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Investigation of the Color, Fastness and Antimicrobial Properties of Wool Fabrics Dyed With the Natural Dye Extracted From the Cone of Chamaecyparis Lawsoniana

Mehmet Kilinc[a*], Seyda Canbolat[a], Nigar Merdan[a], Habip Dayioglu[a], Filiz Akin[b]

[a]*Istanbul Commerce University, Faculty of Engineering and Design, Department of Fashion and Textile Design, Istanbul, Turkey*
[b]*Abant Izzet Baysal University, Vocational High School, Bolu, Turkey*

Abstract

In this study, the wool fabric was mordanted with natural mordant agents extracted from the waste of three different plants. After the mordanting process, the samples were dyed with the natural dye extracted from the cone of Chamaecyparis Lawsoniana. Finally, the fastness properties, color strength (K/S) values and antimicrobial properties of samples were investigated in terms of the type of mordant.

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Keywords: Chamaecyparis lawsoniana, fastness properties,K/S values, antimicrobial properties.

1. Introduction

Natural dyes are produced from plants, fruits and insects such as crustaceans, snail shell, cochineal, plant leaves, plant stems and fruit shells (Ingamells et al., 1993). Natural dyeing began in China and Central Asia then it was technically developed by Egypt. In particular, indigo dyes were developed in India. In addition, 2600 years before BC the Chinese dyed the woven silk fabric with herbal indigo and Chinese green dyes (Bechtold, T., Mussak, R., 2009-Siva, 2007).

* Corresponding author. Tel: +902124400000
E-mail address: mhmtklnc21@hotmail.com

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Natural dyes are environmental friendly, low toxic and less allergenic. Due to these advantages, over the last decade the use of natural dyes has gained momentum in food, pharmaceutical, cosmetic and textile dyeing industry (Samanta, A.K., Agarwal, P., 2009).

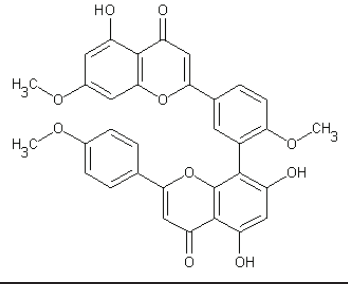
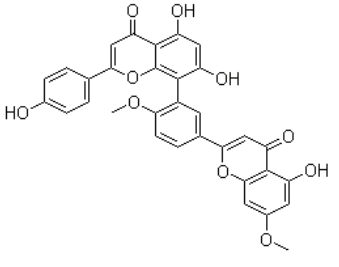
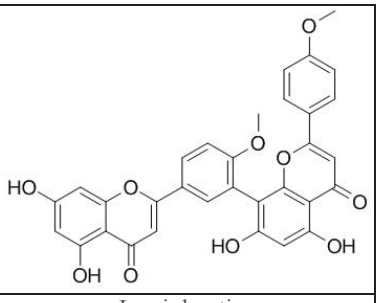
For many years, scientists have investigated the deodorizing/aroma (Sricharussin et al., 2009), insect-repellent (Specos et al., 2010), flame retardant (Huang et al., 2001), protection against to UV rays (Grifoni et al., 2011) of plants dyeing and usability in the textile industry.

Natural dyes consist of catechins, rosmarinic acid, flavonoids, carotenoids, ascorbic acid and anthocyanin groups in the structure, which show natural anti-oxidant property (Yanishlieva, N.V.,, Marinova, E.M., 2001).

The rapidly evolving microorganisms cause bad smells, images and color disorders, staining and fabric strength loss. Microorganisms cause fabric strength loss, odor and staining traces, pathogenic infection in hospital textiles that result from the textiles, garments and shoes fiber degradation (mold) (Gao et al., 2008-Ramachandran et al., 2004). Some researchers have examined the antimicrobial properties of natural dyes and many natural dyes are determined to be resistant to gram-negative bacteria (Gupta et al., 2004-Islam et al., 2013).

Keratin of wool includes complex structure and eighteen amino acids such as cysteine, lysine, arginine, glutamic acid and aspartic acid. Keratin macromolecules consist of cationic, anionic hydroxyl, sulphur-containing, polar and hydrophobic groups. Wool has a helical structure along the length of the polypeptide chain. Wool fibers show amphoteric property that result from the acidic carboxyl group and hydroxyl group. Furthermore, wool has very good heat insulation and hygroscopic ability (Carr, 1995).

Chamaecyparis Lawsoniana (A. Murr) has more than 200 varieties of cultures and can reach up to 60 meter length and 4 meter in diameter. Figure 1 shows the chemical structure of varieties of Chamaecyparis Lawsoniana and the chemical structures were analyzed with HPLC system (Baranowska et al, 2005).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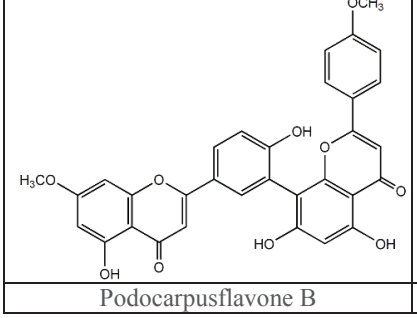
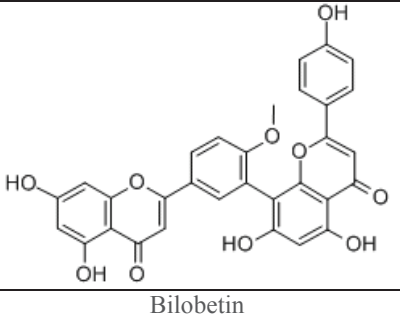
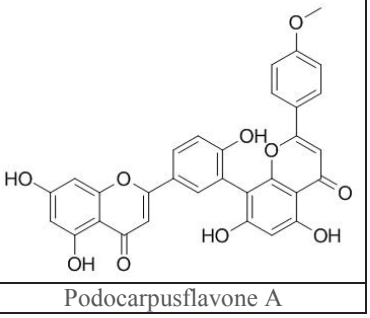
		
Podocarpusflavone B	Bilobetin	Podocarpusflavone A

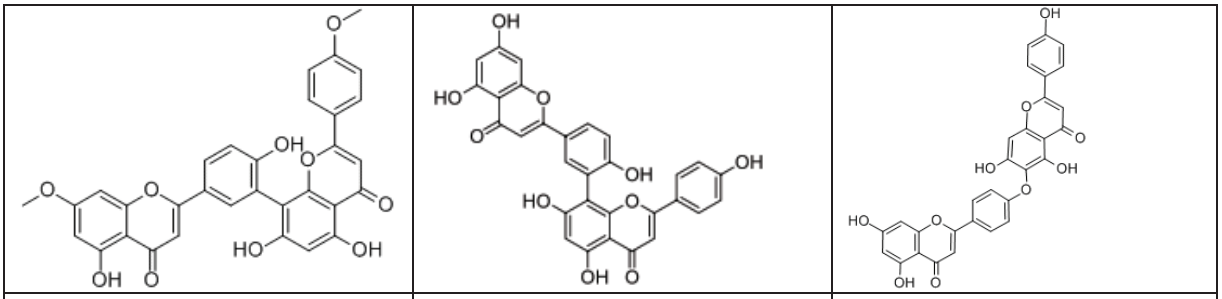


Fig.1. The Structures of Chamaecyparis Species.

Chamaecyparis Lawsoniana oil has good antibacterial and antifungal effects against the different microorganisms that was investigated in many studies (Palá-Paúl et al.,2012). Some studies are related with the antibacterial (Smith, 2007), antiviral (Debiaggi et al.,1988) and antioxidant (Gao et al.,2006) properties of immature cones of Chamaecyparis Lawsoniana.

In this study, the wool fabrics were mordanted with natural mordent agents. After mordanting, the samples were dyed with the natural dye extracted from the cone of Chamaecyparis Lawsoniana. Ultimately, the fastness properties, color strength values and antimicrobial properties of samples were investigated in terms of the type of mordant used.

2. Materials and Methods

2.1. Fabrics

Plain woven wool fabric with 80 g/m^2 weight was dyed with the natural dyes obtained from Chamaecyparis Lawsoniana. Before the dyeing process, the wool fabric was treated with 1 g/l non-ionic washing agent at liquor ratio of 1:50 for 30 minutes at 50 °C.

2.2. Apparatus

Mordanting and dyeing processes were performed in HT laboratory dyeing machine (thermal). (Emsey Teknik) The color measurement was by use of Datacolor 650 Spectrophotometer.

2.3. The Mordanting Process

The samples were mordanted with mordant agent obtained from Cypress Leaf (Cupressus sempervirens), Lemon Peel and the Larch Cones. Cypress tree leaves, extracts of lemon peel and pine cones were used. 1000 g for each plant mordant was boiled 1 hour and 1000 ml of distilled water was used to filter the mordants after cooling.

About 3 grams wool fabric was mordanted with three types mordant agents by four different concentrations as %1, %2, %4 and %8. Mordanting was carried out in a liquor ratio of 1:50 at the boiling temperature for 1 hour. Mordanted samples were waited in the liquor for night then washed under top running water, squeezed and finally dried at room temperature.

2.4. Dyeing Process

The natural dye is obtained by extraction of Chamaecyparis Lawsoniana cones which is from the family of Cupressaceous and species of Chamaecyparis Lawsoniana (A. Murr.) Parlor. The natural dye was obtained that 1000 g cones was boiled and cooled in 1000 ml distilled water, then filtered.

Firstly, wool fabrics were dyed in liquor ratio of 1:50 at the boiling temperature for 1 hour. Secondly, the samples were washed with 500 ml of cold water. Thirdly, washed samples were washed with 500 ml of boiling water. Finally, the samples were washed with 500 ml of cold water then squeezed and dried at room temperature. The dyeing process of wool fabric is given in Figure 2.

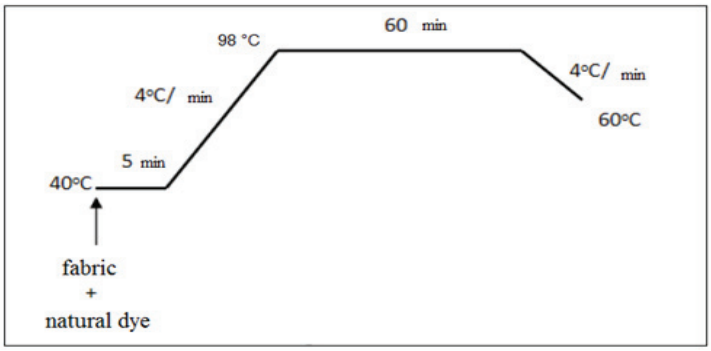


Fig. 2. Dyeing Process of Wool Fabric.

2.5. Washing Fastness

The washing fastness of samples was performed by the application of TS 716 test method (ISO 105-C06, 2010).

2.6. Color Measurement

In this study, Datacolor 650 Spectrophotometer and ISO 105 J01: 1997 standard were used to analyze the Reflectance Values (%R) of wool dyed fabric between 400 and 700 nm (Fairchild, 1997).

The reflectance values of the dyed fabrics were analyzed by using Gretaq Macbeth–Colour Eye 2180UV spectrophotometer and the CIELab values were calculated using illuminant D65 and 10^o standard observer values. The color strength (K/S) values of samples were calculated with the Kubelka-Munk equation (Eqn 1) (Fairchild, 1997) and the reflectance values (R) at the maximum absorption wavelength (λmax). The calculation of K/S values was carried out with regard to the maximum absorption at 520 nm.

$$K/S= (1-R)\ 2/2R \qquad (1)$$

2.6. Antimicrobial Measurements

In this study, ASTM E2149:2013 standard was used to test the antimicrobial effects on dyed wool fabric. By this method, the samples were placed in a laboratory flask containing a dilute suspension of Escherichia coli. The flask is placed onto a wrist-action shaker and shaken for an adequate exposure time, typically 1 hour. Following exposure procedure, sample of the test organism suspension was removed quantitatively analyzed then dyed with for survivors. The resulting plates were incubated, the number of survivors was enumerated and a percent reduction was determined for the test flask as compared to the untreated control suspension (ASTM E2149, 2013).

3. Results and Discussion

3.1. Washing Fastness Results

Table 1 shows the washing fastness of the dyed wool fabric with three different concentration of the mordant and then dyed with Chamaecyparis Lawsoniana dyes.

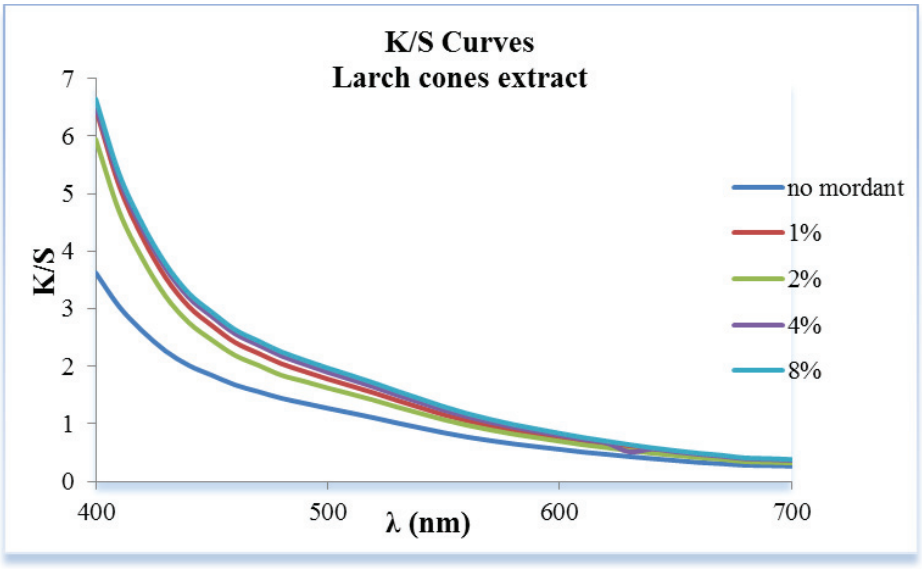
Table 1. The Washing Fastness of Samples.

Samples	Mordant, %	Change Color	Staining					
			CA	Co	PA	PES	PAN	Wo
No Mordant		2	5	4	4-5	5	5	4
Larch cones extract	1	2	4-5	4	5	4-5	4-5	4
	2	1-2	4-5	4-5	4	5	5	5
	4	2-3	5	4-5	4	5	4-5	5
	8	1	5	4	3-4	5	5	4-5
Lemon peel extract	1	3	4-5	3-4	4	5	4-5	4-5
	2	1-2	4-5	4-5	3-4	5	5	4-5
	4	2	4-5	4-5	3-4	5	5	4-5
	8	2	4-5	4-5	3-4	5	5	4-5
Cypress tree leaf extract	1	3	4-5	4	3-4	5	4-5	4-5
	2	1-2	5	4-5	3	5	5	5
	4	1-2	5	4-5	4	5	4-5	5
	8	1-2	5	4-5	4	5	5	5

The results show that, the lower mordant concentrations gave in general better color change and all mordant concentrations lower staining values. The reason of these results was deemed that the chemical structure of mordant agent effected the fastness properties of samples.

3.2. Colorimetric Measurements Results

The results of color strength (K/S) values of the samples dyed via different mordants are given in Figure 3.



(a)

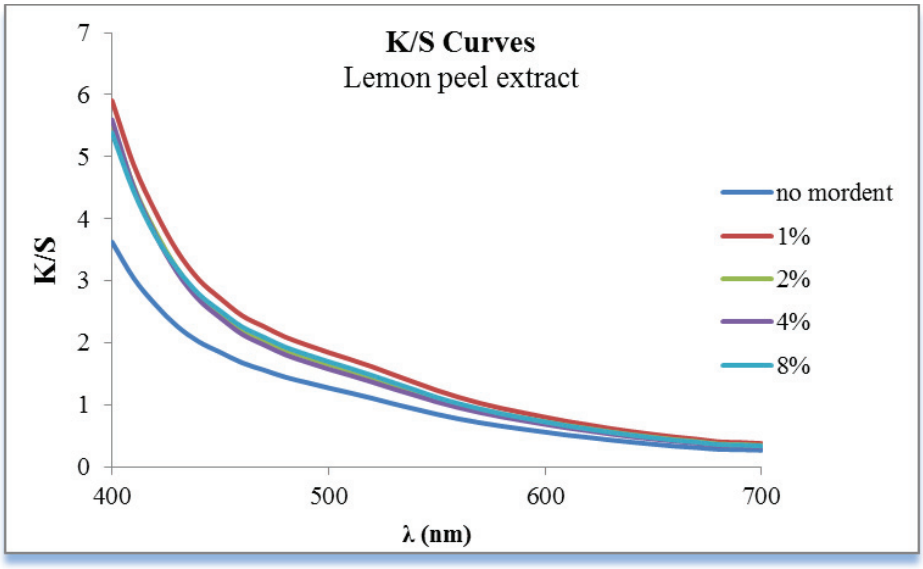


Fig. 3. K/S Curves ((a). The color strength values of larch cones extract, (b). The color strength values of lemon peel extract, (c). The color strength values of cypress tree leaf extract)

The results show that %8 mordant with larch, %1 mordant with lemon peel and %8 mordant with cypress gave better K/S values.

3.3. Antimicrobial Tests Results

Antibacterial activity was not observed in the Chamaecyparis Lawsoniana dyed wool fabric by ASTM E2149:2013 antibacterial test method.

4. Conclusion

The following results about the Chamaecyparis Lawsoniana dyed wool fabric were obtained:

- Despite low levels of dyeing discoloration values of wool material is determined, staining fastness is high. However, an increase in concentration of mordant is not very effective in the development of staining fastness.
- The research show that %8 mordant with larch, %1 mordant with lemon peel and %8 mordant with cypress gave better K/S values.
- Antibacterial activity was not observed in the Chamaecyparis Lawsoniana dyed wool fabric.

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