

An Eco-friendly natural dyeing on wool fabric by using medicinal herbs *kalanchoe pinnata* (patherchatta) and *sida cordifolia* (bala)

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Abstract

Kalanchoe-pinnata and *sida-cordifolia* are natural medicinal herbs found in abundance in various tropical and sub-tropical regions of India. These herbs have excellent curing and healing property and have been used as diseases curing medicines since Vedic eras. But no literature has been found regarding their colouring behavior to textiles. These plants are named by different names in different parts of our country and abroad. Present research is an attempt to explore their colouring behaviour to textiles. In this present research work, woollen fabric was dyed after dye extraction from the *kalanchoe-pinnata* and *sida-cordifolia* leaves using aqueous extraction method and optimization of dyeing condition like concentration of dye and mordants, time, temperature and pH value. Dyeing was carried out in water shaker bath by pre, meta and post-mordanting dyeing procedures using alum, ferrous sulphide and copper as chemical mordants and orange peel extract, goose berry extract and harda as natural mordants. Colour strength, colour values (L^* , a^* , b^*) and various fastness properties of dyed fabric were evaluated using AATCC test standard. Both herbs give a wide colour spectrum in yellow-green region with excellent fastness properties. The overall results show that both of these dyes can be successfully used and explored further for dyeing of wool with medicinal properties.

Keywords: *Sida-cordifolia*, *kalanchoe-pinnata*, natural dye, mordant, L^* , a^* , b^* values, colour fastness.

Introduction

Textile dyeing using chemical mordants generates a large amount of effluents in terms of carcinogenic heavy metals. Therefore, there is direct need to find out suitable eco-friendly mordants and dyes. The use of abundantly available and waste of vegetables, fruits and other natural resources such as orange peel extract, pomegranate peel extract, natural herbs, etc. as natural dyeing and mordanting agents may be better substitutes to synthetic substances. Natural mordants also have a wide application area for mordanting of natural dye, giving rise to different hues of corresponding natural dye. Some available natural mordants can also be used as a natural dyeing agent. Gooseberry powder, harda are this type of natural substances which acts as both dye as well as mordanting agent providing excellent shade. Mordanting can be applied by pre, simultaneously and post-mordanting techniques. Different types of mordants give different shade spectrums according to application whether applied individually or in combinations.

Aim: Aim of the present study was to determine the best dyeing conditions on wool fabric for the selected plants “*kalanchoe pinnata*” and “*sida cordifolia*”. To achieve the goal, some experiments were carried out with different dyeing conditions.

Background of the study

- Both these herbs *k.pinnata* and *s. cordifolia* have been using in medicinal field due its various effective pharmaceuticals properties.
- It is cure different kind of body infection, wound healing and skin disease etc.
- Both these medicinal herbs containing antimicrobial, anti-oxidant and other useful medicinal properties, which will difinitly prove in future scenario of textile.

Principles & objectives

- 1) To study the dyeing ability of two different kind of medicinal plants *k.pinnata* and *s.cordifolia* that can be easily found in india(in tropical and sub-tropical area).
- 2) To investigate the effect of the mordant, pH and affinity for fibres types alongwith shade and colour development.
- 3) To obtained optimized dyeing condition in term of dye and mordant concentration, pH range, temperature, time and M.L.R (material to liquor ratio).
- 4) To conduct experiments for evaluation of dyeing properties, including the colour fastness to washing, colour fastness to light, rubbing fastness in term of dry and wet state and computer colour matching or colour strength.
- 5) To use the regenerated source as the dyeing and to produce eco-friendly dyed fabric.
- 6) To study the experimental data of dyed samples and expressed by means of graphs and curves .

Research methodology

- The thesis is basically research based. The research method used to solve the research question.
- The results of the research question will be presented and discussed by using quantitative approach.
- Experiments are carried out at BPSMV laboratory.
- A comprehensive literature review was conducted to have a better understanding of colour, natural dye, types of natural dyestuffs, mordant as well as fibre types used in the study.
- Dyestuffs were collected from leaves of two different plants (*k.pinnata* and *s. cordifolia*) and aqueous extraction methods were used to extract the dye.
- Experiments of using mordant, different pH and fibre types for dyeing were conducted to achieve a better fixation and absorption of dye with a wide range of colour and depth of the shade.
- Finally, the colour strength of the dyed fabric was evaluated by the CIE L*a*b* measurement. The colour fastness to light and colour fastness to washing of the dyed fabric were conducted according to the AATCC standard.

Scope of study

In the present research project, there are five main scopes being covered in the study. The first scope is to study the natural dye, mordant types and the chemical properties of natural fibres toward natural dyeing by referring to the precious findings. The second scope is to pretreat the materials with mordant and prepare the dyebath with various pH. The third scope is to investigate and compare the colour obtained under different dyeing conditions. The fourth scope is to evaluate the effectiveness of using mordants, impact of pH, and the property of the fibre types by comparing the colour fastness and the various properties varying conditions. The fifth scope for the project is to study the nature of the dyes present in the extract and its effect on the dyed specimens.

Significant of study

The chemical dyes have been largely used all over the world, and the demand for natural dyed garment or product is increasing. This means that the development of natural dye is an important issue making it becomes more user friendly for the dyeing industry or small dyeing house. The use of different mordant and ph can help to produce more colour shade with unlimited colours. Some substantive dyes can provide a strong colour without using mordant. Therefore, natural dye is attracting the world-wide attention again.

The study seeks to explore and capture some natural plants from which dyes can be extracted and applied to selected foods and textile fabrics. The study also plays a distinctive role in providing beneficial information to the textile and food industries, art lecturers, students and scholars. In addition, the study would create the awareness of unexplored plant dyes and finally serve as a reference material to other research works.

Statement of the problem: -

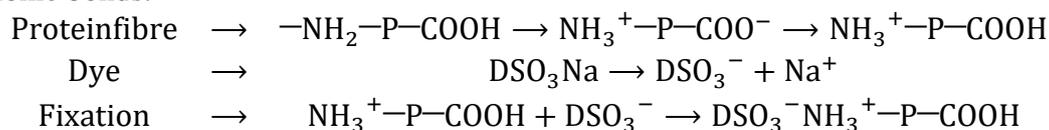
- It is time consuming to extract dye from the raw materials k.pinnata and s.cordifolia.
- Availability of the k.pinnta and s.cordifolia are limited and found only tropical and subtropical areas.
- Availability of the k.pinnta and s.cordifolia are dependent on the growing seasons

Environmental concerns : The natural dyeing should be carried out with the optimum recipes using as less chemical as possible during the dyeing process to reduce the pollutant produced and the harmful effect to the environment. Moreover, the dyestuffs that extracted without chemical used could act as fertiliser after composting in order to reduce the wastage produced and produce an organic fertiliser.

2. Literature Review:

Dyeing of Natural Protein Fibre:

Protein fibres wool have $-NH_2$ and $-COOH$ groups on either sides of polymer chain. Extract colourants of Kalanchoe Pinnata and Sida Cordifolia can react with $-NH_2$ groups of fibre and form ionic bonds.



Kalanchoe Pinnata and Sida Cordifolia Natural Dye

Kalanchoe Pinnata and sida cordifolia herbs can cure disease problems and provide fresh and healthy life. Kalanchoe-pinnata and sida-cordifolia found in tropical and subtropical places. Which have already been used extensively in Ayurveda but their potential in textile colouration and finishing is still unexplored. **Also no literature found of k.pinnata and s.cordifolia on wool fabric.**

3. Material and Method.

a) Material

a) **Herbs collection:** - k.pinnata and s.cordifolia herbs were collected from campus Bhagat Phool Singh Mahila University, Sonapat, Haryana.

b) **Wool fabric:** - 100% wool fabric was procured from local market of sonapat.

c) **Mordants:** - Dry goose berry powder, harda powder and orange peel powder was used as natural mordants and alum, copper sulphate and ferrous sulphate was used as chemical mordants.

b) Methods of mordanting:-

a) **Pre - mordanting:** - in this method the wool was first treated with mordant and then dyed under optimized conditions.

b) **Simultaneous –mordanting:** - in this method the wool was dyed with mordant at a same time under optimized conditions.

c) **Post - mordanting:** - in case of postmordanting the fabric was first dyed under optimized conditions and then treated with mordant.

We have followed pre-mordanting, simultaneous mordanting and post mordanting.

Optimized dyeing recipe and condition of k.pinnata and s.cordifolia:-

A) Optimized dyeing recipe of k.pinnata

M.L.R	-	1:30
K.pinnata	-	20% owf
Chemical mordant	-	20 % owf
(Ferrous, copper, alum)		
Natural mordant	-	25 % owf
(o.peel, goose berry & harda powder)		
pH	-	5-6.5
Temp.	-	90 ⁰ C
Time	-	60 Min.

B) Optimized dyeing recipe of s.cordifolia

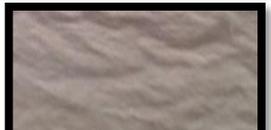
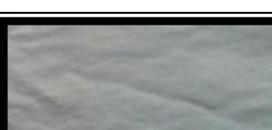
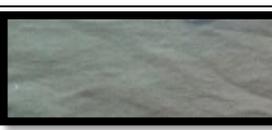
M.L.R	-	1:40
S.cordifolia	-	10% owf
Chemical mordant	-	20 % owf
(Ferrous, copper, alum)		
Natural mordant	-	25 % owf
(O.peel, goose berry & harda powder)		
Ph	-	5-6.5
Temp.	-	95 ⁰ C
Time	-	60 min.

Fabric samples of wool were dyed after optimizing the dyeing conditions with the help of various types of natural as well as synthetic mordants in pre, meta and post mordanting methods of mordanting followed by washing of dyed samples using non-ionic soap solution at 70° C .

4. Result and Discussion

4.1 Result of k.pinnata

Dyed wool fabrics with k.pinnata via pre, meta and post-mordanting methods

K. Pinnata dye	Pre-mordanting	Meta-mordanting	Post- mordanting
Without mordant k.p (20%)			
Dry goose berry powder (25%)			
Harda powder (25%)			
Orange peel powder (25%)			
Copper sulphate (20%)			
Aluminium sulphate (20%)			
Ferrous sulphate (20%)			

Dyed wool fabrics with k.pinnata via pre, meta and post-mordanting methods.

Colour fastness and colour values of dyed woollen fabric with kalanchoe-pinnata

Evaluation of colour fastness to washing and rubbing was ratted from 1 to 5. Rating 1 shows very poor wash and rubbing fastness where as maximum rating is 5 shows excellent wash and rubbing fastness. Results of colour fastness to washing, rubbing, light and colour value in term of L* a* b* and k/s, for both herbs are tabulated in tables.

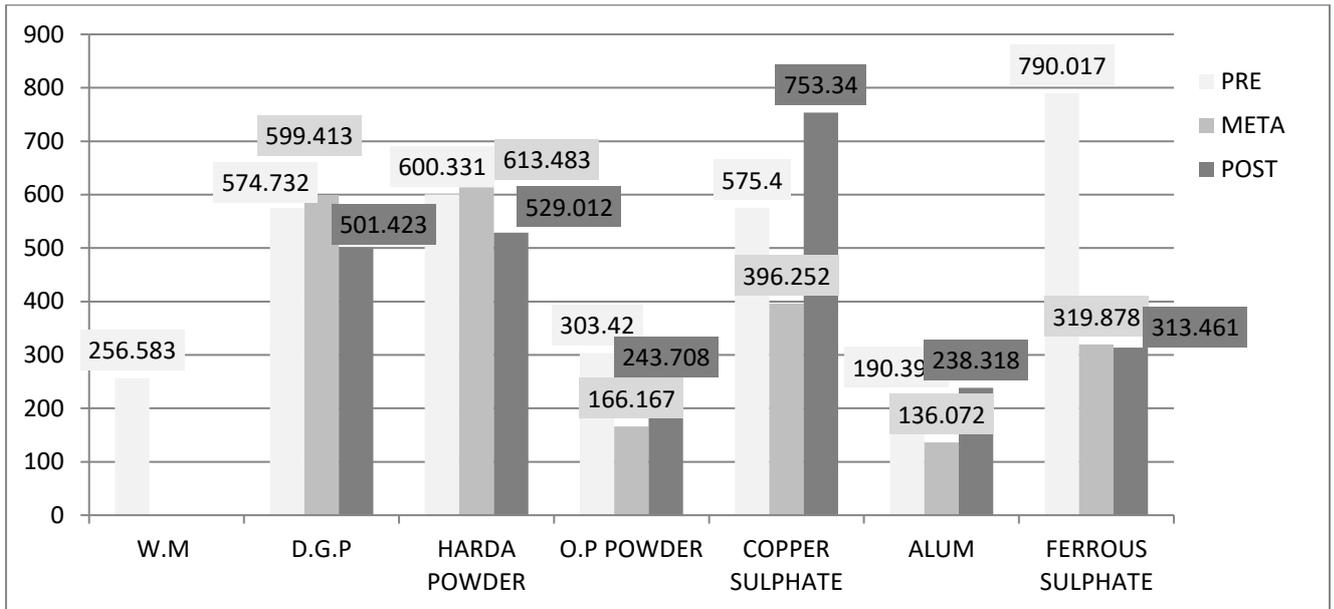
Mordanting method	Mordant used in dyeing of woollen samples with kalanchoe-pinnata							
	Colour coordinates and fastness properties	Without mordant	Goose berry Powder	Harda powder	Orange peel powder	Copper sulphate	Alum	Ferrous sulphate

Pre	L*		75.582	79.698	80.850	77.950	79.281	80.507	76.776
	a*		-0.425	1.403	-0.556	-0.338	-1.227	-3.134	-0.035
	b*		11.137	15.362	17.457	9.458	14.047	16.140	5.664
	K/S		11.917	26.693	27.882	14.092	26.724	8.843	33.995
	W	Colour change	5	5	4	5	5	5	5
		Stain with wool	5	4	5	5	5	5	5
	F	Stain with cotton	5	4	4	5	5	5	4
	L.F		5	4	4	5	5	5	3
	R	Dry state	5	5	5	5	5	5	5
		Wet state	4	3	4	4	3	4	4
Meta	L*		75.582	80.349	82.228	80.818	79.126	78.355	76.913
	a*		-0.425	1.776	-0.341	-3.383	-4.699	-1.111	-0.252
	b*		11.137	17.502	21.120	16.555	12.620	10.902	6.119
	K/S		11.917	27.840	28.493	7.718	18.404	6.320	14.857
	W	Colour change	5	5	5	5	5	5	5
		Stain with wool	5	5	4	5	5	5	5
	F	Stain with cotton	5	4	4	4	5	5	5
	L.F		5	4	3	4	3	4	3
	R	Dry state	5	4	4	5	5	5	5
		Wet state	4	3	4	5	5	5	4
Post	L*		75.582	79.909	81.714	81.003	80.435	81.625	76.946
	a*		-0.425	0.612	-0.197	-1.988	-3.767	-2.695	-0.219
	b*		11.137	15.678	19.664	17.135	16.502	18.666	6.244
	K/S		11.917	23.289	24.570	11.319	34.987	11.069	14.559
	W	Colour change	5	5	5	5	5	5	5
		Stain with wool	5	5	5	5	5	5	5
	F	Stain with cotton	5	4	4	5	5	4	5
	L.F		5	4	4	5	5	5	3
	R	Dry state	5	5	5	5	5	5	5
		Wet state	4	4	4	5	4	5	4

Colour fastness and colour values of dyed woollen fabric with kalanchoe-pinnata

Graphical value in term of colour strength of dyed wool fabric with k.pinnata

Colour strength of dyed wool fabric samples with k.pinnata are as shown in figure.

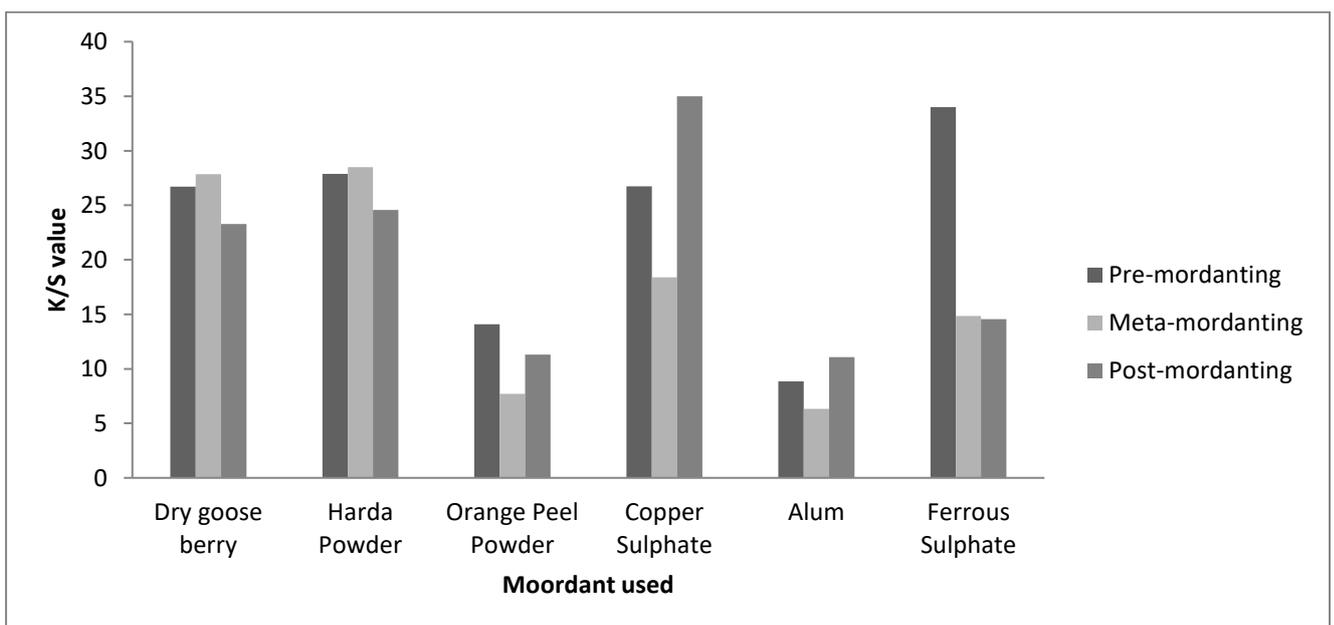


Graphical value in term of colour strength of dyed wool fabric with k.pinnata

Evaluation of computer colour matching in term of colour strength of k.pinnata treated wool fabric ,without mordant is 256.583% , in pre-mordanting method ,highest colour strength is 790.017% of ferrous mordant and lower colour strength is 190.396% of alum mordant .. In meta mordanting method highest colour strength is 613.483% of harda powder mordant and lower is colour strength is 136.072% of alum mordant . In post mordanting highest colour strength is 753.340% of copper sulphate mordant and lower colour strength is 238.318% of alum mordant .

K/S values of dyed woollen fabric by with k.pinnata by various mordants

K/S values of dyed woollen fabric with k.pinnata by various mordants are shown in figure 17.



k/s values of dyed woollen fabric by with k.pinnata by various mordants

4.2 Result of s.cordifolia

Dyed wool fabric samples with s.cordifolia via pre, meta and post-mordanting

S.cordifolia	Pre-mordanting	Meta-mordanting	Post- mordanting
Without mordant			
Dry g.berry powder			
Harda powder			
Orange peel powder			
Copper sulphate			
Alum			
Ferrous sulphate			

Dyed wool fabric samples via pre, meta and post-mordanting methods

Colour fastness and colour values of dyed woollen fabric with s.cordifolia

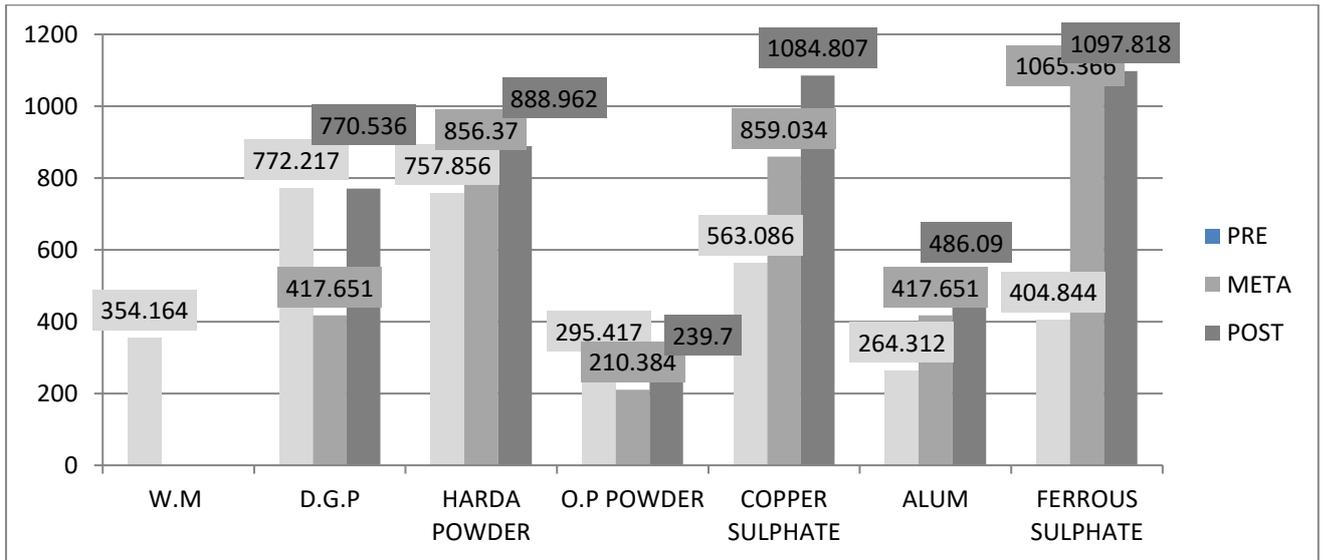
Mordanting method	Mordant used in dyeing of woollen samples with sida-cordifolia							
	Colour coordinates & fastness properties	Without mordant	Goose Berry Powder	Harda Powder	Orange Peel Powder	Copper sulphate	Alum	Ferrous sulphate
	L*	80.790	79.745	81.435	79.414	80.740	80.955	79.347
	a*	-1.933	-1.315	-0.396	-1.599	-4.030	-2.238	-0.718
	B*	16.994	15.616	19.014	13.662	17.335	17.591	13.929

Pre	K/S		11.917	26.693	27.882	14.092	26.724	8.843	33.995
	W	Colour change	5	5	4	5	5	5	5
		Stain with wool	5	5	4	5	5	5	5
	F	Stain with cotton	5	5	4	5	4	4	4
	L.F		5	4	4	5	5	5	3
	R	Dry state	5	5	5	5	5	5	5
		Wet state	4	4	4	4	4	5	4
Meta	L*		80.790	83.045	81.977	81.316	80.866	83.045	78.608
	a*		-1.933	-3.885	-0.138	-2.818	-5.213	-3.885	-0.256
	B*		16.994	22.139	20.622	17.852	17.322	22.139	11.928
	K/S		11.917	27.840	28.493	7.718	18.404	6.320	14.857
	W	Colour change	5	5	5	5	5	5	5
		Stain with wool	5	4	4	5	5	5	5
	F	Stain with cotton	5	4	4	5	4	5	4
	L.F		5	4	3	4	3	4	3
	R	Dry state	5	4	4	5	5	5	5
		Wet state	4	3	4	5	4	4	4
Post	L*		80.790	80.120	82.071	82.170	82.373	85.471	78.940
	a*		-1.933	-1.171	-0.182	-3.309	-5.908	-5.149	-0.545
	b*		16.994	16.557	20.896	19.233	20.968	26.574	12.690
	K/S		11.917	11.672	9.386	17.291	8.317	17.204	22.086
	W	Colour change	5	5	5	5	5	5	5
		Stain with wool	5	5	5	5	5	5	5
	F	Stain with ctton	5	5	4	5	5	4	4
	L.F		5	4	4	5	5	5	3
	R	Dry state	5	5	5	5	5	5	5
		Wet state	4	3	3	4	4	4	4

colour fastness and colour values of dyed woollen fabric with s.cordifolia

Graphical value in term of colour strength of wool fabric with s.cordifolia.

Colour strength of dyed wool fabric samples with s.cordifolia are as shown in fiure 18.

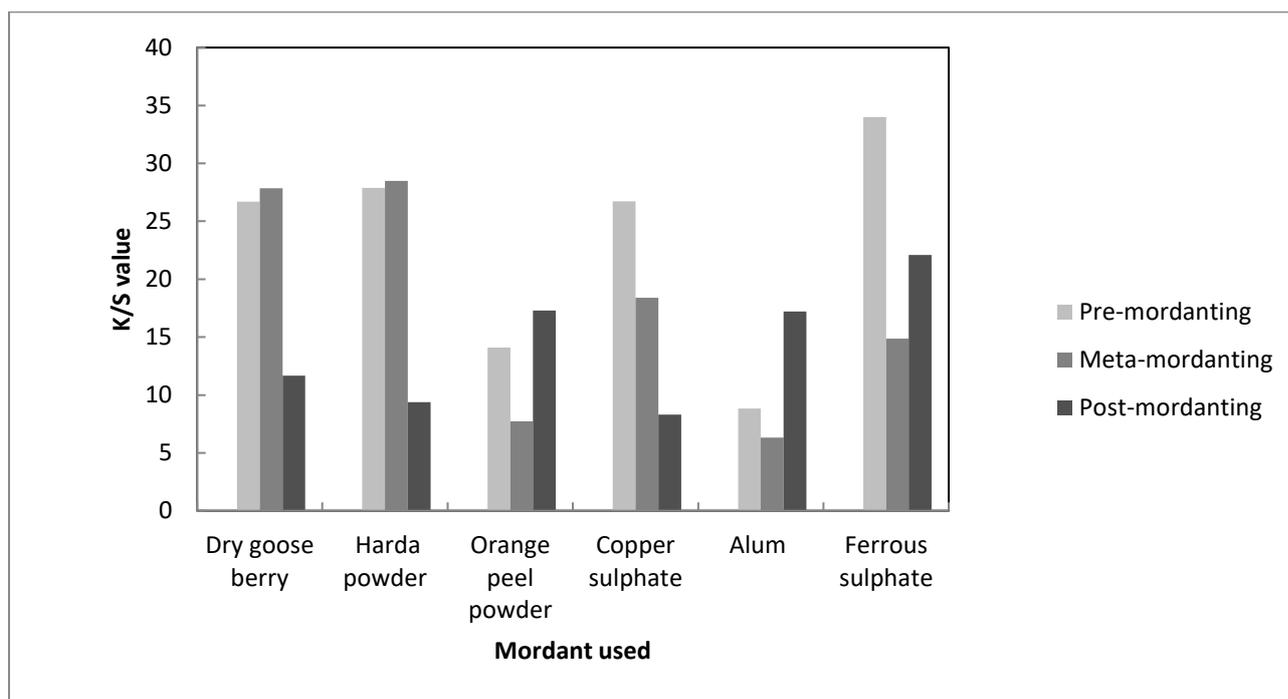


Graphical value in term of colour strength of dyed wool fabric with s.cordifolia

Evaluation of computer colour matching in term of colour strength of s.cordifolia treated wool fabric, without mordant is 354.164%. In pre-mordanting method highest colour strength is 772.217% of dry goose berry powder mordant and lower colour strength is 264.312% of alum mordant. In meta mordanting method highest colour strength is 1065.366% of ferrous mordant and lower is colour strength is 210.384% of o.peel mordant. In post mordanting highest colour strength is 1097.818% of ferrous mordant and lower colour strength is 239.700% of o.peel mordant.

k/s values of dyed woollen fabric with s.cordifolia by various mordants

K/s values of dyed woollen fabric with s.cordifolia by various mordants are shown in figure



k/s values of dyed woollen fabric with *s.cordifolia* by various mordant

In this research following three mordanting methods pre, meta and post, post mordanting method have proved for best colour shade range, than meta and pre.

In comparative study of dyeing *k.pinnata* and *sida cordifolia* on wool fabric, *sida cordifolia* have best performance in term of highest colours strength, depth of colour and application of colour shade range In case of *kalanchoe pinnata*, ripe yellow leaves are provided little bit darker shade instead of raw green leaves.

5. Future scopes: In this research two different kind of medicinal herbs *k.pinnta* and *sida cordifolia* were used for dyeing and provide many different shade of colour with moderate to excellent fastness properties. Further improvement in color yield was observed with increasing dye receipe , dyeing condition in term of dye concentration ,mordant concentration, different level of time, temperature and ph value, different kind of natural and chemical mordants ,, additional mordanting , different applying method, will be obtaining many shade of colour via following three different mordanting methods (pre, meta , post) and it will have also antimicrobial activity as well as dyeing effect in future scenario ,because both herbs containing antimicrobial activity,the presence of phenolic compounds indicate that the plant possess antimicrobial activity.This point reported that plant is effective in the treatment of typhoid fever and other bacterial infections, particularly those caused by *s. Aureus*, *e.Coli*, *b. Subtilis*, *p. Aeruginosa*, *k. Aerogenes*, *k. Pneumoniae* and *s. Typhi*. In this study antibacterial activities of the infusion and methanolic extracts against *s. Aureusi atcc 13709*, *e.coli atcc 9637*, *bacillus*, *p. Aeruginosa*, *k. Pneumonia* and *s. Typhi* using the agar diffusion method; also against *s. Aureus*, *e. Coli*, *s.typhi*, *klebsiella spp* and *p.aeruginosa* using a modification of checkerboard method. Anti-microbial activity of *sida cordifolia* leaf extracts aqueous and methanolic on pathogenic bacteria like *staphylococcus aureus* ,*enterococcus faecalis* ,*pseudomonas aeruginosa*, and *proteus mirabilis* and fungi like *candida albicans* and *cryptococcus neoformans* was tested by disc diffusion method the aqueous extract was found to be moderately effective against bacteria and exhibited high antifungal activity the methanolic

extract was effective on bacteria and did not show any antifungal activity. Acetone fraction did not contain any antimicrobial activity. Increasing concentrations of the extracts exhibited increased zone of inhibition against bacteria and fungi. Cordifolia leaf extract showed highest antibacterial activity against *f. Verticillioides*. By using these herbs separately or combined on cotton and wool fabric can be made antimicrobial finished fabric, because both herbs have antimicrobial property. And also can be made anti-oxidant finished fabric by using these herbs separately or combined because also both herbs have anti-oxidant property. And also can be possible to make bandages and anti-acne fabric due to wound healing and anti-acne property for medical textile. Ultimately these medicinal herbs can play a lead role in medical textile due to much kind of useful and effective medicinal properties. *Sida cordifolia* flowers can be used for dyeing to textile, but without antimicrobial activity.

6. Conclusion: The findings of present study can be concluded as: It can be clearly observed from results that natural mordants have comparable affinity to chemical ones towards woollen textile substrate with darker shades and brilliant hues. The colour fastness properties of natural mordants are also good in comparison to chemical mordants with excellent fastness ratings giving a substitute to synthetic mordants in eco-friendly dyeing process. The k/s values of *sida-cordifolia* and *kalanchoe-pinnata* dyed woollen fabric by various mordants in different mordanting methods are plotted in figures. Graphical values indicate that mordanting techniques affect the colour values regarding colour strength and colour attributes. In case of chemical mordants such as copper sulphate and ferrous sulphate pre-mordanting gives maximum k/s values whereas in natural mordants dry goose berry and harda powder meta-mordanting gives maximum k/s values. In case of orange peel powder and alum mordants maximum k/s values are obtained in post-mordanting method. Overall orange peel as well as alum mordant shows lower k/s values amongst all the six mordants evaluated for *sida-cordifolia* dye. In case of *kalanchoe-pinnata* it can be clearly examined from the graphical values that dry goose berry and harda powder can be also used as alternative to synthetic mordants with good k/s values while orange peel powder shows poor k/s values. Overall in both the natural dyes it can be analyzed that natural mordants can be also used successfully with natural dyes.

It can be concluded from the study that *kalanchoe-pinnata* and *sida-cordifolia* both herbs also act as good dyeing agents for woollen textiles with a wide range of spectrum in yellow green region. Both the dyed samples with natural as well as chemical mordants give well to excellent fastness properties. So, whole dyeing process can be carried out in an eco-friendly manner using natural dyes as well as natural mordants. The renewable natural dyes with eco-friendly mordants i.e. natural mordants have good potential in sustainable textile wet processing. In this research following three mordanting methods pre, meta and post, in which post mordanting method has proved for best colour shade range, than meta and pre. In comparative study of dyeing *k.pinnata* and *sida cordifolia* on wool fabric, *sida cordifolia* has best performance in terms of highest colour strength and application of colour shades instead of *k.pinnata*.

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