CHAPTER V

SUMMARY AND CONCLUSION

Jute is known as golden fibres since long time. This golden fibre is said to have derived its name from the word “jaht” a Sanskrit word. It is used extensively in manufacturing sacks or bags which are used as packaging material for agriculture and industrial products only. In India mostly jute is grown in Kolkata and around it in warm and humid regions. The only country exporting jute on commercial scale today is India. Since jute is produced in India, the price is competitively less compared to other countries.

Jute is considered the eco-friendly alternative due to its bio-degradability and recyclable property. It is vegetable bast fibre extracted from the stem of Corchorus plant. Jute is a lignocellulosic fibre with hemicellulose, cellulose and lignin as the main constitution. It is available in inexhaustible quantities and at low prices and hence can be considered to replace several expensive fibres. It has inherent advantages like silky luster, high tensile strength, low extensibility, considerable heat and fire resistance, high moisture regain, good dyeability and long staple lengths. These advantages make it directly cater to technical and industrial requirements through its appropriate modifications and functional end-uses.

Jute is dyeable with all the dyes used for dyeing cotton. It also exhibits strong affinity towards basic dyes. This affinity is due to the presence of non-cellulosic constituents. Amongst these only direct, acid and reactive dyes are used extensively as they are cheap and easier in application. But the current world awareness about environmental pollution created by synthetic dyes has once again lead to the revival of the use of environmentally friendly less pollutant dyes. This has directed the researches towards exploring natural dyes. Some of the advantages of natural dyes:

1) It is obtained from renewable resources.
2) No health hazards, sometimes it acts as health care
3) Practically no or mild chemical reactions are involved in its preparations.
4) No residual problems.
5) It is harmonized with nature.

Jute in its natural form does not find many end-uses. Its utility can be enhanced by modifications which include bleaching, softening and colouration. Substantial researches have been carried out on the effects of different bleaching agents on jute and dyeing of jute with natural dyes but the correlation between effects of bleaching agents on dyeing performance of jute using different natural dyes was not explored. Bleaching on jute brings out internal changes in the fibre and therefore it was expected that it would affect the physical properties also. Bleaching results in increasing whiteness index which gives the base for colouration. In the present study, an attempt has been made to study the effect of pre-treatments on the dyeing properties when dyed with natural dyes and its effect on the physical properties of the fibre.

5.1 Statement of the problem

In India, jute is the second largest crop cultivated after cotton. It has been mainly used in making the hessian cloth, sacking material, etc. Its use extended to various other fields like geo-textiles, furnishings, non-wovens, handmade articles, accessories is to a limited extend. The inherent properties of jute includes silky luster, good tensile strength, high moisture absorption, heat and fire resistant, dimensional stability, antistatic properties, highly dyeable and also good thermal conductivity property. It feels warm in winter and since it has good moisture absorption property it feels reasonably cooler in summer. But along with these advantages, there are a few disadvantages like harsh feel, stiffness, coarseness; poor wash ability and poor abrasion resistance. The stiffness of fabric has great impact on its bending length or drape co-efficient. These drawbacks restrict its use other than packing material. Its utility can be enhanced by overcoming these drawbacks.

With the increased awareness about the environment, the paradigm shift is towards the use of natural products which are bio degradable and cause minimum or no residual harm to the environment. Due to it natural origin and possession of many favourable properties jute has attracted many researchers. To reduce the chemicals in processing of jute, natural dyes are one of the alternative to produce colour palatte.

Jute has inherent colour which is a drawback to develop colour palatte on jute. Hence, to overcome this, bleaching is required. Bleaching holds the key for successful

production of diversified coloured jute. The primary object of jute bleaching is to get maximum whiteness with minimum loss in strength and retention of whiteness for a longer period. Woolenization, a typical process generally used for jute for imparting crimps in its structure. The crimpness imparted offers wool-like appearance to the fibre.

Substantial research has been carried out on the effects of different bleaching agents on jute and dyeing of jute with natural dyes but the correlation between the effects of bleaching agents on dyeing performance of jute using different natural dyes needs to be explored.

In the present investigation, therefore an attempt has been made to study the effect of various bleaching agents on the physical properties of jute fabric as well as its effect on the dyeing properties when dyed with natural dyes.

5.2 Objectives

1. To study the effect of different bleaching agents on appearance and tensile properties of Jute fabric.
2. To investigate the effect of woollenization as a pretreatment of Jute fabric
3. To find out suitable pretreatment conditions for attractive colour development on jute using natural dyes.
4. To study the effect of different mordants on colour yield of pre-bleached jute
5. To examine an innovative system of mordanting viz. using nano metal particles
6. To analyze the fastness properties of the dyed samples.
7. To produce a color palette with natural dyes.
8. To analyze the fastness properties of the dyed samples.

5.3 Delimitations

1. The study was limited to only two bleaching agents namely: Hydrogen Peroxide and Peracetic acid.
2. The study was limited to only four natural dyes namely: Madder, Turmeric, Eucalyptus leaves and Indian Almond leaves.
3. The study was limited to the use of two metal mordants; alum and copper sulphate and one natural mordant harda.

5.4 Methodology

The study undertaken had an experimental and exploratory structure and was divided into two phases explained as follows:

PHASE I: Pilot study

A pilot study was an essential step for this research since it was exploratory in nature. Pilot work had been divided into two parts: 1) Development of colour palatte and 2) Pre-treatments.

1) **Development of colour palatte**: Four natural dyes namely Madder, Turmeric, Eucalyptus leaves and Indian Almond leaves and three metal mordants – alum, copper sulphate and ferrous sulphate were purposively selected for the study. Colour palatte was developed using these dyes and mordants individually on the bleached jute fabric. Bleaching was done using three bleaching agents namely Sodium Hypochlorite, Hydrogen Peroxide and Peracetic acid with the standard recipe. After bleaching, dyeing in natural dyes was carried out for pre and post mordanted sample. Thus, number of shades developed for these three bleaching agents were 36 shades individually, making the total sample as 72 samples for pre and post mordanting. K/S and L a^* b^* values were observed and analyzed. Based on the results, it was decided to carry forward only alum as a mordant for further study.
2) **Pre-treatments**: Bleaching and Woolenization were the two pre-treatments for the study. Bleaching was carried out using three bleaching agents namely Sodium Hypochlorite, Hydrogen Peroxide and Peracetic acid. These samples

were then dyed with Madder. The physical properties of these samples were tested and the results were compared.

Woolenization of the sample was carried out using standard recipe. Then the sample was dyed with Madder and tested various physical properties. Also, there were experiments carried out to investigate the effect of altering the sequence of bleaching and woolenization. Hence, one set of jute samples was bleached first and then woolenized and another set of jute samples was woolenized first and then bleached with all the three bleaching agents.

PHASE II: Experimentation

Experimentation was carried out using the results obtained from the pilot work. 100% jute fabric was taken and scoured properly then used. It was observed that the samples treated with sodium hypochlorite resulted reasonably higher loss in strength and was also seen from the SEM images show the damage caused to the sample. Hence, it was not used for further study. The best sequence of the pre-treatment was taken further for the next phase. The sequence taken further was Woolenization followed by bleaching using the best optimized bleaching condition obtained from the pilot work.

The scoured jute fabric was then woolenized using the standard recipe and then bleached with hydrogen peroxide, peracetic acid and their combination i.e. sequencial bleaching. Further experiments were carried out to optimize the recipe for hydrogen peroxide and peracetic acid. Variations in terms of time and percentage were used for hydrogen peroxide whereas for peracetic acid, variation was time and pH. For hydrogen peroxide, time variation was 60, 90 and 120 minutes while the percentage variation was 6%, 8% and 10%. In case of peracetic acid, time was 60, 90 and 120 minutes while pH was self (pH 2), pH 6 and pH 7. Then with all these variations in both the bleaching systems, pre-mordanting with alum was done. These bleached, pre-mordanted samples were dyed using four natural dyes namely Madder, Turmeric, Eucalyptus leaves and Indian Almond leaves. Total samples resulted from these experiment were 72. K/S values of all 72 samples were taken and analyzed.

The optimized condition for hydrogen peroxide was 10% concentration of hydrogen peroxide for the time duration of 90 minutes and for peracetic acid, the optimized condition was pH 7 for 90 minutes. In case of sequencial bleaching, initially the jute sample was bleached with peracetic acid and then bleached with hydrogen peroxide.

I] Conditions for pre-treatments:

- **Woolenization:** The scoured jute sample was treated with 15% concentration of sodium hydroxide for 30 minutes at room temperature maintaining the material liquor ratio 1:40. The sample was then neutralized using dilute acetic acid.
- **Hydrogen Peroxide Bleaching:** The scoured fabric was bleached with 10% (v/v) of hydrogen peroxide (30%) using 10% of sodium metasilicate as stabilizer maintaining the material liquor ratio 1:20. The fabric was treated in this solution for 60 minutes at 95^0C. The samples were then neutralized using dilute acetic acid.
- **Peracetic acid Bleaching:** Peracetic acid was prepared by reacting hydrogen peroxide with acetic acid. The most commonly used method for the preparation of peracetic acid was direct, acid catalyzed reaction of 30-98% hydrogen peroxide with acetic acid. For this study, peracetic acid was prepared by reacting hydrogen peroxide (30%) with glacial acetic acid in 1:2 molar ratio at room temperature for 24 hours using sulphuric acid as catalyst. The scoured jute fabric samples were treated with freshly prepared peracetic acid for 90 minutes at pH 7 and the temperature was maintained at room temperature.
- **Sequential Bleaching:** The scoured jute sample was subjected to two consecutive bleaching treatments with a particular bleaching agent under the same condition. The jute sample was first treated with Peracetic acid and then treated with Hydrogen peroxide.

II] Application of Mordants:

From the pilot work it was found that pre- mordanting gave the best result. Hence, for further experimentation, pre-mordanting was finalized. The mordants used were 1) Alum, 2) Harda, 3) Harda followed by Alum, 4) Nano Copper and 5) Nano Copper

followed by Alum. Each sample was pre-mordanted with corresponding mordant separately.

- **Alum:** For corresponding bleaching treatment, the samples were pre-mordanted with alum. The concentrations of alum were 5%, 10%, 15%, 20% and 25%. Then these pre-mordanted samples were dyed. To optimise the concentration of alum, the K/S values of dyed samples were observed and analysed.
- **Harda**: Bleached sample were premordanted using varying concentration of Harda i.e. 5%, 10%, 15%, 20% and 25% for each bleaching treatment. To optimise the concentration of harda, the K/S values of dyed samples were observed and analysed.
- **Harda and Alum:** The samples were first pre-mordanted with 10 % Harda and then the samples were dried. Without washing, the harda pre-mordanted samples were treated with 10% Alum keeping M:L ratio as 1:20. These samples were further dyed.
- **Nano- Copper**: For synthesis of nano- copper, following method was used: The 100ml solution of copper sulphate was kept on shaker plate and the solution was slowly reduced by drop wise addition of very dilute chilled solution of sodium borohydride till the solution turned to light yellow. The bleached jute fabric was treated with nano copper using two techniques i.e. 1) applied directly on bleached jute fabric 2) added into dye bath. The nano Copper was applied to bleached jute fabric using exhaust method at 40^0C keeping material to liquor ratio 1: 40. After 1 hour, the temperature was rised to 80^0C and the material was treated for 30 minutes more. Then the samples were thoroughly washed and dried in air. In other method, the jute fabric was dyed for 15 minutes at 40^0C keeping material to liquor ratio 1: 40 and after 15 minutes of dyeing, the Cu nano solution was directly added into the dyebath. Further the sample was dyed for 30 minutes.
- **Nano-copper and Alum:** The samples were first pre-mordanted with nano-copper and then dried. Without washing, the nano- copper applied and pre-mordanted samples were treated with 10% Alum keeping M:L ratio as 1:20. These samples were then dyed.

III] Application of Natural dyes:

As a natural dye source; madder, turmeric, eucalyptus leaves and Indian Almond leaves were used. Madder and turmeric were obtained in the powdered form whereas Eucalyptus leaves and Indian almond leaves were dried under shade and then powdered. In order to extract the dye, 10% of each dye source was taken and boiled for 30 minutes. The dye extract thus obtained was used for dyeing of the samples. The exhaust dyeing method was employed in this study. Dyebaths were prepared with the required amount of dye, keeping material to liquor ratio 1:40. The pre mordanted samples were kept into the dyebath at room temperature. The temperature of the dyebath was increased to boil gradually and dyeing continued for 1 hour. After dyeing, the pre mordanted samples were thoroughly rinsed and dried.

IV] Testing of physical properties of fabric: The treated fabrics were evaluated for the following physical properties:

1. Fabric Count: Thread count (number of yarns/cm^2) in woven fabrics was determined as per ASTM 2775-98 standards

2. Fabric Thickness: Compress-o-meter was used to determine the thickness of the fabric. It was measured as per ASTM D 1777-96 standard test method.

3. GSM: The mass unit (gm/m^2) was measured as per ASTM D 3776-96 standard test method.

4. Tensile Strength and Elongation of Fabric: It was determined on Instron, Model 1121, 10KN Testing instrument using ASTM test method D5035. The instrument was based on the principle of CRE (constant rate of extension)

5. Optical Indices and K/S values: The optical indices and K/S values were determined on Spectrphotometer Premier Colorscan SS5100

PHASE III: Development of product

Taking into consideration of the treated fabric, it was decided to explore its use in apparels. For that unisex jackets were finalized. To select four, ten jackets were designed. According to the requirement of the selected designs fabrics were dyed with

two dye source namely turmeric and Indian Almond leaves. Drafting and construction were carried out following the specifications of the designs.

5.5 Results and Discussion

The research was aimed of exploring suitable pre-treatments for obtaining improved dyeing properties of jute using natural dyes. Two sources of natural dyes i.e. root and leaves were purposively selected for the study. The root sources were Turmeric and Madder while the leave sources were Eucalyptus Leaves and Indian Almond leaves.

PHASE I: Pilot study

Pilot study was carried out to finalize the mordants, mordanting techniques and the pre-treatments for the study. Four natural dyes namely Madder, Turmeric, Eucalyptus leaves and Indian Almond leaves and three metal mordants – alum, copper sulphate and ferrous sulphate were purposively selected for this study. Colour palatte was developed using these dyes and mordants on the bleached jute fabric. Two aspects were studied: one the shade and amount of colour obtained on jute fabric and second the dyeability of the jute fabric with selected mordants and dyes. The number of shades developed for these three bleaching agents were 36 shades each, making the total sample as 72 samples for two treatments. The colour ranged from bright yellow to dark brown, marron to dark coffee, olive green to dirty dark green and dark grey. The K/S value of madder ranged from 5.84 to 13.79, turmeric ranged from 3.50 to 27.48, Eucalyptus leaves ranged from -1.97 to 18.89 and for Indian Almond leaves ranged from -1.89 to 18.90. It was decided by the researcher and guide based on results to carry forward only alum as a mordant and pre-mordanting technique for further study.

Bleaching and Woolenization were the two pre-treatments finalized. Bleaching was carried out using three bleaching agents namely Sodium Hypochlorite, Hydrogen Peroxide and Peracetic acid. It was observed that with sodium hypochlorite there was mush loss of strength and also SEM images show the damage created to the jute sample with this. Hence, it was not carried forwarded for rest of the study. Hydrogen Peroxide and Peracetic acid showed better results.

The sequence to be followed for the pre-treatments was decided on the basis of the results obtained for whiteness, yellowness and brightness. The treatment with alkali on jute fabrics gives a yellow shade to the fabric. Hence, it was decided to do woolenization followed by bleaching.

PHASE II: Experimentation

Experimentation was carried out using the results obtained from the pilot work.

It was observed from the appearance of the pretreated sample and K/S values for Hydrogen peroxide: 10% at 90 minutes was the best result and for Peracetic acid at pH 7 for 90 minutes was the best result. Those parameters were preferred which caused less damage to the fabric. Hence, these two conditions were taken further for the study. The optimized condition for Hydrogen peroxide and Peracetic acid was 10% concentration at 90 minutes and pH 7 at 90 minutes respectively.

I] Application of pre-treatment:

The scoured jute fabric was woolenized using the standard recipe and then bleached with hydrogen peroxide, peracetic acid and their combinations. The optimized condition for hydrogen peroxide was 10% concentration of hydrogen peroxide for the time duration of 90 minutes and for peracetic acid, the optimized condition was pH 7 for 90 minutes. In case of sequential bleaching, initially the jute sample was first bleached with peracetic acid and then with hydrogen peroxide. All the samples were tested for optical indicies namely whiteness, yellowness and brightness indicies. The best result amongst the three bleaching treatments obtained for sequential bleaching which is also supported by the findings of Chattopadhyay et al.(3). They have also reported that sequential bleaching produce better whiteness with less loss in strength, weight and abrasion resistance. Moreover, it also improves softness of bleached jute fabric to an appreciable extent.

II] Application of mordants:

The pre-mordanting technique was selected for this study. The mordants used were 1) Alum, 2) Harda, 3) Harda and Alum, 4) Nano Copper and 5) Nano Copper and Alum. The application concentration of alum and harda were 5%, 10%, 15%, 20% and 25%.

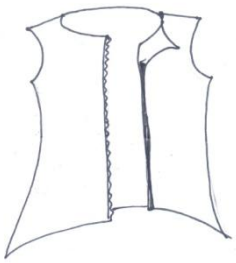
These pre-mordanted samples were dyed. The mordant concentration were optimized from the colour depth of the dyed samples. The results revealed that the concentration of alum which gave the best results was 10% and for harda it was 15%. The concentration taken for sequential mordanting of Harda and Alum was 10% each.

III] Application of Natural dyes:

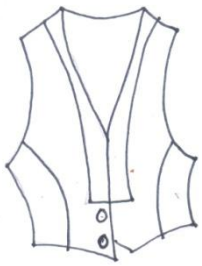
As a natural dye source; madder, turmeric, eucalyptus leaves and Indian Almond leaves were used. The samples were pre-mordanted with the optimized condition of mordants and then dyed with the selected natural dyes. For each dye, five mordant sets were used making total of five samples for each dye. The total numbers of samples obtained for four dyes were 20. K/S value was obtained for each sample.

Phase- III: Development of product

To test the applicability of jute fabric other than sacks and packing material, the treated fabric was explored for its use in apparels. For that ten jackets were designed and best four jackets were purposely selected. Two natural dyes namely Turmeric (root source) and Indian almond leaves (leaf source) were selected for dyeing these finalized jackets.



Design 4



Design 6

Design 7

Design 10

Sketches of final four selected jackets

		
Front	Profile	Back
Design 4		
		
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		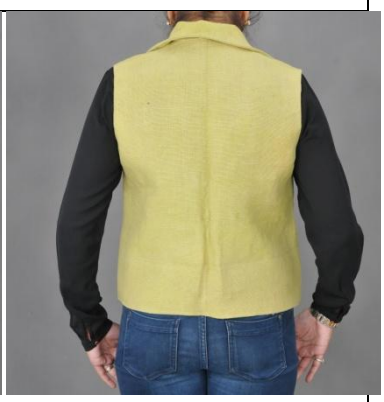
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Photographs of the constructed jackets

5.7 Conclusion

For the present study, two pre-treatments were optimized, one was bleaching and the other was woolenization. The jute samples were bleached using three bleaching agents namely Hydrogen Peroxide bleaching, Peracetic acid bleaching and Sequential bleaching then these samples were pre-mordanted with various mordants like alum, harda, copper-nano, and their combinations. All these pre-mordanted samples were dyed with four natural dyes namely madder, turmeric, eucalyptus leaves and Indian almond leaves. Another set of samples was only woolenized and then pre-mordanted and finally dyed. The third set was first woolenized, then bleached, followed by pre-mordanting and finally dyed.

The results of the first set i.e. bleaching-mordanting-dyeing sequence revealed that sequential bleaching produced the best result so far as colour depth is concerned.

After dyeing, only woolenized samples were a darker compared to only bleached samples. Even the brightness, whiteness indicies were higher compared to the bleached samples.

Hence, woolenization-bleaching-mordanting-dyeing sequence was chosen for further study. The results revealed a better K/S as well as high whiteness, brightness indicies. Even SEM images showed the same.