %Cotton - 50 %Viscose(Co/Cv)	3	4	4	4-5	5	4-5	4	4-5	4-5	4-5

As is known, the fastness properties of natural dyes are low. Mordant process is applied to improve fastness properties [22]. Although the light fastness of natural dyestuffs is known as common problem, the values of light fastness in the study are quite high. The dyeings made with three different mordants, potassium aluminum sulfate, copper sulfate and iron sulfate to get high fastness values. All fastness values are included in the values accepted in the textile industry, excluding washing color changes. The best washing-staining results were obtained from mordanting with potassium aluminum and iron sulfate on 100% viscose knitted textile surfaces [23].

Conclusıon

According to the results of this study, it was observed that iron sulphate mordant was effective in the color measurement results, K / S ratios of different structures knitted surfaces dyed with natural dye obtained from Reseda Luteola L. Plants. It is striking that the light fastness values are high in the results of the study. In addition, the usage of mordant materials causes light colors of dyeing and also red and yellow nuances were obtained. The saturation of all dyeings is high and bright. It is observed that the mordanting agents used in the study were more effective on cotton-containing knitted surfaces.

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