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An Investigation on Beetroot Extraction dye on Khadi Fabric

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ABSTRACT

Textile and Apparel industry play an important role in Indian economy but at the same time it has been criticized for the environmental pollution. Textile processing industry uses a huge amount of chemicals which contain heavy metals, formaldehyde and many other carcinogenic compounds. Use of synthetic dye is a major cause of concern with the release of vast amount of effluents causing water pollution as well as serious damage to the bio-system. The use of eco-friendly herbal dyes is becoming significantly important due to increase in the environmental awareness. Fashion designer, dyers, and textile exporters have started using natural dyes looking at the demand of environment concerns to overcome environmental pollution. Natural dyes are more compatible with the environment as they are non-hazardous, non-allergenic and biodegradable. So, present research study on natural dye of beet- root powder has been carried out to explore its colouration behaviour on khadi textile material. The dye powder was obtained using aqueous extraction method and applied via three techniques of mordanting i.e. pre, meta, and post– mordanting with different chemical and natural mordants. The colour values- L* a* b* and various colour fastness properties of dyed fabrics were evaluated. Our research shows that khadi fabric dyed with beetroot with various mordant have colour coordinates in green-yellow region with satisfactory results of moderate to excellent wash, light and rubbing fastness properties.

Keywords: Natural Dye, Beet root, Khadi, Natural Mordants and Chemical Mordants.

INTRODUCTION

Nowadays environmental concern has become an important factor for the textile industries in the whole world. The textile dyeing and printing industry uses chemicals in large quantities. Eco-friendly natural dyes are used to decrease the pollution of textile industries (Mohan, D. & James, S. 2020). Natural dyes have been used for colouring of textiles from the historic period until the 19th century. Dyeing substances obtained from herbs of animal, mineral, microbial origin, and plants are used to colouration of numerous textile fabrics (Kumar, V. & Prebha, R. 2018).Natural dye has been used since ancient times. As time passed from one generation to the next, the use of natural dyes declined due to lackof documentation, lack of dye techniques, and precise knowledge of extraction from generation to generation (Arora, J. 2017).People are becoming aware of the environmental hazards and its impact on human health, hence they are looking to revive the vintage style of dyeing. Plants, insects, and minerals are the sources of herbal dyes (Singh, N., & Srivastave, R.D. 2019). Plants are one of the foremost capacity supplies of herbal textile dye. All the elements of plant like flowers, stems, bark, buds, fruits, leaves, husks, roots, ect. may act as dyes. Even though plant-based textile dyes are extracted without any difficulty and also non-risky, less poisonous and renewable than artificial dyes (Mohan, D. & James, S. 2020).Nature has provided us with more than 500 dye-yielding plant species. Colour vendors get colour from roots, trunks or fruits, leaves, barks of plants. All colours of the rainbow, obtained from plants. Natural dyes have the property ofbiodegradability and typically have better compatibility with the environment (Kumar, V. & Prebha, R. 2018). Synthetic dyes are used extensively as they are reasonably-priced and convey a vast form of colours butresults into environmental pollutions, hazardous to skin and cause of toxic effluent (Chandran, S.N. 2020). The main reason for the replacement of artificial dyes to natural dyescan be attributed to environmental concern and the hazardous nature of synthetic dyes.

The main reason of the use of natural dyes is to make the process environmentally friendly and hygienic. Natural dyes produce very rare, soothing and smooth tones in comparison to artificial dyes.Mostly natural dyes have some drawbacks in term of poor Colour fastness properties. (Kumar, R. 2021). Natural dyes are environmentally friendlyand alternative for artificial dyes and the artificial range may be replaced as well.

Scientists and researchers are interested to learn about the structure of herbal colourants.Wide practice of natural dyes is because of their high potential, usage of experimental evidence, non-toxic, non-allergic effects and unique colours.Beetroot is famous for medicinal properties and its juice value, which is used in curing of many diseases for human beings. It's mainly found in many countries worldwide like, North Africa, Europe, Turkey, Americas and Asia. In India it is cultivated in Haryana, Himachal Pradesh, Uttar Pradesh, Maharashtra and West Bengal (Clifford, T. 2015, Babarykin, D. 2019, Ceclu, L. &Nistor, V. O. 2020, Mirmiran, P. 2020).Beetroot (Beta vulgaris) is a taproot vegetable possessing several nutritional and health benefits, which includes water-soluble betalainorpiments like betacyanins (red-violet colour) and betaxanthins(yellow-orange colour) (Dias S. 2019). Inone study beetroot dye extracted gives 52% yield in distilled water and 50% yield in acidic medium preparation of herbal gulal from beetroot. In alkaline medium, it gives different percentages yield in different concentrations (Tiwari, Sk. 2020).Natural dye extracted through ethanol water mixer with ultrasonication provided better yield. Use of mordant with beetroot stain was studied on wooden material. Ultrasonication requires high investment ((Anna, L. J 2009, Goktas, O. 2015).In presentstudy, research was carried out for cheap and easy extraction methods for beetroot dye to apply on khadi fabric with different chemical and natural mordants.

RESEARCH OBJECTIVES

Dye ability of Beetroot extracts on khadi fabric and the impact of different mordant and processing condition is studied in this research.

MATERIAL AND METHODS

Material selection and sourcing:

a) Beetroot powder wasprocured from Amazing Enterprise, Banglore.
b) Khadi fabric is taken from Khadi Ashram, Panipat.With following fabric specifications: GSM-140, Thread count-16, EPI-60 and PPI-40.
c) Mordants such as Harda powder, Orange peel, pomegranate peel, Alum, Ferrous Sulphate and Sodium Hydrosulphite was procured from Skymorn Herbs & Dyes Exports, Ghaziabad, U.P., India.

Dye Application method

Optimized Beta vulgarisdying recipe and dyeing conditions as applied on khadi fabricusing water bath shaker machine are listed below:

MLR	: 1:40
Beta vulgaris	: 25 gpl
Natural mordant	: 30 gpl
(Pomegranate powder, Harda powder, Orange peel powder)	
Chemical mordant	: 30 gpl
(Alum, Ferrous sulphate, Sodium hydrosulphate)	
pH	: 5-6.5
Temp.	: 90^0C
Time	: 60 min.

Testing methods

a) Rubbing fastness test

This test is used for determining the colour fastness and the behavior of the surface of a sample on rubbing with a white khadi fabric using crock-o-meter tester.

- No. of rubbing cycles – 10 (as per AATCC8 test standard)
- Fabric tests condition - i) Dry state ii) Wet state
- The rubbing (crock-o-meter) fastness was rated from 1 to 5. Rating 1 shows very poor rubbing fastness and rating 5 shows excellent rubbing fastness.

b) Light fastness test

This test is intended for determining the resistance of the colour of fabric to a well known artificial light source. The Mercury Tungston lamp was used colour fastness to light.

- Testing machine used-Digital light fastness tester for light fastness.
- Exposure time is 40 hrs as per AATCC 16 standard.

c) Wash fastness test

The resistance of a cloth to change in any of its colour characteristics, when subjected to washing is known as colour fastness to washing.

- Wash fastness tester - Wash fastness tester is used for figuring out colouration fastness of textile fabric to washing.
- Washing procedure – A sample 10 X 4 cm swatch of the dyed material is taken and is sandwitched among two adjoiningfabrics and stitched, the pattern and the adjoining material are washed together as per AATCC 61 test standard.

MLR	: 1:40
Specimen size	: 10 x 4 cm
Washing severity	: mild washing
Detergent	: 5 gpl
Time	: 40 min
Temp.	: 40^0C
Still ball	: No
Grey scale	: for assessing change of colour

After the soaptreatment, the sample is rinsed two times with running cold water under a tap. Squeeze it out and let it air dry at a temperature not exceeding 60^0C. The change of colour and staining is estimated with the helpof grey scales as per AATCC 61 test standard.

d) Computer colour matching (CCM) system

Computer colour matching (CCM) is the devicethat measure the colour attributes, and predict the dyeing recipe using the spectrophotometric properties of dyestuff and fibres.

The basic three things are important in CCM:-

1. Colour measurement instrument (spectrophotometers).
2. Reflectance (R %) from a mixture of dyes or pigments applied in a specific way.
3. Optical version of colour imaginative and prescient to closeness of the colour matching (CIE L*a*b)

The following AATCC test method are predominantly used related to computer colour matching which describe methods to calculated colour intensity, colour difference and whiteness index of the fabric.

- AATCC Test Method 110, “Whiteness of Textile,” lists methods for instrumentally measuring and calculating the whiteness and tint of fabrics.
- AATCC Test Method 173, “CMC: calculating Small Colour Differences for Acceptance,” describes how the CMC colour difference scale is calculated and used.
- AATCC Test Method 182, Relative Colour Intensity of colorants in solution, describes the spectrophotometric determination of the colour intensity of a colorant by comparing its transmission measurements to those of a reference colorant.

Measurement of colour attributes

The colour difference value (L*, a*, b*) of the different dyed samples were determined using data colour spectrophotometer and data colour software interfaced with the computer illuminant d65, observer 10^0 and CIE 1976. The result of which are mention in Table 4.2. The instrument was standardized with a white tile. Hunter conform L*, a*, b* have been measured on the instrument of various sample where,

- L signifies lightness (L+-- more lighter, L- -- more darker)
- A signifies redder or greener (a+ -- redder, a- -- greener)
- B signifies bluer or yellower (b+ -- yellower, b- -- bluer)
- $\Delta E = \sqrt{(a_1-a_2)^2 + (b_1-b_2)^2 + (L_1-L_2)^2}$
- Colour strength = $[(k/s)_{batch} / (k/s)_{standard} \times 100]$

The kubelka – munk concept offers the above stated relation among reflectance, and absorbance, where in s is the scattering, k is absorbance and r is the reflectance.

Colour fastness

The various colour fastness such as wash, rubbing and light fastness were checked using IS: 3361-1979, test iii, IS: 766-1988 and IS: 2485-1985 test methods, respectively.

RESULTS AND DISCUSSION

Dyed khadi fabrics with beta vulgaris via. pre, meta and post-mordanting methods

Colour shades of Khadi fabric specimendyed with beta vulgaris via. pre, meta and post mordanting method are shown in Table 1.

Table 1: Dyed khadi fabric with beta vulgaris via.pre, meta and post mordanting method

It can be analyzedthat beet root dye with different mordants naturaland chemical mordant give good shades on khadi fabric.

The Beet root Natural dyes is environmentally friendly and alternative for artificial dyes and the artificial range of chemical mordants and synthetic dyes may be replaced.

Colour value of Dyed khadi fabrics with beta vulgaris
Results of colour values regarding L*, a*, b* and k/s for beta vulgaris are shown in Table 2.

Table 2: Colour value of Dyed khadi fabrics with beta vulgaris

M.M	C.C	W.M	P.P.P	O.P.P	H.P	A.S	F.S	S.H.S
Pre	L*	90.895	91.895	91.592	91.946	90.76	92.389	90.936
	a*	0.901	0.777	0.939	0.758	1.961	0.908	0.367
	b*	3.638	6.906	6.41	7.215	3.667	8.913	2.83
	K/S	3.854	8.256	4.608	8.789	5.743	21.011	2.479
Meta	L*	90.895	92.349	92.229	92.064	90.934	91.489	90.529
	a*	0.901	0.352	0.426	0.246	1.476	0.568	0.559
	b*	3.638	7.967	8.027	7.637	4.181	5.792	0.759
	K/S	3.854	8.26	10.27	4.222	5.409	6.266	1.954
Post	L*	90.895	92.122	91.585	92.035	90.934	91.167	90.642
	a*	0.901	0.128	0.783	0.112	1.476	0.328	0.611
	b*	3.638	7.473	6.475	7.334	4.181	4.86	2.29
	K/S	3.854	9.316	6.037	9.415	5.409	9.339	3.503

(Abbreviation: **M.M**-Mordanting Method, **C.C**- Colour Coodinates, **W.M**-Without Mordant, **P.P.P**-Pomegranate Peel Powder, **O.P.P**-Orange Peel Powder, **H.P**-Harda Powder, **A.S**-Aluminum Sulphate, **F.S**-Ferrous Sulphate, **S.H.S**-Sodium Hydro-Sulphate)

It can be analyzed that L* & b* values of ferrous sulphate are the best in pre-mordanting method, L* value of pomegranate, b* value of orange peel powder are good in meta-mordanting method, L* & b* values of pomegranate are the best in post-mordanting method, and a* values of alum mordant are the best in pre, meta and post-mordanting method, both in natural as well as chemical mordants.

The k/s values of dyed khadi fabricthrough beta vulgaris with various mordants

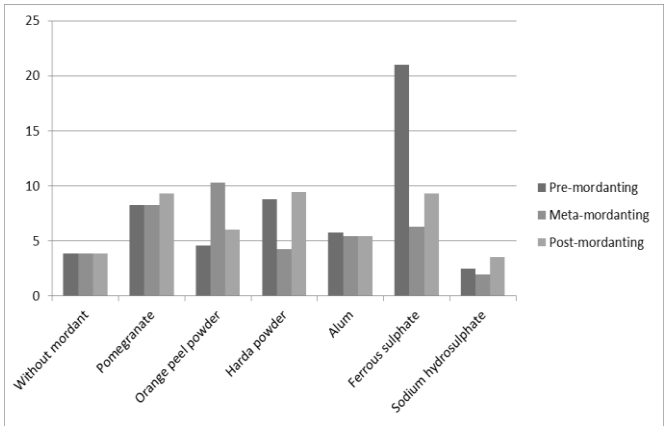

Figure 1: K/S values of dyed khadi fabric throughbeta vulgaris with various mordants.

It can be analyzed that K/S values of ferrous sulphate are the best in pre-mordanting method, K/S values of orange peel powder are the best in meta-mordanting method and K/S values of Harda powder are the best in post-mordanting method, both in natural as well as chemical mordants.

Colour fastness of Dyed khadi fabric with beta vulgaris

The assessment of colour fastness of light fastness, rubbing fastness and washing fastness of beta vulgaris are tabularize in Table 3

Table 3: Colour fastness of dyed khadi fabrics with beta vulgaris.

M.M	F.P	W.M	P.P.P	O.P.P	H.P	A.S	F.S	S.H.S
Pre	L.F	6	6	6	6	6	7	7
	R.F.D	5	5	5	5	5	4	5
	R.F.W	5	3	5	3	5	4	5
	W.F.C.C	5	5	5	5	5	5	5
	W.F.S.T	5	5	5	5	5	5	5
Meta	L.F	6	4	5	6	6	6	7
	R.F.D	5	5	5	5	5	5	5
	R.F.W	5	4	3	5	5	5	5
	W.F.C.C	5	5	5	5	5	5	5
	W.F.S.T	5	5	4	5	5	5	5
Post	L.F	6	5	5	6	6	6	7
	R.F.D	6	5	5	5	5	5	5
	R.F.W	6	4	5	4	5	4	5
	W.F.C.C	6	5	5	5	5	5	5
	W.F.S.T	6	5	5	4	5	5	5

It is clear from the results that all the threenatural mordants also showed a good affinity with dyeand gives darker or comparative similar depth ofshades as compared to chemical mordants. The colour fastness values of all the dyed samples withnatural mordants are good and comparable tosynthetic mordants which shows that these ecofriendly natural mordants has great potential in ecofriendly dyeing.

(Abbreviation: M.M-Mordanting Method, F.P-Fastness Properties W.M-Without Mordant ,P.P.P-Pomegranate Peel Powder, O.P.P-Orange Peel Powder, H.P-Harda Powder ,A.S-Aluminum Sulphate , F.S-Ferrous Sulphate ,S.H.S-Sodium Hydro-Sulphate, L.F-Light Fastness, R.F.D-Rubbing Fastness Dry, RF.W-Rubbing Fastness Wet, W.F.C.C-Wash Fastness Change in Colour, W.F.S.T-Stain Transfer(Khadi))

CONCLUSION

It can be observed that extract of beet root natural dye gives various shades in light pink –light green-yellow region on khadi fabric with the help of various natural and chemical mordants. Reddish tone of beetroot was obtained only with alum mordant. As far as fastness properties concerned, both natural as well as chemical mordants shows good results. It can be also concluded from the above found results that whole dyeing process can be done using renewable eco-friendly natural materials. Therefore there is a great scope for eco-friendly dyeing of khadi textile materials with beetroot.

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