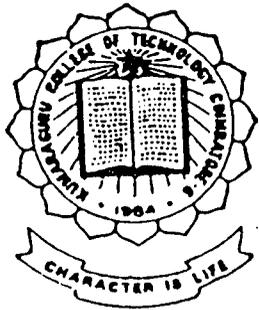


STUDY ON EFFECT OF ENZYMATIC TREATMENT ON COTTON MATERIALS

P-439



PROJECT REPORT



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CERTIFICATE

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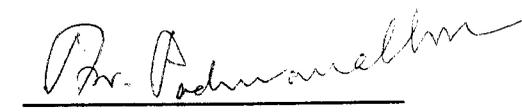
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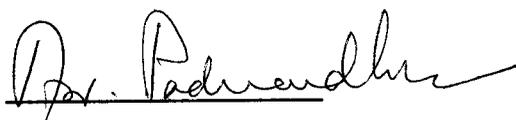
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ABSTRACT

We have studied the influence of enzymatic hydrolysis of single jersey knitted cloth, plain woven cloth and natural coloured cotton by a cellulase enzyme Biosoft AS under the following optimised condition.

M:L = 1:10
PH = 5
Temperature = 50°c
Concentration = 1%owf
(Enzyme)

We found that the enzymatic catalytic reaction affected the properties of cotton cloth whereas the yarn properties taken from the cloths were not. The enzyme was more effective for both single jersey and plain woven cloth than naturally coloured cotton material.

The enzyme treatment significantly reduced the bursting strength, stiffness and crease recovery of both single jersey and plain woven cloth. The result showed an improvement in smoothness and decrease in weight/sq.cm of both single jersey and plain woven 100% cotton cloth. In general, the enzyme treatment significantly affected the physical and aesthetic properties of single jersey and plain woven cloth, which was statistically evident from 't' test.

We have also studied the effect of enzymatic treatment on natural colour cotton fibre by varying the processing parameters at three levels i.e

- (i) Temperature
- (ii) Time
- (iii) Concentration

Maintaining pH and M:L ratio constant. As the temperature, time and concentration increases the natural colour cotton fibre became more finer. But there was no significant .

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INTRODUCTION

Recently, enzymatic treatments have been a focus of interest for cotton finishing pertaining to fabric softness, good performance, and fashionable looks as well as the potential to simplify and cheaper manufacturing process. Complete or partial replacements of pumice stones by cellulase enzymes for the effect of 'stone-washing, on denim is well established(20,27) and the concept of 'bio-polishing' which originated in Japan, has been extended to knitted structures and blended fabrics.(22)

The majority of the development work conducted by textile enzyme producers has been directed towards improving the properties of cellulose fabrics by means of cellulase preparations. New enzyme fabrics have been developed for example for finishing process for cotton, linen, viscose (or) ramie and their blends with synthetic fibres. Today, bio finishing has an important position in finishing .The catalytic reaction rate of cellulase enzyme is affected by many factors such as pH, temperature, and coexisting chemicals in the treatment both or on the substrate.

Reproducibility of the treatment is therefore relatively poor compared to other chemical (or) mechanical textile process. This is one of the biggest disadvantages of this process, although the method is of interest and has several advantages from the viewpoint of energy savings pollution control and safety. (29)

Enzymes, which are capable of degrading the cellulose containing material, exist abundantly in the environment. The sources for cellulase activity normally are moulds belonging to the *Trichoderma*, *Aspergillus* and *Fasarium* genae. The generic origin of the enzyme influences the dependence of the activity on process parameters such as temperature and pH.

Cellulase is produced industrially by fermentation of suitable microorganisms. The enzymes are available in the form of powder or liquid products.

1. LITERATURE SURVEY

1.1 MECHANISM OF ENZYME ACTION ON COTTON TEXTILES

The enzyme cellulase comprise a multi component enzyme system, including endoglucanases (Egs) that hydrolyze cellulose chain randomly, cellobiohydrolase (CBHS) that splits cellobiose from cellulose ends, and cellobiases catalysis, operates first of all to form an enzyme substrate complex. Direct physical contact of enzyme and substrate is required to obtain the complex. Enzymes contain a true activity centre in the form of three-dimensional structures like fissures, holes, pockets, cavities or hollows. Endoglucanases or endocelluloses hydrolyse cellulose polymers randomly along the chain, preferably attacking non-crystalline region.

Cellobiohydrolases or exo-cellulase attack the polymer chain ends and produce cellobiose. α -Glucosidase hydrolyses small chain oligomers, such as cellobiose into glucose. The three types of cellulase components act synergistically in degrading cellulose glucose. (1,2).

The kinetics of reaction, depend on the diffusion of enzyme to and in to the solid phase of the substrate and the diffusion of the reaction products out of the solid phase in to the liquor. For cotton the restriction of the enzyme to the fibre surface is easily achieved, because cellulose is highly crystalline material and possesses only small amorphous areas, making the diffusion of enzymes in to the interior of the fibre nearly impossible.

Thus by regulating enzyme dosage and choosing the right type of enzyme, the catalytic reaction of the enzyme can be confined to the surface of cotton and to the amorphous regions, leaving the fibres, as whole intact.

ENZYME HYDROLYSIS OF COTTON FIBRE

NAME	REACTION
<p>Exo-cellobiohydrolase (1,4-DGlucanase Cellobiohydrolase) Now known as cellulose 1,4 - cellobiosidase.</p>	<p>Hydrolysis of 1,4- D Glucosidic linkage in cellulose releasing cellobiose from non-reducing ends cellulose chain. Also makes native cellulose, especially crystalline regions responsive to disaggregation of molecules.</p>
<p>Endo – 1,4- glucanase (1,4-D Glucan – 4 glucanohydrolase)</p>	<p>Random attack especially on internal 1, 4 - linkages of cellulose (Endohydrolysis)</p>
<p>- D - Glucoside</p>	<p>Reduce cellobiose to glucose.</p>

ENZYMES

Contain activity in three dimensional structures form

- * Fissures
- * Holes
- * Pockets
- * Cavities, or
- * Hollows

COMPLEX FORMATION

**ENZYME – SUBSTRATE -
COMPLEX**

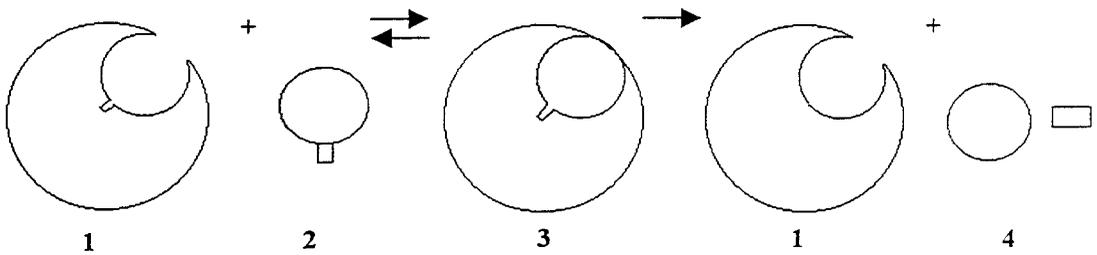
BIOREACTION

**BIO REACTION DUE TO
THE REDUCTION OF
ACTIVATION ENERGY
TO A MULTIPLE OF THE
REACTION SPEED
RELAXATION
CORROSION**

**COMPLEX
DESTRUCTION**

**RELEASE OF
REACTION PRODUCTS
AND THE ORIGINAL
ENZYME**

NATURE OF ENZYME ACTION



1. ENZYME

2. SUBSTRATE MOLECULE

3. ENZYME -SUBSTRATE COMPLEX

4. END PRODUCTS

Using the RMS rather than an aqueous bio scouring system, (3) the effectiveness of the bioscouring was evaluated by measuring the weight loss of cotton substrate, pectin and cotton wax content and by wetness test. It has been shown that the degree of hydrolysis of equivalent or better than that achieved by conventional alkaline. Scouring (or) bioscouring in aqueous media, but with reduced concentration of enzyme and treatment time.

Lea heikinheimo etal (4) showed the impact of monocomponent *Trichoderma reesi* cellulase on the properties of twill and poplin cotton fabrics. Their work revealed that CBHI and EG had different effects on twill and poplin fabrics. Eg caused more strength loss than CBHI but had a more positive effect on bending and pilling properties. His work further showed that EGII caused more strength loss than EGI at higher dosage.

1.2 APPLICATION OF CELLULASE ENZYMES IN FINISHING OF COTTON MATERIAL

Dr. Deepa Rathi stressed the importance (5) of future properties on collaborated research to be undertaken between the specialists in enzyme bioengineering and textile technologist to establish the screening methodology for enzyme treatment according to their field of application.

A combined effect of enzymatic hydrolysis and mechanical action on cotton fibres with the purified *T. reesi* cellobiohydrolase I (CBHI) and endoglucanase II (EGII), was studied by

jaakkopere et al (6). The work revealed that endoglucanase gave rise to straight clean and polished fibres free of fibrillated material than cellobiohydrolase

Endo enriched cellulase composition exhibits high degree of defibrillation and wash fast finishes in significantly lower fabric strength loss on lyocell/cotton blends as well as on 100% lyocell fabrics, and lyocell/linen blends.(7).

Endoglucanases were used in processing of viscose material. The dissolved pulp was modified to a more alkaline soluble form especially by cellulase EGII. The alkaline solubility was found to clearly correlate with the viscosity (8).

EGII resulting in higher weight loss and decreased tear strength as compared to CBHI treatment on cotton twill woven cloth. (9).

Chemometric approach to optimize cellulase treatment of cotton knit was taken by M.L. Gulrajani et al to optimize cellulase treatment of single knitted rib and sinker knitted fabric, with Denifade enzyme (10). But the work doesn't reveal the information about the influence of cover factor of cloth in optimizing cellulase treatment.

Fibres treated with the cellulase with low endoactivity appeared smooth and almost devoid of fibrills then a high level of endoglucanase activity which was responsible for local defects on the fibre

wall. Cotton fabric strength loss was at its best almost 20% better after treating the fabric with the low endoactivity preparation instead of the complete cellulase mixture. (11).

Enzymes offer specific tools for improving both process and products in textile Industries. Using enzymes the product quality can be improved in many aspects and the processing methods can be replaced by environmentally more friendly alternative with low investments cost. (12).

1.3 OTHER PUBLISHED LITERATURE

P.Radhakrishnaiah et al studied the changes(13) in the mechanical and surface properties of plain weave cotton fabrics that was subjected to enzyme treatment with or without mechanical agitation. The work revealed that there were some unique differences in properties between the fabrics subjected to enzyme treatment with and without mechanical agitation, implying that the level of mechanical agitation during treatment significantly altered the finishing effects, including the thermal comfort performance of the faulty fabrics. The work provided the evidence that mechanical agitation of fabrics during enzyme treatment affected not only the thermal comfort performance, but also their textile and aesthetic qualities of the treated fabric.

R.Mori et al studied the bending and shear properties of cotton fabrics subjected to cellulase treatment and compared with those of a polyester staple fabric after alkali treatment. The work revealed that the

inelastic component was reduced less efficiently for the cotton fabrics than for the polyester in bending and shear properties, because the hydrolysis of the cotton fabrics with cellulases took place not only on the fibre surface, but also within the fibre. In contrast, the hydrolysis of the polyester fabric took place only on the fibre surface.(14).

Arthur cavaco et al studied the effects of agitation and Endoglucanases pretreatment on the hydrolysis of cotton fabrics by a total cellulase. They showed that EG treatment with high levels of mechanical agitation made fabrics feel harsher whereas Tc treatment provided fabric softening benefits. Also they suggested that low agitation EG treatment should be followed by high agitation Tc treatment to get effective 'bio polishing' treatment. (15)

The rate of catalytic hydrolysis of cellulose fabrics by a cellulase enzyme in the presence of dyes on a cotton substrate was studied by H.Koo et al. In their study they found that both direct and reactive dyes on the substrate apparently inhibited the enzyme catalytic reaction, whereas a vat dye did not. The enzyme was more active for mercerized than for nonmercerised cotton.(16)

Study of enzymatic hydrolysis of cotton, Linen, Ramie, and Viscose rayon fabrics (17) showed that the fall in strength in yarn was progressive with increasing weight loss for cotton and viscose while for linen and ramie it was slight initially and then increased sharply.



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During the enzymatic hydrolysis of cotton (18), the catalytic reaction of cellulase enzyme was apparently inhibited by both anionic and cationic surfactants. But there was no (18) inhibition with a nonionic surfactant.

Shridhar .V. Chikkodi etal studied the effects of biofinishing on cotton/wool blended fabrics by treating with both cellulase and protease enzymes and showed that the enzyme treatment affected the physical and aesthetic properties of the blended fabric significantly.(19)

Work on (20) “ Enhanced bleaching and softening of Jute pretreatment with polysaccharide degrading enzymes” showed that enzyme pretreatment enhanced bleaching by the removal of cementing materials such as hemicellulose and lignin to improved bleaching was therefore achieved. Enzyme pretreatment made the fibre more flexible and therefore softer.

Enn Kyvna Choe ,etal have studied (21) the effect of pre-existing dyes and fabric types on cellulase treatment of cotton fabrics. Their study showed that the fabric weight loss through cellulase treatment of six different cotton depended on mercersation, yarn size and fabric structure and increased enzymatic hydrolysis on mercerised cotton knits with smaller yarn size. All dyes (vat, Reactive and Direct) used in their study inhibited the cellulase reaction. Compare with mono-reactive direct and vat dyes largest inhibiting effect was with bi-functional dyes.

Structural changes in Hemp fibres as a result of enzymatic hydrolysis with mixed enzyme system were studied by G. Buschle –Diller et al. The work revealed that the largest total porosity and the highest number of small pores occurred when using just cellulase. (22)

Arthur Cavaco et al carried (23) out the study on the hydrolysis of cotton cellulose by engineered cellulases from *Trichoderma reesi*. They showed that characteristics of the activities of TC, EG- rich and CBH- rich mixtures from *Trichoderma reesi*. The activities of TC, EG- rich and CBH- rich were influenced by ionic strength and adsorbed ionic species as well as temperature and pH. Adsorption and kinetic (23) experiments confirmed that increasing mechanical agitation favoured.

Pretreating cotton with enzymes led to fibre swelling, which was enhanced by alkali boil (24). Enzyme systems containing pectinase showed an increased uptake of red dye due to crystallization, during the treatment process and an increased uptake of blue dye after alkali boil. Using cellulase containing enzyme system to pretreat cotton could help minimize the chemicals and energy needed for the conventional treatment processes.

An experiment (25) investigated the inhibitory effects of two ionic dyes Congo red, (C.I Direct Red 28) and orange II (C.I. and Orange 7). On the optical brightening of the cellulase catalysed viscose filament yarn substrates. The work indicated that Congo red exerted a strong inhibitory effect on the catalytic reaction. The inhibitory effect of Orange II

was weaker. The work also showed that there might be a specific interaction between the dye and the enzyme

An enzymatic treatment for removing pills from Garment dyed goods was carried out by Clarke. D. His work showed that application of enzyme treatment before dyeing gave cloth a soft hand dimensional stability and application after dyeing gave cloth an antipilling effect. (26)

1.4 BIOPOLISHING OF JUTE-COTTON UNION FABRIC

A.B. Kundu et al (27) attempted to study the effect of Bio-polishing of jute-cotton union fabric. The appearance and handle of the jute-cotton union fabric had significantly improved by treatment with a commercial enzyme preparation, Biocellulase 2K. The treatment led to the removal of surface hairs from the fabric and induced improvement in soft feeling. The handle of the fabric was improved due to increased drapability and compressibility and reduced stiffness and rigidity. A simple method (28) for wet treatment of jute by a polysaccharide degrading enzyme was described by S.K. Chakraharti et al. Due to the treatment the coarseness and rigidity fibers were reduced and the treatment made jute fibre distinctly softer.

1.5 APPLICATION OF CELLULASE ENZYME IN DENIM WASHING

Cellulases have been used for stone-washing of denims for the last ten years. Bio-washing is a technique involving the use of cellulase enzyme products designed to produce a moderate level of abrasion without the use of pumice stones. The major disadvantages with the usage of pumice stones are overcome with the use of cellulase enzymes.

In the traditional process of denim an oxidising agent such as sodium hypochlorite or potassium permanganate was used, later process made use of pumice stones and the effect was termed as 'stone -wash' effect. Disadvantages of pumice stones method created incentives to develop alternate agents. Modern Bio-technology has provided an attractive solution, passed an application of selective enzymes.(29,30,31)

The Vagabundo process involves the application of a cationic agent to the fabric prior to dyeing which changes the surface of the cotton fibres from negative to positive. After dyeing with soluble liquid sulphur dyes, the fabric is then treated with cellulase enzymes that attack the surface of the cotton fibres, producing a faded appearance with a very smooth hand.(32).

Softness and pleasing highlighted effect can be chemically reproduced without the disadvantages of using stones. Microscopic analysis showed less mechanical damage to fibres at the fabric surface. Softness panel testing illustrated that people cannot tell the difference between enzyme treated fabrics and stone washed fabrics.

Analysis using the Kawabata instruments confirms the similarity(33).

1.6 APPLICATION OF CELLULASE ENZYME IN FINISHING OF JUTE MATERIAL

A.B.Kundu et al studied (28) the effect of pretreatment of jute with polysaccharide degrading enzymes on bleaching. They reveal that the brightness of peroxide bleached jute material increase by about 3% when pretreated with an enzyme mix containing cellulase and xylanase and pretreatment reduced the peroxide requirement for bleaching and made the jute material distinctly softer.

2. METHODOLOGY

2.1 MATERIALS:

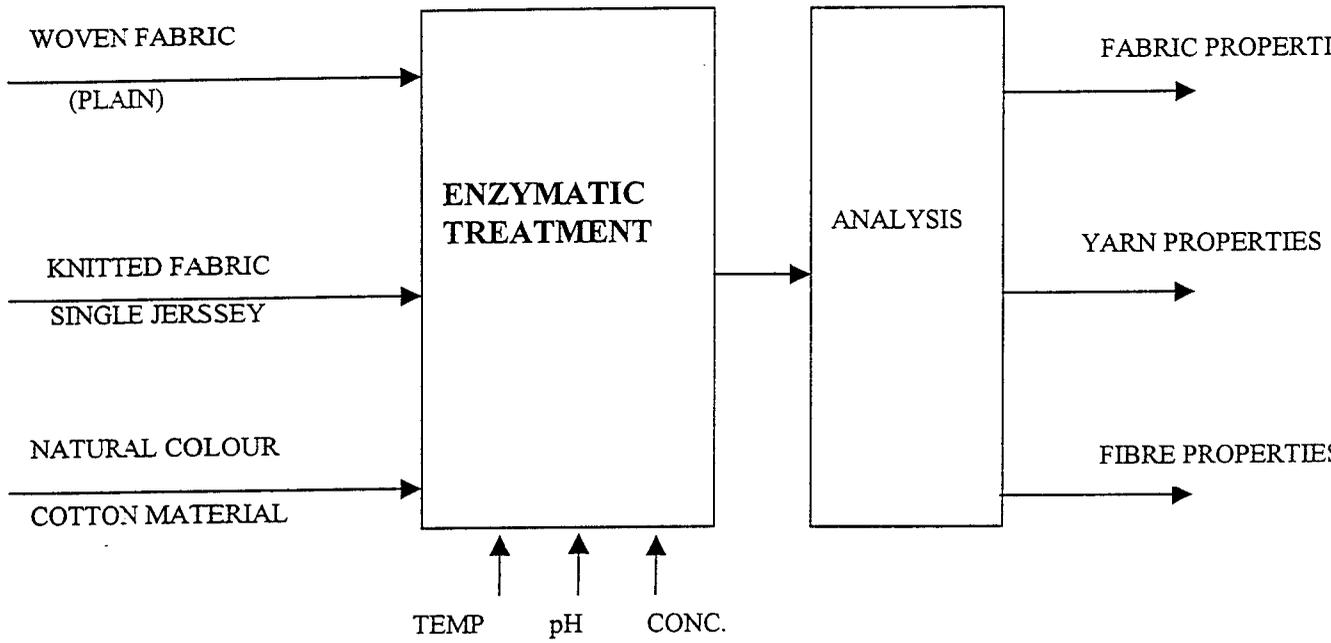
The fabrics taken for enzymatic treatment were 100% single cotton jersey;(properties: 30 s count – warp/weft, 50 courses/inch, 40 wales/inch and 0.0166 gms/cm²), 100% cotton plain woven cotton, (Properties: 39s count – warp/weft, 78.1-Ends/Inch, 59.4 Picks/Inch, 0.0098 gms/cm²) and natural coloured cotton fabric with oxford weave (Properties: weft yarn – natural coloured cotton yarn (Brown) with 10.8s count, warp – 100% white cotton yarn with 40s count , PPI – 25, 0.0163 gms/cm²).The enzyme treatment was also carried on naturally coloured cotton fibre (Brown).

2.2 ENZYME:

The effect of enzymatic hydrolysis on cloth properties as well as on yarn properties were studied by using Bio soft AS, an acid type cellulase enzyme, obtained by the fermentation of non-pathogenic moulds of the *Aspergillus* and *Trichoderma* species and supplied by Biocon, India Ltd, Bangalore.

Also the effect of enzymatic treatment on natural colour cotton fibre (brown) was studied by varying the parameters such as time , temperature and concentration of enzyme, treating pH and M: L as constant parameters.

2.3 ENZYMATIC TREATMENT:



Laboratory winch was used for the enzyme treatment of 100% cotton single jersey cloth, 100% cotton plain woven cloth and natural coloured cotton cloth (oxford weave), by taking the following optimum processing parameters at the speed of 140 rpm.

- ◆ M:L = 1:10
- ◆ pH = 4.5 - 5.0
- ◆ Temperature = 50^o c
- ◆ Time = 15min.
- ◆ Enzyme conc., = 1% on the wt. of the material.

The enzyme treatment of naturally coloured cotton fibre was carried out by varying the processing parameters at three levels as given below,

- ◆ pH - 5
- ◆ Temperature - 50^o c, 55^o c, 60^o c.
- ◆ Time - 15, 20, 25 min.
- ◆ Concentration - 2%, 4%, 6%.

The optimum processing parameters of the enzyme treatment were taken from the recommendation of Biocon India Ltd, Bangalore.

After the enzyme treatment, deactivation of Biosoft AS cellulase was done by raising the temperature of treatment solution above 70^o c for about 30min.

2.4 ANALYSIS:

CLOTH PROPERTIES:

(a) Fabric weight loss:

Fabric weight loss was determined as the difference in the weights of fabric before and after treatment using electronic balance.

(b) EPI/PPI/CPI/WPI:

Ends per inch , Picks per inch, Courses per inch, Wales per inch were determined in the cloth for before and after treatment condition using counting glass.

(c) Count of the yarn in the cloth:

The counts of the yarn in the treated and control cloth were analysed by using Beesley balance

(d) Tensile Strength:

Tensile strength of 100% treated and control cotton cloth of plain woven fabric and naturally coloured cotton was determined by using cloth tensile tester. The sample size was 12" in length 2" in width (12" X 2").

(e) Bursting Strength:

Bursting strength of treated and control cloth of 100% cotton single jersey, 100% cotton plain woven cloth fabric and naturally coloured cotton woven cloth was determined using Bursting strength tester.

(f) Abrasion resistance:

The abrasion resistance of woven, knitted and natural colour cotton was determined by Martindale abrasion tester by constant punchure method.

(g) Crease recovery:

The crease recovery angle was determined for woven, knitted and natural colour cotton by using crease recovery tester.

(h) Stiffness :

The stiffness tester was used to find out the bending length of woven, knitted, and natural colour cotton.

Yarn properties

(a) Linear density:

The linear density of the yarn was determined by finding out the weight of 20cm yarn using electronic balance for warp and weft in case of woven, knitted and weft incase of natural colour cotton.

(b) Twist per Inch:

The TPI of warp and weft yarn of woven cloth and single jersey cloth was determined by ATIRA type twist tester (Untwist and Retwist principle).

Fibre properties

(a) Fineness:

The fineness of the colour cotton fibre was determined by Scheffield Micronaire fineness tester

(b) Grey scale grade:

The change in colour of natural colour cotton was determined by the grey scale grade .

3. RESULTS AND DISCUSSIONS

The values for the control sample and the results of all the experiments are given in table.

3.1 INFLUENCE OF ENZYMATIC TREATMENT ON FABRIC PROPERTIES:

3.1.1 BURSTING STRENGTH

◆ SINGLE JERSEY KNITTED FABRIC:

From table(5.1) and fig(5.5) it was clear that for single jersey (30s count) cloth the enzyme treatment with 1%(owm) dosage resulted in decrease in bursting strength by 6.81%. This loss in bursting strength provided an evidence for progressive attack of enzyme on the material. Further this result was confirmed by 't' test. Annexure(I).

◆ PLAIN WOVEN FABRIC:

It is apparent from the table (5.2) and fig(5.6) that there is an increase in bursting strength by 8.61%. The increase is also in accordance with the 't' test. (Annexure(ii)).

◆ NATURAL COLOUR COTTON FABRIC:

From table(5.3) and fig(5.7) it is concluded that there was a significant increase in bursting strength by % and it is confirmed by the -t- test. Annexure(iii).

3.1.2. ABRASION RESISTANCE:

◆ SINGLE JERSEY KNITTED FABRIC

The Abrasion Resistance of the cloth was decreased by 13.73% and it was apparent from resistance of the cloth was measured by constant puncture method.

◆ PLAIN WOVEN FABRIC

The Abrasion Resistance of the cloth was increased by 11.81% table and is also confirmed by 't' test. Annexure(ii).

◆ NATURAL COLOUR COTTON FABRIC

From table (5.3) and fig (5.7) it could be seen that there was a significant decrease in the abrasion resistance cycles by 28.65% and the same is confirmed by 't' test.

3.1.3. STIFFNESS

◆ SINGLE JERSEY KNITTED FABRIC

From the fig(5.5) and table(5.1) it was apparent that the treatment had the effect on decrease in bending length. But it was significant (table-) only for course (face) and wales (back) of the sample so it was clear that the treatment increased the softness of the cloth.

◆ PLAIN WOVEN FABRIC

From table (5.2) and fig (5.6) it could be inferred that there was an increase in bending length after the enzyme treatment. The trend was also not clear from the 't' test. Annexure(ii).

◆ NATURAL COLOUR COTTON FABRIC

From table(5.3) and fig(5.7) it could be inferred that the bending length of weft face and weft back showed a significant increase by 56.65% and 25% respectively.

3.1.4. CREASE RECOVERY

◆ SINGLE JERSEY KNITTED FABRIC

From table (5.1) and fig(5.5) , it could be inferred that there was a marked reduction noticed in the crease recovery values in the coursewise direction. But the trend was not significant in case of wales direction. (Annexure(i)).

◆ PLAIN WOVEN FABRIC

The crease recovery of the cloth increased after the enzyme treatment for both warpwise direction and weftwise direction by 25.31% and 33.47% respectively table(5.2) and fig(5.6).

◆ NATURAL COLOUR COTTON FABRIC

From table(5.3) and fig(5.7) it could be inferred that enzyme treatment resulted in the increase of crease recovery value by 44.61% which is also reflected in the 't' test

3.1.5. TENSILE STRENGTH.

◆ PLAIN WOVEN FABRIC

The table(5.2) and fig(5.6) shows a significant decrease in tensile strength along warpwise and weftwise direction. The result was also confirmed by 't' test Annexure(ii).

◆ NATURAL COLOUR COTTON FABRIC

From table (5.3) and fig(5.7) it could be inferred that there is an increase in tensile strength. It is proved by the 't' test results.

3.1.6. WEIGHT/SQ.CM.

◆ SINGLE JERSEY KNITTED FABRIC

After the enzymatic treatment the extent of hydrolysis of cotton material was measured as weight loss%. With an enzyme dosage of 1%(owm), the increase in the weight/cm² of single jersey fabric was about 1.98%.(Table fig.).But there was no significance in this result in accordance with the -t- test. (Annexure(I)).

◆ PLAIN WOVEN FABRIC

The weight loss% indicates the extent of hydrolysis of cotton material. The increase in weight/cm² of the woven fabric with an enzyme dosage of 1%(own) was about 8.39%. Further this result was confirmed from the -t- test.(Annexure(ii)).

◆ NATURAL COLOUR COTTON

The effect of enzyme treatment is calculated in terms of weight loss. From table(5.3) and fig(5,7) it could be concluded that there is an increase in weight/sq.cm by 15.95%. This is confirmed by the 't' test.

3.1.7. ENDS PER INCH AND PICKS PER INCH

◆ PLAIN WOVEN FABRIC

From table(5.2) and fig(5.6) it could be inferred that there was a significant increase in Ends/inch and Picks/inch in the enzyme treated cloth. The 't' test result (Annexure(ii)) was confirmed in case of Picks/inch and trend was not clear for Ends/inch.

◆ NATURAL COLOUR COTTON

There is an increase in Ends/inch by 6.2% and Picks/inch by 120%. (Table (5.3) fig(5.7) . This is also made sure by the 't' test.

COURSE PER INCH AND WALES PER INCH

◆ SINGLE KNITTED FABRIC

From table(5.1) and fig(5.5) it could be inferred that there was pronounced increase in courses/inch and Wales/inch in the enzyme treated cloth which was also confirmed from the 't' test(Annexure(I)).

3.2. INFLUENCE OF ENZYMATIC TREATMENT ON YARN PROPERTIES

3.2.1 TWIST PER INCH

◆ SINGLE JERSEY KNITTED FABRIC

From table (5.1) and graph (5.8) it could be inferred that there was no specific change noticed in the TPI values as per the 't' test results.

◆ PLAIN WOVEN FABRIC

From the table(5.2) and fig(5.9) it could be seen that there was a deterioration for warp TPI and is confirmed by 't' test (Annexure(I)). In case of TPI of weft, there is no significant increase and the trend is not clear from 't' test

◆ NATURAL COLOUR COTTON

There is a decrease in TPI of weft by 6.93%. The 't' test also confirms this.

3.2.2. COUNT

◆ SINGLE JERSEY KNITTED FABRIC

From table(5.1) and fig(5.8) it could be inferred that there was no change at all in the count.

◆ PLAIN WOVEN FABRIC

From table(5.2) and fig(5.9) it could be seen that there is no change in count.

◆ NATURAL COLOUR COTTON

From table(5.3) and fig(5.10) it could be inferred that there was no change at all in the count for both warp and weft.

3.3 INFLUENCE OF ENZYMATIC TREATMENT ON FIBRE PROPERTIES

3.3.1 FINENESS

From the table(5.4)it could be inferred that as the temperature,time and concentration increases the fibre becomes more finer but it is not more prominent by the results of 't' test.

3.3.2 GREY SCALE GRADE

From the table (5.4) it could be found that there is a colour change as the time, temperature and concentration increases.

CONCLUSION

From the above study and discussions, we have concluded the following points.

CLOTH PROPERTIES:

(I) BURSTING STRENGTH

- (a) In case of single jersey cloth, there was a decrease in bursting strength value by 6.81%.
- (b) In case of plain woven cloth, bursting strength value had increased by 8.61%.
- (c) In case of natural colour cotton fabric, there was a significant increase in the bursting strength value.

(II) ABRASION RESISTANCE

- (a) The abrasion resistance of enzyme treated single jersey cloth had decreased by 13.73%.
- (b) The abrasion resistance of enzyme treated plain woven cloth had increased by 11.81%.
- (c) In case of natural colour cotton fabric, there was a significant decrease in the abrasion resistance cycles by 28.65%.

(III) STIFFNESS

- (a) A decrease in bending length was noted for the enzyme treated single jersey cloth.
- (b) There was an increase in bending length after enzyme treatment for woven cloth.
- (c) In case of natural colour cotton fabric, the bending length of weft face and weft back showed a significant increase by 56.65% and 25% respectively.

(IV) CREASE RECOVERY

- (a) In case of single jersey fabric, a marked reduction noticed in the crease recovery values in course wise direction but trend was not significant in walewise direction.
- (b) The crease recovery values for enzyme treated woven cloth increase for both warpwise and weftwise direction by 25.3% and 33.4%.
- (c) Enzyme treatment resulted in the increase of crease recovery value by 44.6% in case of natural colour cotton fabric.

(V) ENDS/INCH & PICKS/INCH

- (a) A pronounced increase in course/inch and wales/inch was noted for enzyme treated single jersey cloth.
- (b) In case of natural colour cotton fabric, an increase in ends/inch by 6.2% and picks/inch by 120% was noted.
- (c) In case of woven fabric, there was a significant increase in ends/inch and picks/inch after treatment.

(VI) TENSILE STRENGTH

- (a) In case of woven fabric, a significant decrease in tensile strength along warpwise and weftwise direction was noted.
- (b) In case of natural colour cotton, there was an increase in tensile strength.

(VII) GREY SCALE GRADE

- (a) For natural colour cotton fabric, the colour change in the grey scale grade was 4-5.

YARN PROPERTIES

(I) TWIST PER INCH

- (a) In case of single jersey fabric, no specific change noticed in TPI values.
- (b) In case of woven cloth, there was a deterioration for warp TPI, and trend was not clear for weft TPI.
- (c) In case of colour cotton fabric, there was a decrease in weft TPI by 6.93%.

(II) COUNT

- (a) In case of single jersey fabric there is no change in the count values.
- (b) In case of woven plain fabric there is no change in the count values.
- (c) In case of natural colour cotton fabric also there is no change at all.

TABLE(5.1)

ENZYMATIC TREATMENT ON SINGLE JERSEY CLOTH

S. No.	Properties	No. of Tests	Single Jersey	
			Control Cloth	Enzyme Treated
1.	Bursting Strength (Kgs / cm ²)	20	9.84	9.17
2.	Abrasion Resistance (Cycles)	20	162	139.75
3.	Stiffness (cm)			
	a. Course – Face	10	1.39	1.155
	b. Course - Back	10	1.855	1.775
	c. Wales – Face	10	2.16	2.10
	d. Wales – Back	10	1.78	1.305
4.	Weight / cm ² (gms)	10	0.01666	0.01699
5.	Crease recovery (Degrees)			
	a. Course	10	90	80.5
	b. Wales	10	110.1	118.2
6.	Courses / Inch	10	50.3	51.6
	Wales / Inch	10	40.3	42.3
7.	TPI	20	17.115	17.59
8.	Count (Ne)	10	30	30

TABLE(5.2)

ENZYMATIC TREATMENT ON PLAIN WOVEN CLOTH

S.No.	Properties	No. of Tests	Single Jersey	
			Control Cloth	Enzyme Treated
1.	Bursting Strength (Kgs / cm ²)	20	6.04	6.56
2.	Abrasion Resistance (Cycles)	20	84.25	94.2
3.	Stiffness (cm)			
	a. Warp – Face	10	1.975	2.01
	b. Warp - Back	10	1.775	1.955
	c. Weft – Face	10	1.81	1.915
	d. Weft – Back	10	1.77	1.89
4.	Weight / cm ² (gms)	10	0.00977	0.01059
5.	Crease recovery (Degrees)			
	a. Warp	10	72.3	90.6
	b. Weft	10	75.6	100.9
6.	Ends / Inch	10	78.1	78.4
	Picks / Inch	10	59.4	66.1
7.	TPI			
	a. Warp	20	23.57	21.78
	b. Weft	20	24.07	24.24
8.	Count (Ne)			
	a. Warp	10	39.37	39.37
	b. Weft	10	39.37	39.37
9.	Tensile Strength (Kgs / cm ²)			
	a. Warp	10	3.78	3.24
	b. Weft	10	2.88	2.36

TABLE(5.3)

ENZYMATIC TREATMENT ON NATURAL COLOUR COTTON CLOTH

S.No.	Properties	No. of Tests	Natural colour cotton - weft	
			Control Cloth	Enzyme treated
1.	Bursting strength (kg/cm ²)	10	11.34	13.39
2.	Abrasion resistance (cycles)	20	179.6	128.15
3.	Stiffness (cm)			
	a. Weft – face	10	1.73	2.71
	b. Weft – back	10	2.04	2.55
4.	Weight / cm ² (gms)	10	0.0163	0.0189
5.	Crease recovery (degrees)			
	a. Weft	10	66.8	96.6
6.	Picks / inch	10	25	55.2
7.	TPI – weft	20	16.89	15.72
8.	Count (Ne) – weft	10	10.79	10.79
9.	Tensile strength – weft way (Kgs/cm ²)	10	98.5	103.1
10.	Ends / inch	10	46.8	49.7
11.	Change in colour grey scale grade		-	4-5

NATURAL COLOR COTTON FIBRE [ENZYME TREATMENT]

I. FINENESS (μ /inch)

TABLE 5.4

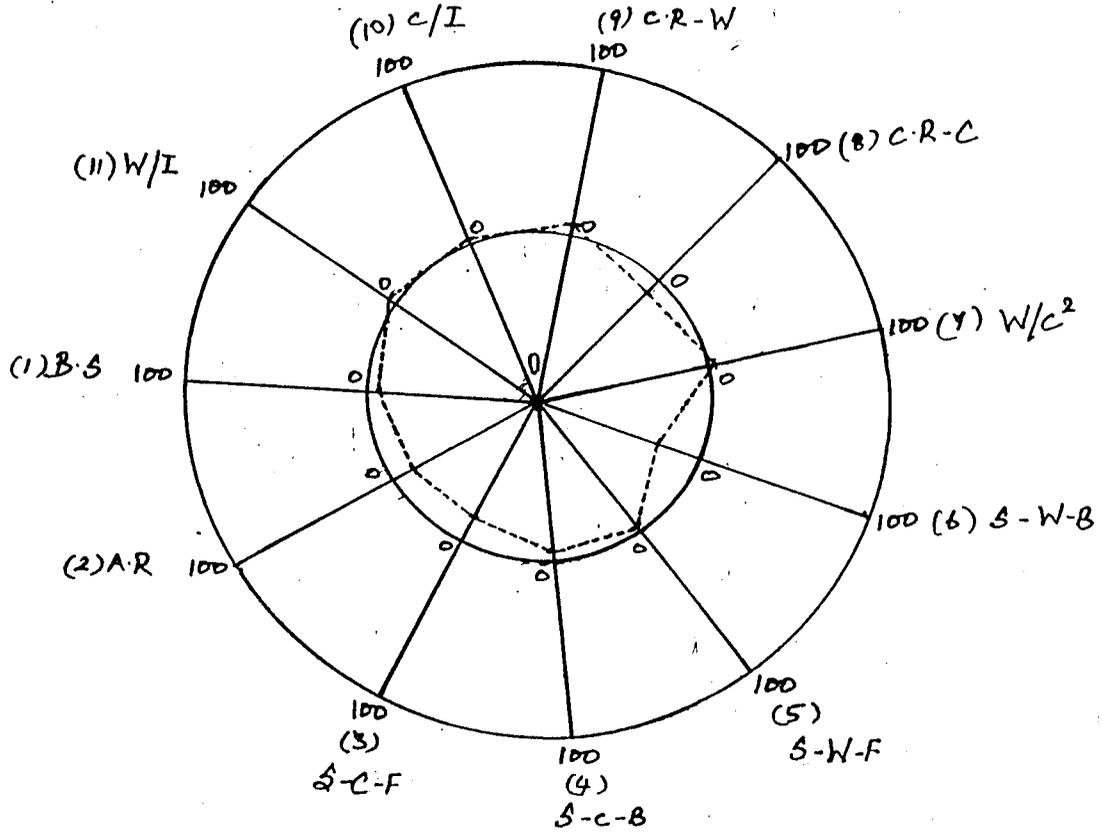
BEFORE	AFTER								
	TEMP 50° c, TIME 15 MIN			TEMP 50° , CONC 4 %			TIME 15 MIN, CONC 4 %		
	CONC. 2 %	CONC. 4 %	CONC. 6 %	TIME. 15 Min	TIME. 20 Min	TIME. 25 Min	TEMP. 50° C	TEMP. 55° C	TEMP. 60° C
3.31	3.35	3.23	3.1	3.315	3.397	3.27	3.365	3.288	3.195

NATURAL COLOR COTTON FIBRE [ENZYME TREATMENT]
II. GREY SCALE GRADE

BEFORE	AFTER					
	TEMP 50 ⁰ c, TIME 15 MIN		TEMP 50 ⁰ , CONC 4 %		TIME 15 MIN, CONC 4 %	
	CONC. 2 %	CONC. 4 %	TIME. 15 Min	TIME. 20 Min	TEMP. 50 ⁰ C	TEMP. 55 ⁰ C
3-4	3-4	4-5	5-6	4-5	5-6	4-5

FIG 5.5

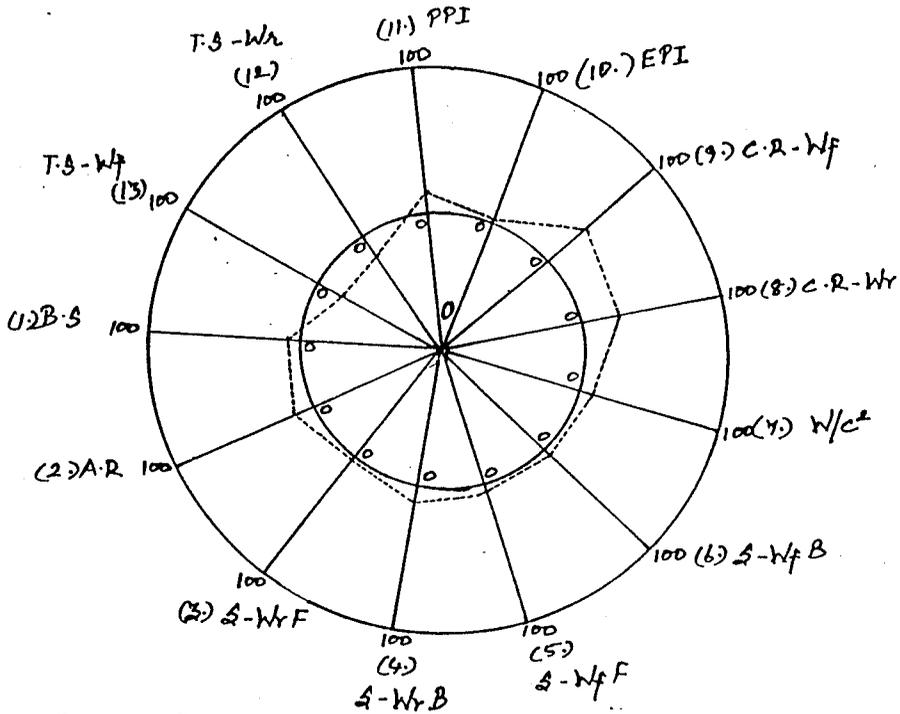
KNITTED – SINGLE JERSEY [FABRIC PROPERTIES]



- (1) B.S → BURSTING STRENGTH [Kgs/cm²]
- (2) A.R → ABRASION RESISTANCE [Cycles]
- (3) S-C-F → STIFFNESS – COURSE FACE [cm]
- (4) S-C-B → STIFFNESS – COURSE BACK [cm]
- (5) S-W-F → STIFFNESS – WALES FACE [cm]
- (6) S-W-B → STIFFNESS – WALES BACK [cm]
- (7) W/C² → WEIGHT/cm² [gms]
- (8) C.R.C → CREASE RECOVERY – COURSE [DEGREES]
- (9) C.R-W → CREASE RECOVERY – WALES [DEGREES]
- (10) C/I → COURSES / INCH
- (11) W/I → WALES / INCH

FIG 5.6

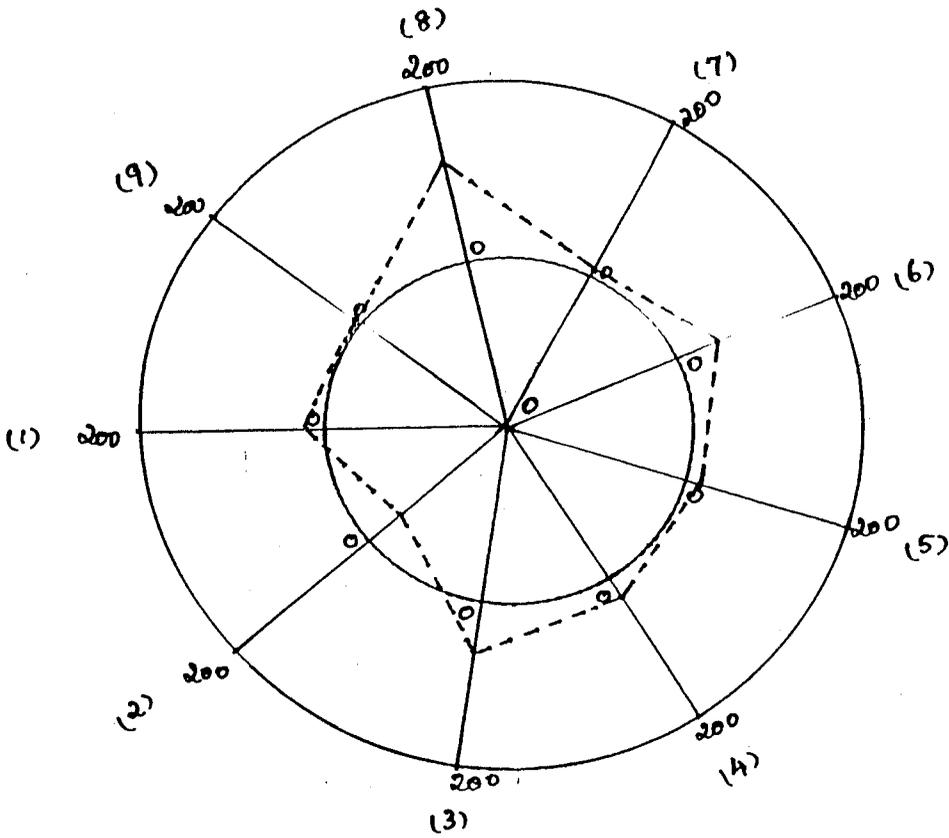
WOVEN – PLAIN WEAVE [FABRIC PROPERTIES]



- (1) B.S → BURSTING STRENGTH [Kgs/cm²]
- (2) A.R → ABRASION RESISTANCE [Cycles]
- (3) S – WrF → STIFFNESS – WARP FACE [cm]
- (4) S – WrB → STIFFNESS – WARP BACK [cm]
- (5) S – WfF → STIFFNESS – WEFT FACE [cm]
- (6) S – WfB → STIFFNESS – WEFT BACK [cm]
- (7) W/C² → WEIGHT / cm² [gms]
- (8) C.R–Wf → CREASE RECOVERY – WARP [DEGREES]
- (9) C.R–Wf → CREASE RECOVERY – WEFT [DEGREES]
- (10) EPI → ENDS / INCH
- (11) PPI → PICKS / INCH
- (12) T.S–Wf → TENSILE STRENGTH – WEFT [Kgs/cm²]
- (13) T.S–Wf → TENSILE STRENGTH – WEFT [Kgs/cm²]

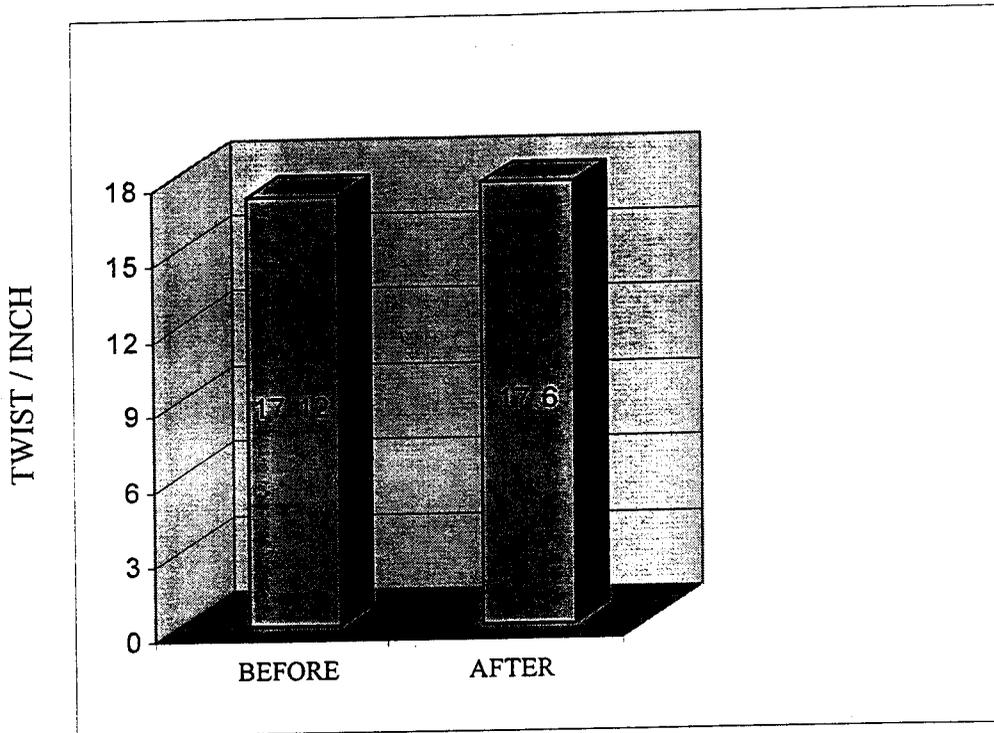
Fig 5.7

NATURAL COLOUR COTTON [FABRIC PROPERTIES]



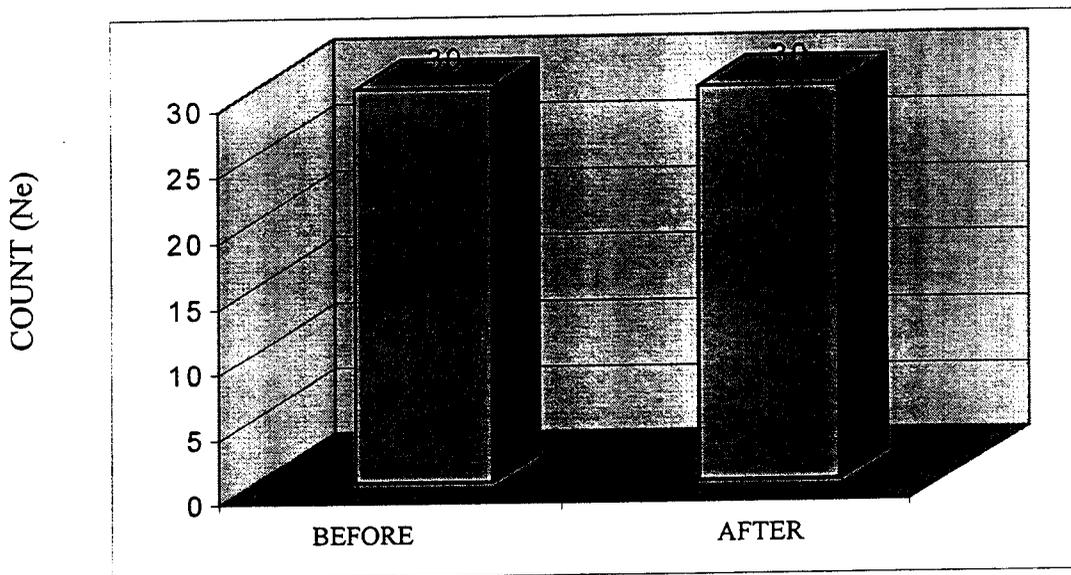
- (1) BURSTING STRENGTH
- (2) ABRASION RESISTANCE
- (3) STIFFNESS – WEFT FACE
- (4) STIFFNESS – WEFT BACK
- (5) WEIGHT / CM²
- (6) CREASE RECOVERY – WEFT
- (7) ENDS PER INCH
- (8) PICKS PER INCH
- (9) TENSILE STRENGTH – WEFT

5.8 ENZYMATIC TREATMENT ON KNITTED YARN PROPERTIES



CONC 1 %

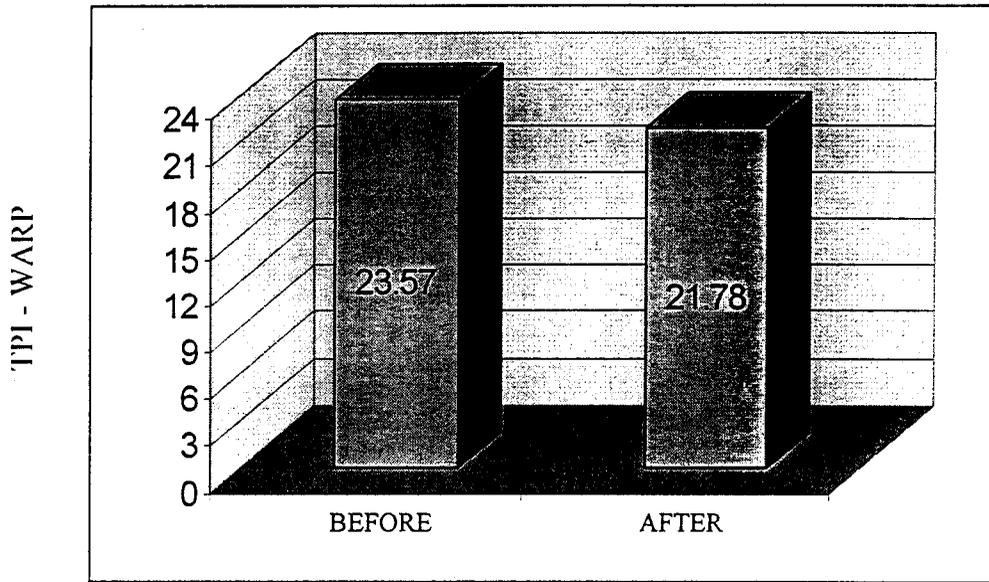
FIGURE IV EFFECT ON TPI



CONC 1 %

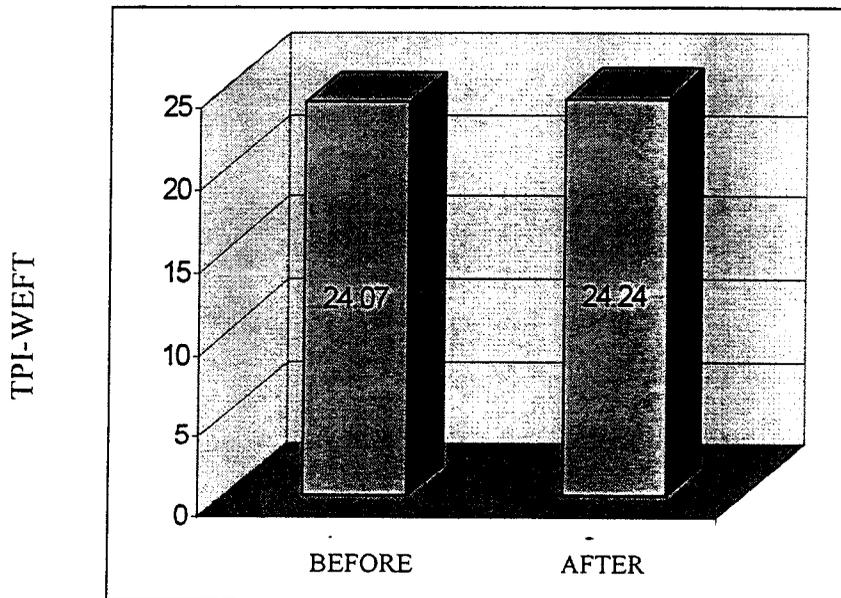
FIG V. EFFECT ON COUNT

5.9 ENZYMATIC TREATMENT ON PLAIN WOVEN YARN PROPERTIES



CONC. 1 %

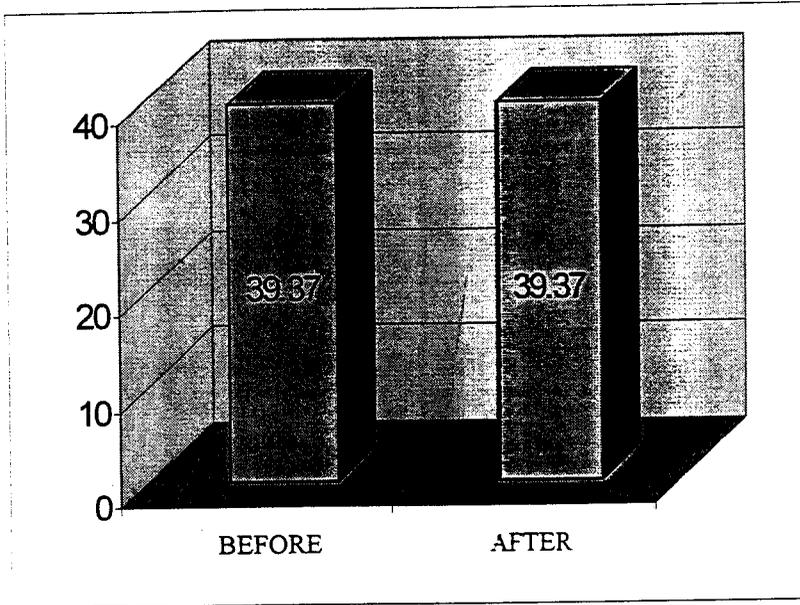
FIG VI. EFFECT ON TPI - WARP



CONC 1 %

FIG VII. EFFECT ON TPI-WEFT

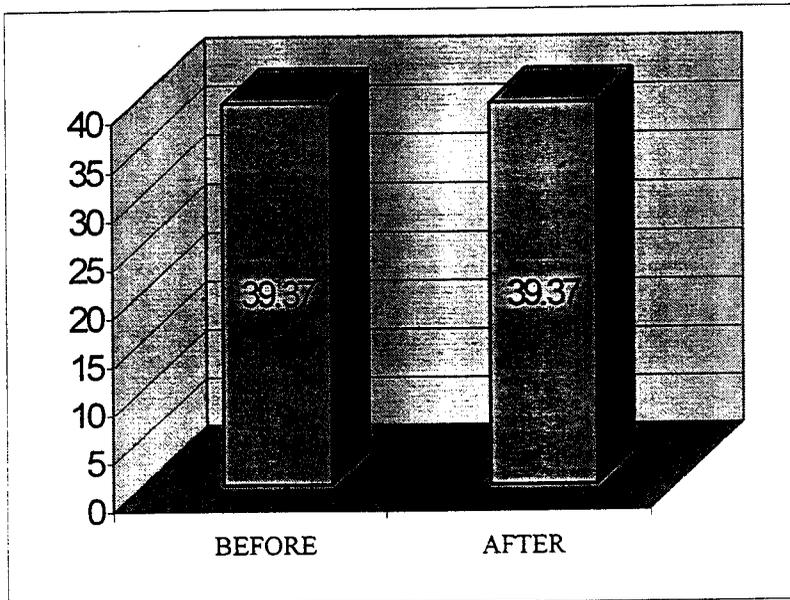
COUNT (Ne) - WARP



CONC 1 %

FIG VIII. EFFECT ON COUNT WARP

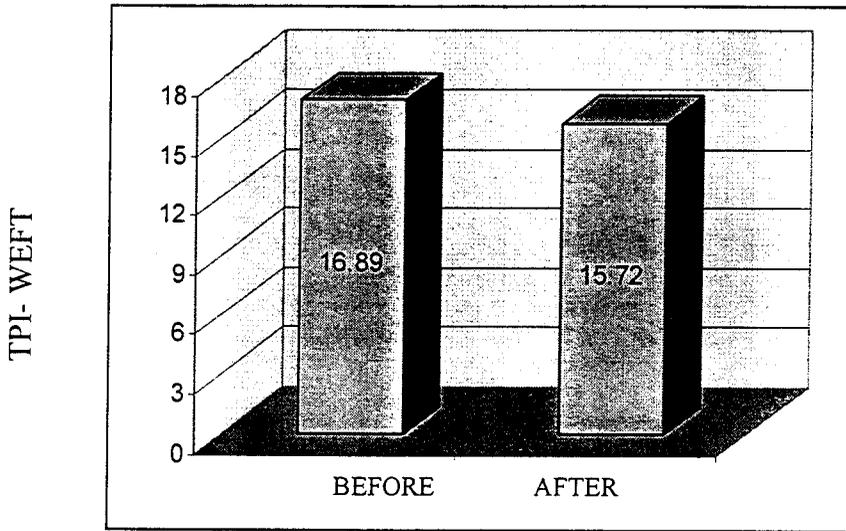
COUNT (Ne) - WEFT



CONC 1 %

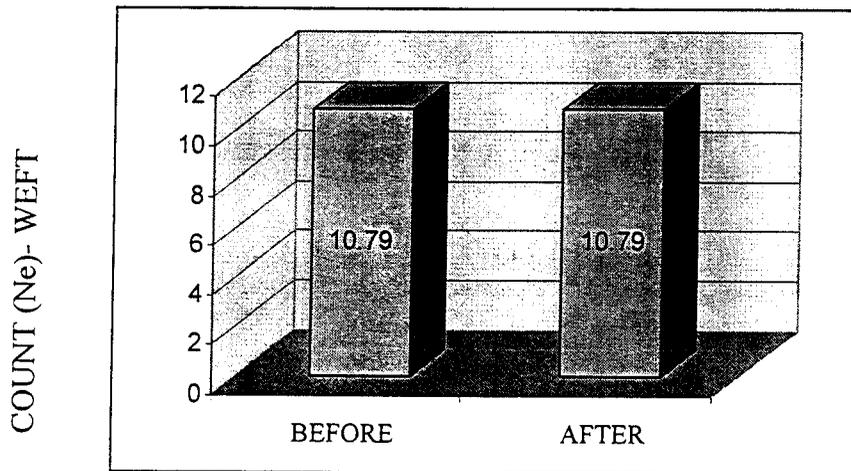
FIG IX. EFFECT ON COUNT WEFT

5.10 ENZYMATIC TREATMENT ON NATURAL COLOR COTTON YARN PROPERTIES



CONC 1 %

FIG X. EFFECT ON TPI - WEFT



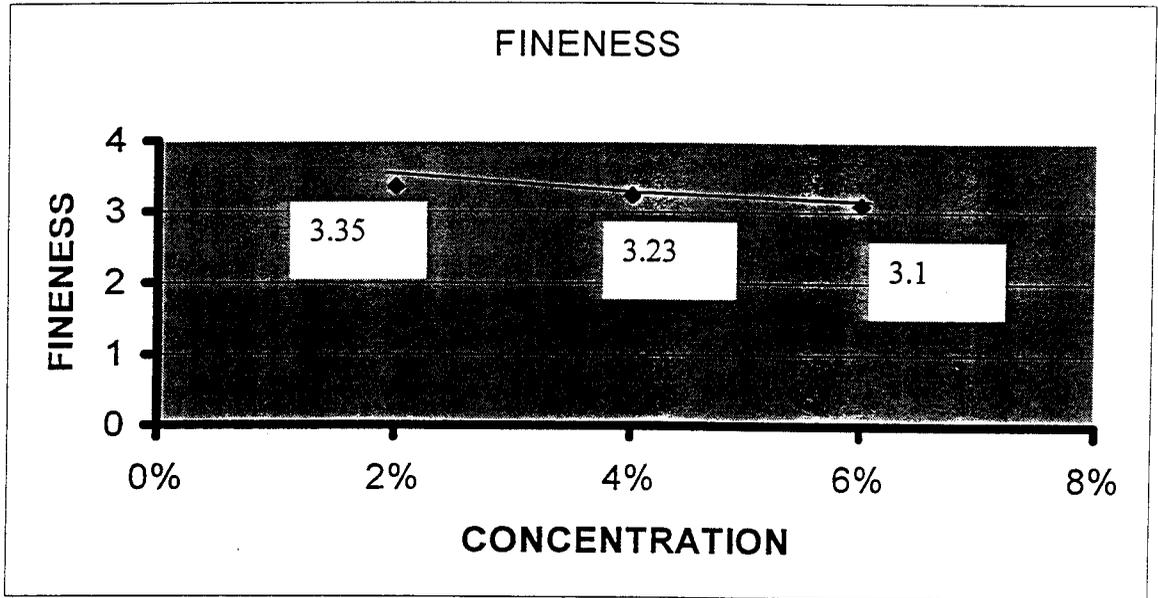
CONC 1 %

FIG. XI. EFFECT ON COUNT - WEFT

NATURAL COLOR COTTON FIBRE

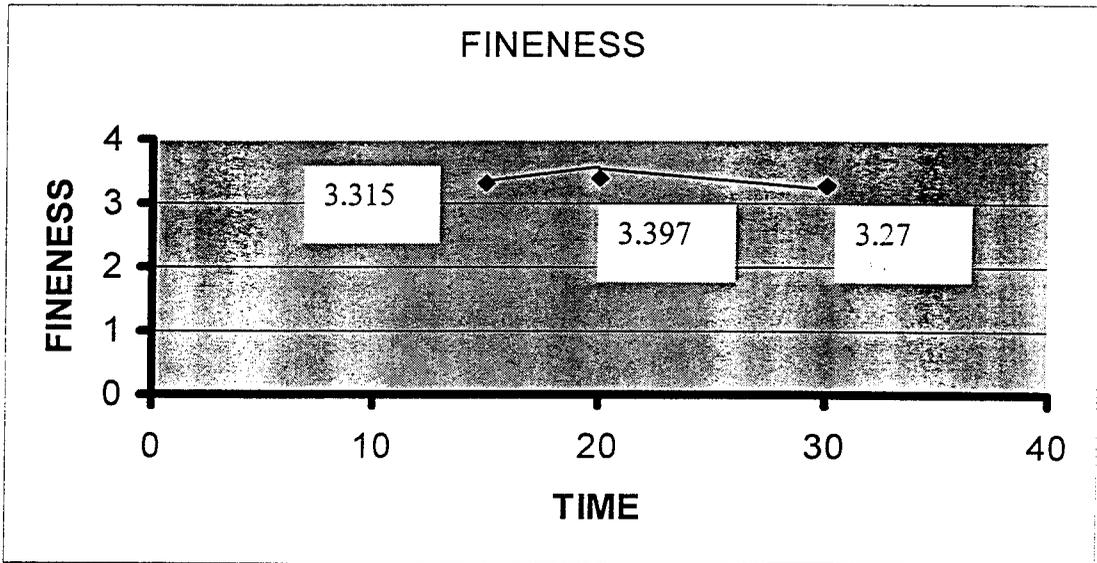
(a)

FIG. 5.11



TEMPERATURE 50° C
TIME - 15 MIN

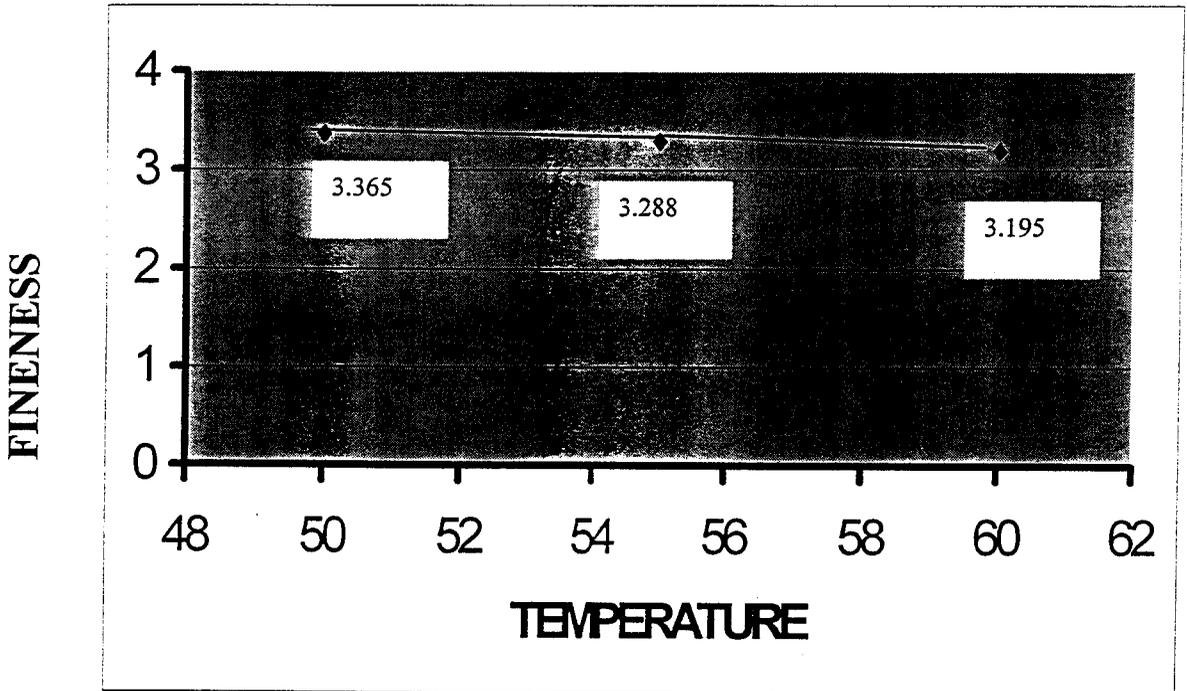
NATURAL COLOR COTTON FIBRE
(b)



TEMPERATURE 50° C
CONCENTRATION 4 %

NATURAL COLOR COTTON FIBRE

(c)



TIME 15 MIN
CONCENTRATION 4 %

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ANNEXURE(I)

ENZYMATIC TREATMENT ON SINGLE JERSEY CLOTH

S.No.	Properties	t Test Values	
		Table t (At 1% level)	Calculated t
1.	Bursting Strength (Kgs / cm ²)	2.704	5.96
2.	Abrasion Resistance (Cycles)	2.704	4.42
3.	Stiffness (cm)		
	a. Course – Face	2.878	3.434
	b. Course - Back	2.878	2.385
	c. Wales – Face	2.878	1.781
	d. Wales – Back	2.878	9.156
4.	Weight / cm ² (gms)	2.878	2.145
5.	Crease recovery (Degrees)		
	a. Course	2.878	7.72
	b. Wales	2.878	11.04
6.	Courses / Inch	2.878	5.814
	Wales / Inch	2.878	5.96
7.	TPI	2.878	2.68
8.	Count (Ne)	-	

ANNEXURE(ii)

ENZYMATIC TREATMENT ON PLAIN WOVEN CLOTH

S.No.	Properties	t Test Values	
		Table t (At 1% level)	Calculated t
1.	Bursting Strength (Kgs / cm ²)	2.704	3.809
2.	Abrasion Resistance (Cycles)	2.704	3.76
3.	Stiffness (cm)		
	a. Warp – Face	2.878	0.647
	b. Warp - Back	2.878	2.354
	c. Weft – Face	2.878	3.979
	d. Weft – Back	2.878	4.47
4.	Weight / cm ² (gms)	2.878	5.35
5.	Crease recovery (Degrees)		
	a. Warp	2.878	23.12
	b. Weft	2.878	65.85
6.	Ends / Inch	2.878	0.545
	Picks / Inch	2.878	15.29
7.	TPI		
	a. Warp	2.704	5.878
	b. Weft	2.704	0.525
8.	Count (Ne)		
	a. Warp	-	-
	b. Weft	-	-
9.	Tensile Strength (Kgs / cm ²)		
	a. Warp	2.878	2.92
	b. Weft	2.878	6.23

ANNEXURE(iii)

ENZYMATIC TREATMENT ON NATURAL COLOUR COTTON CLOTH

S.No.	Properties	t test values	
		Table t (At 1% level)	Calculated t
1.	Bursting strength (Kgs/cm ²)	2.878	6.34
2.	Abrasion resistance (Cycles)	2.704	43.97
3.	Stiffness (cm)		
	a. Weft – face	3.355	8.155
	b. Weft – back	3.355	3.49
4.	Weight / cm ² (gms)	2.878	12.61
5.	Crease recovery (Degrees)		
	a. Weft	2.878	20.5
6.	Ends / Inch	2.878	5.07
	Picks / Inch	2.878	84.41
7.	TPI – Weft	2.704	9.14
8.	Tensile str. – weft (Kgs/cm ²)	2.878	4.51

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