

SUMMARY AND CONCLUSION

CHAPTER V

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Before the advent of synthetic dyes the fabrics used to be ornamented in our country either with Kora (Gray form) or by the use of coloured yarn dyed by utilizing various natural products like roots, barks, flowers, fruits, leaves etc. The process of natural dyeing has been a lengthy and cumbersome process involving great amount of time, energy and skill but largely an eco-friendly process utilizing materials available from nature. With the world becoming more conscious towards ecology and environment there is greater need today to revive our heritage and tradition of natural dyes.

Natural dyes have been used as a means to colour textiles for centuries. All the dyes until the later half of nineteenth century were made of different parts of plants and animals. For thousands of years people all over the world followed the same basic techniques, using roots, stems, barks, leaves, hard woods, berries and flowers of various dye plants and tree, as well as from certain insects and shell fishes. Most natural dyes are non-substantive dyes and require the aid of mordants, to penetrate the yarn/fibre. Certain metal mordants involved in the process of natural dyeing pose a threat to the environment.

Designers have effectively utilized Natural dyes as a design tool. The non reproducibility and non uniformity of shades makes each creation a unique piece. Various kinds of design production methods such as, tie and dye or stitching (shibori), resist printing, stenciling, batik, Indian Ajrakh, kalamkari, ikat and many more such techniques are being practiced by the designers to create unique products. The handicraft industry in many countries has evolved around local talent in the art and craft of dyeing yarn with natural dyes and weaves them to produce speciality fabrics.

Increasing global competitiveness in textiles has created many challenges for textile researchers and industrialists. Last few decades saw the consumers to be highly cognizant regarding the eco friendliness and functionality of the textiles.

Natural dyed fabrics which were a way of life in the past history of our country now fall under the category of concept selling. This is a relatively unique concept in the market and it carries a specific quality or benefit that the buyer is looking for or made to look at. When you sell a concept, you are adding value to the market, and it will be far less price sensitive. This point has been proven by the fact that consumers are willing to pay more for eco-friendly products.

5.1 Objectives

- 5.1.1. To assess the dye ability of cellulose and protein minor fibre with selected natural dyes and mordants.
- 5.1.2. To evolve a colour palette from the selected natural dyes.
- 5.1.3. To assess the fastness properties of the dye on the selected fibres.
- 5.1.4. To assess the eco-parameters of the dye.
- 5.1.5. To explore designs for value addition and product diversification of minor fibres/minor fibre fabrics.
- 5.1.6. To assess the consumer preference for designed products

5.2 Experimental procedure

The experimental procedure was divided into three phases. Pilot study formed the Phase I of the study. Phase II consisted experiments for dye application to develop a colour palette and its spectrophotometer analysis. Optical density and percent transmission tests and test for fastness against agencies of wear and Eco parameters for mordants were conducted. After the development of the colour palette and fastness testing of natural dyes on two minor fibre substrates the Phase III of the study involved the product designing and market evaluation of the designed products.

PHASE I:

Pilot study on cellulose substrate.

A **pilot study** was conducted taking ten natural dyes on cotton fabric. The four metal mordants used for the study were alum, copper sulphate, potassium dichromate

and ferrous sulphate. This allowed the investigator to have “hands on” training in the process of natural dyeing and printing. **Dyes** were selected on the basis of the colour yield; from the pilot study. Hence, a substrate pretreated with myrobolan formed a constant for the study.

The two minor fibre **substrates** selected in order to study the dyeing properties and to evolve a larger colour palette were Eri silk fabric (protein) and Sisal fibre (cellulose). Two aspects of natural dyeing were looked into: one being the dyeability of the fibres with selected metal mordants and natural mordants and the type and amount of colour obtained; and the second aspect was to explore and obtain a larger colour palette by means of composite dyeing. Six natural dyes were selected from the ten dyes explored during pilot study

The **variables of the study** were variation in pH of the dye solution, natural mordants tea and pomegranate rind and composite dyeing with a mixture of two dyes. This was done to extend the colour palette obtained by natural dyes. A large and varied colour palette from the traditional dye sources entails better/more opportunities for using the natural dye and hence increased potential for application of natural dyes.

PHASE II:

Dye application to develop a colour palette

Six natural dyes were selected for the study based on the colour obtained through the dye and their fastness properties on cotton substrate. The selection of six natural dyes from the pilot study was hence; purposive in nature. Three composite dye mixtures were also experimented. Hence, a total of nine dyes were selected for the study. Dyeing at extract pH, acidic and alkaline pH and use of tea and pomegranate rind as natural mordant were the five factors which contributed to a total of 10 pretreatments worked for Sisal and Eri silk fabric. Thus, 90 shades per substrate were developed out of the dye, mordant, fibre and pH combinations explored in the study.

The extracted dye was applied on minor fibres/minor fibre fabrics. The application of natural dyes was done by premordanting technique and standardized extract of natural dyes. The dye was calculated on the amount of liquor required for dyeing. It is taken as 2% in case of root, wood and barks dye source and 4% in case of

leaves and petals of flowers; as the roots, bark and wood yield more colour than the petals. The material liquor ratio was 1:40. The dye source powder was weighed according to the weight of the material and its respective percent shade and the powder was steeped in water according to the liquor ratio and the dye was extracted for 30 minutes at boil. The liquor was maintained by occasionally adding distilled water to the extract in measured quantities. The extract was then allowed to cool and filtered. This liquor was again adjusted to the measured liquor ratio and the extract was taken for spectrophotometric analysis; where the optical density of the extract was recorded.

The dye application was carried out by means of exhaust dyeing method. The extract was distributed in 10 beakers according to the material liquor ratio for the fabric to be dyed. The samples according to the treatment they were to be given were put into the respective beakers. The pH was adjusted to 4, 6, and 8 for the samples that were to be dyed at that pH respectively. 4pH was obtained by addition of 1% Acetic Acid, 6pH was the pH of the extract and 8pH was obtained by adding 1% Sodium Carbonate to the dye liquor. The material liquor ratio for extraction of dyes was 1:40 at boil for 30 minutes. Dyeing took place at 85°C, at 1:40 M:L ratio for 45 minutes.

Evolving a Larger Colour Palette through Composite Dyeing:

The present study had an experimental and exploratory format under which the study also had the objective of exploring the possibility of obtaining new/different colours by combining natural dyes from different colour genre and exploring for newer colour possibilities. Hence the researcher explored the possibility of obtaining different colours by combining an earthy red dye in combination with dyes that gave different colours like ochre yellow to green of Marigold, bright yellow to orange from Flame of Forest and purplish grey obtained from Ratanjot.

- Madder + Marigold
- Madder + Flame of Forest
- Madder + Ratanjot

Evaluation of Eco Parameters of Dyeing Process:

The determination of the residual metal or amount of incorporated metal salts was estimated and it was done by Atomic Absorption Spectroscopy (AAS) at ATIRA for samples treated with copper sulphate and potassium dichromate. The results of the test indicated that the trace metals on the fabric were within permissible limits for ferrous sulphate and copper sulphate; but it ranged 1.0 - 0.05 more in case of potassium dichromate. Hence, all the natural dyed products resulting as an outcome of this study confirmed the eco friendly parameter except for the fabrics mordanted with potassium dichromate, which was amended by working low concentrations of dichromate for the dyed products.

Spectrophotometric Analysis

Colour yield on Eri silk: Percentage dye absorption readings ranged from -62 to 142 for the 90 Eri silk samples dyed with the select natural dyes and 10 mordant combinations. Barring a few samples that have a negative reading rest other fall under the positive dye absorption range indicating average to good dye pickup by the substrate; hence quantification was done with the help of reflectance spectrophotometry. The highest and lowest K/S values obtained were 15.27-1.49.

Colour yield on Sisal fibre: Spectrophotometer analysis of the dyed samples was done in order to assess the percent dye absorption and also the respective k/s values for the selected natural dyes with Sisal fibre. For calculating the percent dye absorption the dye liquor was evaluated on the spectrophotometer before and after the dyeing procedure to assess the optical density of the solution at the specific λ maxima. The percent dye absorption in various dye and mordant combinations during Sisal fibre dyeing ranged from -53 in one case to 121 which was the highest positive score and rest of the readings falling dominantly in the positive dye absorption range indicating the fact that there has been a good amount of dye pickup by the fibre. To quantify this result dyed fibre samples were then taken for analysis on the reflectance spectrophotometer to assess the K/S values of the dyed samples, which ranged from 3.24 to 12.04 which indicate an average to good depth of colour on the dyed samples.

Testing for fastness parameters:

The colours obtained as a result of dyeing experiments for the development of colour palette were tested for their fastness to various agencies of wear. The tests were conducted according to the following standard test methods.

Light Fastness : Test method IS 2454:1985 based on ISO 105/B-1984. ⁽³¹⁾

Rubbing/crocking fastness: Test method IS 766: 1988 based on ISO 105/X-1984. ⁽³¹⁾

Laundering/washing fastness: Test method IS 764:1979, based on ISO, 105/C-1982⁽³¹⁾

The geometric grey scale by ICI (As specified by the Society of Dyers and Colorists) was used for visual assessment to evaluate the rate of staining and colour change of the dyed sample. For the evaluation of the rate of staining of un-dyed cloth, was done by comparing the difference in colour of stained and unstained cloth with the difference represented by the scale. For the evaluation of the change in colour, the rating was done by comparing the difference in colour of tested specimen and the original textile with the difference represented by the scale.

PHASE III:**Product Designing, selection of material and Consumer Acceptance**

The aim of this research was to explore the minor fibres in order to make them suitable for use as home textile material. Four minor fibres Eri silk, Goat hair, Sisal fibre and Jute fabric were selected for designing of products for home décor. It was also observed that most of the fibres in this category have a harsh tactile quality. It was kept in mind that the products designed for use should not be in constant contact of the skin of the user. Hence, the products designed were such that would definitely add a textural quality to the home/hotel interiors at the same time care was also taken to utilize these fibrous materials in such articles of use where the consumer is not in constant touch with the material. The products designed were such that they would consume a good yardage of cloth so as to obtain maximum utility of the material. Hence the following four categories of articles were selected for the application of

natural dyes and the textile material would be Jute and Sisal fabrics in the cellulose category and Eri silk and Goat hair in the protein natural fibre category.

A total of 16 articles were made using the four minor fibres under study in the following product categories:

- Lampshades
- Partition panels
- Wall hangings and
- Floor coverings

Consumer Response:

Consumer acceptance of the designed products in terms of its perceived value, newness of the product, acceptance of the natural dye colour palette in relation to the consumers' awareness of the market of the minor fibres and eco friendliness of the product was studied. Hence, two exhibitions were conducted in order to exhibit the products in different settings to target 500 consumers. The basic criterion for selecting the respondents was that they should have graduation as their minimum qualification.

The products were exhibited in a gallery at Baroda and at a stall obtained at the national handloom and handicraft fair at Ahmedabad. Consumer responses were taken by means of a structured questionnaire for statistical analysis. The mean score of the responses for acceptability and aesthetics of the products is indicative of the fact that most consumers have liked the products. The results for the need level of these kind of products also indicate that the consumers suggest that there is a gap between the demand and supply of these kind of value added products and hence; there could be a good market opportunity if the production of these products scales up to mass market requirement.

5.3 Result and Discussion

5.3.1 Colour palette and reflectance spectrophotometer data obtained through selected dye and composite mixtures with metal mordants, pH variation and natural mordants.

A gamut of 180 shades was produced 90 on each substrate. It was observed that Madder offered a large range of distinctly different shades of dyes with respect to the mordants it is combined with. The range of colours it produced was from light pink, light red violet, red, orange, brown to dark brown and maroon. It is worth noting here that the substrate plays an important role. The range of colours obtained on dyeing of Eri silk and Sisal fibre with Marigold dyes ranged from Khaki brown, olive green, beige, to slate and dark greenish brown. Eri silk samples dyed in Marigold obtained colour ranging from reddish brown to green. Whereas, leaving an exception of two samples all the sample of Sisal fibre obtained a beautiful olive green ranging from dark to light depending on the interference from the mordants they were pretreated with. The positive Da^* values indicated that the Sisal samples had a redder tone compared to the red brown tone obtained by the Eri silk samples.

The k/s values of all the samples of Sisal fibre compared with Eri silk samples dyed with Henna dye indicate that the Sisal fibre samples were lighter in hue compared to the Eri silk fabric samples. This again indicates that Henna acts as an acid dye, exhibiting higher substantivity towards protein fibre compared to cellulose fibre. The DL^* values from Table 4.3.b. indicate that samples pretreated with copper sulphate, potassium dichromate, and Tea were darker compared to the rest of the samples with their k/s values also indicative of the fact; which were 10.53, 14.33 and 6.40 respectively. The Da^* and Db^* reading of samples dyed with Ratanjot at 4pH, 6pH and 8pH indicated that sample dyed at 4pH and 8pH were red with more amount of blue. At the same time the DL^* values indicate that the sample dyed at 4pH was darker compared to the sample at 8pH. Hence, the spectrophotometric evaluation of the samples gave quantifiable data, which supported visual assessment of the dyed samples.

In case of this dye mixture it is observed that all the shades fall under the red blue region; and they are lesser red and more concentrated towards the blue region. Hence, it may be said that out of Madder and Ratanjot dye mixture; Ratanjot dye imparts more colours compared to Madder. The k/s values indicate that the sample pretreated with pomegranate rind exhibits the highest colour strength amongst all the samples.

5.3.2 Eco-parameters of the selected metal mordanted dyed samples.

The study also explored the possibilities of using natural mordants like tea and pomegranate rind as a mordant. Hence apart from the metal mordants natural mordants were also used to investigate if these could be substituted for certain hues. The results of which were quite encouraging as a majority of the dyes gave colours in the range of samples dyed with copper sulphate or with alum with a minor dullness that could be attributed to the non usage of metal mordants. On visual inspection of samples dyed with Flame of Forest dye, it was observed that samples pretreated with potassium dichromate had similar colour yield to the one pretreated with pomegranate rind. When samples dyed with Ratanjot dye were compared; similar observation was obtained in case of samples pretreated with ferrous sulphate to sample pretreated tea. It was hence derived that for Flame of Forest and Ratanjot dyes natural mordants like tea and pomegranate rind can substitute metal mordants to make the resultant products 100% eco friendly. Pomegranate rind was found to be a very good substitute to myrobolan, with comparable or even 5% to 10% more colour value on fabrics (the colours appeared darker but the hue was visibly flatter) and is already commercially available in abundance. Yet the colour fastness of the dyes with pomegranate rind and metal mordants was not as good as the myrobolan treated fabrics; as a result of which the final dyeing samples were done with myrobolan as the basic treatment.

5.3.3 Optical density and percent transmission of spent dye-bath of the experimental variables.

The spent dye liquor left after dyeing procedure was assessed for optical density of the solution. It was ascertained in order to have a qualitative measure of the dye exhaustion from the dye bath. Hence, higher the transmittance obtained; better was the dye exhaustion from liquor. Proportionately higher the transmittance of the dye liquor at a particular wavelength also meant higher k/s values in most cases.

It was observed that Madder dyed at 6pH gave the highest absorbance value. There was a marked difference in the percent dye absorption of Marigold dye at 4 and 8 pH. Ratanjot dye gave 10.76 percent dye exhaustion with tea pretreated fabric and 13.84 when dyed at 6pH, so it is averred that extract pH with metal mordant pretreated fabric gave better dye exhaustion on Eri silk fabric. It was observed that

Madder Marigold dyeing gave very good exhaustion at the extract pH and the k/s values also gave a reading of 9.01 and 11.58 for Sisal fibre and silk fabric respectively. It was observed that the k/s values were higher for Tea and Pomegranate rind mordanted fabrics.

5.3.4 Fastness test of selected dye and composite mixture on Sisal and Eri silk fabric.

Fastness to laundering, rub fastness and light fastness test were carried out for Eri silk fabric dyed with the select natural dyes. The range of ratings for **fastness to laundering** for Eri silk dyed with the 10 mordant combinations ranged from 4-5 in most natural dyes except with Marigold where the average was fastness rating is 3-4 which is average to good result. The **rubfastness** rating for Eri silk fabrics ranged from 2-3 in case of Madder, Marigold, Flame of Forest and Ratanjot and between 3-4 and above for the rest of the dyes leading to the conclusion that the rub-fastness results range from poor to average to good in some cases of dyeing with natural dye on Eri silk substrate. **Light fastness** of the dyed samples was also evaluated by exposing the samples to 10 and 20 hours of ultraviolet light exposure; the results for which are encouraging as most of the samples achieved a rating of 4-5 with minor hue differences like the samples becoming a little bluer or redder after exposure to ultraviolet light. However light fastness rating for Marigold dye and dye combination of Madder and Marigold need a mention as the fastness ratings ranged between 3-4, indicating an average to poor light fastness rating.

It was noticed that the **rub fastness** rating of Sisal fibres with different mordant combinations ranged from average to good with an above all average score range of 3-4. It is also noted that **fastness to laundering** for Sisal fibre ranged from good to very good in most mordant and dye combinations with the overall average rating of 4. Where as the **light fastness** of Sisal fibre was found to be excellent as a rating of 5 was the most dominant score after exposure of samples to 10 and 20 hours of ultraviolet lamp fading. Hence it is deduced that successful and colourfast application of natural dyes was achieved on Sisal fibre by premordanting with metallic and natural mordant.

5.3.5 Value addition of minor fibres/fabrics through natural dyes and designing of products for home décor.

This study was an effort to design products which would have a hand intensive approach rather than totally mechanized process so as to motivate small enterprise activity that will help in the proliferation and acceptance of the fibre products in Indian homes for décor purposes. Hence, low machine intensive, hand techniques were employed in order to design products and a variety of techniques were employed in order to explore multiple ways to enhance one fibre product.

Direct application of print was done by means of stencil and block printing methods. Several variants in block printing were also tried out. The first five techniques detail the use of direct method of print application i.e. stencil printing and block printing. Resist printing techniques were also employed for surface ornamentation of some products. Batik and tie and dye were employed. Two variations; pleating and hand tritik and pleating and twisting were used for the products. Surface ornamentation by means of using embroidery was also done in the form of machine and hand patchwork, metal embroidery, white on white embroidery, braiding and couching and draw-thread methods. Non-woven mesh making technique and tapestry weaving were also employed.

5.3.6 Exhibition of the natural dyed home decor products, consumer responses and statistical analysis

A range of four home décor products in each fibre category was designed for exhibition. Two exhibitions were held one at Trisha Art Gallery, Baroda and the second at National Handloom and Handicraft fair, University Ground, Ahmedabad. A sample of 500 respondents was targeted and the exhibition was promoted through invitation cards, press notes, emails and sms promotion. It was observed that the natural dyed home décor products were well received by the consumers. There was an overall positive response towards the exhibited products. Questionnaires were administered to the visiting respondents and the completely filled ones were coded and tabulated. It was observed that the respondents were eco-conscious. Awareness towards the environment and eco friendly products, related positively with the need for eco friendly product and also that there was a positive correlation between need

and gap in availability of products. The respondents also indicated that the exhibited products do fetch more value to them due to the newness of the fibres which are value added by means of natural dyeing.

5.4 Conclusion

The research was aimed to explore the applicability of natural dyes on minor fibres. The present study was an attempt to investigate scientifically into the art of dyeing with natural dyes. At the same time the study catered to research questions like:

- Whether the natural dyes could be applied on select minor fibres?
- Could eco parameters of the dyes be stated along with the product?
- Would the natural dyed minor fibre products cater to a perceived value addition to the fibres?
- Would these products be accepted enthusiastically by a market of upper middle class consumers?

The following conclusions were derived from the study:

1. The study had overall 9 dyes (six single dyes and three composite mixtures). There were 10 mordant treatments which included plain sample dyeing, metal and natural mordants and variation in pH. A total of 180 shades were developed as an outcome of the dye, fibre, mordant and pH variation.
2. The minor fibres Eri silk and Sisal had good dyeability as the k/s values of the dyed samples exhibited positive scores.
3. In case Madder and Ratanjot dye mixture it was observed that all the shades fall under the red blue region; and they are lesser red and more concentrated towards the blue region. Hence, we may say that out of Madder and Ratanjot dye mixture; Ratanjot dye imparts more colours compared to Madder.
4. All the natural dyed products resulting as an outcome of this study confirmed the eco friendly parameter except for the fabrics mordanted with potassium

dichromate, which was amended by working low concentrations of dichromate for the dyed products.

5. The dye extracts had good optical density and it had a linear relationship with the k/s values obtained for the reflectance spectrophotometer analysis barring a few exceptions like Flame of Forest and Ratanjot when dyed at acidic and alkaline pH.
6. The dyes possessed average to good fastness to light, laundry and crocking except the Flame of Forest dye which had fair to poor fastness to light. Marigold dye had poor rubfastness on Eri silk fabric and overall average fastness was also average.
7. A positive correlation was observed between need and gap in availability of the products and between need and perceived value of the products. It was also concluded from the analysis that there is dearth in variety of products offered in the category of home décor products fashioned out of minor fibres.
8. Hence, there was a high perceived need / existing market opportunity waiting to be tapped in the area of natural dyed value added products.

Hence it was theorized that Minor fibres Eri silk, Sisal fibre, Jute and Goat hair were suitable to be dyed with natural dyes. Use of metal mordants in concentrations stated in the study help to confirm to the eco parameters laid by laws regulating permissible amounts of heavy metals on the substrate. The dye extracts had good optical density and they had a linear relationship with the k/s values obtained from spectrophotometric analysis and possessed average to good fastness to agencies of wear. Products for home décor designed out of minor fibres were well received at the two exhibitions held in Baroda and Ahmedabad. Hence, there is a huge latent potential for natural dyed value added home décor products fashioned out of minor fibres.

5.5 Recommendation

The study was an attempt to address the contribution that natural dyes might make “again” to cultures and economies in a “global” world. A vision of the world of natural dyes renewed both by the awareness of the threats to natural environments and the advances in the field of research.

Continuity of natural dyeing depends largely on transfer of knowledge and appreciation to the younger generation, both in rural areas where the program needs to be 'rooted' and the urban areas which would sustain the program in terms of 'demand'. Dissemination of knowledge is vital in the form of workshops and training centres or action projects. Although the aspect of appreciation comes from use of products in terms of apparel worn or when utilized as a home décor item. Natural dyeing can grow from an academic subject to being utilized at handloom and handicraft training centres. There is a huge potential for the minor/unconventional/underutilized fibres to be utilized into household textiles.

- Other minor fibres could be utilized for value addition and product diversification through designing and application of natural dyes.
- Design sensitization and training workshops utilizing the knowledge of natural dyes and product designing techniques could be imparted to craft clusters through government and non-government organizations.
- Studies on improvement in the tactile and drape qualities of the minor fibres could be undertaken by textile research institutes or as academic projects in order to increase the utility of the fibres.