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Review Article

Dyeing Properties of Wool Fabrics Dyed with Madder Roots, Chamomiles, Pomegranate Peels and Apple Tree Branches Barks Aqueous Extracts

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Abstract

This paper studies the dyeing properties of wool fabrics dyed with madder roots, chamomiles, pomegranate peels and apple tree branches (obtained after pruning) barks aqueous extracts. We have thoroughly investigated the effects of dye bath pH and mordants on the color properties of the aforementioned fabrics. Even without mordanting the wool fabrics dyed with the pomegranate peel have the highest value of colour strength (K/S=14). Mordanting permits to produce different colors and improve the fastness of a dye especially for madder roots, chamomile and apple tree branches bark. Experimental results show that the fastness properties of dyed wool fabrics range from average to excellent even without mordanting.

Keywords: Extraction; Madder Roots; Chamomiles; Pomegranate Peels; Apple Tree Branches Barks Aqueous; Dyeing

Introduction

Dyes derived from natural resources, such as plant, animal, mineral, and microbial, were the only substances available to mankind for the dyeing of textiles until the discovery of the first synthetic dye "mauveine" in 1856 by William Henry Perkin. Rapid research strides in synthetic chemistry supported by the industrialization of textile production not only led to the development of synthetic alternatives to popular natural dyes but also to a number of synthetic dyes in various hues and colors that gradually pushed the natural dyes into obliviousness [1]. However, national and international awareness about exhaustion of natural resources, ecological imbalance, pollution problems and over-disturbed environment due to ample usage of hazardous chemicals have forced to concentrate application of natural dyes which are non-toxic, non-allergic and noncarcinogenic [2,3]. Natural dyes can be used for dyeing almost all types of natural fibers. Current research shows that natural dyes can also be used to dye some synthetic fibers [4]. Apart from their application in textiles, they are, too, used in the coloration of food, medicines, handicraft articles, and in leather processing, and many of the dye-yielding plants are used as medicines in various traditional medicinal therapy [5]. In spite of their inferior fastness, many of natural dyes are antibacterial, antifungal, antioxidant, antileishmanial and anti cancer [2,3]. [3,6]. Furthermore, they are more acceptable to environmentally conscious people around the world. Considerable research work is being undertaken around the world on the extraction and the application of natural dyes [7-11]. The present study focuses on the extraction of natural dyes from madder roots, chamomiles, pomegranate peels and apple tree branches barks (obtained after pruning) and their use in dyeing wool fabrics.

Experimental

Fabrics

Square pieces (17*17 cm2) of unmordanted wool twill fabric; each piece has the weight of 207 gm-2.

Extraction

Plant materials are boiled in 100 ml of water for 60 min at the temperature of 95oC at a bath ratio of 1/20. The dye baths were filtrated and cooled.

Dyeing process

Wool fabrics are dyed by the process illustrated bellow Figure 1. The dyeing was carried out at 1:20 MLR (material to liquor ratio) in Mathis dyeing machine. For mordanting dyes process we use 7,5 gL-1 of mordant, which are copper sulfate, ferrous sulfate and double sulfate of aluminum potassium. All chemicals are purchased from Fluka and Sigma-Aldrich.

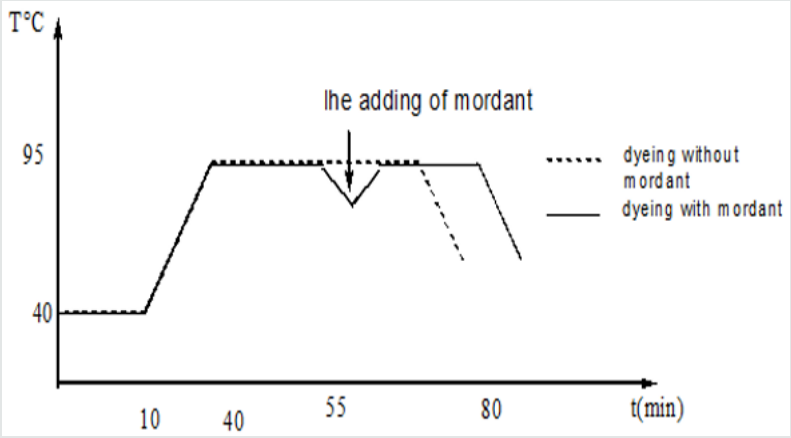


Figure 1: Dyeing process of wool fabric.

Colorimetric Evaluation

The spectral reflectance of the dyed samples was measured by a Spectro Flash SF300 spectrophotometer with dataMaster 2.3 (Datacolor International, USA) using D and 10° standard observer. Color coordinates L*, a* and b*represent lightness or luminosity, redness-greenness of color and yellowness–blueness of color, respectively. They were calculated from the reflectance data for 10° observer and illuminant D65. While the K/S values were calculated by the Kubeka-Munk (equation (1).

$$\frac{k}{S}=\frac{(1-R)^2}{2R}-\frac{(1-R_0)^2}{2R_0} \quad (1)$$

Where R; is the decimal fraction of the reflectance of dyed fabrics.

R0 : is the decimal fraction of the reflectance of undyed fabrics.

K: is the absorption coefficient, and S is the scattering coefficient.

Fastness Testing

The dyed samples were evaluated according to NF and ISO standard methods: ISO 105-X12: 2002 for color fastness to rubbing; ISO 105-C10:2006 for color fastness to washing and ISO 105-B02:1994 for color fastness to light.

Results and Discussion

Dye Extraction

The aqueous extracts of chamomile, pomegranate and madder roots are characterized by colour ranging from yellow brown to red. These coolers are chemically related mainly to polymers of low molecular weight phenolic compounds and anthraquinons [12]. Researchers have identified in Chamomile aqueous extract: herniarin, apigenin-7-diacetyl- glucoside, apigenin-7-glucoside, luteolin-7-glucoside, chlorogenic acid, rating [7]. Apple tree branches bark equeous extract contains phloridzin and some other phenolic compounds. However, the crude extract of the roots of the madder (Rubbia tinctoria) contains about 35 anthraquinones pigments in which alizarin, purpurin, and pseudo purpurin are the major coloring matters [10]. Interestingly, pomegranate peels extract is including anthocyanins, granatonine (an alkaloid) and several of phenolic compounds (such as gallic acid, quince acid, ellagic acid, catechin, kaempferol and mallic acid) [13]. An overview of the aqueous extracts compounds is given in Figures 2-5. On the other hand, Figure 6 shows the UV–vis spectrum of aqueous fractions. It was found that these spectrums of chamomile, apple tree branches barks, pomegranate peels and madder roots aqueous extracts showed three major peaks in the visible region respectively at 359, 400, 520 and 580 nm.

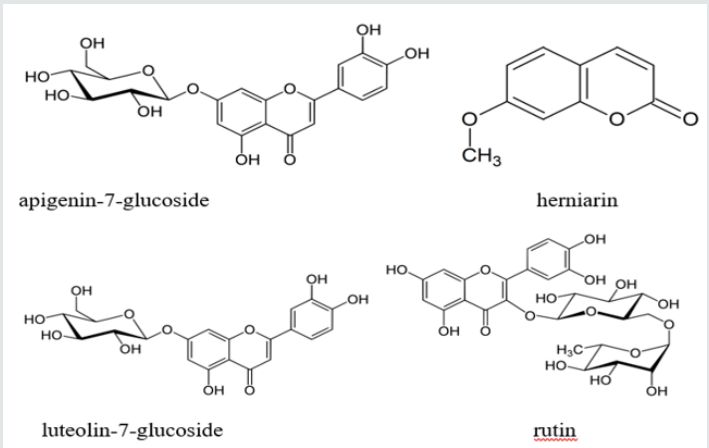


Figure 2: Compounds identified in Chamomile extract.

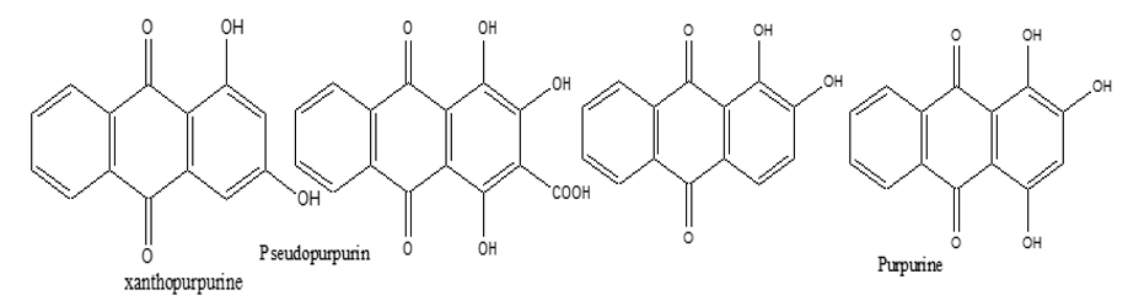


Figure 3: Some of anthraquinones (xanthopurpurine, pseudopurpurin, alizarin and purpurin) identified in madder roots extract.

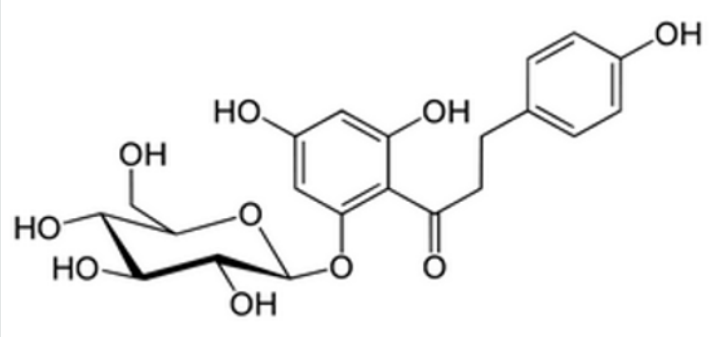


Figure 4: Phloridzin one of phenolic compounds of apple branches tree extract.

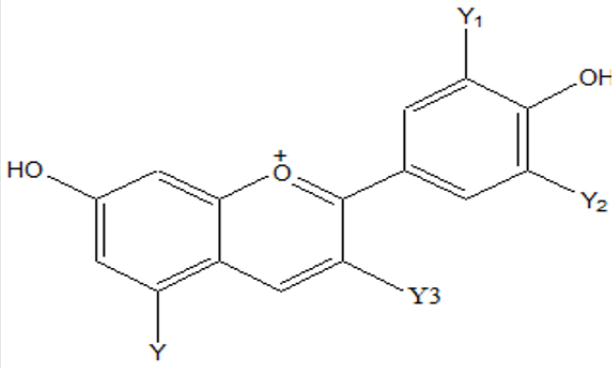


Figure 5: Pomegranate peel anthocyanes.

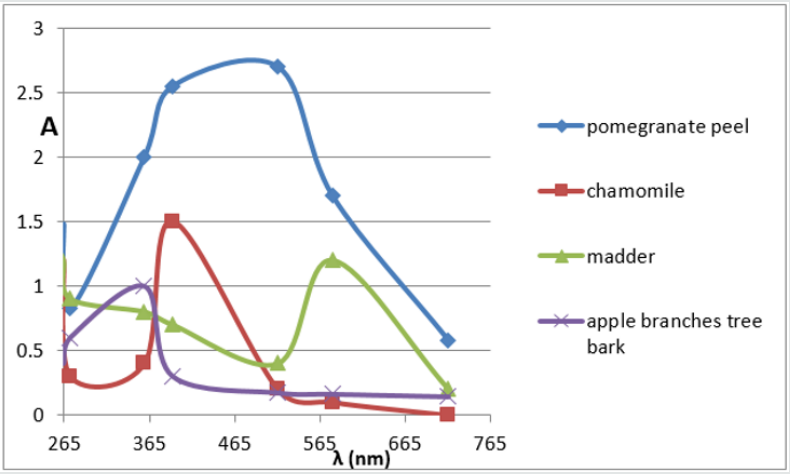


Figure 6: UV–vis spectra of pomegranate peel, chamomile, madder roots and apple branches tree bark aqueous fraction.

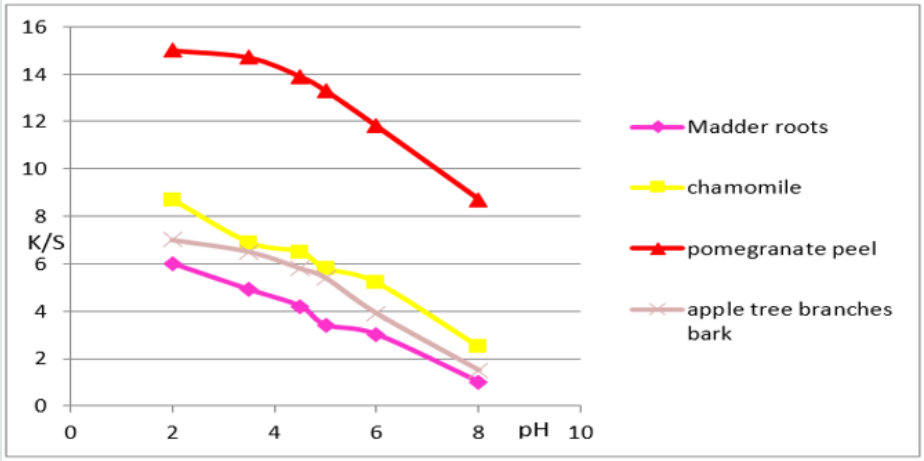


Figure 7: Effect of dye bath pH on the color strength of wool fabrics dyed with pomegranate peel, chamomile, madder roots and apple branches tree bark aqueous extracts.

Effect of pH

The Figure 7 shows that the pH values of the dye bath have considerable effects on the dyeability of wool fabrics while using madder roots, chamomiles, pomegranate peels and apple tree branches barks aqueous extracts. As it is illustrated in Figure 3 the depth of shades of wool fabrics dyed with aqueous extracts of pomegranate peel> chamomile> apple tree branches bark> madder roots. Wool fabric dyed with pomegranate peels extract has remarkably the most important value of depth of shades comparing to the ones dyed with others plant aqueous extracts. The effect of the dye bath pH can be attributed to the correlation between the natural dyes structures and wool fabric. Wool fibres are amphoteric because of the presence of acidic and basic side chains in some of the constituent proteins. Under acidic conditions, all the cationic groups in wool are potential sites for the attraction of negatively charged, anionic acid dyes to wool. The negative charge on wool under alkaline conditions (above pH 8) makes the fibre substantive to dyes that carry a cationic charge (basic dyes). Since natural dyes used are sparingly soluble in water, containing OH groups, it will interact ionically with the protonated terminal amino groups of wool fabric at acidic pH via ion exchange reaction because of the acidic character of the OH groups [14].

Colour Parameters

Natural dyes are either substantive, which need no mordant, or adjective which necessitate a mordant. The majority of natural dyes need a metal salt to create an affinity between the fiber and the pigment. Mordants not only give the dye an affinity, but in many cases, they produce different colors and improve the fastness of a dye [15]. As it is showed in the Table 1a-1d, When mordant was added, the values of L* decreased and the values of K/S increased. Thus, the highest value of L* and lowest value of K/S showed lighter shades, while both the lowest values of L* and the highest values of K/S signify deeper shades of dyed samples. Positive a* and positive b* represent red and yellow, respectively. Therefore, wool fabrics meta-mrdanted with ferrous sulfate have lower value of a*and b* than those meta-mordanted with copper sulfate or meta-mrdanted with alum. Therefore, as it is illustrated in the Table 1b, on adding mordant to pomegranate peel dye bath, we obtain wool fabrics with these shades: pale brown yellow (with Al), yellow brown (with Cu) and greenish grey (with Fe).

Table 1a: Colour parameters of wool fabrics dyed with chamomile.

Mordant 7,5 gL-1	L*	a*	b*	c*	h*	k/s	Colour shades
Potassium alum	62,79	6,52	36,58	37,15	79,89	8,2	
Copper sulfate	50,12	3,58	28,34	28,57	82,6	8,5	
ferrous sulfate	40,47	0,08	11,27	11,27	90,4	8,7	
Without mordant	68,34	3,25	25,86	26,07	82,85	8	

Table 1b: Colour parameters of wool fabrics dyed with chamomile with pomegranate peel.

Mordant 7,5 gL-1	L*	a*	b*	c*	h*	k/s	Colour shades
Potassium alum	64,94	2,38	29,56	29,66	85	14	
Copper sulfate	56,95	8,9	63,54	64,16	82	14,3	

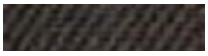
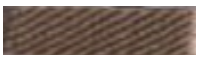
ferrous sulfate	42,64	11,4	33,52	35,4	71,2	14,5	
Without mordant	62,74	5,89	30,06	30,63	78,9	14	

Table 1c: Colour parameters of wool fabrics dyed with apple tree branches bark.

Mordant 7,5 gL-1	L*	a*	b*	c*	h*	k/s	Colour shades
Potassium alum	70,5	8,8	45,5	42,59	81,2	8	
Copper sulfate	50,29	6,52	28,3	29	77	8,8	
ferrous sulfate	42,8	1,34	14,32	14,38	84,6	9	
Without mordant	71,5	46,2	45,59	45,59	82,5	8,4	

Table 1d: Colour parameters of wool fabrics dyed with madder roots.

Mordant 7,5 gL-1	L*	a*	b*	c*	h*	k/s	Colour shades
Potassium alum	53,4	21,38	19,12	28,68	41,79	6,5	
Copper sulfate	50,24	13,2	14,63	19,71	47,95	6,8	
ferrous sulfate	46,35	7,64	12,66	14,79	58,89	7	
Without mordant	55,44	25,9	23,96	35,28	42,77	6,4	

We obtain almost the same shades with chamomile and apple tree branches barks. While, dyeing wool fabrics with madder roots extract brings the most important value of a* even after mordanting. Consequently, it produces shades ranging from red to grey (with Fe).

Fastness Properties

The fastness values to washing, rubbing and light of wool fabrics dyed with aqueous extracts of vegetable dyes, with or without mordants, are shown in Table 2. The Control samples show good washing and rubbing fastness while the light fastness was quite good for wool fabric dyed with chamomile or apple tree branches bark aqueous extracts, however it shows poor fastness for ones dyed with madder roots extract which has improved by mordanting. The light fatness is excellent for wool fabrics dyed with pomegranate peel even without mordanting. This good fastness can be explained by the possible reaction of esterification between the phenol groups of anthocyanins, for example, and the acid groups of wool fiber. Dyeing with pomegranate peel extract gives better results than those obtained with other natural dyes such as Curcumin Saffron and Henna [15]. The dearth of light fastness is known as the foremost problem of natural dyes. Indeed, very few natural dyes give strong colors on vegetable dyes without addition of mordants [16]. Although, pomegranate peels are rich with tannins and tannic acid. Tannic acid is water-soluble phenolic compound that has been used in textile industry for both pre-treatment and post-treatment to increase wash fastness and light fastness, e.g. on cotton fabrics [17]. As already stated by other authors, the fact can be explained by efficient absorption of UV-Visible light by tannins [18].

Table 2: Fastness properties of the dyed samples with or without metallic salts.

Vegetable dye	Mordant	Wash fastness						Light fastness	Rubbing fastness	
		Acétate	Cotton	Nylon	PES	PAC	Wool		D*	W*
Pomegranate peels	Ferrous Sulfate	5	5	5	5	5	5	7-8	4	3
	Copper Sulfate	5	5	5	5	5	4/5	7	4	4
	alum	5	5	5	5	5	4/5	7	5	4
	Without mordant	5	5	5	5	5	4/5	7	4/5	4
Chamomile	Ferrous Sulfate	5	5	5	5	5	5	4-5	3	2/3
	Copper Sulfate	5	5	5	5	5	5	4-5	3/4	3
	alum	5	5	5	5	5	5	6	5	4
	Without mordant	5	5	5	5	5	5	4	4/5	4

Apple tree's bark	Ferrous Sulfate	5	5	5	5	5	5	4	4	3
	Copper Sulfate	5	5	5	5	5	5	6	3	3/4
	alum	5	5	5	5	5	4/5	4	5	4/5
	Without mordant	5	5	5	5	5	4/5	3-4	5	4/5
Madder	Ferrous Sulfate	5	5	5	5	5	5	5-6	5	4/5
	Copper Sulfate	5	5	5	5	5	5	5-6	5	4/5
	alum	5	5	5	5	5	4/5	4	5	4/5
	Without mordant	5	4/5	5	5	5	4	2-3	4	¾

Conclusion

The obtained results have shown that the dyeing potential of the pomegranate peel, chamomiles, madder roots and apple tree branches barks is of considerable value. We notice that pomegranate peel have the greatest value of depth of shade compared to chamomile, madder roots and apple tree branches barks (obtained after pruning) [19-22]. In this paper, there is an assessment of the dyeing properties of wool fabrics via studying the effects of some chemical and physical parameters (pH and mordants) as well as focusing on colour parameters. We obtain a wide range of soft and light colors ranging from brownish hues to reddish ones by dyeing wool fabrics with the pomegranate peel, chamomiles, apple tree branches barks and madder roots respectively. With regards to color fastness, test samples exhibit excellent fastness to washing and to rubbing and good to excellent fastness to light.

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