Chapter-4

MATERIALS & METHODOLOGY

This chapter deals with the test samples and test methods used to carry out the experimentation pertinent to the study. The present study entitled “Development of preparatory processes for making of banana fibre blended fabrics and their evaluation” was conducted in the following steps.

4.1. Fibre stage

4.2. Yarn stage

4.3. Fabric stage

4.1. FIBRE SECTION: SELECTION AND COLLECTION OF MATERIALS AND EXPERIMENTAL METHODS:

4.1.1. Fibres

The banana fibres used in the experiments were the ones extracted by CIRCOT team at Jalgaon, Maharashtra. The Jute fibres used in the experiments were received from NIRJAFT, Calcutta. Cotton fibres available at CIRCOT, Mumbai were used for spinning of the yarns for the study.

4.1.2. Chemicals and Auxiliaries

1. The chemicals and auxiliaries used in the present study namely Sodium Hydroxide (NaOH), Wetting agent (Auxypon), Acetic acid, Glycerin, Turkey red oil (TRO), Sulphuric acid (H₂SO₄), Ammonia (NH₃) were of analytical grade.
2. Commercial grade chemicals and finishes like SANDOSOFT PNLT, CERAPERM 3P h/c, CERAPERM AQUA, CERANINE SWPI Liq supplied by M/s Clariant were used.

Sandosoft PNLT - A highly effective and economical macro emulsion that gives permanent finishing effects on all kind of fibers. It also confers a characteristic smooth surface.

Ceranine 3p h/c - A cationic charged micro amino silicone in a highly concentrated form that can be used for achieving extra-ordinary all round softness on all types of Fibres and fabrics. Ceraperm 3p h/c can be used for all those applications where very good surface handle is desired. It is a Hydrophilic macro emulsion, non ionic in nature. It also imparts Excellent Surface handle and suppleness.

Ceraperm Aqua - Permanent hydrophilic softener based on modified polysiloxane for all types of fabrics. It also confers a pleasant handle on cellulosic fibers.

Ceranine SWPI - A wash fast softener for synthetic fiber material. It also exhibits a unique luxurious hand on polyester fibers and its blends with cotton and viscose.
Plate 27: The Banana Plant
4.1.3. SOFTENING TREATMENTS CARRIED OUT ON BANANA FIBRES: -

Various softening treatments were carried out on banana fibres, which are as follows: -

4.1.3. a. Softening of banana fibres through Alkali treatment: -

Sodium Hydroxide (NaOH) treatment removes impurities from the fiber surface,

Banana fiber sample were treated with three different conc. of NaOH to soften the fiber and make it suitable for spinning. The concentrations used were 0.5%, 1%, 1.5% weight/volume. Treatment was done with sample: liquor ratio of 1:30. Standard procedure used in the institute is as follows.

ALKALINE TREATMENT OF BANANA FIBERS

Protocol: -

1. Weigh out required quantity of banana fibers
2. Check out specific gravity of required conc. Of NaOH
3. Take NaOH in a glass beaker (1:30 ratio)
   4 gm fibre: 120 ml NaOH
4. Add 1-2 drops of wetting agent i.e. auxypon
Mix the solution properly with the help of a glass rod

Add fibers in a beaker such that fibers are immersed in the solution completely

Keep it for ½ hr. Swirl the solution intermediately

Wash out the fibers with warm water 4-5 times

Keep the fibers in 0.1% acetic acid solution (1:30) for 2-4 min

Wash the fibers with distilled water

Dry the fibers at room temperature on a blotting paper.

**PREPARATION OF NaOH SOLUTION**

In the present study 200 grams of banana fibres were used per concentration. Since the MLR used was 1:30 total solution used in each case was 6 litres. For preparation of NaOH solution, 5% NaOH solution was used.

5% NaOH Solution -5gm in 100 ml D/W

5% NaOH Solution-specific gravity 10.76 by Taudal

Given Stock – 5% NaOH solution
For the alkali treatment the NaOH concentrations and the amount of stock solution was adjusted as follows:

Table 4.1.: Preparation of NaOH solution using 5% solution

<table>
<thead>
<tr>
<th>NaOH conc.</th>
<th>Amount of stock (ml)</th>
<th>Amount of Diluent (ml)</th>
<th>Total Volume (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>600</td>
<td>5400</td>
<td>6000</td>
</tr>
<tr>
<td>1</td>
<td>1200</td>
<td>4800</td>
<td>6000</td>
</tr>
<tr>
<td>1.5</td>
<td>1800</td>
<td>4200</td>
<td>6000</td>
</tr>
</tbody>
</table>

DETERMINATION OF SPECIFIC GRAVITY OF NaOH SOLUTION

Specific gravity of 0.5% NaOH solution as per table standard = 1.0095.

Specific gravity of 0.5% NaOH solution observed = 1.01.

4.1.3. b. GLYCERINE TREATMENT OF BANANA FIBERS: -

PROTOCOL

Banana fibres were also treated with glycerol to impart softness. The process is as follows.

Weigh out required quantity of banana fibers

Check out specific gravity of required conc. of Glycerin

Take Glycerin in a glass beaker

30 gm fibre: 100 ml of glycerin along with 500 ml of water.
Add 1-2 drops of wetting agent i.e. auxypon

Mix the solution properly with the help of a glass rod

Add fibers in a beaker such that fibers are immersed in a solution completely

Keep it for overnight i.e. 10 hrs.

Dry the fibers at R.T. on a blotting paper.

4.1.3. c. SOFTENNING TREATMENT OF BANANA FIBERS USING TURKEY RED OIL.

Turkey red oil was used to soften the banana fibres by using the kier-boiling method (kiering). It was done in two different concentrations using the weight by volume method. 30 gms of sample were taken for two different concentrations i.e. 1% and 5%.

Two different beakers were taken for 1% (600ml water and 6gms of TRO) and 5% (600ml of water and 30gms of TRO).

PROTOCOL

Weigh out required quantity of banana fibers

Take TRO in a glass beaker (1:20 ratio)
Mix the solution of TRO and water properly with the help of a glass rod

Add fibers in a beaker such that fibers are immersed in a solution completely

Keep it in the autoclave for about 3hr after the autoclave if heated up and the required pressure is attained.

Wash out the fibers with warm water 4-5 times

Dry the fibers at R.T. on a blotting paper

For both the above softening treatments i.e.: -glycerin and the turkey red oil, evaluation of the physical properties was not done although the fibres had turned soft in terms of their feel but had become very brittle However, it may be mentioned from the feel of the fibers that it appears that some softening had taken place.

4.1.3. d. SOFTENING TREATMENT CARRIED OUT USING COMMERCIAL SOFTENERS: -

The banana fibers were softened using commercial softeners. This work was carried out at “CLARIANT CHEMICALS” (Thane), Mumbai. About 500 grams of sample was taken for each of the four different softening treatments and was evenly arranged in a trough. Each of the softening chemical was then sprayed evenly over the fibers and kept for 48 hours for allowing sufficient penetration of the softening chemical into the fibres.

The following softeners were used for the softening of banana fibers.
1) SANDOSOFT PNLT 30 gpl
2) CERAPERM 3P h/c 20gpl
3) CERAPERM AQUA 20gpl.
4) CERANINE SWPI Liquid 5gpl.

The softened samples of banana fibers were further analyzed for their Tenacity and breaking elongation.

**4.1.4. CELLULOSE ESTIMATION USING SULPHURIC ACID METHOD:-**

**APPARATUS:**

1) Sintered Glass Crucible

   It was of appropriate capacity with a pore size of 90 to 150 microns (porosity 1) and fitted with ground glass stopper.

2) Ventilated Oven

   It was capable of maintaining a temperature of 105+3 C

3) Analytical Balance

   Balance used was capable of weighing to an accuracy of 0.0002g

4) Conical Flask

   It was of 250 ml capacity & fitted with ground glass stopper

5) Filter Flask

   It was provided with connection to filter pump & adapter to enable the crucible to be fitted to it

6) Desiccator

   It was containing self-indicating silica gel or anhydrous calcium chloride
7) Mechanical Shaker to agitate the contents uniformly.

**REAGENTS:**

1) Sulphuric acid solution

   Reagent grade 75 % (m/m) – specific gravity 1.67 at 27ºC

2) Ammonia (Dilute solution)

   Prepared by adding 80 ml conc. Ammonia (specific gravity 0.89) and making up to one liter with water

**Procedure:**

1) Take a test specimen weighing about 1g from the pretreated sample. Dry the specimen kept in a weighing bottle in the drying oven at 105±3 C to constant mass and obtains the oven dry mass of the specimen.

2) Treat the weighed out sample taken in a conical flask with 100 ml of 75% H₂SO₄ solution per gram of the specimen at room temperature. Stopper the flask and shake it carefully to wet out the specimen completely.

3) To the beakers containing the test specimen 75% H₂SO₄ was added gradually in small quantities while stirring the material with a glass rod. Stopper the flask and shake it carefully to wet out the specimen completely.

4) Maintain the flask at room temperature for 30 min with intermittent stirring.

5) 75% H₂SO₄ was diluted to 3% with required addition of water. The solution was boiled for 2h. The insoluble material was allowed to settle by keeping the beaker overnight.

6) Filter the contents of the flask through a sintered glass crucible by suction.

7) Transfer any residual fibers from the flask with little sulphuric acid solution into the crucible. Drain the crucible by applying suction. Wash the residue on the crucible once more with acid solution. Then wash the residue with distilled water thoroughly. Then wash the residue twice with dilute ammonia solution and finally wash the residue with water thoroughly. After each washing drain the crucible with the aid of suction. Dry the crucible
and the residue to a constant mass in an oven at 105+3 C cool in a desiccator and weigh them.

Similarly carry out the test on the other specimen.

4.1.5. a. BENDING RIGIDITY OF BANANA FIBRE

During spinning, the fibre is subjected to lateral forces. This gives cohesion in the fibres. Twisting these fibres then can produce yarn. Thus flexural rigidity of fibres becomes very important for their conversion in to the yarn. Flexibility of a banana fibre is also an important property in spinning of fibres. Higher flexibility means lower flexural rigidity. Flexibility was determined by measuring bending rigidity of a bundle of parallel fibres using Kawabata Bending Rigidity Tester. For this the fibres were mounted on a paperboard as shown in the figure below.

EXPT.I Plate 28: Sample Preparation:-

Instrument used: Bending tester

Method:

20 fibers each for control, 0.5%; 1% and 1.5% NaOH treatment were mounted on a board as shown above. Three such boards for each sample were prepared and tested.
4.1.5. b. DETERMINATION OF BENDING RIGIDITY USING THE KAWABATA (KES-FB2) PURE BENDING TESTER:-

The Kawabata tester is used for obtaining properties related to bending of the fibres. In this instrument one edge of the sample is held by a fixed chuck while the other is held by a moving chuck. The moving chuck follows a fixed orbit turning its head at an angle so that a uniform curvature is maintained on the fibre sample. The instrument gives a graphical output showing the relationship between the curvature K and bending moment for a complete cycle of bending.

Plate 29: Bending rigidity tester
The table below gives the standard testing conditions for measurements with the bending tester. This instrument provides two parameters that characterize the bending property of the fibres. These are explained in the second table below.

**STANDARD TESTING CONDITIONS FOR BENDING MEASUREMENTS WITH KES-FB2.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum curvature</td>
<td>$\pm 2.5\text{cm}^{-1}$</td>
</tr>
<tr>
<td>Rate of change of curvature</td>
<td>$0.5\text{cm}^{-1}/\text{sec}$</td>
</tr>
<tr>
<td>Distance between two chucks</td>
<td>1cm</td>
</tr>
</tbody>
</table>
Table 4.2.: BENDING PROPERTIES MEASURABLE BY USING KES-FB2

<table>
<thead>
<tr>
<th>Property</th>
<th>Definition</th>
<th>Unit</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>B= A-B/1.5cm⁻¹-0.5cm⁻¹</td>
<td>gf.cm/cm.</td>
<td>Bending rigidity: the slope of the bending curve between curvature 0.5cm⁻¹ and 1.5cm⁻¹</td>
</tr>
<tr>
<td>2HB</td>
<td>2HB = Vertical width of bending curve at curvature ±1cm⁻¹.</td>
<td>gf.cm/cm.</td>
<td>Hysteresis of bending moment at curvature ±1cm⁻¹</td>
</tr>
</tbody>
</table>

A – Torque at 0.5cm⁻¹

B – Torque at 1.5 cm⁻¹
Tests were performed after mounting the samples and the mean of values of three specimens per sample were taken as representative values for both B and 2HB.

**4.1.6. DETERMINATION OF OPTIMUM MOISTURE CONDITIONS**

**Oven:** Brabender semi-automatic moisture tester

**Temperature:** 105 ± 0.5°C

**Sample:** Banana fibre

**PROTOCOL:**

1. Take a weight of an empty container
2. Dry the container in an oven for about 2-3 hrs
3. Take a dry weight of container
4. Weigh out required quantity of banana fibers
5. Keep the container with a sample in an oven for 3 hr at 110°C
6. Take out containers from an oven and cool them in a desiccator for 5 min

202
Take a weight of a container with a sample

↓

Keep the containers back in an oven for another 15 min

↓

Repeat the steps till there is consistency in dry weight

↓

Take out containers & keep it in a desiccator

↓

Keep the containers in a moisture chamber

↓

Take a weight of containers after every 24, 48, 72, 96, 120 hrs

EXPT. I

Five containers were first oven dried at 110°C for more than three hours. These were then conditioned in standard atmosphere at 27°C and 65% ±2% rh. For two hours and weighed. After this, the procedure as given in the protocol was followed.

4.1.6. a. DETERMINATION OF OPTIMUM MOISTURE CONDITIONS

EXPT. II

Using the same five containers another experiment was carried out in which the oven dried samples were conditioned for different periods of time ranging from 1.5 hours to 24 hours.
4.1.6. b. DETERMINATION OF OPTIMUM TIME FOR DRYING

To find out optimum time required for oven drying of banana fibres an experiment was conducted using Brabender semi-automatic moisture tester. Temperature was maintained at 105º ±0.5º C for 3, 4 and 6 hours. Oven dry weight for five samples was measured and moisture content was found out.

4.1.7. DETERMINATION OF THE TENSILE PARAMETERS:-

The tensile properties of the fibres bundles were carried out on Instron tensile tester according to the standard CIRCOT procedure. (Handbook of methods of tests for cotton fibres, yarns and fabrics, CIRCOT Publication)\textsuperscript{174}.

Instron is a robust and versatile instrument of Constant Rate of Extension type, used for measurement of a variety of mechanical properties. Its versatility rests in the fact that it is capable of recording the tensile load-elongation curves of a wide range of samples from single fibres of rupture strength less than 10 g to thick fabric strips of strength upto 500kg. A wide spectrum of properties can be studied by using this instrument.

Instron model Universal Testing Instrument is a highly accurate instrument providing outstanding versatility for material testing at loads up to 5KN (500 Kg) in tension, and compression. The basic instrument consists of two assemblies, the loading frame and the electronic control console. A crystal oscillator is used to generate the control signals. This is independent of mains frequency and is a highly stable reference. Digital counting circuits are used to determine crosshead speeds and chart speeds; these ensure absolute relationships between the positions of crosshead motor, the switches and the displays of the extension measurement unit and the chart paper.

The specimen under tensile test is clamped between the two jaws. The clamping of the jaws can be manual or pneumatic. The load sensing is done by a “load cell” which converts the mechanical force into an electrical signal. This electrical signal is used to measure the magnitude of the force. The load cell can be fixed on the stationary top platform or on the movable platform
known as “cross-head”. The specimen to be tested is mounted between the jaws. Of the two jaws holding the specimen the upper jaw is suspended from the load cell. The lower jaw is fixed on the cross head or on the lower stationery platform. The crosshead is made to move in such a way that the specimen starts getting extended. The load developed in the specimen is measured and the load elongation curve is plotted by the electronic panel attached to the instrument.

The specimen behavior under compression can be studied by using a “compression cell”. It is fixed on the lower platform. The specimen to be compressed is held between the two parallel flat horizontal surfaces. One of them is fixed to the compression cell while the other is fixed on to the cross head. The cross head is moved in such a way that the specimen to be tested gets compressed between the two flat surfaces. Load developed during compression is then measured using load-amplifier. Most of the tensile or compressive tests can be controlled through an attached computer. The computer not only controls the tests but also analyses the accumulated data as per the pre-selected program. Some of the special tests, which cannot be selected through computer software, can be carried out by using the control panel and the signals recorded on the chart paper.

The cross-head speed which decides the rate of extension or compression of a specimen can be varied from 0.05mm/min, to 1000mm/mm, in a large number of steps. For the Instron Model (1122) available at CIRCOT, there are four tension load cells and three compression load cells, which cover the total load range of 1g to 500 kg. Depending on the test requirements, the correct load cell is chosen. In the case of rupture studies, cross head speed is adjusted such that the time to break is about 20 seconds. A load extension curve is plotted on the chart. Load extension curve can also be obtained on the monitor directly through computer software. From the load elongation curve, the program calculated the tenacity, strain at break, initial modulus (static modulus) between 10-50 g load range on the stress strain curve, specific work of rupture and secant modulus. For each sample 50 tests were conducted. Mean values of all the parameters and their CV% values were
calculated. The experiments were carried out at ambient humidity of 65±2% rh and 27 ± 2ºC temperature.

4.2. YARN SECTION: SELECTION AND COLLECTION OF MATERIALS AND EXPERIMENTAL METHODS:

4.2.1. Yarns

The banana fibres used in the experiments were the ones extracted by CIRCOT team at Jalgaon, Maharashtra. The jute fibres used in the experiments were received from NIRJAFT, Calcutta. Cotton fibres available at CIRCOT, Mumbai were used for spinning of the yarns for the study.

4.2.2. Chemicals and Auxiliaries

1. The chemicals and auxiliaries used in the present study namely Sodium Hydroxide (NaOH), Wetting agent (Auxypon), Acetic acid, Glycerin, Turkey red oil (TRO), Sulphuric acid (H₂SO₄), Ammonia (NH₃), Hydrogen peroxide, Sodium silicate, Sodium hydroxide were of! analytical grade.

4.2.3. SPINNING OF BANANA FIBRES:-

Blending of cotton/ banana fibres was attempted out in three different ratios i.e.: (80-20%), (65-35%) and (50-50%). For this cotton fibres available at CIRCOT were used and banana fibres procured from Jalgaon were used, which were softened with alkali treatment using 0.5, 1% & 1.5% NaOH. All three ratios were tried out for spinning. The Jute fibres used in the experiments were received from NIRJAFT, Calcutta.

4.2.4. SOFTENING OF BANANA FIBRES THROUGH ALKALI TREATMENT: -

Banana fibers were softened using three different conc. of NaOH. The concentrations used were 0.5%, 1%, 1.5% weight/volume. Treatment was
done with sample: liquor ratio of 1:30. Standard procedure used in the institute as explained in the earlier chapter on fibre studies.

**ALKALINE TREATMENT OF BANANA FIBERS**

1:30 (Fiber: Liquor)

200gm: 6000 ml NaOH

Specific gravity of 5% NaOH = 1.0538 (as per table)

Specific gravity of 5% NaOH observed = 1.05

Fibres treated with alkali (NaOH) 5% were used for blending with cotton during spinning. Spinning was carried out by manually mixing the cotton and banana fibres, which were cut to a length of about 1" in the blow room. The cotton-banana fibres were then taken to the carding machine, wherein they were passed through the card frames, which was blended then to sliver. The card slivers are then drawn out through the draw frames and then spinning was carried out in the ring frame-spinning machine. The fibres were spun to 20's count.

**4.2.5. SPINNING OF BANANA FIBRES USING SANDWICH METHOD:**

The softened banana fibres were stapled to 1" length using fibre tow cutter. These stapled fibres were then mixed with cotton fibres manually. For mixing the fibres proper quantities on weight by weight basis of banana stapled fibres and cotton of variety DCH-32 was taken. The mixing was made as homogeneous as possible. For e.g.: 80:20 blend of cotton: banana, 800 grams of cotton was mixed with 200 grams of banana fibres. This blend was then fed to the blow room for processing. From the lap obtained from blow room the card sliver was prepared using the carding machine. The drawn sliver was then processed using 6-card draw. This sliver was further taken for spinning of the fibres into yarn.
During the spinning operation, it was observed that banana fibres were dropping out due to their stiffness. At each stage of operation very few fibers of banana were getting retained in the final spun yarn which was spun to 20’s count. There too the banana fibres would be partially embedded in the cotton fibre matrix with quite some portion protruding out of the yarn structure. Banana fibre protruding could be easily pulled out from the yarn. It was estimated that overall retention of banana fibres would not have been more than 5%.

Trials were also carried out by blending the banana fibres with the cotton fibres in the carding stage; wherein the cotton fibres of appropriate weight were opened thoroughly and passed through the card frame to obtain carded web before it forms a sliver. The cut and opened banana fibres were then more or less evenly sprinkled over the sliver web of cotton fibres in such a manner that the ready sliver which comes out of the carding machine has banana fibres sandwiched between the cotton fibres. This method could not succeed as uniform sprinkling was not possible.

**4.2.6. MAKING OF 100% BANANA FIBRE YARNS:-**

In order to make 100% banana fibre yarns; the individual long length raw (not treated or softened) filament fibres of banana were taken and twisted in either S/Z-twist direction. The twisted yarns thus are used in the warp direction of the fabric. The banana filament fibres are simply knotted and used in the weft direction of the fabric. The 100% banana fibre fabric thus produced by the above method is not very fine fabric and still needs further processing’s both at the fibre as well as the yarn stage as the entire process is not only time consuming but is not viable for mass production as all the processes are done manually. The need is for a twisting machine which can twist these filaments, or at least some kind of softening treatment which can soften the inherently coarse banana fibres to make them more pliable so that they can be easily taken through a jute spinning system in order to get them spun into yarns and then eventually weaving to be carried out on the handlooms.
4.2.7. PREPARATION OF YARN & STUDY OF YARN CHARACTERISTICS OF BANANA & BANANA/JUTE BLENDED YARNS:

Banana fibres being too thick cannot be spun on the cotton spinning machineries. It is similar to the jute fibres in many respects such as the thickness, flexibility, rigidity etc. Therefore an attempt was made to spin the banana fibres on the Jute spinning system. A technique has been developed for processing the banana fibres on standard jute and mini jute machinery after stapling it to 20 cm. Banana fibre was processed on the standard jute machinery. After some spinning trials, it was found that the spinnability of banana fibres is best with the 20cms to 30 cms staples. The banana fibres were first sprayed with a batching oil-water emulsion of 6% then piled for 48 hours. These fibres were then processed on the standard Jute spinning system. A softener (Fraser) was used for the above mentioned spraying method, 63 pairs of rollers, a baker card (JF-2-half circular), a finisher card (low type-N half circular, 1,2 and 3 drawing frames (Mackie-screw grill) and a sliver spinning frame (Mackie-41/4inch pitch), this is the processing machine on which the banana fibres were spun. These fibres could be spun on the mini jute spinning machine developed at NIRJAFT. Few types of yarns were processed at NIRJAFT, (National Institute for Jute and Allied Fibres Technology), Kolkata.

100% Banana fibres or banana fibres blended with jute in different ratios were also processed in small scale jute spinning machine designed and developed by NIRJAFT. The yarns developed by the same unit were compared. It has been observed that both types of yarns, i.e., developed on mini spinning as well as regular spinning machine, could be used to develop various products. This Mini jute unit might be used like “KHADI SYSTEM” to improve economic conditions of farmers to produce value added items at villages involved with banana plant fibre production.

Yarn as shown in (plate: 32) was prepared at NIRJAFT, Calcutta. The Yarn made from the banana and banana jute blend were tested on star testing
machine, Breaking Load, Elongation, Tex and Tenacity values of different Yarn were found out.

The banana yarn (1) was processed on the mini jute spinning machinery, while the banana yarn (2) was spun using the standard jute machinery. Fine banana yarns were also spun to verify the possibility of spinning a yarn with low tex / low pound yarn. Further the banana yarn (1) was doubled to see the improvement in the characteristics after doubling. For comparing, the 100% jute yarns were also studied and tested. In addition the banana: jute blend of 80:20 ratios was also prepared. The average breaking load, tex, tenacity were studied at CIRCOT using the universal Star testing machine with 10 kg load cell capacity. The gauge length used was 50 cms, the cross head speed is 50 mm/min adjusted to get the breaking in 12 to 30 seconds. Twenty strands were broken for each sample. After break, each strand was cut at the jaw faces and weighed to get the linear density in tex and the tenacity in g/tex.

Jute/ banana Fabrics blend of 70:30 blend ratios were prepared at NIRJAFT, Calcutta. About 3.5kgs of yarns were made available for the study. The yarns were further studied for basic properties. The same yarn was further used in preparation of the woven fabric where both warps and wefts used in the fabric were from the same yarn.

4.2.8. BLEACHING OF SAMPLES USING HYDROGEN PEROXIDE (1%) BLEACH:-

Bleaching

The Procedure Of Improving The Whiteness Of Textile Material, With Or Without The Removal Of Natural Colouring Matter And/or Extraneous Substances, By A Bleaching Agent.

Bleaching Agent

A Chemical Reagent Capable Of Destroying Partly Or Completely The Natural Colouring Matter Of Textile Fibres, Yarns And Fabrics, And Leaving Them

The samples both previously kiered as well as the fresh ones are bleached using hydrogen peroxide bleach for 1 hour at required constant temperature. The samples bleached are,

1) 100% banana fibre yarns both from the first as well as the second lot
2) Banana/jute blended yarns (80/20)
3) 100% Jute yarns

MLR: 1:20

Temperature: 80-85ºC

Weight of the sample: 80 gms

Chemicals: Hydrogen peroxide (1ml for 10 ml of water) 30% weight/volume hydrogen peroxide.

\[
\text{Sodium silicate} \quad (1.5g/lt)
\]

\[
\text{Sodium hydroxide} \quad (1g/ly)
\]

A cationic softener 1% by weight is to be treated for 10 mins, (MLR: 1:5) on dry weight basis.

**Calculations:**

Since, MLR: 1:20,

Wt of the sample =80 gms

\[80 \times 20 = 1600 \text{ ml of water.}\]

Hydrogen peroxide = 1ml for 10ml

\[
\text{Sodium silicate} = 1.5\text{gms/lt}
\]
1.5×1.6ml

= 2.40gms of Na-silicate to be taken.

Sodium hydroxide = 1gm/lt for 1600 ml

1.6×1

= 1.6 gms of Na-hydroxide to be taken.

**Protocol:**

1) Weigh out required quantity of samples.
2) Take the required measured quantities of Na-silicate and Na-hydroxide in to a large vessel and dissolve them is measured volume of water.
3) Add the labeled samples in the above solution and keep it in the water bath till the required temperature is attained.
4) Add the required amount of cationic softener into the solution.
5) After the required temperature (80-85ºC) is attained, add the measured quantity of hydrogen peroxide bleach to the water bath.
6) Keep the above solution in the water bath for about 1 hour at the constant temperature of 80-85ºC.
7) After an hour, take out the samples and wash them thoroughly with D/W.
8) Dry the samples at R.T. on a blotting paper.

Thus, two sets of yarns are prepared for the above experiment. One set of yarns are only bleached, whereas the other second set of yarns are first kiered and then further bleached and then both the above sets of yarn are further tested for their strength, tenacity and tex values.

**4.2.9. KIERING TREATMENT**

The samples to be kiered are,

1) 100% banana fibre yarns both from the first as well as the second lot
2) Banana/jute blended yarns (80/20)
3) 100% Jute yarns

MLR: 1:20

Concentration: 1%

Alkali: Sodium hydroxide (NaOH)

Specific gravity of 1% NaOH =1.0095 (as per table)

Time: 1 hour

Temperature: 120-121ºC

Pressure: 15lbs/sq.inch. (Psi)

Apparatus: beakers, measuring spoons, weighing scale, Autoclave.

Weight of the sample: 40 grams. (40gms × 4sets)

Water taken = 800 ml (1:20 MLR), (40 gms wt of the sample).

\[20 \times 40 = 800 \text{ ml of water.}\]

1% NaOH = 800×1/100 = 8gms of NaOH to be taken.

**Protocol:**

1) Weigh out required quantity of samples.
2) Check out specific gravity of required concentration of NaOH.
3) Weigh out the required quantity of sodium hydroxide.
4) Dissolve the weighed quantity of NaOH into the measured volume of water thoroughly with the help of a glass rod.
5) Add the samples in the above solution such that samples are immersed in the solution completely.
6) The vessel for kiering is then placed in a pre-heated Autoclave for about 1 hour after the required temperature and pressure is attained.
7) After an hour, take out the samples and wash them thoroughly with D/W.

8) Dry the samples at R.T. on a blotting paper.

4.2.10. PREPARATION OF JUTE/ BANANA BENDED YARNS:

Banana fibre is twice as coarse as mesta and as strong as jute. Unlike jute its structure is non-meshy and filaments are well separated; they are two-and-a-half times as extensible as those of jute. In the yarn, too, the extension was 3-4%. The banana fibre being more porous, it appeared to be soft, owing to its coarser dimensions, it filaments were less pliable than those of jute and mesta. Banana fibres and jute fibres were further taken for blending. Banana fibres were processed on the following standard jute machinery: - a softener (Fraser, 63 pairs of rollers), a Barker Card (JF2, half circular), A Finisher Card (low, type N, half circular), first, second and third Drawing Frames (Mackie, screw gill), and a sliver Spinning Frame (Mackie, 4 1/4″ pitch).

The fibres were mixed at the finisher-card-feed stage, as is the normal practice in jute mills. Banana fibres were blended with jute at different ratios were also processed in small scale jute spinning machine designed and developed by NIRJAFT. About 3.5kgs of yarns were made available for the study. The yarns developed by same unit were compared. It has been observed that both the developed yarns could be used to develop various products. This Mini jute unit (as shown in plates:33-37) might be used like “KHADI SYSTEM” to improve economic conditions of farmers to produce value added items at particular village involved with banana plant fibre production. Blends with higher percentage of banana could not be spun because the quality deteriorates with an increase in the percentage of banana fibres. So a banana/ jute blended yarn of 70:30 blend ratio was prepared following the above mentioned procedure.
Plate 32: The Banana Yarns

The process flowchart of jute and banana/jute fibre processing.

Softener (Fraser, 63 pair of roller)

↓

Breaker card (JF2, half circular)

↓

Finisher card (low, type N, half circular)

↓

1\textsuperscript{st} drawing (Mackie, screw gill)

↓

2\textsuperscript{nd} drawing

↓

3\textsuperscript{rd} drawing
Banana fibres were blended with jute were also processed in small scale jute spinning machine designed and developed by NIRJAFT. It has been observed that the developed yarns could be used to develop various products. This Mini jute spinning unit might be used like “KHADI SYSTEM” to develop economic conditions of farmers to produce value added items at particular village involved with banana plant fibre production.
Plate 34: Banana fibres on Jute Carding Machine
Plate 35: Jute Miniature Drawing Frame
Plate 36: Jute Miniature Spinning Frame
Plate 37: Banana fibre yarns on the spinning frame.
4.2.11. DETERMINATION OF THE TENSILE PARAMETERS:

In subsequent processing such as winding, warping or weaving, the yarn is generally used in the form of individual strands and not as skeins. Also for studying the elastic behavior of the yarn, such as extensibility, stress strain relationship, etc., it is necessary to carry out the tests on single strands of yarn to facilitate clear interpretation of the results. Hence, the average tensile strength of single strand of yarn is widely used quality characteristic. In the present study the measurements were carried out on the Instron Tensile strength tester, which works on the principle of CRE (Constant Rate of Elongation), is a highly accurate & versatile instrument of constant rate of extension type, used for measurement of a variety of mechanical properties.

4.2.12. AQUEOUS SWELLING AND STRETCHING OF THE BANANA FIBRE AND THE BANANA FIBRE BLENDED YARNS:

Since fibre strength realization in banana fibre yarns is less than 20%, it was decided to soak the yarns in water at high temperature and pressure. The yarn sample I was therefore kept in kiering vessel at 135ºC and 15 psi. The sample was kept in two forms, in slack condition and also in stretched condition. Test results on these yarns do not show any improvement in yarn properties. Some other means of improving fibre strength realization in yarns has to be attempted. In jute we find good strength realization as when you take Jute fibre, the strength is 15 to 20 g/tex and in Jute yarn the strength is 10 to 12 g/tex. The strength realization in jute is around 50 to 60%. In Banana fibres the strength is 30g/tex and in the Banana yarn the strength is only 6-7g/tex. So there is hardly 20% strength realization. So in case of the Jute where there is 50% strength realization, the yarn strength is not getting affected. In cotton also the strength realization is 55%. Banana has relatively lower strength realization values because of the low cohesive forces. The present study was done to see whether at high temperature and pressure the yarn becomes more cohesive and shows improvement in their mechanical properties. It was soaked in water and kept at high temperature and pressure.
(4 pbs/sq\(^m\)) and boiled for three hours. Another sample was kept in stretched condition same as above in the kiering vessel. High temperature (130°C) pressure (14 pbs/sq. inch) is maintained. However after the samples were taken out and dried and was further tested for their tensile parameters.

A stretching gadget designed to stretch fibres or yarns in a parallelized manner was used for this study. The gadget consists of two jaws mounted on a stretching frame. One of the jaws remains fixed while the other can be moved. Its movement is gauged with the help of a scale and vernier arrangement. The procedure is as follows;

The yarn sample is taken and holding one of the ends, the other end is fixed to one of the jaws, followed by fixing the other end to the other jaw. The jaws holding the yarns were then placed on the stretching frame. The initial lengths of the yarns are noted down. Then the entire gadget with the yarn (in slacked state) and in the stretched condition was kept immersed in a beaker containing tap water and kept in the kiering vessel at high temperature (130°C) and pressure (4 pbs/sq\(^m\)) and boiled for three hours. The samples were then taken out and kept for drying and then were further tested for tensile parameters.

4.2.13. DETERMINATION OF DIRECTION OF TWIST IN THE YARN:-

Parallel, drafted fibres are twisted around their own axes to form the yarn. As the amount of twist in yarn increases, the strength of yarn increases. As the amount of twist in yarn increases, the strength of yarn increases. Beyond the optimum twist, yarn strength decreases. Twist is measured with the help of the twist teste as shown in plate:38.

The direction of twist is expressed as either ‘S-Twist’ or the ‘Z-Twist’, and the convention followed for designating the same is as follows:

S-Twist: The twist in yarn due to which its spirals are in line with the middle portion of the letter S when the yarn is held in a vertical position.
Z-Twist: The twist in yarn due to which its spirals are in line with the middle portion of the letter Z when the yarn is held in vertical position.

In the Indian standard method for determination of twist in yarn, the twist has been defined as 'the spiral disposition of the components of yarn' and is generally expressed as the number of turns per unit length of yarn. Commonly used term is turns per inch (TPI).

4.2.14. DETERMINATION OF TURNS PER INCH IN THE YARN:

Measurement of twist: The number of turns per unit length is an important characteristic of the yarn. Commonly used term is turns per inch (TPI). On untwisting, yarn gets either elongated or contracted. Single yarns are extended while they are untwisted.

The turns per inch are determined with a Good brand’s Doubling Twist Tester. Measurement is made by untwisting 250mm (10 in.) length of the specimen held between the clamps. Due care is taken to see that the specimen is not partially untwisted prior to the test. A tension equivalent to (tex/2) g where the
tex number denotes the linear density of the yarn is applied to the specimen while gripping it between the clamps, and also when measuring the twist take up. Fifty tests are carried out for each sample and the average number of turns per unit length is calculated from the value of turns obtained and the length of the specimen before untwisting.

4.2.15. DETERMINATION OF LINEAR DENSITY OR COUNT IN THE YARN:

The fineness of a yarn is usually expressed in terms of its linear density or the count. For determining the linear density of the yarn it is important to know the weight of the given length of the yarn. The procedure adopted for determination of the linear density in this study is similar to that prescribed in the Indian Standard Method. The yarns are sampled accordingly to obtain 100m skeins, which are then conditioned in the standard atmosphere and weighed correct to 0.01g on a suitable balance and the values of the count calculated there from.
4.3. FABRIC SECTION: SELECTION AND COLLECTION OF MATERIALS AND EXPERIMENTAL METHODS:

Various factors such as the type of weave, the characteristics of the yarn used, the finishing treatments given, etc., influence the quality of fabrics. Even in the same fabric, the properties along the warp direction may be different from those along the weft, as the number of threads per unit length and the characteristics of yarns used in these two directions are usually different. Further, the individual warp threads come from different packages and the weft yarns used in different portions of the fabric belong to different weft pirns. In view of the above, it is necessary to test samples from various portions of the fabric, representative of both the warp and the weft directions, in order to obtain a reliable and complete idea of the properties of a fabric. All the tests on fabrics are carried out after
conditioning the samples under standard atmospheric conditions of 27 ± 2% relative humidity, unless otherwise specifically required.

4.3.1. Fibres and Yarns

The banana fibres used in the experiments were the ones extracted by CIRCOT team at Jalgaon, Maharashtra. The Jute fibres used in the experiments were received from NIRJAFT, Calcutta. Cotton fibres available at CIRCOT, Mumbai were used for spinning of the yarns for the study.

4.3.2. Fabrics used:

The fabrics use for the study are Banana:Cotton union blended fabric and 70:30 Jute:Banana blended fabrics which are discussed in the previous chapter on yarn section.

4.3.3. Dyes

Four commercially available reactive and sulphur dyes, supplied by M/s Clariant® India Ltd were used for the dyeing experiments without any further purification. The dyes used were as follows,

1. Sulphur N-blue (15% shade)
2. Sulphur H-green. (15% shade)
3. Reactive blue (15% shade)
4. Reactive green. (15% shade)

4.3.4. Chemicals and Auxiliaries

The chemicals and auxiliaries used in the present study namely Sodium Hydroxide (NaOH), Wetting agent (Auxypon), Acetic acid, Sulphuric acid (H₂SO₄), Ammonia (NH₃), Hydrogen peroxide, Sodium silicate, Sodium hydroxide were of analytical grade.

Commercial grade chemicals and finishes like HOSTAPAL MRN LIQUID, SIRRIX 2 UD.IN LIQUID, BACTOSOL ACG LIQUID, BACTOSOL ADF Pdr,
ARKOFIX NEC LIQ, CERALUBE HD LIQ, CERALUBE JNF LIQ, APPRETAN CF-B LIQ, APPRETAN MB EXTRA LIQ, APPRETAN PUL LIQUID, IMEROL NLF IN LIQUID supplied by M/s Clariant® India Ltd were used.

HOSTAPAL MRN LIQUID is a non-ionic wetting, washing and cleaning agent.

- It possesses an excellent wetting power over the wide pH and temperature conditions.
- It exhibits an outstanding detergent effect and is quite stable to alkalis and acids.
- It is an excellent scouring and milling agent.
- It is a clear, colourless biodegradable liquid, non-ionic in nature.
- It is chemically composed of alkyl Phenol Polyglycol ether.

SIRRIX 2 UD.IN LIQUID is a proton based product.

- It is high in polyvalent properties.
- It is a chelating agent which ionizes metallic particles, thereby prohibiting catalytic damage to cellulosic fibres.
- It exhibits pH buffering function in both alkaline and acidic regions.
- It is a colourless clear liquid and is based on organic acid.

BACTOSOL ACG LIQUID is a cellulose complex based on selected enzymes, for biopolishing of cellulosic substrates.

- It improves the wearing comforts and is suitable for creating various fashion effects.
- Due to its versatile action as it completely modifies the surface of the fabric by enzymatic action i.e.: enzymatic desizing of (CMC) Carboxyl Methyl Cellulose derivatives.
- Chemically it comprises of enzyme strains based on stabilized cellulose in buffered medium.
- The pH is adjusted at 4.5-5.5. And the temperature is maintained at 50-60 deg C for about 45-90 min depending upon the end use requirement.

- It facilitates the removal of dead/immature cotton and reduction of any fibre hairs on the surface.

- It is widely used to produce the peach skin and the bio-touch effects in finishing.

- It could be widely used in all types of machines like the jets, winches, jiggers and soft-flow techniques and the drum-washing.

**BACTOSOL ADF Pdr** is a cellulase enzyme widely used for biopolishing.

- It is rapid in action as it reduces processing time.

- It imparts good luster, besides giving a clean and fresh look to the fabrics after treatment.

- It chemically comprises of a mixture of acid cellulases. It needs to be applied through the exhaust method and after all cellulase enzyme treatment is over the reaction is stopped by de-activating the enzyme which is done by adjusting the pH to 10 or by increasing the temperature to 75 deg C and running the process for ten minute.

- This process is used as a precautionary measure against strength loss.

- Chemically it is a mixture of acid cellulases.

- Biopolishing is carried out with 1.0 % on weight of fabrics at a pH of 4.5-5 with acetic acid and run for 45 min at 55 deg C temperature.

**ARKOFIX NEC LIQ** is a cross-linking agent with zero chlorine retention on finished fabrics.

- It is suitable for imparting dimensional stability to the fabrics as it meets the requirement of the consumer labels like the Eco-Tex Std. 100.

- It is a colourless, clear liquid and chemically is a modified N-Methylol dihydroxy ethylene urea.
- It may be applied through padding or dip method and cured for 2-3 min or shock cured at 25-30 secs at 175 deg C.
- It requires a pH of around 4.5-5.5.
- It ensures zero chlorine retention on the finished fabrics.
- Its application amount may vary from 40-120 gpl.

**CERALUBE HD LIQ** is a softener that imparts a very smooth and soft handle to the textiles.

- It is a thin white to yellowish coloured emulsion,
- It is mildly cationic in nature.
- It is chemically an aqueous dispersion of aliphatic polyolefins.
- It is normally applied through padding techniques and the pick up is around 70%-100%.

**CERALUBE JNF LIQ** is a softener that is widely recommended for textile fabrics.

- It is chemically an aqueous dispersion of aliphatic polyolefins.
- It is specially designed for application by the exhaust method in short liquor jets.
- It is cationic in nature
- It imparts an excellent soft handle to the fabric.
- It may be applied both through the padding or the exhaust methods at 30deg C-40 deg C.
- It requires a pH of about 4.5-6.

**APPRETAN CF-B LIQ** is a pure acrylic self cross linking binder for high pigment loading.

- It is useful for medium, soft pure acrylic coating, and stable to high pigment loading.
- It is anionic in nature and chemically is characterized as a pure acrylic Co-polymer.
• It is generally applied by coating methods and is cured after drying at 150 deg C for 5 min.

**APPRETAN MB EXTRA LIQ** is a concentrated stiffener with excellent body.

• It imparts excellent suppleness and full handle modifying effect with body and bounce.
• It also imparts crease resistance to the treated fabrics along with anti-slip properties.
• It is non-ionic in nature.
• Chemically composed of polymeric compounds.
• It is applied through padding methods and requires the pH to be around 5.0 and needs to be cured after drying at around 19 deg C for 30-40 seconds or pad-shock-cure at 1800 deg C for 45-60 sec.

**APPRETAN PUL LIQUID** is an aqueous polyurethane dispersion.

• It imparts a high abrasion resistance to fabrics.
• It has high covering power, good solvent resistant.
• It can be used for both padding as well as coating applications.
• It is a bluish white transparent dispersion, anionic in nature.
• It improves the abrasion resistance of the fabrics.
• It is generally applied through coating methods.
• It has very good physical properties.
• It is anionic in nature.
• It is miscible in all proportion with water with medium, tough, elastic handle with low tackiness.
• After application, it is dries at 100 deg C for 3 min and further cured at 150 deg C for 5 min.

**IMEROL NLF IN LIQUID** is an effective, low foaming detergent.

• It is pale yellow in colour and chemically an Alkyl Phenyl Polyglycol ether product.
• It is non-ionic in nature.
• It is an excellent scouring agent with good wetting and detergent action which removes oils and contamination of all types imparting a clean and absorbent fabric.
• It is compatible with enzymes and stable to alkalis and with liquors with up to 25 g/l caustic soda solid.
• It foams only minimally.
• It is eco-friendly as it produces no toxic effluents.

4.3.5. PREPARATORY PROCESS:

4.3.5.1. SCOURING:

The raw banana/jute blended fabrics were scoured in a lab jigger using 1g/L of non-ionic wetting agent, 2g/L of proton based sequestering agent, 4g/L of soda ash, 1g/L of detergent, 1:10 MLR, 5.5 pH, 60 deg C (temp), 30 min. After scouring the fabric samples were washed thoroughly in hot water and normal water and neutralized with acetic acid (2ml/L) followed by usual cold washing and finally air-dried.

4.3.5.2. BLEACHING

The scoured banana/jute blended fabrics were further taken for conventional hot \( \text{H}_2\text{O}_2 \) bleaching in a lab jigger using 3g/L of caustic soda, \( \text{H}_2\text{O}_2 \) 6ml/L, stabilizer 1.5ml/L, 95 deg C (temp), 60 min (time) followed by hot rinse at 80 deg C for 10 min, followed by cold rinse, neutralized with acetic acid (2ml/L) followed by usual cold washing and finally air dried. The bleached fabric was also treated with an optical brightening agent (OBA-0.7%) in the same bath for 60 min, MLR 1:10 and the temp 95 deg C.

4.3.6. FINISHING

**HOSTAPAL MRN Liq Conc** = 1 g/l.

**SIRRIX 2 UDI** = 2 g/l.

Soda Ash = 3%
MLR: 1:10.
Temperature = 60 deg C.
Time = 30 min.
Hot Rinse = 85deg C for 20 min.

**4.3.7. BIOPOLISHING:**

This is a process to remove the protruding fibers of a fabric through the action of an enzyme. This enzyme selectively acts on the protruding fibers and cease to work after finishing the work by a simple raise in temperature of the treatment bath. Biopolishing of the banana/jute blended fabrics after scouring was carried out using 1% cellulolytic enzyme owf, a proton based chelating agent 0.5% owf, at 55 deg C and pH 5.5-6 for 60 minutes keeping the material to liquor ratio 1:10. After the treatment the temperature of the bath was raised to 90 deg C for deactivation of the enzyme and maintained at that temperature for 15 minutes. The samples were then washed in cold water and then dried.

**BIOLASE FCE (N) = 1%**

**SIRRIX 2 UDI = 0.5%**.

MLR: 1:0.
pH = 5.5-6.
Temperature = 55deg C.
Time = 1hr.

**4.3.8. SOFTENING:**

This was carried out using the dip method due to very good pick up properties of the fabric. A cationic softener 20g/L, Acetic acid 0.5g/L, MLR 1:10 was followed by drying at room temperature and curing at 180 deg C for 2minutes. Softening was also carried out using a combination of micro amino silicone-based softener 20g/L and a macro-emulsion based silicone product
10g/L applied through padding technique with a pH of 5.5 and material to liquor ratio 1:10 followed by air drying and curing at 150 deg C for 3 minutes.

**LEOMIN PNLI = 3%**.

Acetic acid = 1.5 %.

MLR: 1:10.

Temperature = 60 deg C.

Time = 30 mins.

**4.3.9. RESIN TREATMENT:**

A wax based cross-linking agent 30 g/L was applied through padding technique at pH5.5 and MLR 1:10. The fabrics after padding were air dried and cured at 180 deg C for 2 minutes.

Application = Padding technique.

**ARKOFIX NEC PLUS = 20 g/l.**

**CERALUBE HD = 15 g/l.**

**SOLUSOFT MW =10 g/l.**

Mgcl2 = 6 g/l.

MLR: 1:10

pH = 5.5.

**DIP METHOD:**

**CERALUBE JNF = 30g/l.**

**CERAPERM 3-P-PLUS = 20 g/l.**

MLR: 1:10.

pH = 5.5.

**4.3.10. HANDLE FINISH**
An aqueous polyurethane dispersion 100g/L was also used for finishing the banana/jute blended fabrics keeping the material to liquor ratio 1:10, pH 5.5 - 6 and was applied through padding technique and air dried and finally cured at 150 deg C for 3 minutes.

4.3.11. FABRIC TESTS:-

All the tests on fabrics are carried out after conditioning the samples under standard atmospheric conditions of 27 ± 2ºC temperature and 65±2% relative humidity.

4.3.11.1. SAMPLING

Various factors such as the type of weave, the characteristics of the yarn used, the finishing treatments given, etc, influence the quality of fabrics. Even in the same fabric, the properties along the warp direction may be different from those along the weft as the number of threads per unit length and the characteristics of yarns used in these two directions are usually different. Further, the individual warp threads come from different packages and the weft yarns used in different portions of the fabrics belong to different weft pirns. It is therefore, necessary to test samples from various portions of the fabric, representative of both the warp and the weft directions, in order to obtain a reliable and complete idea of the properties of a fabric. Random selection does not yield better results than systematic selection; Hence systematic selection could be adopted for routine testing in view of its practical advantages, although random sampling would be theoretically more appropriate. Each test specimen is drawn from a different portion of the cloth such that no two test specimens have the same warp or weft threads. The portion from which each test specimen is drawn, is clearly marked P₁, P₂, T₁, T₂ etc., where P and T indicate respectively, the warp and weft, and the numerical figures indicate the specimen number. The layout of strips is represented in plate: 40.
4.3.11.2. DETERMINATION OF THICKNESS OF FABRIC:

The thickness of the fabric is determined by following the procedure mentioned as per the Standard IS: 7702-1975. Thickness measurements on fabrics are made with a Compressometer, equipped with three upper pressure foot, having diameters 25mm, 76mm and 178mm. Usually, the presser foot having a diameter of 25mm i.e., an area of about 6.2sq.cm is used and a pressure of about 100 g per sq. cm or 1 lb. per. Sq. in. is applied. The
thickness of the specimen is measured as the distance between the reference plate on which the specimen rests and a circular presser foot that exerts a specified pressure on the area under test. The fabric is laid flat on the bottom plate or the ‘anvil’ of the micrometer and the upper plate or the ‘presser foot’ is slowly lowered until a definite pressure is applied on to the fabric, the thickness reading on the dial of the micrometer is then recorded. The measurements are made at (10) different portions of the fabric, care being taken to ensure that the places chosen are at least 150mm away from the selvedges, and the average value is expressed correct to 0.02mm or a thousandth of an inch. The mean of the measurements are then calculated to the degree of precision specified in the test.

4.3.11.3. DETERMINATION OF ENDS AND PICKS PER UNIT LENGTH OF FABRIC:

The threads per unit length were determined in accordance with the procedure mentioned in the Standard IS: 1963-1981. The determination of the number of threads, or ends and picks per unit length of the fabric is very important for the analysis of the fabric. The tests are carried out under standard atmospheric conditions, with a micrometer thread counter placed perpendicular to the warp threads in the sample; the number of threads per inch is counted at 10 places randomly distributed on the sample. The mean of these 10 readings gives the number of threads per inch. By placing the micrometer thread counter perpendicular to the weft threads in the sample, the number of picks per inch is counted in a similar manner. The mean of 10 readings taken from different places gives the number of picks per inch. The number of ends and picks per centimeter is easily calculated from these values.
4.3.11.4. DETERMINATION OF THE COUNT OF YARN REMOVED FROM THE FABRIC:-

The fineness of a fabric depends upon the count of the warp and the weft yarns used for its manufacture. The count of the yarn was determined following the standard mentioned in IS: 3442-1980. The fineness of a fabric depends upon the counts of the warp and the weft yarns used for its manufacture. For determining the count of the yarn removed from the fabric, ten specimens each for the warp and the weft directions are cut from the fabric and then ten threads are removed from each specimen are removed and the 100 threads of warp and weft are weighted separately in lots of ten. The average value of count (C) of the warp and the weft threads are calculated from the total weight (W mg) and the total straightened length (l in.) of the respective threads, by using the formula,

\[ C = \frac{15l}{W}. \]

4.3.11.5. DETERMINATION OF THE CLOTH COVER FACTOR:-

Woven fabric is a structure characterized by the interdependence of properties such as ends and picks, count of warp and weft yarn and arrangement of yarns in the warp and weft directions. A fabric is a structure characterized by the interdependence of most of its dimensional properties, such as ends and picks, count of warp and weft yarn, etc.

For determining the cloth cover factor of banana fibre blended fabrics, Yarns are removed from the fabric and is further examined under the projection microscope (Projectine), where the yarn diameter is measured in mm and about 100 readings are collected for each type of specimen. The mean, S.D, C.V of the readings were then found out. Since the Magnification used was approximately around 70x. Using the mentioned magnification value, the diameter of the yarn is calculated w1% which gives the diameter of the particular yarn.
Plate 41: Schematic View of Cross Sections of Threads in a Fabric

When a scale of 0.5mm was magnified under the microscope, it was found to be equal to 35mm. Therefore corresponding to each division of projection scale, the sample size is calculated as follows,

Sample size (division on scale) = 0.5 ÷ 35mm.

Magnification used was approximately around 70x (1 division = 0.0143)

The diameter of the yarn is firstly calculated, and then using the calculated yarn diameter the cover factor is further calculated.

Cover factor gives an idea of the area covered per inch. Therefore,

The area covered per square inch = \( n \times d \).

Where \( n \) is the threads (ends/picks) per inch and \( d \) is the diameter of the warp or the weft yarns.

Therefore the cover factor for warp yarns \( (K_w) = \frac{n \times d}{\text{total area and}} \)
The cover factor for weft yarns \((K_2) = \frac{n \times d}{\text{total area}}\) and so the Total cover factor can be calculated as \(K_1 + K_2 - K_1 K_2\) because warp and weft threads are also covering each other in the fabric.

### 4.3.11.6. DETERMINATION OF THE WEIGHT PER UNIT AREA:

The tests are carried out after conditioning the fabrics in the standard atmosphere, and as per the procedure mentioned in the Standard IS:1964-1970. Wherein the fabric is laid across a smooth flat measuring table without applying any more tension than necessary to make it lie straight. Four test pieces measuring 250 mm × full width are cut from the fabric and are weighed accurately. The average weight per meter length of the fabric is given by the sum of the weights of the four test specimens. For determining the weight per unit area, the average weight per meter length of the fabric is divided by the width of the fabric in meters and the results are reported. All the fabric samples prepared were limited in quantity. Therefore use of 25cm×25cm fabric pieces for determination of weight per unit area was not possible, therefore test was done using 10cm×10cm pieces.

### 4.3.11.7. DETERMINATION OF THE TENSILE STRENGTH:

The methods used for determining the breaking strength is the raveled strip method, which gives the breaking load required to rupture a specific width of fabric. It is particularly used for comparison of the effective strength of yarns in the fabric with their strength before weaving. The procedure followed was as per the mentioned Indian Standard IS:1969-1985. Each specimen is cut with its width about 14mm (minimum 20 threads) more than required width, and threads (minimum 10 threads) are raveled out from both sides of the strip equally to reduce the width of the specimen excluding the fringes to the required level. The breaking load tests are carried out using the Good brand’s Horizontal Cloth tester which is a CRT (Constant rate of Traverse) type of machine. A specimen size of 50 mm × 200 mm (distance between the clamps) with sufficient extra length of fabric on either side for holding it in the clamps is
generally used. Six specimens are tested for each warp and weft directions. The rate of traverse used is 300 mm (12 in.) per min, with the usual tolerance of 15 mm (0.5 in.). The mean value of the breaking strength in each case is expressed in Kilogram’s. Elongation at break can be easily obtained from the load-elongation graph recorded by the machine.

4.3.11.8. DETERMINATION OF THE TEARING STRENGTH:-

Tear resistance is the average force, in Newton’s, required to tear a test specimen over a specified length. The tear strength of the fabrics is determined by the ballistic method employing the KMI tearing strength tester similar to the Elmendorf apparatus. The procedure followed was in accordance with the Standard IS: 6489-1993. This instrument measures the average force required to propagate a tear originating from a cut in the fabric. The rectangular test specimen having a specified precut slit is mounted between clamps of the instrument, is subjected to a tearing force generated by the (energy stored) rapid swing of a sector shaped pendulum. The energy expended in tearing the specimen is used to determine the tearing resistance of the specimen. One of the clamps is fixed on the pendulum while the other is mounted on the frame of the instrument. With the pendulum in the raised position, the two clamps are aligned and the sample is punched out by a cutting die and is clamped tightly. A knife on the frame is used to make a 20 mm (0.8 in.) slit in the specimen. When the pendulum is released, the fabric tears across its width from the end of the cut to the opposite edge through a distance of 43 mm (1.7 in.). The arc through which the pendulum swings is related to the energy consumed in tearing. The average force required for the tear, obtained by dividing the energy by twice the length of the tear, indicated on the scale. The readings were discarded when the specimen slips in the jaws or while tearing deviates beyond the base of the slit in such a way that the tear is not completed in the notch at the top of the specimen. Six specimens each from the warp and weft directions are tested and the average tearing strength in grams for the warp and weft directions are reported separately.
4.3.11.9. DETERMINATION OF THE WEAR AND TEAR:-

Abrasion which is one aspect of wear is caused by rubbing away of the component fibres and yarns of the fabric. Abrasion resistance of the fabrics in this study was carried out using Martindale Abrasion tester also called as Cloth rubbing or Wear testing machine. In this instrument the material is rubbed by the multidirectional movement of the specimen holders against the abradant surface. The multidirectional movement is achieved by the imposition of two simple harmonic motions at right angles to each other on the plate on which the specimen holders are fitted. Depending on the type of fabric to be tested, the roughness of the abrading surface and the load on the top of the specimen holder are decided. The experiment was carried out according to method described in the Standard, IS: 12673:1989.

Four specimens of 38 mm (1.5 in.) diameter are cut and fixed on the four circular specimen holders which are mounted under desired load (30-125 g/cm²) on the brass plate subjected to multidirectional motion. The abradant paper or cloth is fastened to each of the four tables’ beneath, such that the fabrics mounted on the specimen holder rub uniformly against the abradant surfaces. The estimation of wear that has taken place (end point) is made in two ways, (1) visually, by noting the number of rubs required for the formation of holes in the fabric and (2) by determining the loss in weight of the fabric after the specified number of rubs as the initial weight of the fabric before mounting is recorded for finding out the loss in weight after the experiment.
4.3.11.10. DETERMINATION OF THE (STIFFNESS) BENDING LENGTH OF THE FABRICS:

The stiffness of the fabric was measured in accordance with the Standard IS: 6490-1971. The principle employed is to measure a particular length of the fabric specimen of specified dimensions which when used as a cantilever bends to a constant angle under its own weight. Bending length equals half the length of rectangular strip of fabric that will bend under its own weight to an angle of 41.5°. It is also equal to the length of a rectangular strip of materials that will bend under its own weight to an angle of 7.1°. It is expressed in centimeters. Rectangular warp way and weft way test specimens of 25×200 mm size preferably with the help of template from different portions of the fabrics were cut after the fabrics were conditioned for at least 24 hours. The tester is placed on a table and inclined reference line is at eye level and the platform is adjusted accordingly so that it is horizontal in position. Place one of the specimens on the platform with the scale on top of it length wise and the zero of the scale coinciding with the leading edge of the specimen. Holding the scale in the horizontal plate, specimen is pushed along with the scale slowly and steadily when the leading edges project beyond the edge of the platform. An increasing part of the specimen will overhang and start bending under its own weight. The pushing is stopped once the tip of the fabric reaches the level of the inclined plane. The length of the over hanging portion from the scale to the nearest millimeter. Four readings from each specimen with each side up first at one end and then at the other is noted. The average of the four readings for each test specimen is then calculated separately for both warp way and weft way specimens in the method mentioned below,

\[
\text{Bending Length (C)} = \frac{L}{2}\text{ cm.}
\]
4.3.11.11. DETERMINATION OF THE BURSTING STRENGTH OF THE FABRICS:

The Bursting strength of the fabrics was determined by following the method adopted in the Standard IS: 1966-1975. A bursting strength tester having a central opening of 30 mm diameter and having a capacity of 0-70 kg per sq. cm is used at this institute. The representative sample is placed over the diaphragm and the lower clamping plate. The sample should be at least 100 mm × 100 mm (4 in. × 4 in.) in size. The tripod and the upper clamping plate are lowered by rotating the clamp wheel, applying sufficient clamping pressure to prevent slippage of the sample between the plates during the test. The lazy hand (i.e. maximum hand) indicator of the pressure gauge dial is set at zero or at a point on the scale below the point at which bursting will occur. The tester is equipped with a Forward-off-Reverse operating lever. The operating lever is put in position 'F' (forward) so that the shaft of the hydraulic piston will start rotating in clockwise direction at a constant speed of 120rpm till the sample bursts, the operating lever is brought to the central stop position and the motor is allowed to stop. The operating lever is then put in 'R' (reverse) direction of rotation so that the piston will return to its start position. Motor stops automatically in this position. The bursting pressure indicated by the maximum hand is recorded. The procedure is repeated in five other areas of the sample avoiding overlapping of the clamping areas and taking care that as far as possible no two specimens contain the same warp or weft threads. The mean of the values of all the six tests is calculated and reported.

4.3.12. HAND-MADE 100% BANANA FABRIC

A trip was made to KVIC (Khadi Village industries commission), Trivandrum unit to carry out trials in banana fibre spinning and weaving. The variety of banana fibre used is Nendran (plate:42) which costs approximately Rs 110/kg, the colour is off-white and is a superior quality fibre free of pithy matter.
The banana fibre cloth which was obtained from KVIC is a union blended fabric, where the warp is made up of 100% cotton and the weft used is banana filament fibres that are knotted and made into a continuous banana filament fibre (cannot be called as a yarn as it is not twisted). In KVIC till date the superior quality banana fibres are all manually combed, dyed, plaited or designed in several ways in making of handicraft articles.

Plate 42: The Banana fibres
Plate 43: Hand twisting of banana fibres

Plate 44: Making of Banana fabrics on the hand-loom
4.3.13. EXTRACTION OF FIBRES:-

Hand extraction of fibres are carried out using a sharp edged blade with an handle and the banana sheaths are scrapped thoroughly till all the pithy matter and the starch gets completely removed to obtain the silky strands of banana fibres which requires further combing after it has been completely dried in shade to avoid breakage.

Making of 100% banana fibre yarns and fabric:-

In order to make 100% banana fibre yarns; the individual long length raw (not treated or softened) filament fibres of banana are taken and twisted (plate:43) in either S/Z -twist direction. The twisted yarns thus are used in the warp direction of the fabric. The banana filament fibres are simply knotted and used in the weft direction of the fabric. The 100% banana fibre fabric thus produced by the above method on the hand-loom (plates:44 &45) is not very fine fabric and still needs further processing’s both at the fibre as well as the yarn stage as the entire process is not only time consuming but is not viable for mass production.
production as all the processes are hand done manually. The need is for a twisting machine which can twist these filaments, or at least some kind of softening treatment which can soften the inherently coarse banana fibres to make them more pliable so that they can be easily taken through a cotton or a jute spinning system in order to get them spun into yarns and then eventually weaving to be carried out on the handlooms.
4.3.14. PREPARATION OF COTTON/BANANA UNION FABRICS:

Plate 46: Cotton: Banana union fabric

Plate 47: Cotton: Banana union fabric
Though banana fibres could be spun on jute spinning system, the yarns produced were very coarse. Also, these yarns are very hairy. An attempt was been made to weave 100% banana fabrics, which failed, as it was not possible to use these yarns in the warp. But union fabrics (as seen in plates:46-49) could be prepared in small quantity using these yarns in weft while using cotton yarn in warp. Weaving could be carried out only in handloom, as the quantity of yarn produced was not sufficient to be taken up in power loom. Fabric appearance is good and it can be easily used in upholstery.

Properties of cotton – banana union fabrics were prepared at Mahila Samabaya Silpa Kutir Ltd., in Manipuram village, Barrackpore, West Bengal. As the banana yarn is very coarse and with lot of protruding fibres, it was not possible to use it in the warp. Therefore, cotton yarn of about 10s count was used in warp. The weft yarn was made from 100% banana fibres.

All the tests were carried out under standard atmospheric conditions.

Ends and picks were measured using a pick counter. Averages of ten readings are reported. Weight per unit area was determined using 10cmx10cm pieces. Five pieces were weighed to get the average values. Thickness was determined using thickness tester. Tearing strength was measured using Elmendorf tearing tester. Abrasion resistance was measured using Martindale abrasion tester. Weight loss in fabric for 100 cycles was measured and is expressed in percentage with reference to the original weight. Bending length of fabrics expressed in cm gives the stiffness of fabric in that particular direction. Tensile test results are given in below. These were carried out on the Instron. Gauge length used was 10cm and the cross head speed was 10mm/min.
Plate 48: Cotton:Banana Union fabric
Plate 49: Cotton: Banana Union Fabric With Extra Weft Design
4.3.15. SHEARING OF COTTON/BANANA BLENDED FABRICS:

The cotton/banana handloom woven fabrics were having protruding fibres on its surface which may be due to the presence of banana fibres in the blends so this could be removed only through shearing because of the longer lengths of the protruding fibres which makes the singeing operation normally carried out with cotton fabrics rather difficult or impossible to be carried out. Hence to give an even surface to the fabrics and at the same time to improve its smoothness and feel, shearing had to be carried out with these fabrics.

Plate 50: Shearing Technique
Plate 51: Schematic representation of the Shearing technique.

4.3.16. METHOD TO EVALUATE THE PICK UP %

FOR PAD METHOD:

GSM of fabric A (control) = 333

GSM of fabric B (after padding) = 452

Therefore the pick up % = \((a-b)/b \times 100\).

Pick up = 35.73%

FOR DIP METHOD:

GSM of fabric A (control) = 282
GSM of fabric B (after padding)= 550

Therefore the pick up % = \((a-b)/b \times 100\).

Pick up = 95%.

4.3.17. FINISHING OF COTTON: BANANA FABRICS:

The cotton/banana union fabrics was further scoured and then treated with various enzymes. All the finishing treatments were carried out using the facilities available at Clariant India Ltd. Since the union fabric could not be produced in bulk quantities, the sample size for the finishing treatments were limited due to which all the finishing’s and coatings tried out on the cotton/banana union fabrics could only be visually analyzed and those which were both feel-wise and look-wise appealing in terms of their handle and comfort properties were further repeated and tested for few of their physical properties like weight per unit area, fabric thickness, bending length, abrasion resistance and the tensile strength.

The following treatments and finishes were tried out on the cotton/banana union fabrics:

1. Scouring

2. Bio-polishing

3. Softening

4. Resin treatments

5. Padding with enzymes like

6. Coatings

4.3.18. PREPARATION OF JUTE/BANANA FABRICS:

4.3.18.1. BLENDING OF BANANA WITH JUTE FIBRES:
Banana fibres and jute fibres were further taken for blending. The fibres were mixed at the finisher-card-feed stage, as is the normal practice in jute mills. Banana fibres were blended with jute at different ratios were also processed in small scale jute spinning machine designed and developed by NIRJAFT. The yarns developed by same unit were compared. It has been observed that both the developed yarns could be used to develop various products. This Mini jute unit might be used like “KHADI SYSTEM” to develop economic conditions of farmers to produce value added items at particular village involved with banana plant fibre production. Jute/ banana Fabrics blend of 70:30 blend ratios were prepared at NIRJAFT, Calcutta. The yarns were further studied for basic properties. Blends with higher percentage of banana could not be spun because the quality deteriorates with an increase in the percentage of banana fibres. So a banana/ jute blended yarn of 70:30 blend ratio was prepared following the above mentioned procedure.

4.3.18.2. Preparation of Jute/Banana fabrics

The jute/banana yarns prepared in the above manner is further taken on the hand-loom to make jute/banana blended fabrics having warp and weft of the jute/banana blended yarns. As the jute/banana yarn is very coarse and with lot of protruding fibres, there were technical difficulties in the weaving of the fabric. About ten meters of fabric of 36 inch width was produced.

FLOW DIAGARM

Hank
↓
Drum winding & pirn winding
↓
Warping
4.3.19. FABRIC TESTS:

All the tests were carried out under standard atmospheric conditions.

Ends and picks were measured using a pick counter. Averages of ten readings are reported. Weight per unit area was determined using 10cmx10cm pieces. Five pieces were weighed to get the average values. Thickness was determined using thickness tester. Tearing strength was measured using Elmendorf tearing tester. Abrasion resistance was measured using Martindale abrasion tester. Weight loss in fabric for 100 cycles was measured and is expressed in percentage with reference to the original weight. Bending length of fabrics expressed in cm gives the stiffness of fabric in that particular direction. Tensile test results are given in below. These were carried out on the Instron. Gauge length used was 10cm and the cross head speed was 10mm/min

4.3.20. SHEARING OF JUTE/BANANA BLENDED FABRICS:

The jute/banana handloom woven fabrics were having protruding fibres on its surface which may be due to the presence of banana fibres in the blends so this could be removed only through shearing because of the longer lengths of the protruding fibres which makes the singeing operation normally carried out with cotton fabrics rather difficult or impossible to be carried out. Hence, to give an even surface to the fabrics and at the same time to improve its smoothness and feel, shearing had to be carried out with these fabrics.

4.3.21. FINISHING OF JUTE: BANANA FABRICS:
The Jute/banana blended fabrics was further scoured and then treated with various enzymes. All the finishing treatments were carried out using the facilities available at Clariant India Ltd. The treated fabrics were further tested for few of their physical properties like Ends & Picks per inch, weight per unit area, fabric thickness, tearing strength, tensile strength, bending length, abrasion resistance and the bursting strength. The whiteness index values for the jute/banana fabrics were also analyzed to compare the effects before and after bleaching.

The following treatments and finishes were tried out on the cotton/banana union fabrics:

1. Scouring
2. Bleaching
3. OBA-treatment
4. Bio polishing
5. Softening
6. Resin treatments
7. Padding with enzymes

4.3.21.1. SCOURING:

Scouring (washing with detergents, alkaline solutions, or enzymes to remove foreign matter)

HOSTAPAL MRN Liq Conc = 1 g/l.
SIRRIX 2 UDI = 2 g/l.
BIOLASE FCE = 1 g/l.
MLR: 1:10.
Ph = 5.5.

Temperature = 60 deg C.

Time = 30 min.

Hot Rinse = 85deg C for 20 min.

**4.3.21.2 BLEACHING:**

The Procedure of Improving the Whiteness of Textile Material, With or Without the Removal of Natural Colouring Matter and/or Extraneous Substances, By a Bleaching Agent.

**HOSTAPAL MRN Liq Conc** = 1 g/l.

Caustic Soda = 3g/l.

Hydrogen Peroxide (H2O2) = 6ml/l.

Stabilizer SIFAM = 1.5 ml/l.

Temperature = 95 deg C.

Time = 60 min.

Hot Rinse= 80deg C for 10 min.

Followed by cold rinse.

**4.3.21.3. OBA-Treatment:**

Optical brighteners, also called optical bleaches or fluorescent whitening agents, are a group of colorless, fluorescent chemicals that absorb ultraviolet light and emit it back as visible blue light. This blue light masks any *yellowing* that may be present in the treated material and makes it seem brighter and whiter than it would otherwise naturally appear to the eye. (FBAs) or fluorescent whitening agents (FWAs) are dyes that absorb light in the ultraviolet and violet region (usually 340-370nm) of the electromagnetic spectrum, and re-emit light in the blue region (typically 420-470nm). Fluorescent activity is a short term or rapid emission response, unlike phosphorescence, which is a delayed emission. These additives are often
used to enhance the appearance of color of fabric and paper, causing a perceived "whitening" effect, making materials look less yellow by increasing the overall amount of blue light reflected.

To be carried out along with the bleaching process in the same bath.

**LEUCOPHORE BMF = 0.7%.
Time = 60 min.
Temperature = 95 deg C.
MLR = 1:10.**

**4.3.21.4. BIOPOLISHING:**

It helps to create a smooth fabric appearance and introduce a degree of softness without the use of traditional, topically applied chemicals. Bio-polishing is a process in which cellulase enzymes modify the surface of cotton fabrics in a manner that permanently prevents pilling and increases smoothness and softness. When the fibre ends are removed, pilling cannot occur, colours appear brighter and the surface appears less fuzzy or cleaner. Additional benefits of bio-polishing includes,

- Reduced hairiness
- Softer hand with greater tradability
- Environmentally friendly solution

**BIOLOSE FCE (N) = 1%**

**SIRRAX 2 DI = 0.5%.
MLR: 1:0.
pH = 5.5-6.
Temperature = 55deg C.
Time = 1hr.**

**4.3.21.5. SOFTENING:**
Application technique = Dip method.

**LEOMIN PNLI** = 20g/l.
Acetic acid = 0.5g/lt.
MLR: 1:10.
Pad-Dry -Cure at 180 deg C for 2 min.

### 4.3.21.6. RESIN TREATMENT:

Application = Padding technique.

**CERALUBE HD** = 30 g/l.
Acetic acid = 0.5g/lt.
MLR: 1:10
pH = 5.5.
Pad-Dry-Cure at 180 deg C for 2 min

### 4.3.21.7 DIP METHOD (SOFTENING):

Application technique = Dip method.

**CERAPERM MW** = 20g/l.

**CERAPERM UP** = 10 g/l.
MLR: 1:10.
pH = 5.5.
Pad-Dry-Cure at 150 deg C for 3 min

### 4.3.21.8. FINISHING:

Application = Padding technique

**APPRETAN 94111** = 100 G/L.
pH = 5.5-6.

MLR = 1:10.

Pad-Dry-Cure at 150 deg C for 3 min

4.3.22. **WHITENESS INDEX OF JUTE: BANANA FABRICS:**

A spectrophotometer is used to measure the colour of an object. It is attached to a personal computer with advances in software which requires a high performance processor, sufficient disk storage and high resolution colour monitor. The whiteness index of the bleached and the grey samples of the jute/banana blended fabrics were assessed on the JAYPAK4892 computer colour matching system. The instrument was standardized by white tile. A whiteness index maintains a “the perfect” white standard to which all your white samples are compared against. This standard has the value of 100 as the perfect white. Totally four readings were determined for each of the dyed samples were determined. Measurement of Whiteness and Brightness Indices as per Hunter Lab-Scale formula for whiteness index and brightness index as per the ISO-standard formula were directly evaluated using a computer aided reflectance spectrophotometer ad associate colour measurement relevant software.

The spectrophotometer is used to measure the color of a sample, which can be done in two ways,

1. By measuring reflectance from the coloured object or
2. By collecting and measuring the light after it has passed through transparent liquid or a solid sample.

These values are recorded at a number of wavelengths across the visible spectrum and converted into digital information. This information is used in computer colour difference by the computer. Spectrophotometer is a very high precision instrument to measure accurately and swiftly, reflectance or transmission, with a very high degree of short and long term stability. The spectrophotometer attached with the system is the colour graph. Spectrophotometer is the heart of the colour matching system and colour
graph is an easy to use true double beam instrument. The instrument makes transmittance scans in the range of 400 mm to 700 mm in 10 nm or 20 nm increments. Sample and reference ports on the right side of the instrument, there is a assembly that secure both the sample to the sample port and white standard tile marked ‘reference’ to the reference port. The sample holder and the reference holders are flexible and require very little pressure to pull away from the sample or reference ports. The sample holder is adjusted for different sizes of samples by loosening the thumb screws to slide the sample rest upward or downward to the appropriate height.

**MAKING A SAMPLE MEASUREMENT:**

There is no preferred sequence to switch on the system. After warming up for 30 minutes minimum, measurements were taken. Once initialization has been successfully completed, the white standard tile marked ‘reference’ was placed on the reference holder, so that the white unmarked side was clamped against the reference port. The white standard tile marked ‘sample’ was placed in the sample holder so that the white tile unmarked side was clamped against the sample port. The calibrate key was pressed on the control panel; after the terminal displayed ‘calibration complete’ the instrument was ready to make standard trial scans.

**4.3.23. DYEING OF JUTE/BANANA BLENDED FABRICS:**

The jute/banana blended fabrics were further dyed using two different shades of sulphur and reactive dyes. The dyeing was carried out using the facilities available at Clariant India Ltd (Thane).

The jute/banana blended fabrics were dyed using four different dyes namely:

1. **Sulphur N-blue** (15% shade)
2. **Sulphur H-green.** (15% shade)
3. **Reactive blue** (15% shade)
4. **Reactive green.** (15% shade)
Instrument used: **INFRA Colour Dyeing Machine.**

### 4.3.23.1. SULPHUR DYEING:-

The dyes are absorbed by cotton from a bath containing sodium sulfide or sodium hydrosulfite and are made insoluble within the fiber by oxidation. During this process these dyes form complex larger molecules which are the basis of their good wash-fastness. Sulfur dyes are water insoluble. They have to be treated with a reducing agent and an alkali at temperature of around 80 degrees Celsius where the dye breaks into small particles which then becomes water soluble and hence can be absorbed by the fabric.

Heating and adding a substance like common salt facilitates the absorption. After this the fabric is removed from the dye solution and then taken for oxidation. During the oxidation step the small particles of dye once more form the parent dye which is insoluble in water. This oxidation can be done in air or by using oxidizing agents like hydrogen peroxide or sodium bromate in a mildly acidic solution.

The procedure followed for **Sulphur dyeing** is as follows:

**Dye used:**

1. Diresul RDT Blue
2. Diresul RDT Green

The dye bath was made with dye (15%, owf) and sequestering agent (2 g/L), anionic wetting agent (5 g/L), reducing agent (25 g/L), caustic soda (25 g/L) and the material to liquor ratio was kept at 1:20. The bleached fabric samples were dipped into the dye bath and kept for 45 minutes at 70-85 deg C in an Infra colour-dyeing machine. After the treatment, oxidation is carried out by adding stabilized oxidizing agent (10 g/L), acetic acid (7-8%) for maintaining the pH around 5, temp 60 deg C for 5 minutes. Thereafter the samples were washed with cold water, soaped with an Ultravan Ju (2 g/L) for 15 minutes at boil followed by usual cold washing and drying. The same procedure of dyeing and oxidation was followed for both the above dyes.
The dyes are absorbed by fabrics from a bath containing sodium sulfide or sodium hydrosulfite and are made insoluble within the fiber by oxidation.

**By exhaust method:**

Ladiquest liquid = 1-2 g/lt.
Leonil UH = 3-5 g/lt.
Reductor D powder = 20-25 g/lt.
Caustic soda = 20-25 g/lt.
Temperature = 70ºc – 85ºc
Time = 45 min.

**For Oxidation:**

Diresul oxidant BRI liquid = 7-10 g/lt.
Acetic acid (for pH to be around 3-5) = 7-8 g/lt.
Time = 5 min.
Temperature = 60ºc
Dye 1% conc.

**4.3.23.2. REACTIVE DYEING:-**

Reactive dyes are used to dye cellulosic fibres. The dyes contain a reactive group, either a haloheterocycle or an activated double bond, that, when applied to a fibre in an alkaline dye bath, forms a chemical bond with an hydroxyl group on the cellulosic fibre. Reactive dyeing is now the most important method for the coloration of cellulosic fibres. Reactive dyes have a low utilization degree compared to other types of dyestuff, since the functional group also bonds to water, creating hydrolysis.

The procedure followed for **Reactive dyeing** is as follows:

Drimagene ER = 0.5 g/lt.
Glauber’s salt = 60 g/lt.

Soda ash = 20g/lt.

Dyes used;

1. H-green
   Drim-Yellow LT = 1.2%
   T. cl-b = 2.4%
   BL.HF = 0.5%
   CI5-B = 0.79%
   BL.HFRI = 0.240%
   Navy-HFEN = 2.150%

The dye bath was made with dye (15%, owf) and glaubers salt (60g/L), leveling agent (0.5 g/L) and the material to liquor ratio was kept at 1:20. The bleached fabric samples were dipped into the dye bath and kept for 1 hr in an Infra colour-dyeing machine. After the treatment, sodium carbonate (20g/L) was added in the bath and kept for about 45 minutes under the same conditions. Thereafter the samples were washed with cold water, soaped with an Ultravan Ju (2g/L) for 15 minutes at boil followed by usual cold washing and drying. The same procedure was followed for both the above dyes.

4.3.24. FASTNESS PROPERTIES OF DYED SAMPLES:

4.3.24.1. EVALUATION OF THE COLOUR STRENGTH OF DYED SAMPLES:-

The colour strength of the Reactive and the Sulphur dyed samples (K/S) was measured under the most commonly used source i.e. daylight (illuminant D65) for the 10° standard observer on Gretag Macbeth Colour Eye XTH Spectrophotometer attached to a personal computer, over the range 400-700 nm. The instrument was standardized by a white tile. K/S is the ratio of
absorption coefficient (K) versus the scattering co-efficient (S) for reflectance measurements as for the following equation,

\[ \frac{K}{S} = \frac{(1-R^2)}{2R}, \text{ where } R \text{ is the reflectance.} \]

\('K/S' is commonly referred to as function of reflectance f(R). The results in \( K/S \) are directly proportional to the concentration (C). This feature and its additive nature form the basis for computer colour matching. The results were recorded in terms of CIELAB coordinates \( L^*, a^*, b^*, C^*_{ab} = (a^* + b^*)^{1/2} \) and \( h^* \) with the indication of lighter/darker, redder/greener, yellower/bluer and the difference in saturation. The \( K/S \) data of the dyed samples were also generated using computer through the strength evaluation programme. The colour measurement depends upon the wavelength of the colour. The wavelength can be defined as, the distance measured along the line of propagation, between two points that are in phase on adjacent waves. Wavelength distribution determines the colour of light; Wavelength of the visible light ranges from about 400nm to about 700 nm. The CIE \( L^*A^*B^* \) is used in most of the colour applications. \( L^*, a^*, b^*, C^*_{h} \) specify colour in three dimension space.

L: Specifies lightness/darkness

A: Specifies redness/greenness.

B: Specifies yellowness/blueness.

C: Specifies chroma or saturation.

H: Specifies the hue angle.

- L varies from 100 to 0. For perfect white, L is 100 and for black it is zero.
- When a is positive, colour is red; when a is negative colour is green.
- When b is positive colour is yellow; when b is negative colour is blue.
- When a and b are both zero, that means the colour is neither red (or green) nor yellow (or blue). In simple words, it does not have any tone (or chroma). In colorimetric languages, it is known as achromatic.
colour. Such colour may be neutral gray-light or dark or black or white depending on the L value.

- When a is positive and b is positive – colour is in Quadrant I. Reds Oranges and Yellows falls in Quadrant I.
- When a is negative and b is positive – colour is in Quadrant II. Greenish yellows, Greens fall in Quadrant II.
- When a is negative and b is negative – colour is in Quadrant III. Greens, Bluish green and Blues fall in Quadrant III.
- When a is positive and b is positive – colour is in Quadrant IV. Blues, Violets and Reds fall in Quadrant IV.
- The chroma or saturation ‘C’ is the distance between achromatic point and colour and is calculated from a and b using following equation.
- Chroma can be explained from the ‘ab’ plot. Longer the distance of a colour from achromatic point, higher is the chroma or brighter is the colour. All bright yellows, oranges, reds, greens, blues, violets have higher chroma values. Shorter the distance of colour, lower is the chroma of less saturated is the colour or duller is the colour. Browns, grays, olives, coffees have low chroma values.

Thus, computerized colour matching system was used to measure the $\lambda_{\text{max}}$, K/S value and reflectance values of different types of reactive and sulphur dyed banana/jute fabrics.
4.3.24.2 EVALUATION OF THE WASHING FASTNESS OF THE DYED SAMPLES

The Colour fastness of the samples dyed in reactive and sulphur dyes against washing were assessed according to IS: 3361-1979 (Bureau of Indian Standards, 1982a). test method ISO2 washing test. Samples were assessed using the grey scale of colour change and staining.

Procedure

The test specimens were prepared by placing 10 cm × 4 cm fabric, one piece made of the same kind of fibre as that of the textile sample to be tested and the second piece made of the fibre as indicated in the standard. A specimen of dyed material measuring 10 cm × 4 cm was sandwiched between two pieces of undyed fabric measuring 10 cm × 4 cm and the three pieces were held together by stitching on all the four sides. The fibre blend composition of one of the colourless materials enclosing the specimen was the same as the
dyed material i.e. cotton and the other was wool. The composite specimen was placed in the water tight stainless steel containers of 500 ml capacity of the laudermometer containing 5g/lt of neutral soap solution. The laudermometer used for the experiment has eight cylinders each of 500 ml capacity. The MLR used was 1:20 and manufactured by SASMIRA, (Bombay). It is a big metal box with a rod as the central axis on which eight jars each with 500 ml capacity, two on each spoke. The cylinders were attached by a screw arrangement by fixing the cylinders and then tightening the screws. The metal box was filled with water which was heated up to 80ºC. The samples were put in the cylinders with the required amount of water and then the cylinders were fixed and the rotor put on, thus the central axis starts moving, dipping the jars in and out of the water maintaining the temperature. The material to liquor ratio was maintained at 1:5. The samples were worked in the laudermometer for 45 minutes at 50ºC ± 2ºC at a speed of 40±2 revolutions/minute. At the end of the washing cycle the samples were removed and rinsed twice in cold water and squeezed. The stitching along the two long sides and one short side were opened out and the samples were dried at room temperature (~30ºC). The change in colour is then evaluated by the method prescribed in IS: 768-1982 and the degree of staining of the two pieces of the adjacent fabrics by the method prescribed in IS: 769-1982.

The change in colour of the treated specimen and the degree of staining on the two adjacent white specimens were evaluated with the help of the Grey Scale for assigning the ratings from 1-5 as per the following grades.

**Table 4.3.: Grey Scale for colour change and staining.**

<table>
<thead>
<tr>
<th>Degree of Change</th>
<th>Rating</th>
<th>Degree of Staining</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible/no change (Excellent)</td>
<td>5</td>
<td>Negligible/no change (Excellent)</td>
<td>5</td>
</tr>
<tr>
<td>Slightly changed (Good)</td>
<td>4</td>
<td>Slightly changed (Good)</td>
<td>4</td>
</tr>
<tr>
<td>Noticeably changed (fair)</td>
<td>3</td>
<td>Noticeably changed (fair)</td>
<td>3</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---</td>
<td>--------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Considerably changed (poor)</td>
<td>2</td>
<td>Considerably changed (poor)</td>
<td>2</td>
</tr>
<tr>
<td>Heavily changed (Very Poor)</td>
<td>1</td>
<td>Heavily changed (Very Poor)</td>
<td>1</td>
</tr>
</tbody>
</table>

### 4.3.24.3 EVALUATION OF THE PERSPIRATION FASTNESS OF The DYED SAMPLES:-

- The colour fastness of the reactive and sulphur dyed samples against acidic and alkaline perspiration was carried out according to Indian Standard **IS: 971-1983** (Bureau of Indian Standards, 1982a). Change in colour and degree of staining on an adjacent multi-fibre fabric was assessed by the aid of the grey scales.

**Procedure**

Two adjacent fabrics each measuring 10 × 4 cm, one piece of fabric made of the same kind of fibre as that of textile to be tested and the second piece made of the fibre as indicated in the standard. A specimen of dyed material measuring 10 cm × 4 cm was sandwiched between two pieces of undyed fabric measuring 10 cm × 4 cm and the three pieces were held together by stitching along one of the shorter sides to form a composite specimen.

The alkaline solution was freshly prepared containing the following per litre:

- 0.5g of 1-histidine monohydrochloride monohydrate (C₆H₉O₂N₃ HCL.H₂O);
- 5g of sodium chloride (NaCl); and 5g of disodium hydrogen orthophosphate dodecahydrate (Na₂ HPO₄ 12H₂O). The solution is brought to pH8 with 0.1 N sodium hydroxide solution.

The acid solution was freshly prepared containing the following per litre:

- 0.5g of 1-histidine monohydrochloride monohydrate (C₆H₉O₂N₃ HCL.H₂O);
5g of sodium chloride (NaCl); and 5g of sodium dihydrogen orthophosphate dilydrate (Na H₂PO₄ 2H₂ O). The solution is brought to pH 5.5 with 0.1 N acetic acid solution.

One of the above prepared samples are thoroughly wetted in alkaline solution at a liquor ratio of 50:1 and allowed to remain in the solution at room temperature for 30 minutes. It is then pressed and removed from time to time to ensure good and uniform penetration of the liquor. The excess solution was drained off using two glass rods and the composite specimen is placed between acrylic resin plates measuring about 11.5 x 6 cm under pressure of 12.5 kPa (5 kg). The testing device (perspirometer) holding the composite specimen is then placed in the oven for four hours at 37 ± 2ºC. After which the composite specimen is opened by breaking the stitches on all the sides except one and is dried by hanging it in air at temperature not exceeding 60ºC with the three parts in contact only at the remaining line of stitching. All the specimens were similarly treated in the acidic solution as mentioned above to evaluate the colorfastness of the specimen against acidic perspiration. The change in colour is then evaluated by the method prescribed in IS: 768-1982 and the degree of staining of the two pieces of the adjacent fabrics by the method prescribed in IS: 769-1982.

<table>
<thead>
<tr>
<th>Degree of Change</th>
<th>Rating</th>
<th>Degree of Staining</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible/no change (Excellent)</td>
<td>5</td>
<td>Negligible/no change (Excellent)</td>
<td>5</td>
</tr>
<tr>
<td>Slightly changed (Good)</td>
<td>4</td>
<td>Slightly changed (Good)</td>
<td>4</td>
</tr>
<tr>
<td>Noticeably changed (fair)</td>
<td>3</td>
<td>Noticeably changed (fair)</td>
<td>3</td>
</tr>
<tr>
<td>Considerably changed (poor)</td>
<td>2</td>
<td>Considerably changed (poor)</td>
<td>2</td>
</tr>
<tr>
<td>Heavily changed</td>
<td>1</td>
<td>Heavily changed</td>
<td>1</td>
</tr>
</tbody>
</table>
4.3.24.4. EVALUATION OF THE RUBBING FASTNESS OF THE DYED SAMPLES:-

The colour fastness of the reactive and sulphur dyed samples to rubbing was carried out according to Indian Standard IS: 766-1988. Change in colour and degree of staining was assessed by the aid of the grey scales.

Procedure

A crock meter is the device which has a rubbing finger of 3.2 cm diameter with a circular transition and a flat area of 2.5 cm diameter with a circular transition of 0.32 cm radius. The rubbing finger exerts a downward force of 22N, moving to and fro in a straight line along a 10 cm track. Two specimen fabrics each measuring 14 × 5 cm for dry rubbing and two pieces for wet rubbing. One specimen of each pair has the long direction parallel to the warp yarns and the other parallel to the weft yarns. The specimen is fixed to the rubbing device by means of clamps such that the long direction of the specimen follows the track of the device. With the dry rubbing cloth flat in place over the end of the finger of the testing device, rub it in to and fro in a straight line along a track 10 cm long on the dry specimen, 10 times to and fro in 10 seconds, with a downward force on the finger of 22N or 9N. The tests are then repeated with a rubbing cloth that has been wetted with water by placing it on the grating and dropping evenly on to it its own mass of water, after rubbing, dry the cloth at room temperature. The staining of the rubbing cotton clothes is then assessed with the grey scale by the method prescribed in IS: 769-1982.

Table 4.5.: Grey Scale for colour change and staining.

<table>
<thead>
<tr>
<th>Degree of Change</th>
<th>Rating</th>
<th>Degree of Staining</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible/no</td>
<td>5</td>
<td>Negligible/no</td>
<td>5</td>
</tr>
</tbody>
</table>
### 4.3.24.5. EVALUATION OF THE LIGHT FASTNESS OF THE DYED SAMPLES:-

All the reactive and sulphur dyed banana/jute-blended fabrics were subjected to light fastness test as specified in IS: 2454-1985 (Bureau of Indian Standards, 1982a). The samples were exposed to artificial light source, equipped with xenon arc and mercury-tungsten florescent, whose wavelength is similar to that of sunlight. It has light fastness grades from 1 to 8. The change was compared with the original specimen and accessed by blue light fastness grey scale of colour change and staining.

#### Procedure

The test specimens and the Blue Wool standards (1-8) were mounted in such a way that ¼ of the total length of the test specimen and standards were covered with an opaque black paper. The assembly was exposed to light and the effect of light was observed periodically. The samples and the standards should be of equal size and shape in order to avoid errors in assessment due to over rating the visual contrast between unexposed and exposed parts on the longer specimens as against the narrower standard.

#### Assessment of light fastness (photo fading)

The change in colour of the dyed specimen was compared with the change that had occurred in the Blue Wool standard patterns under suitable
illumination. The light fastness of the specimen is the number of standard pattern, which showed similar changes (visual contrast) between the exposed and unexposed portions of the specimen. Sometimes, intermediate ratings were also assigned according to following grades:

Outstanding 8
Excellent 7
Very good 6
Good 5
Fairly good 4
Fair 3
Poor 2
Very poor 1

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