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Application of Pomegranate Natural Dye on Banana Fiber

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Abstract

he use of natural dyes and natural finishes on textiles has become a matter of importance because of the increased environmental awareness to avoid hazardous synthetic dyes (soluble and Non water soluble) and synthetic chemicals. The objective of this study is to dye Banana fiber with pomegranate peel natural dye for comparative analysis of colour efficiencies (K/S), CIE *L*a*b** values and the colour fastness properties. Pre-mordanting and post-mordanting of banana fiber were carried out using alum, stannous chloride and ferrous sulphate mordants. Results were achieved for dyeing at 90°C for 60 min at 10%, 30% and 50% concentration of the dye on the weight of fabric using pre- and post-mordant dyeing techniques. Treated fiber showed a substantial increase in colour depth (K/S) and adequate wash, light and rubbing fastness properties without and with mordanted and dyed banana fiber.

Keywords: Banana Fiber, Pomegranate Natural Dye, Alum, Ferrous Shulphate, Stannous Chloride, Weighing Balance, Water Bath, Hot Air Oven.

Introduction

Natural dyes are colorants that are extracted from various parts of plants such as flowers, roots, barks, leaves and fruits as well as from insects (N. Punrattanasin et al., 2013). Natural dyes are completely biodegradable, anti-allergic, non-toxic and have deodorizing properties (Kulkarni *et al.,* 2011). The natural dyes demand continuously increasing because it does not require any strong acids andalkalis in their applications and productions (Kulkarni *et al.,* 2011; Jung, 2016). Recently, interest has grown in natural dye applications in the textile industry as a result of the urgent demand for eco-friendly and biodegradable products.

Natural dyes were used as substitute of synthetic dyes due to environmental conditions. They are non-polluting, non-carcinogenic and eco-friendly. Synthetic dyes are broadly disparaged in the world because, they cause water pollution and waste disposal problems. Natural dyes are environmental friendly, biodegradable and non-toxic. They are attracting the awareness of people. Some of natural dyes are anti-allergic and proved to be safe for body contact.

The botanical name of Pomegranate is '*Punicagranatum'* which belongs from the family ofPunicacea. The Punicagranatum is firstly a native of Persia and neighboring countries, but nowadays it cultivates in all warm countries of the world (Sheets *et al.,* 1994). The pomegranate rind contains a significant amount of tannin approximately 19% with pelletierine (Kulkarni *et al.,* 2011; Tiwari *et al.,* 2010).

Pomegranates are reported as antimicrobial agents and the fabrics which are dyed with pomegranate peel dye are used as anti-allergic and antibacterial (Alihosseini and Sun, 2011). In pomegranate peel, granatonine is the main coloring component which is present in the form of N-methyl granatonine (Satyanarayana *et al.,* 2013).

A mordant is an element which makes chemical reaction between the dye and fibers (Samanta andAgarwal, 2009). Mordants are metal salts which make a bridgebetween the dye and fabrics andincrease the dye uptake properties (Vankar, 2009). Natural dyes without mordants have very lowfastness properties because they have very low affinity towards fibers and fabrics (Ali *et al.,* 2007).

Figure 1 explains the chemical structure of Granatonine which is a dyeing material in pomegranante peel. This compound provides color to the dye and the study of thisSome important natural dyes are pomegranate, eucalyptus, kamala, madder, henna, turmeric etc (Adeel *et al.,* 2009; Kechi *et al.,* 2013).

Dyestuff pomegranate dye: It is a natural coloring matter. Coloring substance used was extracted from pomegranate peel (figure 1).

Figure1. (a) Pomegranate Peel (b) Dried peel (c) Powder of Pomegranate Peel

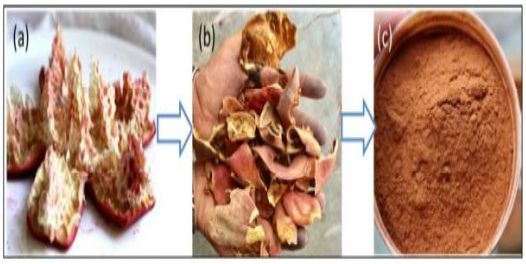


Figure2. Chemical Structure of Granatonine (dyeing material) in Pomegranate Peel

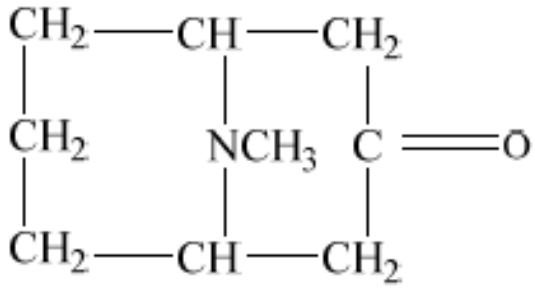
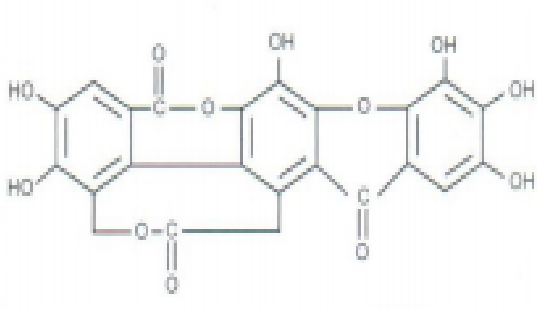


Figure3. Chemical Structure of Puncia granatum



Experimental

Chemicals

Laboratory grade metallic salts such as ferrous (II) sulphate, (FeSO4.7H2O) manufactured by Rankem RFCL Ltd Stannous Chloride ($SnCl_2$) manufactured by Fisher Scientific and Alum ($KAl(SO_4)_2$)were used as a mordant.

Raw Material Preparation

The ready for dyeing banana fiber was extracted from plant. Peels were separated from pomegranates and washed with water to remove the dust particles and other wastes. The peel was kept in direct sunlight for drying. After drying, the dried peels were grind into powder with the help of grinder machine. The grinded powder was used for the extraction process.

Methods

Extraction methods used for Pomegranate

The peel of pomegranate was dried in sunlight for few days for complete removal of moisture present in the peel.Then the dried rinds of pomegranate were crushed in the mixture for the powder form.then the powder is screened by the screening machine.

Mordanting

Pre and post-mordanting with Alam

Alam solution was freshly prepared by dissolving (5%) of alum in distilled water at a liquor ratio 1: 30 and treated at laboratory HTHP dyeing machine with program- mable time and temperature control at 60^0C for 60 min. Fibers were then squeezed and air dried in pre mordanting and same procedure applied after dyeing in post mordanting .

Pre and post-mordanting with ferrous Sulphate

Ferrous Shulphate solution was freshly prepared by dissolving (5%) of Ferrous Shulphate in distilled water at a liquor ratio 1: 30 and treated at laboratory HTHP dyeing machine with program- mabletime and temperature control at 60^0 for 60 min. Fibers were then squeezed and air dried in pre mordanting and same procedure applied after dyeing in post mordanting.

Pre and Post-Mordanting with Stannous Chloride

Stannous chloride solution was freshly prepared by dissolving (5%) of stannous chloride in distilled water at a liquor ratio 1: 30 and treated at laboratory HTHP dyeing machine with program- mabletimeandtemperaturecontrol at 60^0 for 60 min. Fibers were then squeezed and air in pre mordanting and same procedure applied after dyeing in post mordanting.

Dyeing procedure

Three different mordants (Alum, Ferrous Shulphate, and stannous Chloride) were used for dyeing as pre- and post-mordanting agents. Mordanting and dyeing were carried out in a laboratory HTHP dyeing machine with program- mable time and temperature control. The required amount of dye was taken according to the dyeing shade of 10, 30, and 50%, respectively, on the weight of fabric (o.w.f.). Around neutral pH and material-to-liquor ratio of 1:50 were maintained, and dyeing was carried out at 90ºC for 60 min.

Weight of fabric *Required mordant %

Amount of mordant required in mL =

$$\frac{\text{Weight of fabric *Required mordant \%}}{\text{Concentration of stock solution prepared \%}}$$

Amount of dye required in mL =

$$\frac{\text{Weight of fabric * Required shade \%}}{\text{Concentration of stock solution prepared \%}}$$

Evaluation of Dyeing

Evaluation of dyeing was done by determining K/S and L*, a*, and b* values using computer color matching system. Color depth of the samples was evaluated measuring reflectance values by using I control computer color matching

system. The relative color strength (in term of the K/S value) of peel of pomegranate extract natural dyed banana fiber s was measured using the following Kubelka– Munk equation:

$$\frac{K}{S} = \frac{(1-R)^2}{2R}$$

Where *K* is the absorption coefficient, *S* is the scattering coefficient, and *R* is the reflectance of the dyed fiber at the wavelength of maximum absorption.

Results and discussion

Natural dyeing with Pomogranate peel extracts dye on Banana fiber. It is observed in Table 1 that the K/S values of the banana fiber with Pomogranate peel extract dye solution itself increased even without the use of mordant with increase in dye concentration.

When mordant was used before or after dyeing, there was increase in the K/S values, which is attributed to distinct chelation and complex formation of coloring compound with mordant, thus improving fixation on the fiber, giving enhanced K/S values. Different mordants, however, influenced this fixation of dye on fiber to a different extent. This is attributed to increasing the amount of colorant. Pomogranate peel natural dye extract in combination with alum, ferrous Shulphate and stannous Chloride mordants onto Banana Fiber produced good improvement in color depth (K/S), and their values were in positive color coordinates in terms of a* (red) and b* (yellow) values.

Thus, they showed shifts in their tones, resulting in beautiful gamut of colors as compared with the dyeing obtained without using mordant.

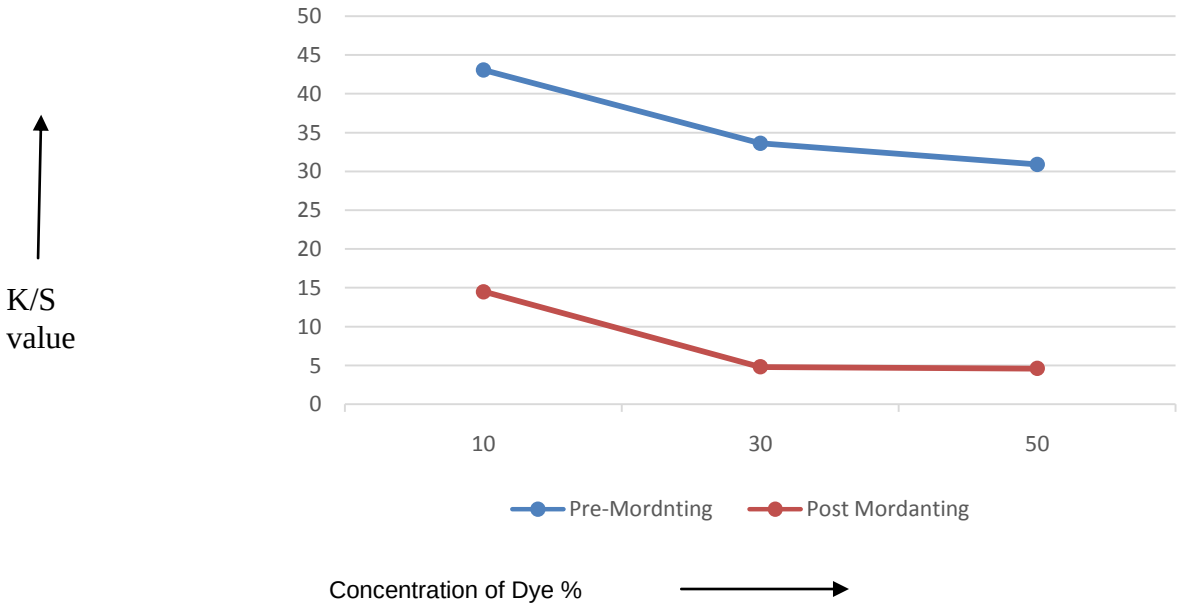
Table1. K/S values and Color Coordinates of Dyed Banana Fiber without and with Mordant Getting Fixed on Banana Fiber

Type of Mordant	Dye Conc. % o.w.f.	K/Svalue	L*	a*	b*
Alam (5%) Pre-mordnting	10	43.06	33.48	3.69	27.65
	30	33.61	22.17	7.96	30.36
	50	30.90	20.66	6.53	28.46
Post Mordanting	10	14.51	8.93	3.78	15.36
	30	4.82	7.32	0.71	3.32
	50	4.61	4.00	0.52	3.21
Ferrous Sulphate (5%) Pre-mordnting	10	25.26	12.49	8.71	18.02
	30	29.63	16.10	8.43	19.92
	50	31.15	15.81	7.96	20.66
Post Mordanting	10	42.75	29.68	4.74	33.84
	30	23.47	12.17	7.81	27.92
	50	29.10	17.83	6.46	29.03
Stannous Chloride (5%) Pre-mordnting	10	12.14	5.25	4.19	12.82
	30	4.07	-7.51	1.78	2.53
	50	1.62	-14.18	0.91	0.21
Post Mordanting	10	34.93	21.46	9.54	23.30
	30	26.26	18.38	5.80	22.80
	50	30.51	20.21	6.70	23.12

L*: lightness (0 = black, 100 = white), a*: red–green coordinates (positive values = red, negative values = green), b*: yellow–blue coordinates (positive values = yellow, negative values = blue).

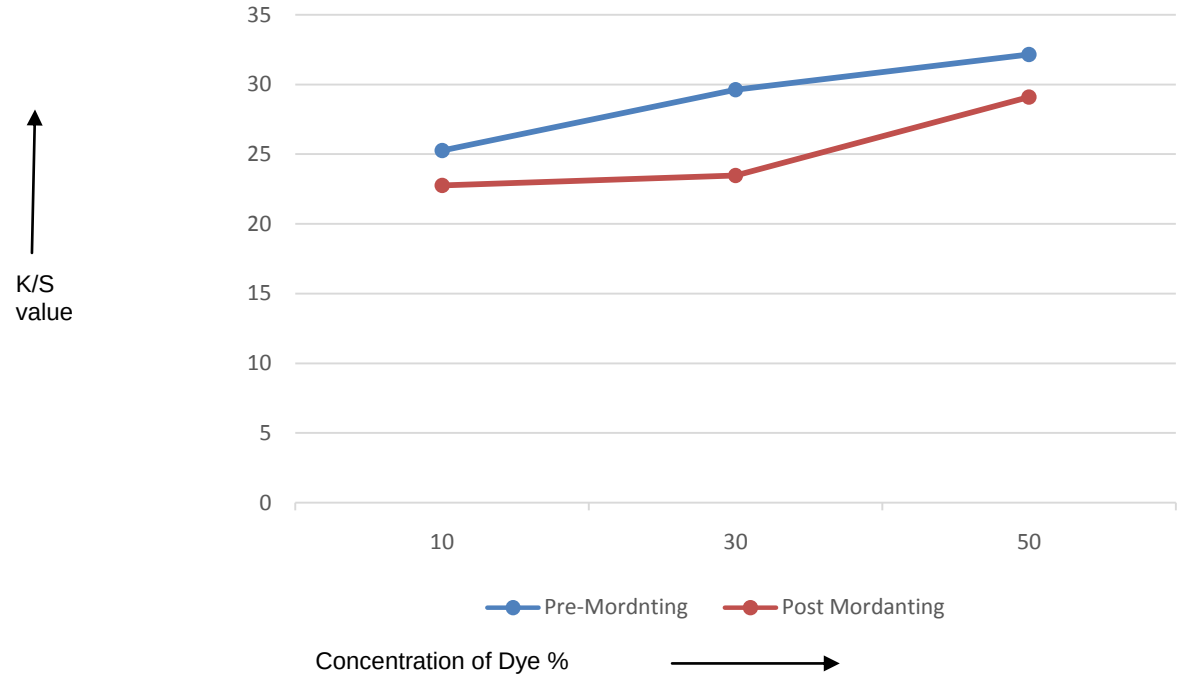
The figure 4 indicated the colour strength (K/S value) of Pomegranate peel extract dye while using different concentration of 10%, 30% and 50 % of dye using alum mordant. The results representing the k/s value is more in case of Pre-mordanting in comparison to post-mordenting. The colour strength of the natural dye extracted from Pomegranate peel extract dye showed the colour strength is more in case of pre- mordanting.

Figure 4



The figure 5 indicated the colour strength (K/S value) of Pomogranate peel extract dye while using different concentration of 10%, 30% and 50 % of dye using stannous chloride mordant. The results representing the k/s value is more in case of post-mordanting in comparison to pre-mordenting. The colour strength of the natural dye extracted from Pomogranate peel extract dye showed the colour strength is more in case of post- mordanting.

Figure 5



The figure 6 indicated the colour strength (K/S value) of Pomogranate peel extract dye while using different concentration of 10%, 30% and 50 % of dye using stannous chloride mordant. The results representing the k/s value is more in case of post-mordanting in comparison to pre-mordenting. The colour strength of the natural dye extracted from Pomogranate peel extract dye showed the colour strength is more in case of post- mordanting.

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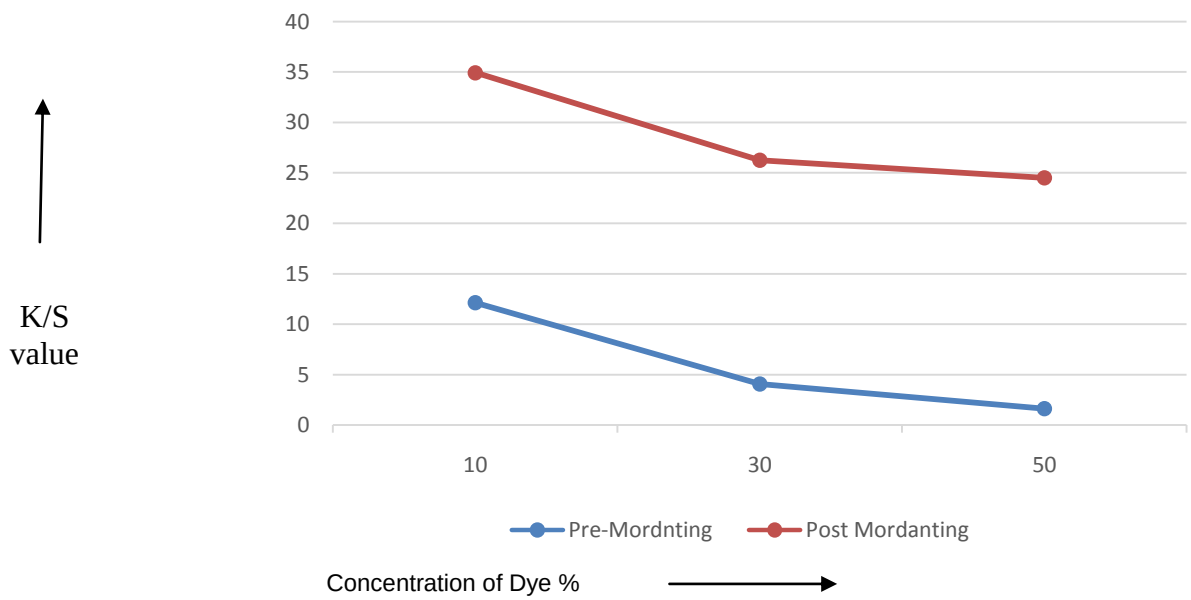
Figure 6



Assessment of fastness properties of dyed Banana Fiber

The fastness ratings of banana fiber dyed without and with mordant at different dye concentrations of 10, 30, and 50% are presented in Table 2. These results indicate that the washing fastness of the banana fiber dyed with Pomegranate natural dyewas very good to excellent (4 to 4–5) and the light fastness was of good to very good (5 to 5–6) grades. The color fastness was found to be in the range of 4 to 4-5, i.e. very good to excellent, for the banana fiber dyed with mordant. This clearly indicates that dye fixed during exhaust dyeing maybe due to the formation of metal chelates in the presence of tannin. Hence, after mordanting, these tannins become insoluble in water, and thus ultimately improve washing fastness properties. Also, fixation level of dye increases and so also its resistance to photofading and rubbing.Natural dyes are less substantive and thus require a mordant to fix them on fiber andprevent color from either fading with exposure to light or washing. These pre or post-mordanting has different effects on the shade obtained after dyeing and also on fastness properties. Alum is a white powder, safe for hands and easy to use and produces bright shades and relatively good light fastness.

It is, therefore, necessary to choose a proper mordanting methodto get the desired shade and fastness properties.

Type of Mordant	Dye Conc. % o.w.f.	Washing fastness		Light fastness		Rubbing fastness (Dry)		Rubbing fastness (wet)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Alum (5%)	10	4-5	4-5	6	6	5	5	4-5	4-5
	30	4-5	4-5	6	5-6	5	4-5	4-5	4-5
	50	4-5	4	5-6	5-6	5	4-5	4-5	4-5
Ferrous Sulphate (5%)	10	4-5	4-5	6	5-6	5	5	5	4-5
	30	4-5	4-5	5-6	5-6	5	4-5	4-5	4-5
	50	4-5	4	5-6	5	5	4-5	4-5	4-5
Stannous chloride (5%)	10	4-5	4-5	6	5-6	5	5	4-5	4-5
	30	4-5	4	5-6	5-6	5	4-5	4-5	4
	50	4-5	4	5-6	5	5	4-5	4	4

Conclusions

Pomegranate natural dye extract can be successfully employed on banana fiber with different mordants for dyeing of banana fiber as a natural source of colorant. Banana fiber showed higher color depth in terms of K/S values on pre and post mordanting with alum, Ferrous Shulphate, stannous Chloride. The banana fiber

showed K/S values as the mordant were varied from Ferrous Shulphate, stannous Chloride alum for pre & post-mordanting technique. The fastness ratings of banana fiber dyed with mordant at different dye concentrations of 10, 30, and 50% indicate that thefastness of the banana fiber was good to excellent, for the banana fiber dyed with pre and post mordanting technique.

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