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Effect of selected mordants on the application of eco-friendly natural dye from *Spinacia oleracea* L. Leaves

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Abstract
Coloration of fabric is a major process in the production of textile material. In the present study, natural dye was extracted from Spinach leaves by using ethanol as solvent system for extraction. The overall process was carried out by mordanting the fabrics through pre-mordanting and post-mordanting system. It was done by using the natural mordant i.e. pomegranate rind as well as synthetic mordant i.e. stannous chloride and copper sulphate either by individually or in combination in the ratio of 9:1, 7:3 and 5:5 for each fiber and method of mordanting. The Different tone and shades were obtained on wool fibers in control and in combination of mordants such as pomegranate + stannous chloride and pomegranate + copper sulphate. Depending upon the mordants used the colour obtained on textile from Spinach extract may give different shades. The shades generated in natural mordant as well as synthetic mordants were all unique and different than control. The dyes produced were dyed on wool fabric and tested for their color fastness to washing properties.

Keywords: Dyes, wool fiber, Spinach leaves, natural & synthetic mordants

Introduction
The use of non-toxic and eco-friendly natural dyes on textiles has become a matter of significant importance because of the increased environmental awareness in order to avoid some hazardous synthetic dyes [1]. Recently, a number of commercial dyes and small textile export houses have started looking at the possibilities of using natural dyes for regular basis for dyeing and printing of textiles to overcome environmental pollution caused by the synthetic dyes [2]. For successful commercial use of natural dyes, the appropriate and standardized dyeing techniques need to be adopted without scarifying required quality of dyed textiles materials [3]. The extraction of colorant is the first stage in the natural dyeing process [4]. Extraction is the separation of the desired colour component by breaking the cell wall using physical or chemical techniques from the plant into a solvent medium under employment conditions [4-6]. Use of natural unconventional sources for dyeing of textiles can make the dyeing process cheaper and eco-friendly. The main idea of extracting dyes from plant (natural) sources is to avoid the environmental pollution. Present days with global concern over the use of eco-friendly and biodegradable materials, considerable research work is being undertaken around the world on the application of natural dyes in textile industry.
Spinach (*Spinacia oleracea*) is a green leafy vegetable (Family Amaranthaceae), low in calories is considered as a good source of vitamins (ascorbic acid, riboflavin, niacin and folic acid) minerals (iron and calcium) and dietary fibers. Spinach leaf extract used as the natural dyes for a dye-sensitized solar cell (DSSC) [7]. As the Spinach leaf extract have not been explored and undocumented with respects to dyeing in textile industry, the present work was a small step in utilizing the value of Spinach leaves as a source of natural dye for wool fabrics and to understand the process of dying during wool cloth coloration using different natural as well as synthetic mordants.

Materials and Methods
Source: A dark variety of spinach leaves were collected from the Amravati Market. The fresh spinach was used for the extraction and dyeing process.
Substrate: Wool fabric was selected for the study and collected from local market of Amravati and cut in a proper weight is 250 mg. Wool fabrics were used for the work.
Chemicals: 2% Stannous chloride, 2% Copper sulphate are used as chemical mordants and 2% pomegranate rind was used as a natural mordant.

The mordants were used individually as well as in a combination of natural and chemical mordants in the ratio of 9:1, 7:3 and 5:5 by employing pre-mordanting and post-mordanting method.

Methodology

For dyeing both natural (*Pomegranate rind*) and synthetic mordants (Stannous Chloride and Copper Sulphate) were used. The dying of wool fibers was done by using mordant individually as well as mordants in combinations. The dying of wool fibers was carried out in following steps.

- Extraction of dye.
- Mordanting.
- Dyeing.
- Fastness test.

Extraction of dye

50 gm of fresh spinach leaves were boiled in 100 ml ethanol. Extraction was carried out by boiling at 800 C gradually increasing the temperature up to 1000 C for 1 hour with regular stirring. After that the extract was filtered using muslin cloth. Dark green coloured filtrate was obtained from the fresh spinach leaves.

Extraction of a natural mordant (Pomegranate rind)

The outer surface of pomegranate (rind) was peeled off, washed thoroughly, dried in shade and powdered by the mechanical process. The stock solution of each mordant was prepared by dissolving 2 gm of powder in 100ml of ethanol.

Mordanting

Mordanting was achieved by pre-mordanting (before dyeing) and post mordanting (after dyeing) system. For mordanting, accurately weighed wool samples were rinse with ethanol and then treated with chemical mordants *viz*. copper sulphate (2%) and stannous chloride (2%) as well as natural mordants viz. Pomegranate rind (2%). The stock solution of each mordant was prepared by dissolving 2gm of powder in 100ml of ethanol. The mordant combinations viz. pomegranate rind: copper sulphate and pomegranate rind: stannous chloride was used in the ratio of 9:3, 7:3 and 5:5. The wool fabrics were treated with different metallic salts and natural mordants by following two steps.

Dyeing

Pre-mordanting method

For each of the selected mordant, the textile material is first immersed into the mordant solution (stannous chloride and copper sulphate individually as well as in combinations) and then brought to heating at 100 °C for 30 min with material-to-liquor ratio of 1:40. The dried pre-mordanted fabrics were then placed in a 100 ml of dyebath, gradually raising the temperature to 100 °C and allowed to simmer for 50 minutes. The dyed fabrics were removed and cool washed in a 2g/l detergent solution.

Post-mordanting method

The dried scoured wool fabrics were placed in a 100 ml of spinach dye bath, gradually raising the temperature to 100 °C and allowed to simmer for 50 minutes. The dyeing process was carried out in the dye bath without mordant. The dyeing was carried out for one hour at 50 °C. The dyed fabric was dried and the wool fiber was mordanted in the solution at 100 °C for 50 minutes.

Fastness Test

The dyed material was tested for light, wash and rub fastness. Light fastness was analyzed by exposing the dyed material to direct sun light for 1 day [8]. The wash fastness was carried out by washing the dyed fibber with soft detergent. The rub fastness of the dyed fibber wash carried out by rubbing the fibber and checking for fading of colour [9-11].

Results and Discussion

The detailed results of extraction of natural dye from spinach leaves by using ethanol as a solvent system and its application to wool fabric samples (photographs of dyed fabrics) using various mordants and mordanting techniques are presented in the Table 1. Natural dye mostly requires a mordant to be fixed on to the fibre. Common mordants like alum, copper sulphate, potassium dichromate, iron salt and stannous chloride have an affinity for the dye and the fibre, they form an insoluble precipitate with the dye in the fibre [12]. In the present study, the wool fabrics generally used in textile was selected for dyeing and ethanol used as solvent. The overall process was carried out by mordanting the fabrics through pre- mordanting and post-mordanting system. Mordant plays a very important role in imparting colour to the fabrics, mordanting was done by using the natural mordants i.e. pomegranate rind as well as synthetic mordant i.e. stannous chloride and copper sulphate either by individually or in combination in the ratio of 9:1, 7:3 and 5:5 for each fiber and method of mordanting. Depending upon the mordants used, the colours obtained on textile fibre from Spinach extract exhibited different green shades. The shades generated in natural mordant as well as synthetic mordant were all unique and different than control.

Effect of mordants and mordanting methods on Colour fastness

Natural dye mostly requires a mordant to be fixed on to the fibre. In the present study, the colour of extract (dye) was green and the wool fabrics were dyed with dye without application of any mordant was considered as a control to determine colour fastness. The dyed wool fabrics were tested for light fastness, wash fastness and rub fastness. The colour fastness is usually rated either by loss of depth of colour in original sample or is expressed by staining scale [12]. Wash fastness was carried out by washing the dyed fibre with non-ionic detergent (1 g/lit). Light fastness was analyzed by exposing the dyed material to direct sunlight for 24 hours. The rub fastness of the dyed fibre was carried out by rubbing the fibre and checking for fading of colour [10]. Below the tables revealed the fastness properties of spinach leaves extract dyed with wool fabrics. When wool fabric was tested for light, wash and rub fastness, it was found to exhibit moderate which rated 3, good rated by 4 and poor results which rated by 2 for the colour change, 5 rated for colour stained (Table No 1 & Figure 1).

Table 1: Colour properties of dyed wool fabrics with ethanol

Mordant with solvent	Method of Mordanting	Light Fastness		Wash Fastness		Rub Fastness	
		CC	CS	CC	CS	CC	CS
PR + Ethanol	Pre –M	4	5	3	5	2	5
CuSO4+ Ethanol		4	5	3	5	3	5
SnCl2+ Ethanol		4	5	2	5	2	5
PR + Ethanol	Post – M	3	5	2	5	2	5
CuSO4+ Ethanol		4	5	2	5	2	5
SnCl2+ Ethanol		4	5	3	5	2	5

PR: Pomegranate Rind, Pre-M: Premordanting, Post-M: Post mordanting; CC - Colour Change, CS 0 - Colour Stained

Table 2: Colour fastness of dyed wool fabrics with spinach leaves dye using selected mordents and mordanting methods with Ethanol (Solvent)

Mordant	Method of Mordanting	Mordant Proportions	Light Fastness		Wash Fastness		Rub Fastness	
			CC	CS	CC	CS	CC	CS
CuSO4 + PR	Pre-Mordanting	9:1	4	5	3	5	2	5
		7:3	4	5	3	5	2	5
		5:5	3	5	2	5	2	5
	Post-Mordanting	9:1	3	5	2	5	2	5
		7:3	3	5	3	5	2	5
		5:5	4	5	2	5	2	5
SnCl2 + PR	Pre-Mordanting	9:1	4	5	3	5	3	5
		7:3	4	5	3	5	2	5
		5:5	4	5	2	5	2	5
	Post-Mordanting	9:1	4	5	3	5	2	5
		7:3	4	5	3	5	2	5
		5:5	4	5	3	5	2	5

PR-Pomegranate Rind, CC - Colour Change, CS - Colour Stained

Copper Sulphate: Pomegranate rinds

When wool fabric treated with copper sulphate: Pomegranate rinds in combination with different proportion (9:3, 7:3 and 5:5) and was tested for light, wash and rub fastness, it exhibited moderate which rated 3, good rated by 4 and poor results which rated by 2 for the colour change, 5 rated for colour stained. The results are tabulated in Table 2 & Fig 1.

Stannous chloride: Pomegranate rind

The wool fabric was treated with Stannous chloride: Pomegranate rinds combinations with different proportions (9:3, 7:3 and 5:5) with ethanol and evaluated for colour fastness to light, washing and rubbing, the results showed good to poor results (Table 2 and Figure 1).

Results indicated that intensity of colours on dyed samples was changed after washing, exposing to sunlight and subjected to rubbing. During washing the sample, there is a little change in the colour. This is may be due to several factors, such as the dye itself decomposes, thus converting to colorless or a differentially coloured compound. Since most of the natural dyes have hydroxyl groups, which ionize under alkaline conditions, some of the samples dyed in acidic conditions faded when washed with alkaline soaps. The use of mild non-ionic soaps is recommended for use with these dyes [13]. Direct sunlight was used for determination of light fastness of the dyed samples for tenure of 24 hours [14]. Good light fastness by using copper sulphate as a mordants due to strong co- ordination tendency, enhances the interactions between the fiber and the dye, resulting in high dye uptake as well as protects the chromophore from photolytic degradation [12, 15]. Natural dyes have better biodegradability and generally have higher compatibility with the environment. They are non-toxic, non-allergic to skin, non-carcinogenic, easily available and renewable [13].

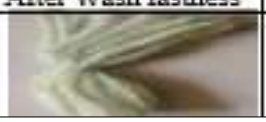
				
	Stannous Chloride ($SnCl_2$)	After light fastness	After Wash fastness	After rub fastness
				
Premordanting (In-combination)	Premordanting Cu +PR 9:1	After light fastness	After Wash fastness	After rub fastness
				
				
	Premordanting Cu +PR 7:3	After light fastness	After Wash fastness	After rub fastness
				
	Premordanting Cu +PR 5:5	After light fastness	After Wash fastness	After rub fastness
				
	Premordanting Sn +PR 9:1	After light fastness	After Wash fastness	After rub fastness
				
	Pre mordanting Sn +PR 7:3	After light fastness	After Wash fastness	After rub fastness
				
	Pre mordanting Sn +PR 5:5	After light fastness	After Wash fastness	After rub fastness
Post-mordanting (Individual)				
	Pomegranate rind	After light fastness	After Wash fastness	After rub fastness
				

Fig 1: Effect of Fastness properties on colour consistencies of treated wool fibres

Conclusion

The present investigation revealed that the ethanol extract of fresh spinach leaves has the dyeing potential as a source for wool dyeing. The whole process of extraction and dyeing is ecologically safe. The shade generated in natural mordant as well as synthetic mordants were all unique and different than control. The results revealed that the potential of colour retention on wool was good and gave brilliant colour and even absorption when mordant used in combination as compared to individual mordant. The fastness properties obtained are found to be good for wool. The present study was a small step in utilizing the value of natural Spinach leaves by extracting the natural dye and understands the process of dyeing during wool fabrics coloration using different natural. Future research can be conducted by testing the application of the Spinach leaves. Dye on other fabrics with different mordant and the mordanting techniques.

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