Study of Dyeing of Cotton Fabric using Peanut Pod Natural Dyes using Al2So4 CuSo4 and FeSo4 Mordanting Agent

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Abstract**—** *The decline in the use of artificial colourants due to their toxicity in food and textile industry, put forward by international market has increased the importance of natural raw materials. From those, peanut pod (Arachis hypogaea) with solid applications is one of the most important sources of natural dyes. The major colouring component in peanut is pods, extracted from the fresh and dried peanut pod. The aim of present work is to evaluate peanut pod powder as natural textile dyestuff. The work consists of three steps, i.e. extraction, characterization and dyeing processes. The dye extraction procedure is conventional and traditional. Dyeing of cotton fabrics with the extract of peanut pod powder has been carried out and dyeing has been optimized using three mordanting agents as: Alum, Copper Sulphate and Ferrous Sulphate. Finally, dyed fabric have been subjected to different textile laboratory tests e.g., colour fastness, light fastness, washing fastness and rubbing fastness (dry and wet).*

Keywords— Peanut Pod, Natural Dyes, Cotton Fabric, Mordanting Agents, Environmental Friendly.

I. INTRODUCTION

Dyes are generally used in textile, paper, cosmetic, food, pharmaceutical and leather industries. Water pollution due to discharge of non-biodegradable coloured effluents from textile dye manufacturing and textile-dyeing sill is one of the major environmental concerns in the world today. Strong colour imparted by synthetic dyes to the receiving aquatic ecosystems poses aesthetic and serious ecological problems such as inhibition of benthic photosynthesis and carcinogenicity. Textile industry uses and rejects high amounts of water, its wastewater being the main way by which dyes are discharged into the environment [1-2]. Textile effluents are characterized by strong colour and high concentrations of organic and inorganic compounds caused by residual dyes that were not fixed to the fibers during the dyeing process [3-4]. The serious environmental problems of public health concern related to coloured wastewaters containing synthetic dyes have diverted researchers promptly to look for eco-friendly products. Hence, there is a world's movement to return to the natural dyes [5-6].

In this paper we have shown that the natural dye-stuffs of plant origins, grown in Beawar, Rajasthan, used as peanut pods systems can be developed scientifically and can be substituted for the textile dyes. These peanut pod dyes can be produced in large scale and could be prepared commercially and economically [7]. The practice of peanut pod systems for preparing dye-stuffs and the processes of dyeing has been developed using modern technological methods [8-9].

These natural dyes derived from the plants of Beawar, Rajasthan are found to be of high quality, and thus these plants need to be protected for conservation of biodiversity. People can utilize these peanut pod dyes in large scale, commercially, by establishing processing units and can replace the use of chemical dyes which are hazardous from the environmental point of view [10-11]. As Rajasthan amidst its rich diverse peanut pods harbors many dye yielding plant species in abundance, we carried out a study to revive and restore the traditional dyeing practices using the traditional biomordant Alum, Copper Sulphate and Ferrous Sulphate in place of metal mordant [12]. This work was designed with an aim to focus on the innovative methods of dye extraction, mordant study and by means of application of modern technology to sharpen the skills of tribal traditional dyers of Rajasthan. Although a lot of work has been done on natural dyeing with other sources, our approach is towards development of ecofriendly natural dyeing [13-16].

II. MATERIAL AND METHOD

2.1 Growing and Characterization of Peanut Pod

The peanut is grown as an annual crop. It can grow up to 21/ 2 feet (75 centimeters) high and from 3 to 4 feet (90 to 120 centimeters) across. Peanut plants range in type from bunch plants to runner plants6-8. Bunch plants grow upright. Runner plants spread out on or near the ground as they grow as shown in Figure 1.

FIG.1. PEANUTS FOUND FROM THE ROOTS AND CRUSHED POWDER OF THE PEANUT POD.

2.2 Cultivation

Peanut plant grows best in light, well-drained and sandy soil. They need much sunshine, warm temperature, moderate rainfall, and a frost-free growing period of four or five months. Farmers prepare the soil by plowing it deeply and thoroughly. Loose soil is important so that the pegs can penetrate the soil easily. Farmers plant peanut seeds 2" to 3" (5 to 8 centimeters) deep at intervals of 3" to 6" (8 to 15 centimeters), and in rows 24" to 36" (60 to 90 centimeters) apart.

2.3 Selection of dye source and extraction method

The first part of this research work was to get the peanut pods. For this research work peanut pod were collected from local market of Beawar City and then classified it into two segments, dark and light color peanut pod then after this peanut pod were dried into non sunlight area. After dried we grind them into mixer grinder. Preparation of the dye bath for dyeing using natural dye involves crushing, soaking and boiling are usually necessary to extract the dye from the vegetable matter. In general the coarser the material, the longer it should be soaked and boiled. In the process of crushing, grinder is used to make it in the powder form. When the powder form is ready, it is mixed with water solvent and heated on gas burner to extract the dye [17-18].

2.4 Pre-Treatment of Fabrics (Scouring)

Firstly scouring treatment was given to cotton fabric. The objective of scouring was to reduce the amount of impurities to obtain level and reproducible result in finishing operations "caustic soda boil" method was used for scouring [19] then fabrics were ready for dyeing as shown in Table 1.

TABLE 1
COTTON FABRIC WERE SCOURED USING RECIPE

Parameters	Value
Sodium carbonate	2gm/lt
Detergent	5gm/lt
Temperature	50
Time	30min
M.L.R	1:30

Scouring bath was made up by adding detergent and sodium carbonate and fabric was treated for 30 min at 50-60°c temperature. After scouring material was removed, rinsed thoroughly and squeezed gently. The scoured fabric was dried at room temperature [20].

III. MORDANTING METHODS

A few dyes can be applied by any of 3 methods (pre, simultaneous and post) but generally one of the processes gives better results than the other in case of most of dyes [21-22].

3.1 Premordanting

The fabric is mordanted first, rinsed thoroughly with water and then it is dyed with dye solution. It's being a two bath process, consumes more time, water, steam. This method gives most level results.

3.2 Simultaneous mordanting and dyeing

It is one bath process dyeing and mordanting is done together in same bath. The fabric to be mordanted and dyed must be covered with water, so that can be stirred easily and dye and mordant can circulate thoroughly and reach each part quickly. Fabric should be properly checked and conformed that; mordant should be well dissolved before dyeing mixed with fabric.

3.3 Post mordanting

It consists of simple dyeing and since the lake is not formed at this stage, perfect penetration of dye takes place. The subsequent mordanting fixed the dye through lake formation.

3.4 Natural Mordants

In this present research work three mordanting agents are utilized. These are Alum (Al_2So_4), Copper Sulphate ($CuSo_4$) and Ferrous Sulphate ($FeSo_4$).

3.5 Optimization of mordant concentration

10% concentration of mordant was used. The mordanting was done and samples were dyed employing extraction time, dye, dyeing time, dyeing temperature. Optimum mordant concentration was decided on the basis of evenness, brightness and darkness of the colour.

IV. SELECTION OF TEXTILE SUBSTRATE

We have taken fabrics for this experimental work and that is cotton fabric. Determination of preliminary data of fabric can be given in three steps listed below.

4.1 Thread count

One square cm was marked on the cotton, linen and jute fabric and number of warp and weft thread were counted. Five readings were taken and then average was calculated [23].

4.2 Thickness of the fabric

Thickness tester was used to measure thickness. Fabric was ironed to remove wrinkles. The lever of pressure foot was raised and fabric was put on anvil. Pressure foot was released slowly and thickness of fabric was measured in mm from dial after 30 seconds. Thickness was determined at ten different places and mean was calculated [23].

4.3 Weight per unit area

Five specimen or samples of 5"×4" were cut at random from fabric and weighted on electrical balances. The average of these five readings was taken. Weight/ Unit area was calculated as given below.

$$W = \frac{\text{wt(gm)}}{28} \times \frac{36 \times 36}{20(\text{square inch.})}$$

4.4 Depth of shade (k/s value)

The k/s value at 630 nm was determined by JAYPAK spectrophotometer. Peanut pod natural dye treated with different mordanting agents such as alum, copper sulphate and ferrous sulphate on different fabric such as cotton, linen, jute, cotton/jute, satin, silk and polyester at different % such as 10% and 15% were determine by using digital potentiometer (DP001, pico make) at different time intervals.

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

K/S value of dyed samples was assessed with the help of spectrophotometer. Only those samples which gave best results after dyeing with natural dyes and their combination was send to BHILWARA Laboratory for determination of K/S value.

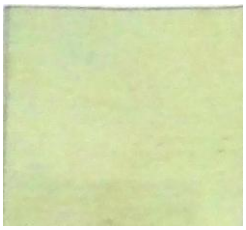
V. RESULT ANALYSIS OF COTTON FABRICS WITH MORDANTING AGENTS

Good colorfastness continues to be major concern of the consumers. Beauty of color on any fabric is of no value to consumer unless the dye is considered fast under conditions, it will be used, and that's why in this study colorfastness of different chemicals on different fabrics was assessed. The fabric is like: Cotton. The above discussed points can be understood by different analysis with five point gray scale, which is given by the six different tables [24-26].

TABLE 2
COTTON FABRIC WITH COPPER SULPHATE IN PRE, SIMULTANEOUS AND POST MORDANTING CONDITION

Fabric	Specimen	Dye & Mordant	Dye %	Mordanting	Color Change Sun Light	Color Change Rubbing (Wet)	Color Change Rubbing (Dry)	Color Change Washing Fastness
Cotton Fabric		Peanut Pods (pp)	-	-	-			
	1	PP+ Copper Sulphate	10%	Pre	4	4/5	5	4/5
	2	PP+ Copper Sulphate	15%	Pre	4	4/5	5	4
	3	PP+ Copper Sulphate	10%	Simultaneous	4	4	4/5	4
	4	PP+ Copper Sulphate	15%	Simultaneous	4	4	4/5	4
	5	PP+ Copper Sulphate	10%	Post	4/5	4	4/5	4
	6	PP+ Copper Sulphate	15%	Post	4	4/5	4/5	4/5

TABLE 3
COTTON FABRIC USING COPPER SULPHATE WITH K/S ANALYSIS

Fabric	Specimen	Dye & Mordant	Dye %	Mordanting	K/S Value	Testing Results
Cotton	1	PP+ Copper Sulphate	10%	Pre	8.49	
	2	PP+ Copper Sulphate	15%	Pre	7.98	
	3	PP+ Copper Sulphate	10%	Simultaneous	7.63	
	4	PP+ Copper Sulphate	15%	Simultaneous	8.81	
	5	PP+ Copper Sulphate	10%	Post	8.16	
	6	PP+ Copper Sulphate	15%	Post	9.98	

It can be observed from the table 2 and 3 that cotton fabric is reacted with the copper sulphate mordanting agent with 10% and 15% dyed solution. Here we have worked on three different conditions as Pre, Simultaneous and Post mordanting. In this we have observed that cotton fabric gives best result with the 10% and 15% in the pre mordanting condition at color change rubbing dry condition with in all tests.

TABLE 4
COTTON FABRIC WITH FERROUS SULPHATE IN PRE, SIMULTANEOUS AND POST MORDANTING CONDITION

Fabric	Specimen	Dye & Mordant	Dye %	Mordanting	Color Change Sun Light	Color Change Rubbing (Wet)	Color Change Rubbing (Dry)	Color Change Washing Fastness
Cotton Fabric		Peanut Pods (pp)	-	-	-			
	1	PP+ Ferrous Sulphate	10%	Pre	4/5	4/5	5	4/5
	2	PP+ Ferrous Sulphate	15%	Pre	4/5	4/5	5	4/5
	3	PP+ Ferrous Sulphate	10%	Simultaneous	4	4	4/5	4/5
	4	PP+ Ferrous Sulphate	15%	Simultaneous	4	4	4/5	4
	5	PP+ Ferrous Sulphate	10%	Post	4/5	4	4/5	4
	6	PP+ Ferrous Sulphate	15%	Post	4	4/5	4/5	4/5

TABLE 5
COTTON FABRIC USING FERROUS SULPHATE WITH K/S ANALYSIS

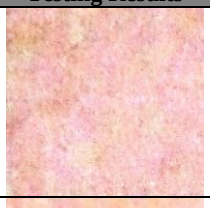
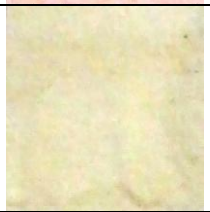
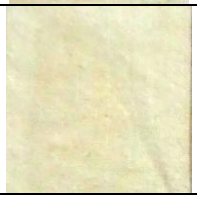
Fabric	Specimen	Dye & Mordant	Dye %	Mordanting	K/S Value	Testing Results
Cotton	1	PP+ Ferrous Sulphate	10%	Pre	5.71	
	2	PP+ Ferrous Sulphate	15%	Pre	4.94	
	3	PP+ Ferrous Sulphate	10%	Simultaneous	6.11	
	4	PP+ Ferrous Sulphate	15%	Simultaneous	7.23	
	5	PP+ Ferrous Sulphate	10%	Post	5.81	
	6	PP+ Ferrous Sulphate	15%	Post	6.95	

It can be observed from the table 4 and 5 that cotton fabric is reacted with the ferrous sulphate mordanting agent with 10% and 15% dyed solution. Here we have worked on three different conditions as Pre, Simultaneous and Post mordanting. In this we have observed that cotton fabric gives best result with the 10% and 15% in the pre mordanting condition at color change rubbing dry condition (all tests).

TABLE 6
COTTON FABRIC WITH ALUM IN PRE, SIMULTANEOUS AND POST MORDANTING CONDITION

Fabric	Specimen	Dye & Mordant	Dye %	Mordanting	Color Change Sun Light	Color Change Rubbing (Wet)	Color Change Rubbing (Dry)	Color Change Washing Fastness
Cotton Fabric		Peanut Pods (pp)	-	-	-			
	1	PP+ alum	10%	Pre	4/5	4	4/5	4
	2	PP+ alum	15%	Pre	5	4	4	4
	3	PP+ alum	10%	Simultaneous	4	4/5	4/5	4/5
	4	PP+ alum	15%	Simultaneous	4/5	4	4/5	4/5
	5	PP+ alum	10%	Post	4/5	4	4	4
	6	PP+ alum	15%	Post	4/5	4	4	4/5

TABLE 7
COTTON FABRIC USING ALUM WITH K/S ANALYSIS

Fabric	Specimen	Dye & Mordant	Dye %	Mordanting	K/S Value	Testing Results
Cotton	1	PP+ alum	10%	Pre	8.94	
	2	PP+ alum	15%	Pre	7.37	
	3	PP+ alum	10%	Simultaneous	8.31	
	4	PP+ alum	15%	Simultaneous	9.45	
	5	PP+ alum	10%	Post	8.97	
	6	PP+ alum	15%	Post	8.59	

It can be observed from the table 6 and 7 that cotton fabric is reacted with the alum mordanting agent with 10% and 15% dyed solution. Here we have worked on three different conditions as Pre, Simultaneous and Post mordanting. In this we have observed that cotton fabric gives best result with the 15% in the pre mordanting, 10% and 15% in pre, simultaneous and post mordanting condition gives good to very good results.

VI. CONCLUSION

From the study, it may be concluded that the selected dye sources namely peanut pod are highly suitable for Cotton material with ferrous mordant. The pre-mordant with 10%& 15% of dye, techniques are mostly suitable for Cotton material. These dyes are safe and eco-friendly. Therefore, their use will definitely minimize the health hazards caused by the use of synthetic dyes. These natural dyes give some medicinal properties also.

ACKNOWLEDGEMENTS

One of the authors (Ms. Megha Kumari Chhipa) is thankful to Department of Home Science, Swami Keshwanand Rajasthan Agriculture University (SKRAU), Bikaner, Rajasthan, INDIA for providing experimental and measurements facilities. The author also would like to thank, Department of Textile Engineering, M.L.V. Textile & Engineering College, Pratap Nagar, Bhilwara (Raj.) India, providing research facility for the measurement of K/S value.

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