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The Examination of the Effects of Quercus Aegilops Extract Used as Natural Mordant on Colourfulness Features of Natural Dyeing

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***Abstract*—Ecological textiles or eco textiles means a recyclable product or a product that can be recycled into an environmentally harmless product which has been produced by paying regard to environment during all process steps from, which does not harm the user. Natural dyeing, which is of great importance in the textiles industry in terms of being economical and applicable, has a number of advantages thanks to its features such as health, ecological cycle and providing biological availability. With the use of natural mordant as a binder during dyeing both dyeing and mordant become important for environmentally friendly processes. This study examines the usability of natural dye extract obtained from Helichrysum Arenarium, which has a wide range around the world, and Quercus Aegilops natural mordant in dyeing of Karabuk Eflani cloth, a regional weaving. Eflani cloth is made from 100% cotton staple. In this study Eflani cloth woven from 100% cotton yarn with Helichrysum Arenarium was dyed with 5 different concentrations of natural mordant. L*a*b* values of the samples of dyed cotton cloth were measured and compared using CIE L*a*b* colour space system. Also, lightfastness and washing features of dyeing were examined. Colour scale was darker and more vivid in dyeing made with Quercus Aegilops natural mordant compared to dyeing made without mordant.**

Keywords—eflani cloth; helichrysum arenarium; natural dyeing; natural mordants; quercus aegilops.

I. INTRODUCTION

Natural colorants, which have been used since the early ages, are derived from plants, invertebrate animals, and minerals. Today, the most important source of natural colorant is herbal colorants. Herbal dyes are derived from plant sources such as leaves, cones, bark, and root without applying a chemical process or by applying the least chemical process [1].

Although environmental problems have increased recently, chemical dyes are used in an overwhelming amount compared to natural dyes. The drawbacks of synthetic dyes such as little degradability, harmful effects on the environment and causing allergy have augmented the interest on natural dyes. The future is bright for dye plants.

Natural dyes are used in food, textile, cosmetics, and pharmaceutical industries [2-4].

Eco textiles based on natural dyes in evaluating ecological and economic sources have become more attractive to produce. Yellow, red, green, and dark grey shades are derived from various plant materials [5].

Dyeing plants have natural chromogens such as indigo, anthraquinone, naphthoquinone, tannin, phenalones, anthocynanins, tannis, carotenoid and chlorophyll that are used for obtaining various pigment colours [6].

Mordant substances are used to bind the dye to the fibre while dyeing textiles with natural dyes. There are many studies in which alternative, environmentally-friendly mordants such as praseodymium chloride[7], aluminium mordants[8], lime, ash and burnt charcoal [9] have been used because metal salts (for ex. Potassium dichromate) used as mordants are environmentally harmful.

Also, there are a lot of studies in which Quercus Aegilops (Figure1) extract used as bio mordant in this study was used as mordant and features such as colour, fastness, being antibacterial and antimicrobial were examined [11- 15].

Helichrysum Arenarium plant extract (Figure 2) which was used as natural dye in this study is also used to cure renal stone disease and urinary tract diseases in alternative medicine [16]. There are also studies in which its antioxidant and antimicrobial features and phenolic and flavonic content were examined [17].

Handicraft items which are among the most important elements symbolizing and introducing a given culture are also the most tangible documents that reflect that country's lifestyle. Societies have reflected their artistic tastes, feelings, ideas, and daily lifestyles on these handicraft items [18].

Eflani cloth is a traditional type of weaving produced from 100% cotton yarn and in hand loom (Figure 3). Eflani weavings are weaved in plain weaves and in Anatolia they are used as headscarf also known as Cember. Average height and average width of these scarves are 120, 68 cm and 49, 24 cm respectively. By seaming the two weaved pieces off, a square-like shaped scarf is created [19].

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Fig 1. Quercus Aegilops.



Fig 2. Helichrysum Arenarium.



Fig 3. Eflani cloth.

II. Materials and Methods

The aim of this study is to examine the natural dye derived from Helichrysum Arenarium and Quercus Aegilops Extract, which is used as natural mordant for dyeing Eflani cloth, in terms of colour values, wash, and lightfastness.

A. Fabric

In this study 100% cotton Eflani cloth weaved in plain weave was used. Fabric weight, weft density and warp density were as follows: 100 g.m-2, was15,4 tel/cm and was 13,4 tel/cm respectively.

Yarn count was 20/1 Ne. Quercus Aegilops extract was used as bio mordant and Helichrysum Arenarium extract was used as natural dye.

B. Equipments

Gyrowash Washer Tester
Lightfastness tester (Solarbox 3000E)
Data-colour Spectra Flash 600

C. Mordanting with Quercus Aegilops Extract

After boiling in 100 mL distillate water for one hour, 100 g Quercus Aegilops was filtered and cooled. The mordanting flotte prepared at 1/100 ratio was prepared in accordance with the conditions given in Table 1 and the material was processed at boiling temperature for 1 hour. The mordanted samples were kept in flotte for 24 hours and the samples were dried by removing the extra water.

TABLE I.Mordanting conditions

Code	Mordant Concentration
0	No Mordant
1-A	3% Quercus Aegilops
1-B	5% Quercus Aegilops
1-C	10% Quercus Aegilops
1-D	15% Quercus Aegilops
1-E	20%Quercus Aegilops

D.Preparation of Dye Extract From Helichrysum Arenarium and Dyeing Flotte

535 g. of asplenium ceterach was boiled in 5350 mL distillate water and then filtered and cooled. The dyeing flotte was prepared by adding the colorant in 10 g/L concentration to the flotte of which flotte rate was 1/100.

E.Dyeing Process

Dyeing was started at 30°C. Flotte was elevated to boiling temperature in 20 minutes and 1-hour of dyeing was carried out at this temperature. The dyed samples were kept in flotte for 24 hours and then wash and cold wash processes were carried out.

F.Colour Measurements

Colour measurements of the dyed samples were done via Datacolor Spectra Flash 600 plus reflectance spectrophotometer using Datamaster software according to CIELab system. Colour measurements were done using

10° observer and D65 light source [20]. Formula 1 was used to calculate the colour values in accordance with CIELab system.

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

In the formula above, L* stands for lightness-darkness value, a* stands for redness-greenness value, and b* stands for yellowness-blueness value. ΔL* value being (-) shows that the sample is darker than the standard and being (+) shows the sample is lighter. Δa* value being (–) shows that the colour is turning into green and it being (+) shows the colour is turning into red. Δb* value being (-) shows that blue nuance is more, it being (+) shows that yellow nuance is more.

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$\Delta E^* < 1$ shows that there is a small difference and $\Delta E^* > 1$ shows that there is a great difference between the two colours (standard and sample). ΔC^* being (+) shows high chroma; that is to say saturation. ΔH^* is angular difference. "h" (degree) rotation angle which shows an increase from red towards yellow is a measure of colour. For instance h=0° corresponds to a red shade, h=90° corresponds to a yellow shade, and h=270° corresponds to a blue shade.

G. K/S Values

Colours of the dyed samples were evaluated via colouring power (K/S) calculated using Kubelka-Munk equation (Formula 2)

$$K/S = (1-R)^2/2R \quad [2]$$

R: reflectance value of the fibre in wavelength in the maximum absorption

K: absorption co-efficient

S: scattering co-efficient [20].

H.Fastnesses of the Dyeing:

Wash fastness tests of the samples were done using wash fastness test machine by ISO 105-C06 [21] standard (Gyrowash / James H. Heal Co. Ltd.) and evaluation was done via both reflectance and spectrophotometer by ISO A05 [22] standard.

Lightfastness tests of the samples were done using lightfastness test machine (Solarbox 300E) by TS 1008 EN ISO 105-B02 standard [23] and total colour difference (ΔE^*) between the test samples and untested sample was evaluated in spectrophotometer.

III. Results and Discussion

A.Colour Measurements

Spectrophotometric values of the samples dyed with asplenium ceterach extract after being mordanted in 5 different mordant concentrations are shown in Table 2. The unmordanted sample (Code: 0) was accepted to be the standard in the measurements.

TABLE II. SPECTROPHOTOMETRIC COLOUR MEASUREMENT VALUES

Code	ДL*	Да*	Дb*	ДC*	ДH*	ДE*
1-A	-3,969	0,430	0,911	0,955	-0,320	4,095
1-B	-5,198	0,646	-0,079	0,005	-0,651	5,238
1-C	-6,726	1,050	1,550	1,677	-0,831	6,982
1-D	-7,655	0,849	2,433	2,520	-0,539	8,077
1-E	-8,768	1,223	1,131	1,294	-1,050	8,924

When the spectrophotometric colour values are examined, it is seen that samples are darker, redder, yellower, and more vivid than the standard. Total colour difference of the samples are not among the industrially-accepted values ($\Delta E^* > 1$). (Table 2)

Table 3 shows the colour strength values (K/S) of the dyeing. The highest value was obtained from the unmordanted sample and the highest value was obtained from the sample dyed using 15% mordant (Code:3-D).

TABLE III. K/S VALUES OF THE COLOUR STRENGTH

Code	K/S
0	1,69
1-A	2,02
1-B	2,05
1-C	2,2
1-D	2,8
1-E	2,57

B.Wash Fastness and Lightfastness

After the dyed samples were washed by ISO 105-C06 standard, colour change and staining wash fastness were measured in spectrophotometer by ISO A05 standard and lightfastness tests were carried out by TS 1008 EN ISO 105-B02 standard, and total colour difference between the untested sample and test samples (ΔE^*) was evaluated in spectrophotometer (Table 4).

TABLE IV. WASH FASTNESS AND LIGHTFASTNESS VALUES OF THE DYEING

Code	ДE* Y	ДE* 1	ДE* 2	ДE* 3	ДE* 4	ДE* 5	ДE* 6	ДE* I
0	9,988	1,792	7,947	0,598	1,134	1,144	4,03	6,135
1-A	10,185	0,874	1,061	0,258	0,482	0,94	4,521	3,948
1-B	7,924	2,179	0,752	0,263	0,655	0,541	3,784	5,541
1-C	10,989	1,613	1,039	0,24	0,506	0,451	3,72	7,998
1-D	9,975	3,379	0,744	0,551	0,393	1,222	2,94	7,03
1-E	8,856	2,158	1,025	0,432	0,601	1,106	3,322	8,472

ΔE^* Y: Colour change; ΔE^* 1: Staining, Wo; ΔE^* 2: Staining, PAN; ΔE^* 3: Staining, PET; ΔE^* 4: Staining, PA;
ΔE^* 5: Staining, Co; ΔE^* 6: Staining, CA; ΔE^* I: LightFastness

In all dyeings, wash fastness colour change values were higher than the values of the samples before washing.

The sample with the lowest wool staining degree was obtained from the dyeing carried out after being mordanted with 3% mordant substance and the sample with the lowest polyacrylonitrile staining degree was obtained from the dyeing carried out after being mordanted with 15% mordant substance. The sample with the lowest polyester staining degree was obtained from the dyeing carried out after being mordanted with 10% mordant substance and the sample with the lowest polyamide staining degree was obtained from the dyeing carried out after being mordanted with 15% mordant substance. The sample with the lowest cotton staining degree was obtained from the dyeing carried out after being mordanted with 10% mordant substance and the sample with the lowest acetate staining degree was obtained from the dyeing carried out after being mordanted with 15% mordant substance.

The sample with the best lightfastness was obtained from the dyeing after being mordanted with 3% mordant substance en (Table 4).

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IV. CONCLUSIONS

- When the spectrophotometric colour values are examined, it is seen that all the samples were darker than the standard based on the increasing mordant concentration (ΔL*= negative value).
- All the dyeings were red nuanced in terms of lightness and darkness (Δa*= positive value). The highest red nuance was obtained from the dyeing carried out after being mordanted with 20% mordant.
- In terms of yellowness-blueness, blue nuance was higher in the sample mordanted in 5% concentration and yellow nuance was higher in other samples.
- Total colour difference of the samples are not among the industrially accepted values (ΔE*>1).
- Chroma or saturation value were better than the standard in all dyeings (ΔC*= positive value). The highest saturation was obtained from the dyeing carried out after being mordanted with 15% mordant substance.
- The highest colour strength value was obtained from the dyeing carried out after being mordanted with 15% mordant substance.
- In all dyeings wash fastness colour change values were higher than the values of the samples before washing.
- In wash fastness Staining values the best results were obtained from the samples of 3% mordant-wool, 15% mordant-PAN, 10% mordant PET, 15% mordant-PA, 10% mordant-cotton and 15% mordant-acetate respectively.
- The sample with the best lightfastness was obtained from the dyeing carried out after being mordanted with 3% mordant substance.

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