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Investigation of Colorimetric Properties of Woolen Yarn Dyed with Rheum Ribes Plant Root Extract

MENDERES KOYUNCU
Department of Chemistry, Faculty of Arts and Sciences
Yuzuncu Yil University, 65100 Van, Turkey
Fax: (90)(432)2251415; Tel: (90)(432)2251136; E-mail: menderes@yyu.edu.tr

The dyeing of wool yarn using Rheum ribes roots as natural dye has been studied in conventional method. The effects of dyeing show higher colour strength values obtained by the latter. Dyeing with Rheum ribes roots has been shown to give good dyeing results. The results of washing fastness properties of the dyed wool yarn were fair to good. CIELAB values have also been evaluated and discussed.

Key Words: Natural dyes, Wool yarn, Rheum ribes, Dyeing, Fastness.

INTRODUCTION

Since prehistoric times, natural dyes have been used for many purposes such as the colouring of natural fibers wool, cotton and silk as well as fur and leather. The dyes were also used to colour cosmetic products and to produce inks, watercolours and artist's paints.

The chemical structure of a dye molecule is divided in two parts *i.e.*, the main chromophore and the auxochromes groups. The analysis of the natural dyes listed in Colour Index revealed that almost 50 % of all natural dyes used to colour textiles are flavonoid compounds. Most of the remaining natural dyes fall within 3 chemical classes *viz.*, anthraquinones, naphtoquinones and indigoids[1].

The use of natural dyes to colour textiles declined rapidly after the discovery of synthetic dyes in 1856, until they were virtually unused by 1900. Common use of synthetic fibres and chemicals in textile industry and old techologies will cause rapid pollution of earth and serious ecological problems in future. The best industry is the one that pollutes the earth the least. Natural dyes can exhibit beter biodegradability and generally have a higher compatibility with the environment. Considerable research work is being undertaken around the world on the application of natural dyes[2].

This study aims to discuss the importance of application of vegetable dyestuff in textile industry and to study Rheum ribes roots used for dyeing the fist time and to introduce a new vegetable dyestuff.

Rheum ribes is locally known as usgun, uçgun or isgin and found mostly in Eastern Turkey, Lebanon and Iran. According to the results of the chemical study on material collected from Erzincan, chrysophanol, physcion, rhein, aloe-emodin, physcion-8-O-glucoside, aloe-emodin-8-O-glucoside, sennoside, sennoside A and rhaponticin were found in the subterranean parts of the plants. The amount of the anthtacene derivatives is about 0.1%[3]. Rheum ribes are grown on huge rocks and small stones on the sides of mountains. It can grow as tall as 40 cm. The plant has leaves on the lower parts of the body and no leaves on the upper parts. This plant is collected in spring, eaten by people and sold by some families to gain some income. It is either used in meals or eaten as fruit. In view of the fact that there is no systematic study on its usage as a natural dye. In this study, the roots of Rheum ribes were used for dyeing white woolen yarn and dyeing with Rheum ribes has been shown to give good dyeing results. CIELab values of colour yarns were measured according to dyeing styles and washing fastness and measured colour values were compared with each other.

EXPERIMENTAL

The roots of Rheum ribes were collected freshly from Hakkâri, Turkey. The roots were air dried at room temperature and stored in bottles until use.

Wool yarn was obtained from local people (from women who use wool yarn to produce kirmen, tesi or topaç and wool yarn factory.

The instruments used in this study were UV-Vis (Analytikjena specord 40); Konica Minolta CM-3600d Spectphotometer; YK-12 dyeing device; colour box; Hanna pH meter; Pascal Engineering Gatwick Road Grawkg Sussec Blender; Hettich EBA 3S centrifuge; 1/10 sensitive balance.

$CuSO_4 \cdot 5H_2O$; $KAl(SO_4)_2 \cdot 12H_2O$ (Merck, D-6100 Darmstadt, Germany, CH_3OH (Merck, D-6100 Darmstadt, Germany).

Dye extraction: The dried roots were crushed and dissolved in distilled water and allowed to boil in a beaker kept over water bath for quick extraction for 5 h. All the colours were extracted from the roots by the end of 5 h. The solution was filtered for further use. The colourant showed one major peak, λ_{max} at 550 nm in the visible region and absorption constant has been calculated from absorption-concentration diagram slope (Fig. 1).

Dyeing: Dyeing was performed using a liquor ratio of 1:50 at 95ºC open beakers with manual agitation of the material. The wool yarn was added to the extract, temparature was raised to 95ºC within 15-20 min and maintained for 45 min. As a mordating procedure was used, the calculated amount of mordant was added to the dye bath after 20 min at 95ºC. Adjustment of pH 4.5-5.0 was made.

In case of mordanting, $CuSO_4 \cdot 5H_2O$ or $KAl(SO_4)_2 \cdot 12H_2O$ was added to the dye bath to give a final concentration of 20 mL L^{-1} $CuSO_4 \cdot 5H_2O$ and 20mL L^{-1} $KAl(SO_4)_2 \cdot 12H_2O$, respectively. The detailed dyeing procedure is given in literature[5-8]. At the end of dyeing period at 95ºC the dyebath was cooled down to *ca.* 40ºC and the dyebath was removed as to start with rinsing. After dyeing, excess dye was removed from the dyeings by rinsing two times with cold water.

The CIELab coordinates for the dyeings were measured using a Konica Minolta CM-3600d spectphotometer and The values are calculated from 5 repetitive measurements at the same place of sample.

Fastness testing: The dyed wool yarns were tested according to ISO standard methods. The specific tests were; IS-687-79.

The CIEL a and b coordinates for the coloured wool yarns were measured using a Konica Minolta CM-3600d spectphotometer. The values are calculated from 5 repetitive measurements at the same place of sample.

RESULTS AND DISCUSSION

Relationship between extracted and transmission: Table-1 shows the concentration and transmission (% T) values. The T value was 1.727 at 1/10 concentration while it was 57.590 at 1/100 concentration.

TABLE-1
CONCENTRATION AND TRANSMISSION VALUES

C (Concentration)	T (%) (Transmission)	C (Concentration)	T (%) (Transmission)
1/10	1.727	1/60	34.480
1/20	13.260	1/70	48.960
1/30	24.460	1/80	50.480
1/40	26.090	1/90	54.750
1/50	32.980	1/100	57.590

A linear relationship was found between concentration and transmission values. Amount of transmission was increased with more dilution. The relationship between absorption and concentration was presented in (Fig. 1). As shown in Fig. 1, when absorption values were appeared on graphic across concentrations, obtained line shows availibility for Lambert-Beer law. The slope value of this line shows molar absorption constant (ε). This value was measured as 2.0396. At the end of the experiment it was reached that the connection between absorption and concentration was significant ($p < 0.01$). Regression equation of changeable was found as $Y = 0.027 + 2.0396\ X$.

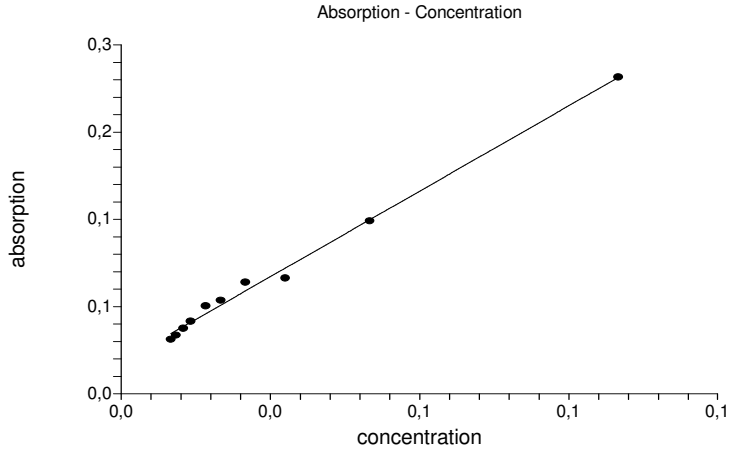


Fig. 1. Relation of absorption-concentration at 550 nm
Slope = 2.0396; R-Squared = 0.9944; Correlation = 0.9972;
Estimated model - (2.27408832294771E-02) + (2.03962792377856)*
(concentration)

Determination coefficient was (R^2) 0.9944. This result means that a good harmony was realized between absorption and concentration.

Dyeing: In the dyeing experiments the aqueous extract and methyl alcohol were used. In Table-2 representative results of dyeings with extracts are given. The aqueous extracts could be used in different variations of the dyeing process, *e.g.*, as direct dye or with the addition of a mordant[6].

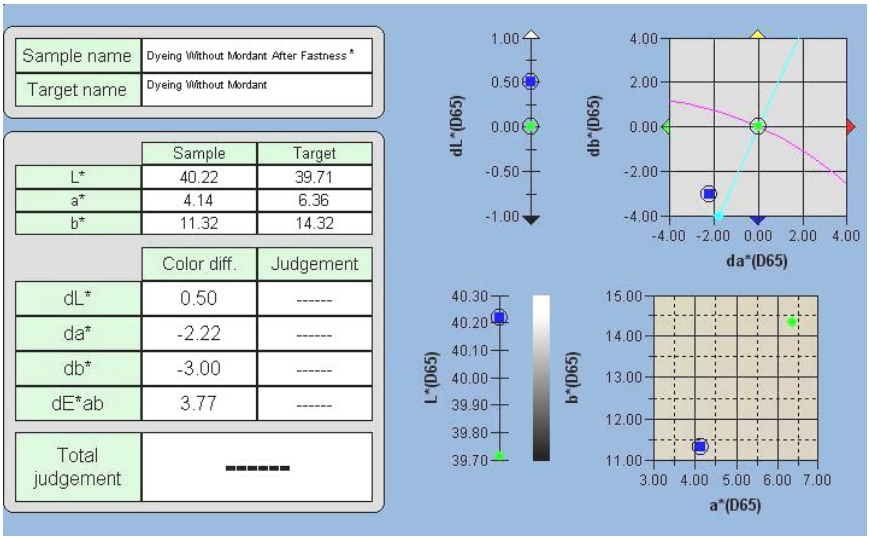
TABLE-2
REPRESENTATIVE RESULTS OF DYEINGS FROM DRIED RHEUM RIBES PLANT ROOTS ON WOOL YARN

Material	Mordant	Colour obtained	Colour obtained after washing
Wool yarn	Direct	Light brown	Milky brown
Wool yarn	($CuSO_4 \cdot 5H_2O$)	Dark green	Green-brown
Wool yarn	($KAl(SO_4)_2 \cdot 12H_2O$)	Dark brown	Light brown
Wool yarn	Methyl alcohol	Mustard yellow	Dark brown

The lightness (L*) value increased after washing as shown in Table-3. This increase was the sign of lighter and brighter colours of the sample before washing. As a result, when da* 2.22 sample passsed to green after washing in L*a*b* colour space chromaticty diagram, db*-3.00 sample passed to blue after washing in L*a*b* colour space chromaticity $\Delta E^*ab = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} = 3.77$ value means that the total of value in

dyeing and colour differences after washing. ΔE*ab means that the little difference is the similar example and colour.

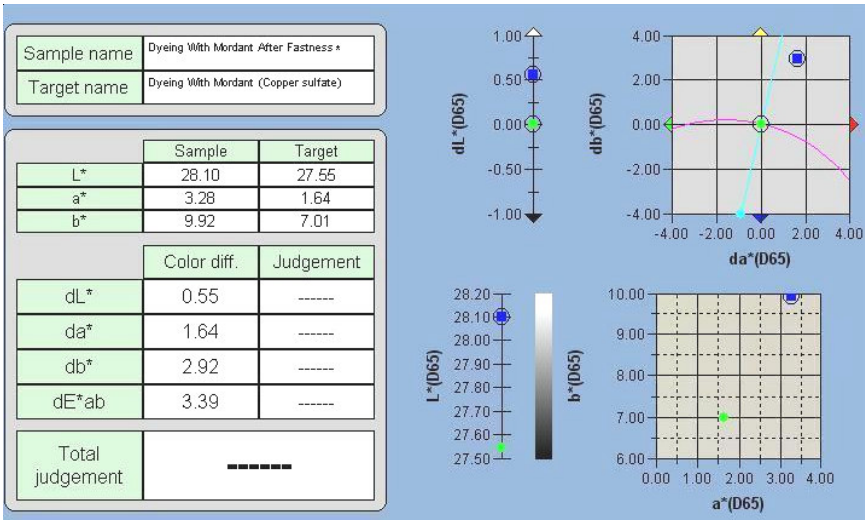
TABLE-3
L*a*b* AND COLOUR DIFFERENCE VALUES OF COLOURS OBTAINED AFTER DYEING WITHOUT MORDANT AND AFTER WASHING IN L*a*b* COLOUR SPACE SYSTEM



* Wash fastness

The lightness (L*) value of dyed white woolen yarn increased as shown in Table-4. This increase means that the example seemed lighter- brighter than the one before washing. Increasing of lightness (L*) value also corroborated this in device in which measure a* and b* values were increased[1]. All of the three values (L*a*b*) increase, which means brigher and more yellow colours. Present study showed that the L*a*b* are increase. a* the L*a*b* colour space has been alienated from achromatic centre in colour circle as da* 1.64 and more redness and more saturation across the fist value and b* value have become alienated from achromatic centre as 2.92 and occurred more yellowness and more saturation than before washing value. Vankar *et al.*[4] showed that the CIELab values for the copper sulphate and ferrous sulphate show darker colour as compared to other mordanted fabrics. Present study showed that dyeing with copper sulphate give dark colour $\Delta E^*ab = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} = 3.39$. The value (3.39) qualifies the colour difference of dyed examples between before and after washing. When this value reduced, two colour got close to each other, in a way its wash fastness well.

TABLE-4
L*a*b* AND COLOUR DIFFERENCE VALUES OF COLOURS OBTAINED IN DYEING WITH MORDANT (COPPER SULFATE) AND AFTER WASHING IN L*a*b* COLOUR SPACE SYSTEM



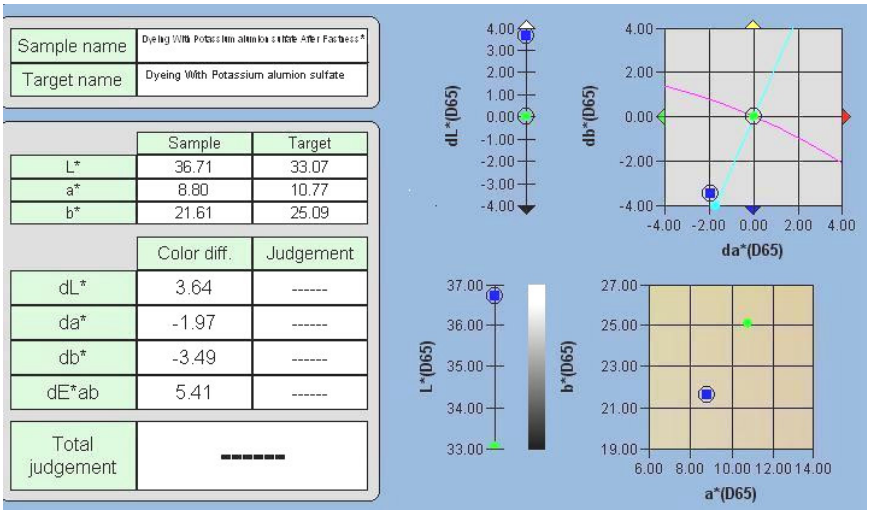
* Wash fastness

In another experiment, dyeing was applied in similar dyeing method but by using difference mordant [$KAl(SO_4)_2 \cdot 12H_2O$]. As shown in Table-5. lightness (L*) value increased in that experience after washing too. It was classified that colour was brighter after washing than before washing. In their study, Koyuncu and Kul[8] showed that increase in lightness (L*) values of coloured yarns after washing was reported in dyeing of wool yarn made of some plants such as *Allium cepa* L., *Alnus glutinosa* L., *Rubai tinctorum* L., *Mentha* sp. and *Rhus* sp. da* value was measured as -1.97 and db* value was measured as -3.49. da*-1.97 value means that sample changed into green region in L*a*b* colour space chromaticity diagram after washing and db*-3.49 value means that sample was changed into blue region after washing.

$\Delta E^*ab = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} = 5.41$, the reason of this, the measure was greater than the others in which different mordant was used.

Dyeing with methyl alcohol extract of Rhenum ribers roots: Mustard yellow and suspension extract was obtained in an extraction which was applied to Rhenum ribers roots, methyl alcohol solvent and a yellow colour extract and colour. In comparing both extracts, methyl alcohol seems to be more homogenized which does not contain solid remains. Orska-Grawry *et al.*[9] have shown that for acidic extraction of dyes from fibres, ethanol was used. Due to its higher boiling point than methanol it

TABLE-5
L*a*b* AND COLOUR DIFFERENCE VALUES OF COLOURS OBTAINED IN DYEING WITH MORDANT (POTASSIUM ALUMION SULFATE) AND AFTER WASHING IN L*a*b* COLOUR SPACE SYSTEM



* Wash fastness

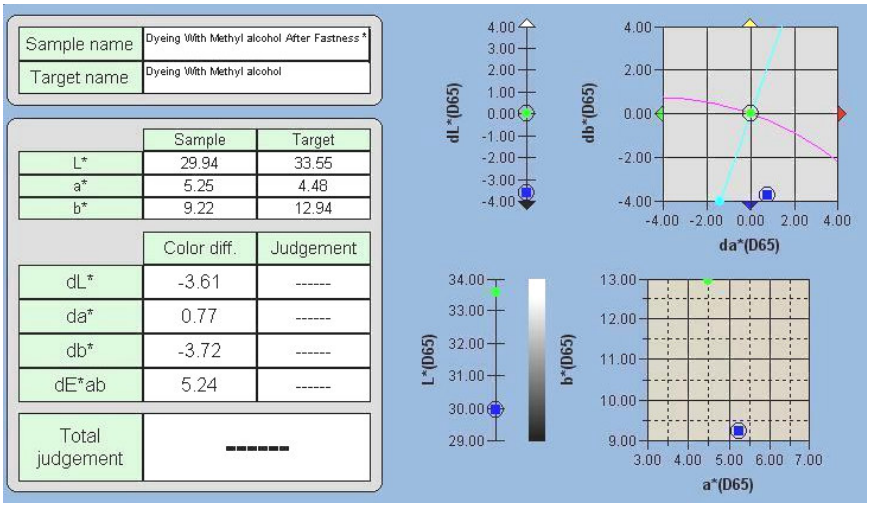
evaporates slower from the extraction solution enabling a more efficient extraction of dyes.

The lightness (L*) value of L*a*b* of colours obtained in dyeing was applied with methyl alcohol extract and $CuSO_4 \cdot 5H_2O$ mordant and (pH: 4.5-5.0) was reduced. This decreased value was completely normal, because sample changed from mustard yellow into dark brown after washing. Because of this, lightness, darkness and brightness criteria were not the same as the compared sample. In some studies, it was pointed out that many different colours and tones were found out by using various types of mordants in wool yarns dyed using defined dyeing methods. Montazer *et al.*[10] have shown that an evaluation has been carried out of the effect of ammonia on the colouring properties of dyed wool with a range of natural dyes. They have carried out in all cases that after-treatment with ammonia caused a decrease in the lightness (L*) values; da* 0.77 value defines that sample changed into more red after washing and became more saturation and db*-3.72 value defines that sample changed into blue region after washing relativily before washing and saturation reduced.

$\Delta E^*ab = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} = 5.24$ is a higher value. It is possible to say that it was natural, because dyed yarn changed completely into a different colour. Colour differences after washing fastness were done and during dyeing changed between (ΔE^*ab) 3-5 values. It can be

considered that these values are normal or not. But it is thought that these values are quite a bit normal values in natural dyeing. Because the main quality of natural dyeing is that colours do not become pale but change into another colour quality after washing.

TABLE-6
L*a*b* AND COLOUR DIFFERENCE VALUES OF COLOURS OBTAINED IN DYEING WITH METHYL ALCOHOL EXTRACT AND AFTER WASHING



* Wash fastness

Conclusions

In the first period of experience, solutions of extracts obtained from extraction with water were prepared in a concentrations between 1/10 and 1/100 mL and transmission (% T) and wavelength (nm) were measured with UV-Vis spectrometer and these measures were available for Lambert-Beer law. The wavelength of the extract washed with water was found as 462 nm and the measure of the average of five absorptions was found as 0.2492. A relation between concentration and transmission was obtained when extract dilute transmission (% T) increased.

It is ascertained that dyeing in which technical devices were used was applied faster and more shorter in time in dyeing studies by using a new plant and taking dyestuff in plant root in two different solvent with mordant and without mordant and in traditional method or with technical device. It is appeared that dyeing with device is better about time and energy and easiness than dyeing in traditional method. It can be advised that water can be more suitable than methyl alcohol or ethanol in dyeing, extraction might be done with these kind of solvent but methyl alcohol or ethanol can not be used in other periods of dyeing.

Despite same colours obtained in dyeing of handmade yarn and that made in factory, the colour of the yarn which was produced in factory seems brighter than the other. The reason of this difference is the twist of the yarn which was produced in factory is equal, this means that using the yarn which was made in factory gives available results.

It is concluded that because of Rheum ribes plant is a new plant for dyeing and of increasing of importance of natural dyeing, this plant should be widely cultivated.

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