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Eco–friendly dyeing of fabric and wool yarn samples with *Morus nigra* leaf extracts

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Abstract: *Morus nigra* L. is a biologically important plant. In addition to the biological importance of the extracts obtained from its various parts, it is used as a material in various fields. In this work, dyeing properties of the cotton fabrics and the wool yarns with *Morus nigra* L. leaf extracts were investigated. In dyeing studies using *Morus nigra* L. leaf extracts, yellow tones were obtained in dyeing cotton fabrics, and green and yellow tones were obtained in dyeing wool yarns. Washing, rubbing and light fastness of dyed textile products were examined. According to the results, cotton fabrics showed better dyeing potential than wool yarns. As a result, *Morus nigra* L. leaf can be used as a natural dyeing agent in the dyeing of textile products.

Keywords: *Morus nigra* L*,* natural dyes, mordant, color, extract.

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1. INTRODUCTION

The use of synthetic dyes in the textile industry is increasing day by day and poses a great concern for the environment. Since most of the synthetic dyes are produced from toxic chemicals, they have negative effects on human health and the eco-system. Harmful effects such as mutagenicity or toxicity arising from the production and application of synthetic dyes direct the studies in the field of textiles to eco-friendly natural dyes (1). It is thought that natural dyes are safer for the environment than synthetic dyes and produce less harmful waste during the dyeing process. However, the lower affinity of natural dyes for textile products is considered a disadvantage (2). The simple extraction processes used for the production of natural dyes make it more advantageous and greener than synthetic dyes, which are produced in multiple steps and where many synthetic processes are involved (3).

Extracts obtained from various parts of plants have an important place in material chemistry in addition to their strong biological properties. The natural dyes used especially in the dyeing of textile products are obtained from plant extracts, and are a very important alternatives to synthetic dyes due to their properties such as being biodegradable, non-allergenic and non-toxic (4, 5). In addition, natural dyes prepared by using parts of plants such as leaves and fruits can be considered environmentally friendly and economical.

Mulberry trees can live in different climatic conditions, such as tropical, subtropical and moderate, throughout the world and show a wide distribution from sea level to heights exceeding 4000 meters (6). Various morphological parts of mulberry such as leaves, fruits, roots and stems have been used for different purposes (7). *Morus nigra* L. (Moraceae), known as ‘‘black mulberry” or “wild mulberry” belongs to the genus Morus and used as an expectorant, antiseptic, sedative, diuretic, laxative antioxidant, and anthelmintic (8, 9). It has important effects due to the presence of flavonoids, tannins, coumarins, triterpenoids and steroids in its composition (10). The studies in the literature have shown that *Morus nigra* L. has anti-oxidant, anti-bacterial, cytotoxic, anti-inflammatory and anti-cancer properties (11–15). It has also been reported that it can be used for dyeing textile products (16).

The aim of this study is to investigate the usability of *Morus nigra* L. leaves for dyeing textile products. The findings obtained in the study showed that black *Morus nigra* L. leaves can be used successfully in the dyeing of textile products (wool yarn and cotton fabric). The studies show that there is plenty of isoquercitrin in *Morus nigra* L. leaves (9, 17). The complex between the mordants used and isoquercitrin (Figure 1) shows the property of dyestuff.

2. EXPERIMENTAL

2.1. Materials

Morus nigra L. leaves were collected in July from Tokat, Turkey. Iron(II) sulfate heptahydrate ($FeSO_4.7H_2O$), copper(II) sulfate pentahydrate ($CuSO_4.5H_2O$) and aluminum potassium sulfate dodecahydrate ($AlK(SO_4)_2.12H_2O$) were used as mordant and were obtained from Merck. The color properties of the dyed textile products were evaluated by Spectrophotometer (Premier Colorscan SS 6200A). Light, washing and rubbing fastnesses of dyed textile products were determined using Atlas weather–ometer, Launder–ometer and 255 model crock–meter, respectively. Spectral reflectance measurements were determined with a Konica Minolta 3600d spectrophotometer.

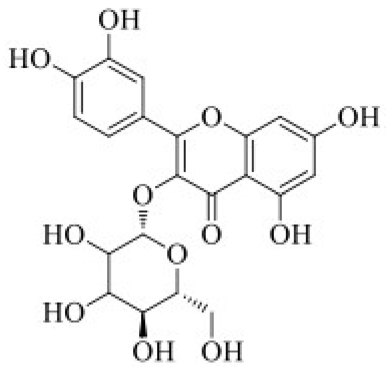

Figure 1: The structure of isoquercitrin.

2.2. Method

Dried *Morus nigra* L. leaves (100 g) were refluxed on soxhlet tool using distilled water. This process was continued until the mixture became colorless. We applied pre–, meta– and post– mordanting methods as in our other studies (18–20).

2.2.1. Pre–mordanting method

The textile products (5 g) were heated in 0.1 M mordant solution (100 mL) for 1 h at 90 ℃. The textile products (5 g) was heated in 0.1 M mordant solution (100 mL) for 1 h at 90 ℃. After cooling the samples, it was rinsed with distilled water and put into dye–bath solution (100 mL). It was heated at 90 ℃ for 1 h. The dyed samples were rinsed with distilled water and dried.

2.2.2. Meta–mordanting method

0.1 M mordant solution, dyestuff solution and textiles were placed in the flask and heated at 90 °C for 1 h. After cooling, it was rinsed and dried.

2.2.3. Post–mordanting method

The textile products (5 g) were first treated with the dyestuff solution at 90°C for 1h. After cooling, it was rinsed with distilled water and put into 0.1 M mordant solution (100 mL) and heated for 1h at 90°C. The dyed samples were rinsed with distilled water and dried.

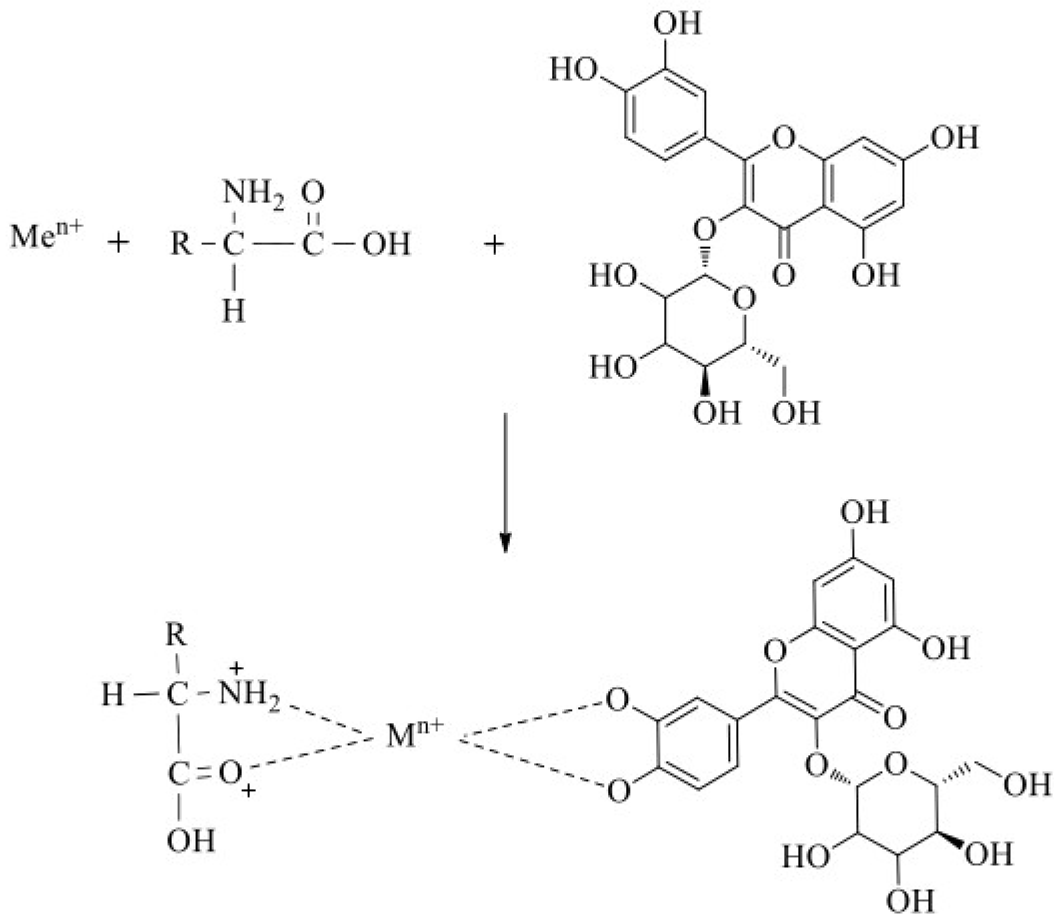

Figure 2: The proposed mechanism of dyestuff with mordants for wool yarn.

3. RESULTS AND DISCUSSION

The studies have shown that *Morus nigra* L. leave extracts contain abundant isoquercitrin (4, 14). Therefore, we suggested the mechanisms in Figures 3 and 4, considering that the dyestuff in *Morus nigra* L. leaves is isoquercitrin. Mordants are the most important agents used in natural dyes to exhibit dye properties. It provides better adhesion of the dyestuff to the fiber or fabric and increases the fastness of dyed fibers. In this study, we used $CuSO_4$, $FeSO_4$ and $AlK(SO_4)_2$ metal salts as mordants.

Free amino ($–NH_2$) and carboxyl groups (–COOH) of wool yarn are suitable for complexing with metals. At the same time, the oxochrome groups of the dyestuff can form stable complexes with metals (Figure 2). The metal complex formed between the $–CH_2O$ groups in the cellulose molecules in the cotton fabric and the –OH groups in the dyestuff isoquercitrin shows dyestuff properties (Figure 3).

Fastness values and color codes for dyed textile products are given in Table 1. Color codes were determined using the Pantone Color Guide (Table 1). From green to beige for $CuSO_4$, gray tones for $FeSO_4$, and yellow tones for $AlK(SO_4)_2$ were obtained. Fastness values are listed as $CuSO_4$, $FeSO_4$ and $AlK(SO_4)_2$. When Table 1 is examined, the fastness values for all three mordants are higher in the post mordanting method. Green tones were obtained for $CuSO_4$, brown tones for $FeSO_4$, and yellow tones for $AlK(SO_4)_2$. If we are to rank, the fastness results can be listed as $CuSO_4$, $AlK(SO_4)_2$ and $FeSO_4$. As a dyeing method, we can list it as post–, meta– and pre–mordanting method.

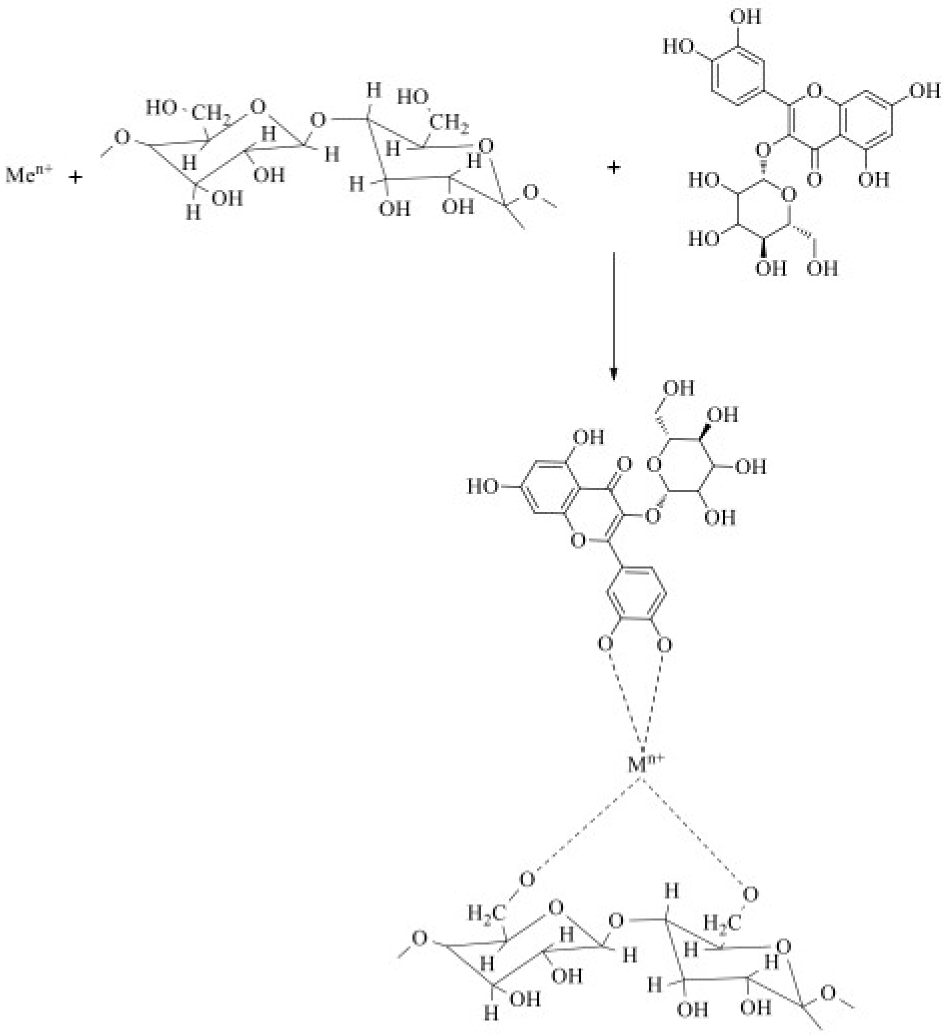

Figure 3: The proposed mechanism of dyestuff with mordants for cotton fabric.

CIE-Lab is a three-dimensional color space with *L**, *a**, *b** parameters. The *L** axis takes values between 0 and 100, and 0 represents black and 100 represents white. *a** is the red/green axis and negative values of *a** represent green and positive values represent redness. *b** is the yellow/blue axis and negative values of *b** indicate blueness and positive values indicate yellowness (21, 22). The K/S values of the dyed samples were determined using the Kubelka-Munk equation (23). K/S and *L**, *a**, *b** values of textile products are given in Table 2. In this study, while yellow and pale yellow color tones are obtained in cotton fabrics, green, dark green and yellow color tones are obtained in woolen yarns. All dyed textile samples with *Morus nigra* L. leaves extracts are as in Figure 4.

Table 1: Wash, rubbing and light fastness values of dyed samples.

	Method	Mordant	Wash fastness[a]	Rubbing fastness[b] (wet–dry)	Light fastness[c]	Color code (Pantone)
Cotton	Pre–	$FeSO_4$	3	4/5–4/5	3/4	481 CS
	Meta–		4	4/5–5	4	7530 CS
	Post–		5	5–5	4/5	482 CS
	Pre–	$CuSO_4$	3/4	5–5	4/5	4545 CS
	Meta–		4	4/5–5	4/5	4535 CS
	Post–		5	5–5	4/5	7535 CS
	Pre–	$AlK(SO_4)_2$	3	4/5–4/ 5	4/5	7492CS
	Meta–		3/4	5–5	4/5	586 CS
	Post–		5	5–5	5	587 CS
		unmordant	3	5–5	3/4	580 CS
Wool yarn	Pre–	$FeSO_4$	3	4/5-4/5	2/3	4495 CS
	Meta–		3/4	5–5	4	403 CS
	Post–		4	4/5–5	4	7536 CS
	Pre–	$CuSO_4$	3	4/5–4/5	3/4	620 CS
	Meta–		3/4	5–5	4/5	5763 CS
	Post–		4/5	5–5	4/5	557 CS
	Pre–	$AlK(SO_4)_2$	3	4–4/5	4	7404 CS
	Meta–		3/4	4/5–5	4/5	7402 CS
	Post–		4	5–5	4/5	557 CS
		unmordant	4	5-5	3/4	617 CS

[a]Wash and [b]rub fastness 1 = poor, 5 = very good, [c]Light fastness 1 = very poor, 8 = outstanding

Table 2: K/S and *L** *a** *b** values of textile products.

Fabric	**Mordant**	***L****	***a****	***b****	**K/S**
Cotton	$FeSO_4$	60.55	–4.55	29.38	5.86
		59.25	–4.50	27.32	5.70
		56.99	–3.00	26.40	5.62
	$CuSO_4$	51.66	5.44	28.45	11.26
		55.45	5.0	22.28	9.35
		57.95	5.46	21.09	10.20
	$AlK(SO_4)_2$	66.25	–0.99	43.35	5.90
		6829	–0.90	40.30	5.95
		69.75	–0.35	44.33	6.12
Wool	$FeSO_4$	62.01	–3.03	30.01	6.87
		61.90	–2.46	29.05	5.11
		63.01	0.98	32.66	6.88
	$CuSO_4$	52.88	5.89	20.52	11.01
		50.05	5.65	21.67	7.05
		53.06	7.99	24.45	5.99
	$AlK(SO_4)_2$	70.72	–0.20	40.36	5.63
		69.36	0.54	38.99	5.60
		72.75	–0.64	42.44	5.75
unmordant–cotton	–	64.36	–0.98	26.19	4.70
unmordant–wool	–	66.45	–1.5	27.21	5.89

Figure 4. Samples dyed with *Morus nigra* L. leaf extract.

4. CONCLUSION

Natural dyes are an important alternative to synthetic dyes because they are environmentally friendly and economical. In this present work, the *Morus nigra* L. leaves aqueous solution was used for dyeing of cotton fabric and wool yarn. Yellow color tones were obtained in the dyeing of cotton fabrics. Green, dark green and yellow color tones were obtained in the dyeing of wool yarns. As a result, considering that *Morus nigra* L. is a natural product, it can be concluded that it can be an easy-to-access and environmentally friendly textile dye. It also offers an economical dyeing opportunity.

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