# *Results and Discussion*

# 4. RESULTS AND DISCUSSION

The results of the study are discussed under the following headings:

**4.1. Industrial Survey**

**4.2. Optimization of Enzymes used for Bio Pretreatment**

**4.3. Visual Assessment**

**4.4. Laboratory Tests**

**4.5. Techno Economic Study**

## 4.1. INDUSTRIAL SURVEY

The primary aim of the industrial survey was to gather authentic information about the fibres, yarns and fabric structures commonly used in the knitting industries, the pretreatment procedures followed, the value addition processes like dyeing and finishing that were commonly chosen by the buyers who placed orders based on the preferences of the customers. The industrial survey included the following features:

### Details of the Industries Surveyed

Of the two hundred industries surveyed, 34% were small scale industries, 45% were medium scale industries and 21% were large scale industries. The categorization of the industries were based on the fixed assets in terms of plant and machinery as specified by the Small Industries Development Bank of India - http://www.financialexpress.com. A majority of the industries (95%) had a business experience of five years and above.

### Operations Undertaken by the Industries

About 36% of the industries surveyed specialized in knitting, processing and apparel manufacture whereas 24% undertook knitting and processing. Only 21% of the industries surveyed undertook yarn manufacture, knitting, processing and apparel manufacture, while 19% had industrial outlets especially for wet processing

### Fabrics Mostly Preferred by Customers

Cotton was the first choice by 100% of the industries followed by lycra cotton 87% and polyester cotton as third choice by 67% of the industries surveyed. Figure 1 shows the fabrics preferred by the customers.

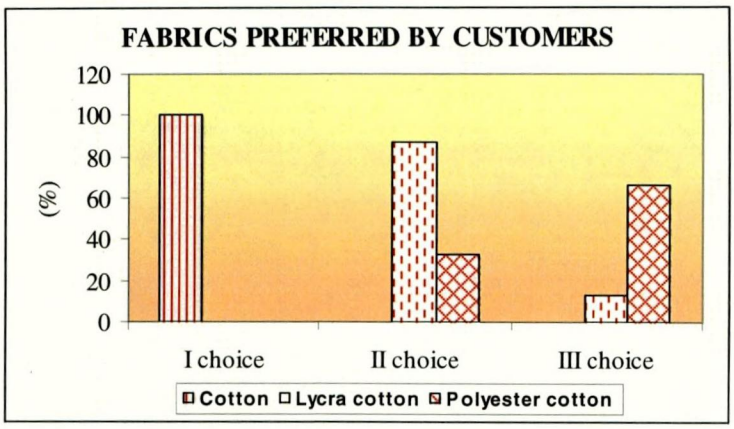



**FIGURE 1**

**Fibers, Yarn Type and Yarn Numbers commonly used by the Industries**

Details regarding fibers, yarn type and yarn numbers commonly used by the industries is given in Table XIII. From the Table XIII, it is clear that, shankar 6 (51%) stood first due to its characteristics in producing good quality yarn followed by Russian imported cotton (23%), blended cotton (14%), MCU 5 variety 7% and Mech Cotton 5%.

**TABLE XIII**

**FIBRES, YARN TYPES AND YARN NUMBERS COMMONLY USED BY THE INDUSTRIES**

| 1. | Cotton Fibres | Number | % | 3. | Cotton :Yarn Number | Number | % |
|---|---|---|---|---|---|---|---|
| | **Shankar 6** | **102** | **51** | | **30 Ne** | **154** | **77** |
| | Russian Cotton | 46 | 23 | | 20 Ne | 24 | 12 |
| | Blended cotton | 28 | 14 | | 40 Ne | 22 | 11 |
| | MCU 5 Cotton | 14 | 7 | | | | |
| | Mech Cotton | 10 | 5 | | | | |
| **2.** | **Cotton Yarn Types** | **Number** | **%** | **4.** | **Lycra : Denier** | **Number** | **%** |
| | Combed | **80** | **40** | | 40 Ne | **92** | **46** |
| | Carded | 64 | 32 | | 30 Ne | 62 | 31 |
| | Semi Combed | 30 | 15 | | 20 Ne | 34 | 17 |
| | Super Combed | 26 | 13 | | 50 Ne | 10 | 5 |

- As for yarn, 30 Ne combed was frequently used but where economics were considered 30 Ne carded was used.
- The lycra denier commonly used to produce lycra cotton knits, was 40 Ne by 46% industries.

**Type of Knitting and Structures Knitted**

- Weft knitting was very popular (89%)when compared to warp knitting (11%) and among the weft knitted structures, single jersey 45%, 1x1 rib 27% followed by interlock 16% and pique 12%.

**Wet Processing Methods Undertaken by the Industries**

- Cent percent of the industries used chemical pretreatment with four step after treatment as they did not want any rejection of orders and problems.
- Commonly used dyes were reactive hot brand (95 %) since colour fastness was good and this was followed by direct dyes (5 %)
- Enzymes were used by 100% of the industries only for bio polishing as it was specified by the overseas buyer. Bio washing was carried out by 25 % of the industries as the other manufacturers were relying on stone washing.

**Effluent Particulars and Pollution Control**

- Effluent generated was 80,000 to 3,00,000 litres per day by 45% of the surveyed industries; 50,000 to 80,000 litres per day by 34% industries and above 3,00,000 litres per day by 21% of the surveyed industries.
- With regard to effluent treatment methods, about 50% of the industries were using chemical flocculation methods, while 40% were using reverse osmosis and the remaining 10% were following combination methods to recycle both water and salt. However the State Government was formulating rules for the use of reverse osmosis effluent treatment shortly. Hence the industries had to be prepared to equip themselves to reach the standards prescribed by the government. None of the industries opted for biological treatments as they were of the opinion that the conditions for the growth of the micro organisms were difficult to maintain in Tirupur.
- The recycled water was used by 48% industries for gardening, 32% for boiler (steam generation) and 20% used the treated water for processing.
- Cent per cent of the industries were aware of the norms prescribed by the Pollution Control Board PCB and the ultimate aim of a processor was Zero Discharge
- Cent per cent of the industries conducted daily checks on inlet water before using it for processing. In the case of check on effluent water, 48% conducted weekly checks, 23% fortnightly,19% checked on daily basis, and 10% conducted a monthly check.

**Enzyme Usage**

- Regarding usage of enzymes in processing, 65% industries did not want any change in existing conditions, 20% of the industries wanted to try alternatives for chemicals namely enzymes or follow clean technologies, 15% were interested in special machinery that could be profitable as well as environment friendly.

- **Advantages and Disadvantages of Using Enzymes**

  The Table XIV shows the advantages and disadvantages of using enzymes in wet processing as stated by the industries surveyed.

**TABLE XIV**

**OPINION OF ENZYME USAGE IN WET PROCESSING**

| ADVANTAGES OF USING ENZYMES IN PROCESSING | | | DISADVANTAGES OF USING ENZYMES IN PROCESSING | | |
|---|---|---|---|---|---|
| **Particulars** | **No.** | **%** | **Particulars** | **No.** | **%** |
| Eco friendly | 110 | 55 | Very Expensive | 84 | 42 |
| Degradation of environment avoided | 42 | 21 | Performance of the enzyme to reach the required end product | 38 | 19 |
| Human friendly | 26 | 13 | Shelf life and maintenance of conditions for storage of enzymes | 30 | 15 |
| Mild Working conditions | 14 | 7 | Difficulty in maintaining specific conditions required to activate the enzymes | 26 | 13 |
| Saves time and energy | 8 | 4 | Lack of knowledge to check enzyme activity | 14 | 7 |
| | | | Training of all levels of industry personnel | 8 | 4 |

- From Table XIV it is clear that, 55 per cent of the industries surveyed were of the opinion that enzymes were eco friendly whereas 21% opted for enzymes as a method to control environment degradation.

- About 42% of the industries felt that enzymes were very expensive whereas 19% were doubtful about enzyme process output.

## TABLE XV

## TREATMENT CONDITIONS AND RESPONSE OBSERVED AND CALCULATED AFTER BIOSCOURING WITH PECTATE LYASE ENZYME – 100% COTTON

| Sample | Coded Levels | | | Variables | | | Weight Loss | | Absorbency | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pH | Enz. Conc | Temp. | Calculated value | Observed value | Predicted value | Observed value |
| 1 | 1 | 0 | 1 | 9 | 0.4 | 65 | 3.337 | 3.49 | 5.375 | 5 |
| 2 | 1 | 1 | 0 | 9 | 0.5 | 55 | 3.132 | 3.17 | 7 | 8 |
| 3 | -1 | 1 | 0 | 8 | 0.5 | 55 | 3.067 | 3.54 | 5.75 | 6 |
| 4 | 0 | -1 | 1 | 8.5 | 0.3 | 65 | 3.11 | 3.43 | 4.375 | 5 |
| 5 | 0 | 1 | -1 | 8.5 | 0.5 | 45 | 3.28 | 2.96 | 7.625 | 7 |
| 6 | 1 | 0 | -1 | 9 | 0.4 | 45 | 2.727 | 3.01 | 8.375 | 8 |
| 7 | -1 | 0 | 1 | 8 | 0.4 | 65 | 2.872 | 2.59 | 5.625 | 6 |
| 8 | 0 | 0 | 0 | 8.5 | 0.4 | 55 | 2.173 | 2.17 | 3 | 3 |
| 9 | 0 | 1 | 1 | 8.5 | 0.5 | 65 | 3.44 | 3.25 | 4.625 | 4 |
| 10 | 1 | -1 | 0 | 9 | 0.3 | 55 | 2.752 | 2.28 | 5.25 | 5 |
| 11 | -1 | 0 | -1 | 8 | 0.4 | 45 | 2.732 | 2.58 | 8.625 | 9 |
| 12 | 0 | -1 | -1 | 8.5 | 0.3 | 45 | 2.52 | 2.71 | 7.375 | 8 |
| 13 | -1 | -1 | 0 | 8 | 0.3 | 55 | 2.357 | 2.32 | 7 | 6 |
| 14 | 0 | 0 | 0 | 8.5 | 0.4 | 55 | 2.173 | 2.18 | 3 | 3 |
| 15 | 0 | 0 | 0 | 8.5 | 0.4 | 55 | 2.173 | 2.17 | 3 | 3 |

The correlation coefficient between the observed value and the calculated values obtained from the above equations for weight loss and absorbency are 0.861 and 0.960 respectively. The goodness of fit of the model for weight loss and absorbency was 85.2% and 92.3% respectively. The F value of 5.37 for weight loss and 6.63 for absorbency, show

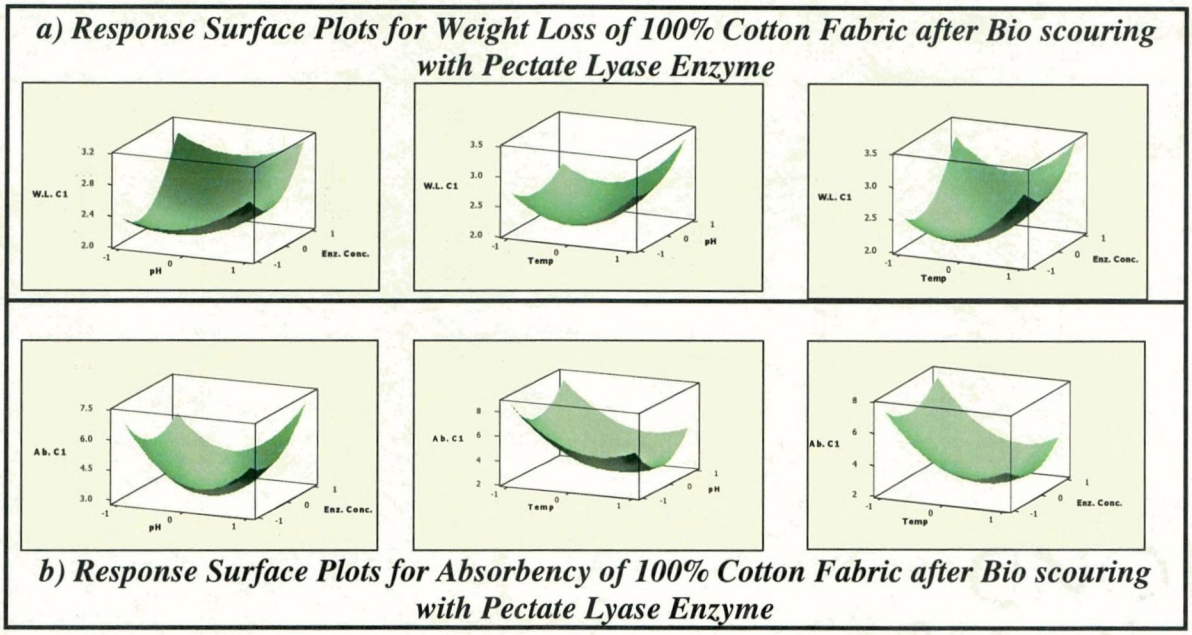
that the effect of all the parameters taken together was significant at 5% level. These values show that the observed values are in agreement with the response surface equation.

**Weight Loss**

In Figure 2, the surface plots for weight loss reveal that the weight loss was slightly higher when the pH and temperature were at the -1 level whereas the weight loss was very high when the pH and temperature were at the +1 level. The weight loss was marginally high when the enzyme concentration was decreased and very high when the enzyme concentration was increased. Suman and Khambra (2007), state that the weight loss increased with the increase of enzyme concentration and time. The lowest weight loss was seen at the 0 level in all the three surface plots.

**Absorbency**

It is noticed in Figure 2, that the absorbency time was high when the pH and enzyme concentration was increased or decreased. When the temperature was decreased to -1 level the absorbency time was relatively high indicating that the enzyme was not fully active resulting in inefficient scouring. When the temperature was increased to +1 level the time was comparatively lower than the previous condition but still higher than the 0 level. The lowest time for absorption was found at the 0 level in all the three surface plots.




***a) Response Surface Plots for Weight Loss of 100% Cotton Fabric after Bio scouring with Pectate Lyase Enzyme***

***b) Response Surface Plots for Absorbency of 100% Cotton Fabric after Bio scouring with Pectate Lyase Enzyme***

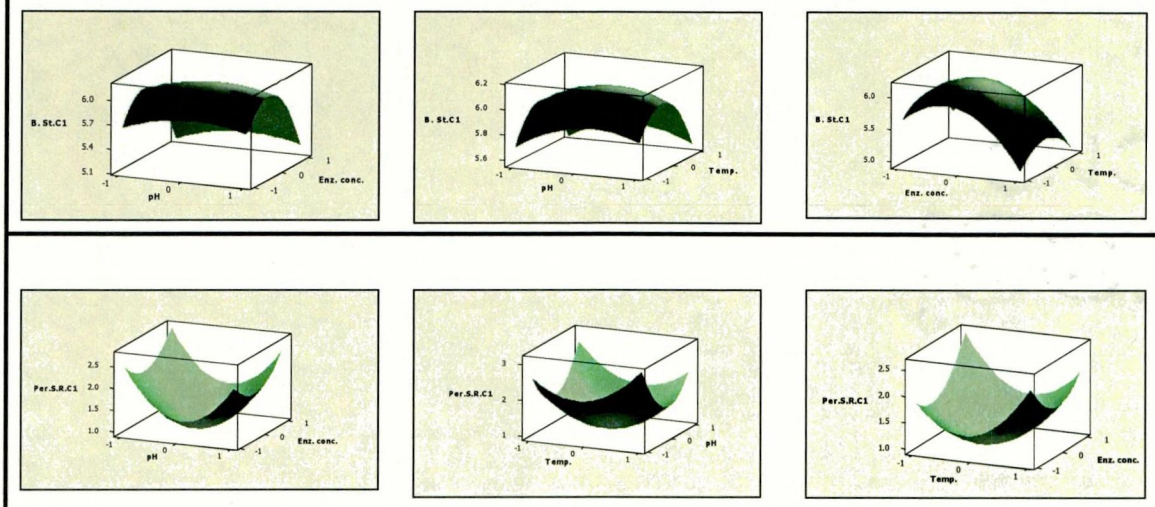
**FIGURE 2**

The correlation coefficient between the observed value and the calculated values obtained from the above equations are 0.969 and 0.889 respectively. The goodness of fit of the model for bursting strength and peroxide scale rating was 94% and 89.2% respectively.

**TABLE XVI**
**TREATMENT CONDITIONS AND RESPONSE OBSERVED AND CALCULATED AFTER APPLICATION OF CATALASE ENZYME – 100% COTTON**

| Sample | Coded Levels | | | Variables | | | Bursting Strength | | Peroxide Scale Rating | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pH | Enz. conc | Temp. | Calculated Value | Observed Value | Predicted Value | Observed value |
| 1 | -1 | 0 | -1 | 5.5 | 0.1 | 40 | 5.7 | 5.6 | 2.625 | 3 |
| 2 | 0 | 1 | 1 | 6 | 0.15 | 60 | 4.962 | 5 | 2.125 | 2 |
| 3 | 1 | 0 | 1 | 6.5 | 0.1 | 60 | 5.6 | 5.7 | 2.375 | 2 |
| 4 | 1 | 1 | 0 | 6.5 | 0.15 | 50 | 5.237 | 5.1 | 2.5 | 3 |
| 5 | 0 | 0 | 0 | 6 | 0.1 | 50 | 6.133 | 6.1 | 1 | 1 |
| 6 | 0 | 0 | 0 | 6 | 0.1 | 50 | 6.133 | 6.1 | 1 | 1 |
| 7 | 0 | -1 | -1 | 6 | 0.05 | 40 | 5.637 | 5.6 | 1.875 | 2 |
| 8 | 1 | 0 | -1 | 6.5 | 0.1 | 40 | 5.825 | 5.8 | 2.875 | 3 |
| 9 | 0 | 1 | -1 | 6 | 0.15 | 40 | 5.037 | 5.2 | 2.625 | 2 |
| 10 | -1 | 1 | 0 | 5.5 | 0.15 | 50 | 5.162 | 5.1 | 2.75 | 3 |
| 11 | 0 | 0 | 0 | 6 | 0.1 | 50 | 6.133 | 6.2 | 1 | 1 |
| 12 | 0 | -1 | 1 | 6 | 0.05 | 60 | 5.362 | 5.2 | 2.375 | 3 |
| 13 | -1 | -1 | 0 | 5.5 | 0.05 | 50 | 5.662 | 5.8 | 2.5 | 2 |
| 14 | 1 | -1 | 0 | 6.5 | 0.05 | 50 | 5.737 | 5.8 | 2.25 | 2 |
| 15 | -1 | 0 | 1 | 5.5 | 0.1 | 60 | 5.575 | 5.6 | 3.125 | 3 |

*a) Response Surface Plots for Bursting Strength of 100% Cotton Fabric after Catalase Enzyme Treatment*







*b) Response Surface Plots for Peroxide Scale Rating of 100% Cotton Fabric after Catalase Enzyme Treatment*

**FIGURE 3**

The F value of 8.77 for bursting strength and 4.17 for peroxide scale rating show that the effect of all the parameters taken together was significant at 5% level. These values show that the observed values are in agreement with the response surface equation.

**Bursting Strength**

All the three surface plots in Figure 3, indicate that bursting strength was high at the level 0 which was pH 6, temperature 50 and enzyme concentration 0.1% owf. It was noticed that the when the pH and the temperature were away from the optimum, there was a decrease in bursting strength. This can be attributed to the fact that enzymes give best results at the right pH, temperature and enzyme concentration. It was also found that the lowest bursting strength was noticed when the enzyme concentration increased. Hazare (2006) explains that the catalase enzyme is a highly efficient enzyme which converts five million molecules of hydrogen peroxide to water and oxygen with one enzyme molecule, in one minute.

**Peroxide Scale Rating**

The lowest values in the peroxide scale rating indicated absence of hydrogen peroxide in the bath. In Figure 3, the three surface plots highlight the same trend as in bursting strength. The scale rating was found to be higher at the extreme ends of all the three surface plots showing that the activity of the catalase enzyme was affected by the changes in temperature and pH rendering it inactive resulting in high scale readings.

**Statistical Analysis**

Table XVII shows the observed and predicted results of bio polishing of cotton weft knits with acid cellulase enzyme. The response surface equations for weight loss and pilling scale rating are given below:

$$\text{Weight Loss} = (4.51667) + (0.02\ X_1) + (0.2\ X_2) + (0.2\ X_3) + (0.15667\ X_1\ X_1) + (0.19667\ X_2\ X_2) + (0.23667\ X_3\ X_3) + (-0.08\ X_1\ X_2) + (-0.04\ X_1\ X_3) + (0.08\ X_2\ X_3)$$

$$\text{Pilling Scale Rating} = (5) + (0.125X_1) + (0.625X_2) + (0.25\ X_3) + (-0.625X_1X_1) + (-1.625X_2X_2) + (-0.875\ X_3X_3) + (0.25\ X_1X_2) + (0\ X_1X_3) + (0\ X_2X_3)$$

**TABLE XVII**

**TREATMENT CONDITIONS AND RESPONSE OBSERVED AND CALCULATED AFTER APPLICATION OF ACID CELLULASE ENZYME – 100% COTTON**

| Sample | Coded Levels | | | Variables | | | Weight Loss | | Pilling Scale Rating | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pH | Enz. conc | Temp. | Calculated value | Observed value | Predicted value | Observed value |
| 1 | 0 | 1 | -1 | 4.5 | 1.5 | 40 | 4.87 | 5.11 | 2.88 | 3 |
| 2 | -1 | 0 | -1 | 4 | 1 | 40 | 4.65 | 4.79 | 3.13 | 3 |
| 3 | 1 | 0 | 1 | 5 | 1 | 60 | 5.09 | 4.95 | 3.88 | 4 |
| 4 | -1 | -1 | 0 | 4 | 0.5 | 50 | 4.57 | 4.63 | 2.25 | 2 |
| 5 | -1 | 0 | 1 | 4 | 1 | 60 | 5.13 | 4.95 | 3.63 | 4 |
| 6 | 1 | 0 | -1 | 5 | 1 | 40 | 4.77 | 4.95 | 3.38 | 3 |
| 7 | 0 | -1 | 1 | 4.5 | 0.5 | 60 | 4.87 | 4.63 | 2.13 | 2 |
| 8 | 0 | 0 | 0 | 4.5 | 1 | 50 | 4.52 | 4.55 | 5 | 5 |
| 9 | 0 | 1 | 1 | 4.5 | 1.5 | 60 | 5.43 | 5.27 | 3.38 | 3 |
| 10 | 0 | -1 | -1 | 4.5 | 0.5 | 40 | 4.63 | 4.79 | 1.63 | 2 |
| 11 | -1 | 1 | 0 | 4 | 1.5 | 50 | 5.13 | 5.11 | 3 | 3 |
| 12 | 0 | 0 | 0 | 4.5 | 1 | 50 | 4.52 | 4.49 | 5 | 5 |
| 13 | 0 | 0 | 0 | 4.5 | 1 | 50 | 4.52 | 4.51 | 5 | 5 |
| 14 | 1 | 1 | 0 | 5 | 1.5 | 50 | 5.01 | 4.95 | 3.75 | 4 |
| 15 | 1 | -1 | 0 | 5 | 0.5 | 50 | 4.77 | 4.79 | 2 | 2 |

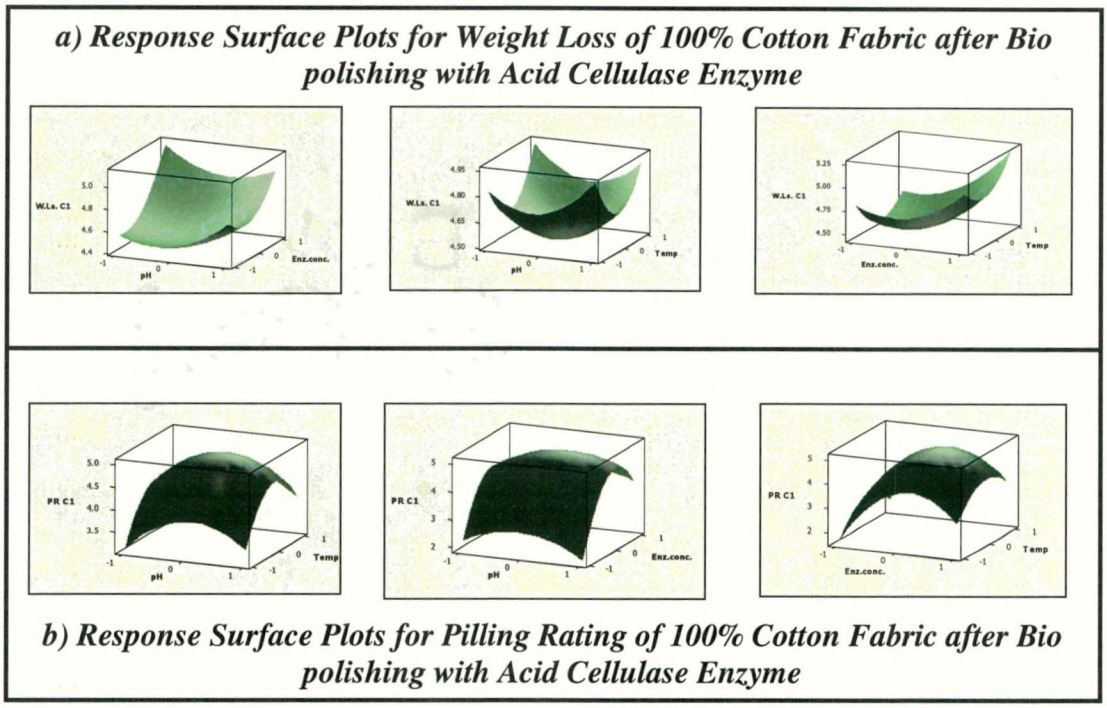
The correlation coefficient between the observed value and the calculated values obtained from the above equations are 0.986 and 0.978 respectively. The goodness of fit of the model for weight loss and pilling scale rating was 97.3% and 95.7% respectively. The F value of 20.26 for weight loss and 12.28 for pilling scale rating show that the effect of all the parameters taken together was significant at 1% level. These values show that the observed values are in agreement with the response surface equation.

## Weight Loss

From Figure 4, it can be noted that the weight loss increased substantially with increase in enzyme concentration. Achwal (2003), states that cellulase catalyses the hydrolytic cleavage of the cellulosic chains producing soluble products leading to weight loss. Since enzymes are target specific and accelerate the reaction, the increase in concentration attacks the primary wall of the cellulose resulting in increased weight loss. When the pH was lowered the weight loss was marginally high but maximum weight loss was observed at increased pH. The weight loss was high when there was an increase or decrease in temperature.

## Pilling Scale Rating

The three surface plots in Figure 4, reveal that a lowered scale rating was observed when there was a decrease or increase in pH and temperature When the enzyme concentration was decreased a drastic lowering of scale rating was noticed which proved that the enzyme concentration was not sufficient to carry out the reaction leading to lower rating in the pilling scale. The highest scale rating was observed at the 0 level in all the three variables pH, enzyme concentration and temperature.




*a) Response Surface Plots for Weight Loss of 100% Cotton Fabric after Bio polishing with Acid Cellulase Enzyme*

*b) Response Surface Plots for Pilling Rating of 100% Cotton Fabric after Bio polishing with Acid Cellulase Enzyme*

**FIGURE 4**

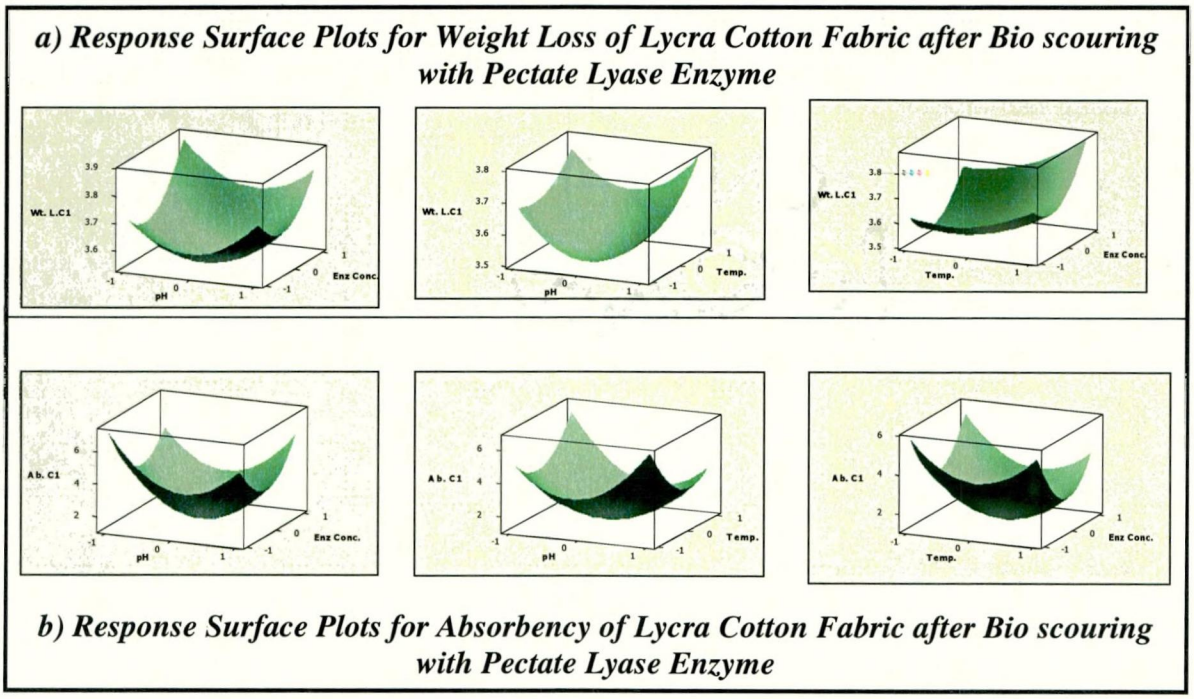
## TABLE XVIII

## TREATMENT CONDITIONS AND RESPONSE OBSERVED AND CALCULATED AFTER BIOSCOURING WITH PECTATE LYASE ENZYME – LYCRA COTTON

| Sample | Coded Levels | | | Variables | | | Weight Loss | | Absorbency | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pH | Enz. conc | Temp. | Calculated value | Observed value | Predicted value | Observed value |
| 1 | 0 | 0 | 0 | 8.5 | 0.4 | 55 | 3.553 | 3.55 | 1.333 | 1 |
| 2 | 0 | 0 | 0 | 8.5 | 0.4 | 55 | 3.553 | 3.55 | 1.333 | 1 |
| 3 | 0 | 1 | 1 | 8.5 | 0.5 | 65 | 4.431 | 3.86 | 4.25 | 4 |
| 4 | 1 | 1 | 0 | 9 | 0.5 | 55 | 4.186 | 3.82 | 5.875 | 6 |
| 5 | 1 | 0 | 1 | 9 | 0.4 | 65 | 3.795 | 3.81 | 3.875 | 4 |
| 6 | 0 | 1 | -1 | 8.5 | 0.5 | 45 | 4.264 | 3.72 | 5.5 | 5 |
| 7 | 0 | 0 | 0 | 8.5 | 0.4 | 55 | 3.553 | 3.56 | 1.333 | 2 |
| 8 | -1 | 0 | -1 | 8 | 0.4 | 45 | 3.685 | 3.67 | 5.125 | 5 |
| 9 | 0 | -1 | -1 | 8.5 | 0.3 | 45 | 3.059 | 3.63 | 5.75 | 6 |
| 10 | -1 | 1 | 0 | 8 | 0.5 | 55 | 4.649 | 3.88 | 5.375 | 6 |
| 11 | 0 | -1 | 1 | 8.5 | 0.3 | 65 | 3.136 | 3.68 | 5.5 | 6 |
| 12 | 1 | 0 | -1 | 9 | 0.4 | 45 | 3.632 | 3.62 | 6.625 | 7 |
| 13 | -1 | -1 | 0 | 8 | 0.3 | 55 | 2.949 | 3.72 | 7.125 | 7 |
| 14 | 1 | -1 | 0 | 9 | 0.3 | 55 | 3.386 | 3.75 | 5.625 | 5 |
| 15 | -1 | 0 | 1 | 8 | 0.4 | 65 | 3.767 | 3.78 | 6.375 | 6 |

The correlation coefficient between the observed value and the calculated values obtained from the above equations for weight loss and absorbency are 0.994 and 0.977 respectively. The goodness of fit of the model for Weight Loss and Absorbency was 99.0% and 95.6% respectively. The F value of 52.39 for weight loss and 12.07 for absorbency,

show that the effect of all the parameters taken together was significant at 1% level. These values show that the observed values are in agreement with the response surface equation.




*a) Response Surface Plots for Weight Loss of Lycra Cotton Fabric after Bio scouring with Pectate Lyase Enzyme*

*b) Response Surface Plots for Absorbency of Lycra Cotton Fabric after Bio scouring with Pectate Lyase Enzyme*

**FIGURE 5**

**Weight Loss**

From the surface plots in Figure 5, it can be observed that when the pH and temperature were decreased the weight loss was marginally high. When both these parameters were increased the weight loss was very high. The same trend was observed with the variable enzyme concentration.

**Absorbency**

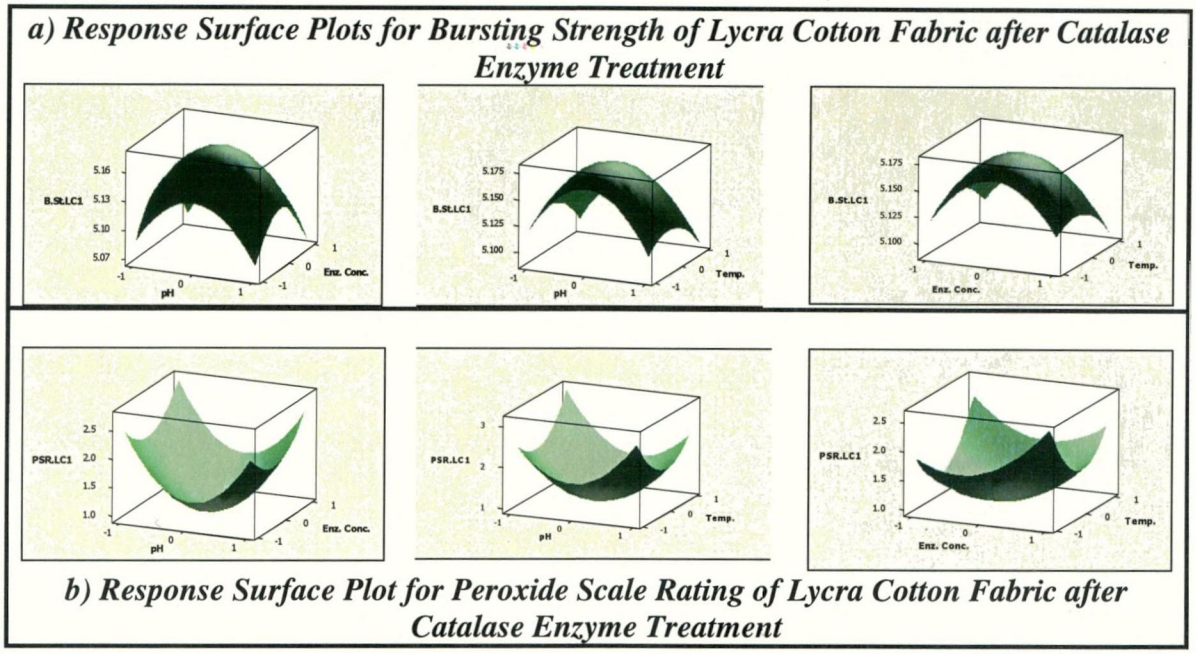
The surface plots in Figure 5, revealed that the absorbency time increased when the pH and enzyme concentration was increased or decreased. The absorbency time was highest when the temperature was lowered and marginally high when the temperature was increased. This may be due to the fact that enzymes work well in optimum conditions of temperature, pH and enzyme dosage. An increase or decrease from the optimum conditions may cause adverse actions or inactivate the enzyme. Blanchard *et al.*(2000) state that enzyme reactions are complex because a wide range of factors are involved in each particular system like solution pH, reaction time, temperature, enzyme dosage, the particular strain of enzyme and nature of the substrate. Any change prior to enzymatic treatment will influence the reaction mechanism.

| Sample | Coded Levels | | | Variables | | | Bursting Strength | | Peroxide Scale Rating | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pH | Enz. conc | Temp. | Calculated value | Observed value | Predicted value | Observed value |
| 1 | 0 | 1 | -1 | 6 | 0.15 | 40 | 5.12 | 5.12 | 2.625 | 2 |
| 2 | -1 | 0 | -1 | 5.5 | 0.1 | 40 | 5.12 | 5.12 | 2.625 | 3 |
| 3 | 0 | 0 | 0 | 6 | 0.1 | 50 | 5.177 | 5.18 | 1 | 1 |
| 4 | 1 | 1 | 0 | 6.5 | 0.15 | 50 | 5.07 | 5.07 | 2.5 | 3 |
| 5 | -1 | -1 | 0 | 5.5 | 0.05 | 50 | 5.09 | 5.09 | 2.5 | 2 |
| 6 | 0 | 0 | 0 | 6 | 0.1 | 50 | 5.177 | 5.17 | 1 | 1 |
| 7 | 0 | -1 | -1 | 6 | 0.05 | 40 | 5.12 | 5.12 | 1.875 | 2 |
| 8 | 0 | 1 | 1 | 6 | 0.15 | 60 | 5.09 | 5.09 | 2.125 | 2 |
| 9 | 1 | -1 | 0 | 6.5 | 0.05 | 50 | 5.08 | 5.08 | 2.25 | 2 |
| 10 | 0 | 0 | 0 | 6 | 0.1 | 50 | 5.177 | 5.18 | 1 | 1 |
| 11 | 0 | -1 | 1 | 6 | 0.05 | 60 | 5.11 | 5.11 | 2.375 | 3 |
| 12 | 1 | 0 | -1 | 6.5 | 0.1 | 40 | 5.11 | 5.11 | 2.875 | 3 |
| 13 | 1 | 0 | 1 | 6.5 | 0.1 | 60 | 5.09 | 5.09 | 2.375 | 2 |
| 14 | -1 | 0 | 1 | 5.5 | 0.1 | 60 | 5.1 | 5.1 | 3.125 | 3 |
| 15 | -1 | 1 | 0 | 5.5 | 0.15 | 50 | 5.08 | 5.08 | 2.75 | 3 |

The correlation coefficient between the observed value and the calculated values obtained from the above equations are 0.997 and 0.949 respectively. The goodness of fit of the model for Bursting Strength and Peroxide Scale Rating was 99.6% and 90.2% respectively. The F value of 150.78 for bursting strength and 8.32 for peroxide scale rating show that the effect of all the parameters taken together was significant at 1% level. These values show that the observed values are in agreement with the response surface equation.

## Bursting Strength

On analysis of the surface plots in Figure 6, it can be inferred that there was a reduction in bursting strength when pH, temperature and the enzyme concentration was increased or decreased.




*a) Response Surface Plots for Bursting Strength of Lycra Cotton Fabric after Catalase Enzyme Treatment*

*b) Response Surface Plot for Peroxide Scale Rating of Lycra Cotton Fabric after Catalase Enzyme Treatment*

**FIGURE 6**

## Peroxide Scale Rating

The surface plots in Figure 6, reveal the lowest scale readings at the 0 level for pH, enzyme dosage and temperature. The scale ratings were high when the levels were increased or decreased indicating that the conversion of the number of hydrogen peroxide molecules to water and oxygen were lesser when compared to the optimum level.

## Statistical Analysis

Table XX shows the observed and predicted results of bio polishing of lycra cotton weft knits with acid cellulase enzyme. The response surface equations for weight loss and pilling scale rating are given below:

$$\text{Weight Loss} = (6.58667) + (0.01\ X_1) + (0.105\ X_2) + (0.055\ X_3) + (-0.13708\ X_1\ X_1) + (0.03292\ X_2\ X_2) + (-0.08208\ X_3\ X_3) + (0.0075\ X_1\ X_2) + (-0.0025\ X_1\ X_3) + (-0.0125\ X_2\ X_3)$$

$$\text{Pilling Scale Rating} = (5) + (0.125\ X_1) + (0.75\ X_2) + (0.125\ X_3) + (-0.75\ X_1\ X_1) + (-1.5\ X_2\ X_2) + (-0.75\ X_3\ X_3) + (0.25\ X_1\ X_2) + (0\ X_1\ X_3) + (-0.25\ X_2\ X_3)$$

The correlation coefficient between the observed value and the calculated values obtained from the above equations are 0.989 and 0.963 respectively. The goodness of fit of the model for weight loss and pilling scale rating was 97.9% and 92.9% respectively. The F value of 25.42 for weight loss and 7.27 for pilling scale rating show that the effect of all the parameters taken together was significant at 1% level showing that the observed values are in agreement with the response surface equation.

**TABLE XX**

**TREATMENT CONDITIONS AND RESPONSE OBSERVED AND CALCULATED AFTER APPLICATION OF ACID CELLULASE ENZYME – LYCRA COTTON**

| Sample | Coded Levels | | | Variables | | | Weight Loss | | Pilling Scale Rating | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | pH | Enz. conc | Temp. | Calculated value | Observed value | Predicted value | Observed value |
| 1 | 1 | -1 | 0 | 5 | 0.5 | 50 | 6.38 | 6.39 | 1.875 | 2 |
| 2 | 0 | 0 | 0 | 4.5 | 1 | 50 | 6.587 | 6.59 | 5 | 5 |
| 3 | -1 | 0 | -1 | 4 | 1 | 40 | 6.3 | 6.28 | 3.25 | 3 |
| 4 | 0 | -1 | -1 | 4.5 | 0.5 | 40 | 6.365 | 6.38 | 1.625 | 2 |
| 5 | 0 | 1 | 1 | 4.5 | 1.5 | 60 | 6.685 | 6.67 | 3.375 | 3 |
| 6 | -1 | -1 | 0 | 4 | 0.5 | 50 | 6.375 | 6.38 | 2.125 | 2 |
| 7 | 0 | 0 | 0 | 4.5 | 1 | 50 | 6.587 | 6.58 | 5 | 5 |
| 8 | 0 | -1 | 1 | 4.5 | 0.5 | 60 | 6.5 | 6.47 | 2.375 | 2 |
| 9 | -1 | 1 | 0 | 4 | 1.5 | 50 | 6.57 | 6.56 | 3.125 | 3 |
| 10 | 1 | 1 | 0 | 5 | 1.5 | 50 | 6.605 | 6.6 | 3.875 | 4 |
| 11 | -1 | 0 | 1 | 4 | 1 | 60 | 6.415 | 6.44 | 3.5 | 4 |
| 12 | 0 | 0 | 0 | 4.5 | 1 | 50 | 6.587 | 6.59 | 5 | 5 |
| 13 | 1 | 0 | -1 | 5 | 1 | 40 | 6.325 | 6.3 | 3.5 | 3 |
| 14 | 0 | 1 | -1 | 4.5 | 1.5 | 40 | 6.6 | 6.63 | 3.625 | 4 |
| 15 | 1 | 0 | 1 | 5 | 1 | 60 | 6.43 | 6.45 | 3.75 | 4 |

**Weight Loss**

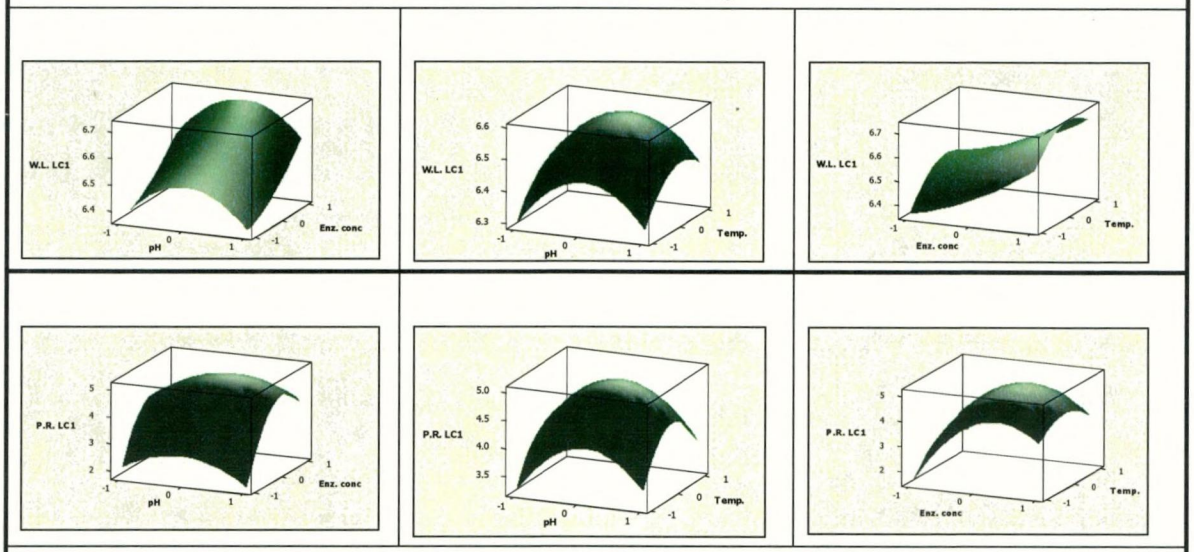
The weight loss was found to decrease when the pH was decreased or increased which showed that the enzyme reaction was not performed and the pilling rating was low, as seen in Figure 7. This trend was also observed when the temperature was altered but the decrease was marginally low. The surface plots revealed that the weight loss was very high when the enzyme dosage was increased. Cellulase enzyme causes the hydrolysis of cellulose releasing products of decomposition which were dispersed in the primary wall matrix. This process is repeated at extremely rapid rates producing pathways in the primary wall that

allow the enzyme to reach the secondary wall which contains the main constituent of cellulose. Increase in dosage leads to the enzymatic destruction of the cellulose resulting in high weight loss and strength loss, explain Etters *et al.* (2004).

**Pilling Scale Rating**

In the case of pilling, a higher scale value indicates good results. From Figure 7, it can be noted that a higher scale value was observed when the pH and temperature were at 0 level and a lower scale value resulted when the pH and temperature was increased or decreased. A drastic reduction of scale value was noticed when the enzyme dosage was reduced indicating that there was not enough enzyme to constitute the reaction of cellulose hydrolysis. There was a marginal decrease in scale rating when the enzyme concentration was high.

***a) Response Surface Plots for Weight Loss of Lycra Cotton Fabric after Bio polishing with Acid Cellulase Enzyme***




***b) Response Surface Plots for Pilling Scale of Lycra Cotton Fabric after Bio polishing with Acid Cellulase Enzyme***

**FIGURE 7**

From the observations stated above, the weight loss and absorbency were taken as the criteria for the optimization of pectate lyase enzyme for both cotton and lycra cotton weft knits and the best scouring efficiency was attributed to pH of 8.5, enzyme dosage 0.4 % owf and $55^0$C temperature. In the case of the catalase enzyme, bursting strength and peroxide scale rating was analysed and the optimum conditions for best performance were pH 6, enzyme dosage 0.1 % owf and $50^0$C temperature for both cotton and lycra cotton fabrics. The optimized conditions for cotton and lycra cotton fabrics treated with acid cellulase were pH 4.5, enzyme dosage 1 % owf and $50^0$C temperature, when the weight loss and the pilling

scale rating were studied. The optimized conditions met the pretreatment requirements of good absorbency, weight loss and strength loss within acceptable limits and good results in the rating scales. Hence these conditions were statistically evaluated and taken as the process conditions for the bio pretreatment of cotton and lycra cotton weft knits.

## 4.3. VISUAL ASSESSMENT

The results of the visual assessment of the dyed 100% cotton and the lycra cotton weft knits are given in Table XXI and Table XXII.

### 100% Cotton

The 100% cotton, bio pretreated and dyed samples, with and without bio polishing and the chemical pretreated and dyed samples with and without bio polishing, were assessed visually with regard to general appearance, colour, evenness, texture and lustre. The Table XXI presents the visual assessment ratings of the light blue (B1) and dark blue (B2) 100% cotton weft knits that were subjected to bio/ chemical pretreatment, with and without bio polishing and subsequent dyeing.

With respect to general appearance, Table XXI reveals that 70-78% of the judges rated the bio pretreated and dyed samples as good while 52-67% rated the chemical pretreated and dyed samples as good. The bio pretreated, bio polished and dyed samples were rated as good by almost 100% of the judges and 82-91% judges rated the chemical pretreated, bio polished and dyed samples as good.

About 79-85% felt that the light blue colour was bright and 78-91% felt that the dark blue colour of the bio pretreated and dyed samples were medium, while 67-80% rated the light blue colour as bright and 71-82% felt that the dark blue was medium with regard to the chemical pretreated and dyed samples.

The bio pretreated and dyed samples were rated as evenly dyed by 98-100% of the judges while chemical pretreated and dyed samples were rated as evenly dyed by 95-99% of the judges. About 82-91% rated the bio pretreated and dyed samples as medium in texture while 56-67% judges rated the chemical pretreated and dyed samples as medium in texture. Seventy six to ninety one per cent of the judges rated the bio pretreated and dyed samples as medium in lustre and 56-67% rated the chemical pretreated and dyed samples as medium in lustre. In all the criteria analyzed, it may be noted that the fabrics made from combed yarns exhibited better ratings than the fabrics made from carded yarns.

## TABLE XXI
## VISUAL ASSESSMENT RATINGS OF DYED 100% COTTON WEFT KNITS

| S. No. | Dyed Samples | CRITERIA ANALYSED | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | General Appearance | | | Colour | | | Evenness | | Texture | | | Lustre | | |
| | | G | F | P | B | M | D | E | UE | S | M | C | H | M | L |
| **Bio Pretreated, Dyed** | | | | | | | | | | | | | | | |
| a. | C1SJ B1 | 71 | 29 | - | **85** | 15 | - | 99 | 1 | - | 89 | 11 | - | 87 | 13 |
| b. | C1RB B1 | 70 | 30 | - | 80 | 19 | 1 | 99 | 1 | - | 83 | 17 | - | 76 | 24 |
| c. | C2SJ B1 | 75 | 25 | - | **85** | 15 | - | **100** | - | - | 90 | 10 | - | **91** | 9 |
| d. | C2RB B1 | **78** | 22 | - | 79 | 20 | 1 | **100** | - | - | 89 | 11 | - | 90 | 10 |
| e. | C1SJ B2 | 73 | 27 | - | 21 | 79 | - | 98 | 2 | - | 88 | 12 | - | 85 | 15 |
| f. | C1RB B2 | 70 | 30 | - | 10 | 90 | - | 99 | 1 | - | 82 | 18 | - | 83 | 17 |
| g. | C2SJ B2 | 76 | 24 | - | 22 | 78 | - | **100** | - | - | **91** | 9 | - | 86 | 14 |
| h. | C2RB B2 | 74 | 26 | - | 9 | 91 | - | 99 | 1 | - | 89 | 11 | - | 85 | 15 |
| **Chemical Pretreated, Dyed** | | | | | | | | | | | | | | | |
| a. | C1SJ B1 | 52 | 48 | - | **80** | 17 | 3 | 98 | 2 | - | 65 | 35 | - | 66 | 34 |
| b. | C1RB B1 | 60 | 40 | - | 75 | 20 | 5 | 95 | 5 | - | 56 | 44 | - | 57 | 43 |
| c. | C2SJ B1 | 65 | 35 | - | 77 | 23 | - | **99** | 1 | - | **67** | 33 | - | **67** | 33 |
| d. | C2RB B1 | **67** | 33 | - | 67 | 25 | 8 | 98 | 2 | - | 58 | 42 | - | 59 | 41 |
| e. | C1SJ B2 | 60 | 40 | - | - | 80 | 20 | 97 | 3 | - | 66 | 34 | - | 65 | 35 |
| f. | C1RB B2 | 63 | 37 | - | - | 71 | 29 | 96 | 4 | - | 57 | 43 | - | 56 | 44 |
| g. | C2SJ B2 | 56 | 44 | - | - | 82 | 18 | 98 | 2 | - | **67** | 33 | - | **67** | 33 |
| h. | C2RB B2 | 61 | 39 | - | - | 74 | 26 | 95 | 5 | - | 59 | 41 | - | 58 | 42 |
| **Bio Pretreated, Bio Polished, Dyed** | | | | | | | | | | | | | | | |
| a. | C1SJ B1 | **100** | - | - | 95 | 5 | - | **100** | - | **100** | - | - | 11 | 87 | 2 |
| b. | C1RB B1 | 99 | 1 | - | 96 | 3 | - | **100** | - | **100** | - | - | 17 | 80 | 3 |
| c. | C2SJ B1 | **100** | - | - | **100** | - | - | **100** | - | **100** | - | - | **25** | 75 | - |
| d. | C2RB B1 | **100** | - | - | 99 | 1 | - | **100** | - | **100** | - | - | 20 | 80 | - |
| e. | C1SJ B2 | **100** | - | - | **100** | - | - | **100** | - | **100** | - | - | 12 | 87 | 1 |
| f. | C1RB B2 | **100** | - | - | **100** | - | - | **100** | - | **100** | - | - | 18 | 80 | 2 |
| g. | C2SJ B2 | **100** | - | - | **100** | - | - | **100** | - | **100** | - | - | 9 | 91 | - |
| h. | C2RB B2 | **100** | - | - | **100** | - | - | **100** | - | **100** | - | - | 11 | 89 | - |
| **Chemical Pretreated, Bio polished, Dyed** | | | | | | | | | | | | | | | |
| a. | C1SJ B1 | 89 | 11 | - | **85** | 15 | - | **100** | - | 99 | 1 | - | 7 | 80 | 13 |
| b. | C1RB B1 | 83 | 17 | - | 80 | 19 | - | **100** | - | 98 | 2 | - | 3 | 81 | 16 |
| c. | C2SJ B1 | 90 | 10 | - | **85** | 15 | - | **100** | - | **100** | - | - | 5 | 91 | 4 |
| d. | C2RB B1 | 89 | 11 | - | 79 | 20 | - | **100** | - | **100** | - | - | 2 | 90 | 8 |
| e. | C1SJ B2 | 88 | 12 | - | 21 | 79 | - | **100** | - | 98 | 2 | - | 8 | 85 | 7 |
| f. | C1RB B2 | 82 | 18 | - | 10 | 90 | - | **100** | - | 97 | 3 | - | **10** | 83 | 7 |
| g. | C2SJ B2 | **91** | 9 | - | 22 | 78 | - | **100** | - | **100** | - | - | 7 | 86 | 7 |
| h. | C2RB B2 | 89 | 11 | - | 9 | 91 | - | **100** | - | **100** | - | - | 6 | 85 | 9 |

G – Good, M – Medium, F – Fair, B – Bright, D – Dull E – Even, UE – UnEven, S – Soft, C - Coarse, H – High, L – Low

In the case of the bio polished and dyed samples, it is seen from Table XXI that 99-100% judges rated the bio pretreated, bio polished and dyed samples as good in general appearance, 95-100% bright in colour, cent per cent rated as evenly dyed and smooth in texture and 9-25% high in lustre. The chemical pretreated, bio polished and dyed samples were rated as good in general appearance by 82-91%, bright in colour by 9-85%, evenly dyed by cent per cent, 97-100% rated as smooth in texture and 2-10% rated the samples as high in lustre.

**Lycra Cotton**

The panel ratings of the chemical / bio pretreated, with and without bio polishing and dyed lycra cotton weft knits, are presented in Table XXII. The samples were visually assessed on criteria namely general appearance, colour, evenness, texture and lustre.

From the Table XXII it is evident that 73-81% of the judges rated the bio pretreated and dyed samples as good in general appearance while 60-61% felt that the chemical pretreated and dyed samples were good in general appearance. With regard to colour, about 77-83% felt that the light blue colour (B1) was bright and 7-20% rated the dark blue colour (B2) as bright, in the case of bio pretreated and dyed samples. In the case of chemical pretreated and dyed samples, 65-78% rated the samples dyed with light blue colour as bright and 71-80% felt that the samples dyed with dark blue colour as medium in the rating scale.

The bio pretreated and dyed samples were rated as evenly dyed by 98-100% while 94-100% felt that the chemical pretreated and dyed samples were even. About 84-93% and 74-89% judges considered the bio pretreated and dyed samples were medium in texture and lustre respectively while 56-67% and 52-63% felt that the chemical pretreated and dyed samples were medium in texture and lustre respectively.

With respect to the pretreated, bio polished and dyed samples, Table XXII shows that 98-100% of the judges considered the bio pretreated, bio polished and dyed samples as good in general appearance and 80-87% rated the chemical pretreated, bio polished and dyed samples, as good in general appearance.

About 94-99% rated the bio pretreated, bio polished and dyed samples as bright in colour while 79-85% judges rated the chemical pretreated, bio polished samples dyed with light blue colour as bright and 9-22% rated the samples dyed with dark blue colour as bright. pretreated, bio polished and dyed samples, as good in general appearance.

## TABLE XXII
## VISUAL ASSESSMENT RATINGS OF DYED LYCRA COTTON WEFT KNITS

| S. No. | Dyed Samples | CRITERIA ANALYSED | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | General Appearance | | | Colour | | | Evenness | | Texture | | | Lustre | | |
| | | G | F | P | B | M | D | E | UE | S | M | C | H | M | L |
| **Bio Pretreated, Dyed** | | | | | | | | | | | | | | | |
| a. | LC1SJB1 | 74 | 26 | - | **83** | 17 | - | 99 | 1 | - | 91 | 9 | - | 85 | 15 |
| b. | LC1RBB1 | 73 | 27 | - | 78 | 21 | 1 | 99 | 1 | - | 85 | 15 | - | 74 | 26 |
| c. | LC2SJB1 | 78 | 22 | - | **83** | 17 | - | **100** | - | - | 92 | 8 | - | **89** | 11 |
| d. | LC2RBB1 | **81** | 19 | - | 77 | 22 | 1 | **100** | - | - | 91 | 9 | - | 88 | 12 |
| e. | LC1SJB2 | 76 | 24 | - | 19 | 81 | - | 98 | 2 | - | 90 | 10 | - | 83 | 17 |
| f. | LC1RBB2 | 73 | 27 | - | 8 | 92 | - | 99 | 1 | - | 84 | 16 | - | 81 | 19 |
| g. | LC2SJB2 | 79 | 21 | - | 20 | 80 | - | **100** | - | - | **93** | 7 | - | 84 | 16 |
| h. | LC2RBB2 | 77 | 23 | - | 7 | 93 | - | 99 | 1 | - | 91 | 9 | - | 83 | 17 |
| **Chemical Pretreated, Dyed** | | | | | | | | | | | | | | | |
| a. | LC1SJB1 | 60 | 40 | - | **78** | 19 | 3 | 96 | 4 | - | 66 | 34 | - | 62 | 38 |
| b. | LC1RBB1 | 62 | 38 | - | 72 | 23 | 5 | 94 | 6 | - | 56 | 44 | - | 53 | 47 |
| c. | LC2SJB1 | **67** | 33 | - | 75 | 25 | - | **100** | - | - | **67** | 33 | - | **63** | 37 |
| d. | LC2RBB1 | **67** | 33 | - | 65 | 27 | 8 | 97 | 3 | - | 58 | 42 | - | 55 | 45 |
| e. | LC1SJB2 | 60 | 40 | - | - | 80 | 20 | 97 | 3 | - | 66 | 34 | - | 61 | 39 |
| f. | LC1RBB2 | 63 | 37 | - | - | 71 | 29 | 96 | 4 | - | 57 | 43 | - | 52 | 48 |
| g. | LC2SJB2 | 66 | 34 | - | - | 82 | 18 | **100** | - | - | **67** | 33 | - | **63** | 37 |
| h. | LC2RBB2 | 62 | 38 | - | - | 74 | 26 | 95 | 5 | - | 59 | 41 | - | 54 | 46 |
| **Bio Pretreated, Bio Polished, Dyed** | | | | | | | | | | | | | | | |
| a. | LC1SJB1 | 99 | 1 | - | 94 | 6 | - | **100** | - | **100** | - | - | 10 | 89 | 1 |
| b. | LC1RBB1 | 99 | 1 | - | 95 | 5 | - | **100** | - | **100** | - | - | 12 | 84 | 4 |
| c. | LC2SJB1 | **100** | - | - | **99** | 1 | - | **100** | - | **100** | - | - | 10 | 88 | 2 |
| d. | LC2RBB1 | **100** | - | - | **99** | 1 | - | **100** | - | **100** | - | - | 10 | 89 | 1 |
| e. | LC1SJB2 | 98 | 2 | - | 97 | 3 | - | **100** | - | **100** | - | - | 12 | 86 | 2 |
| f. | LC1RBB2 | 99 | 1 | - | 98 | 2 | - | **100** | - | **100** | - | - | **25** | 70 | 5 |
| g. | LC2SJB2 | **100** | - | - | 97 | 3 | - | **100** | - | **100** | - | - | 8 | 91 | 1 |
| h. | LC2RBB2 | **100** | - | - | 98 | 2 | - | **100** | - | **100** | - | - | 10 | 89 | 1 |
| **Chemical Pretreated, Bio polished, Dyed** | | | | | | | | | | | | | | | |
| a. | LC1SJ B1 | 74 | 26 | - | **83** | 17 | - | 99 | 1 | - | 91 | 9 | - | 85 | 15 |
| b. | LC1SJB1 | 73 | 27 | - | 78 | 21 | 1 | 99 | 1 | - | 85 | 15 | - | 74 | 26 |
| c. | LC1RBB1 | 78 | 22 | - | **83** | 17 | - | **100** | - | - | 92 | 8 | - | **89** | 11 |
| d. | LC2SJB1 | **81** | 19 | - | 77 | 22 | 1 | **100** | - | - | 91 | 9 | - | 88 | 12 |
| e. | LC2RBB1 | 76 | 24 | - | 19 | 81 | - | 98 | 2 | - | 90 | 10 | - | 83 | 17 |
| f. | LC1SJB2 | 73 | 27 | - | 8 | 92 | - | 99 | 1 | - | 84 | 16 | - | 81 | 19 |
| g. | LC1RBB2 | 79 | 21 | - | 20 | 80 | - | **100** | - | - | **93** | 7 | - | 84 | 16 |
| h. | LC2SJB2 | 77 | 23 | - | 7 | 93 | - | 99 | 1 | - | 91 | 9 | - | 83 | 17 |

G – Good, M – Medium, F – Fair, B – Bright, D – Dull E – Even, UE – UnEven, S – Soft, C - Coarse, H – High, L - Low

All the samples, irrespective of the treatment undergone, the fabric and the colour, were rated as evenly dyed by cent per cent of the judges. The bio pretreated, bio polished dyed samples, were rated as smooth in texture and high in lustre by 100% and 8-25% respectively while chemical pretreated, bio polished dyed samples were rated as smooth in texture and high in lustre by 97-100% and 1-10% respectively. In all the criteria analyzed, it was noted that the fabrics made from combed yarns exhibited better ratings than the fabrics made from carded yarns.

From the above, it can be highlighted that the bio pretreated and dyed samples, with and without bio polishing, were rated higher in all the aspects analysed when compared to their chemical counterparts.

## 4.4. LABORATORY TESTS

The results of the laboratory tests are discussed under the following heads, namely, Geometrical Properties, Tests after Pretreatment and Bio Polishing and Tests after Dyeing and Wear.

### 4.4.1. Geometrical Properties

The geometrical properties of 100% cotton weft knits and lycra cotton weft knits include Wales and Courses per Unit Length, Stitch Density, Loop Length, Thickness, Count, Mass per unit area and Geometrical Constants (Kw, Kc, Ks, R). The results of the above mentioned tests are as follows:

**100% Cotton**

The geometrical properties of 100% cotton single jersey and rib, knitted with carded yarns (C1SJ, C1RB) and 100% cotton single jersey and rib, knitted with combed yarns (C2SJ and C2RB) are discussed in Table XXIII

From the Table XXIII, it is clear that the wales per centimeter in the single jersey fabrics showed an increase in number after pretreatment and bio polishing in the fabrics knitted with the carded and combed yarns. This may be due to considerable area shrinkage after pretreatment and bio polishing where the fabric in the bath was subjected to the tumbling mechanism of the soft flow machine. The courses per centimeter, on the other hand, followed a different trend of decrease after pretreatment followed by a marginal increase after bio polishing. There was a gradual decrease in the mass and thickness of the fabric after pretreatment and bio polishing.

## TABLE XXIII

## GEOMETRICAL PROPERTIES OF COTTON WEFT KNITS

| S. No | Sample Particulars | Wales per cm | Courses per cm | Stitch Density ($cm^2$) | Loop Length (cm) | Thickness (mm) | Ne (Tex) | Mass ($g/m^2$) | Geometrical Constants | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Kw / Uw | Kc / Uc | Ks / Us | Loop Shape Factor (R) |
| 1 | **C1SJ** Control | 12.6 | 20.47 | 257.95 | 0.29 | 0.52 | 30's | 138 | 3.65 | 5.94 | 21.69 | 1.63 |
| | - CV% | 3.02 | 2.39 | 5.13 | 6.90 | 7.69 | 0.13 | 3.28 | 6.30 | 4.72 | 11.04 | 1.84 |
| | Chemical Pretreated - CV% | 16.53 | 18.11 | 299.46 | 0.28 | 0.48 | 30's | 131 | 4.63 | 5.07 | 23.48 | 1.10 |
| | | 1.45 | 2.87 | 4.28 | 7.14 | 5.00 | 0.13 | 2.41 | 6.05 | 5.72 | 5.00 | 1.82 |
| | Bio Pretreated -CV% | 16.53 | 18.11 | 299.46 | 0.30 | 0.50 | 30's | 135 | 4.96 | 5.43 | 26.95 | 1.10 |
| | | 2.66 | 2.26 | 4.88 | 10.00 | 5.00 | 0.17 | 3.05 | 7.66 | 8.66 | 5.00 | 0.91 |
| | Chemical Pretreated, Bio Polished - CV% | 16.14 | 17.71 | 285.98 | 0.28 | 0.44 | 30's | 127 | 4.52 | 4.96 | 22.42 | 1.10 |
| | | 1.73 | 2.93 | 4.61 | 10.71 | 8.33 | 0.17 | 3.15 | 9.29 | 8.67 | 17.69 | 1.82 |
| | Bio Pretreated, Bio Polished - CV% | 16.54 | 18.90 | 312.48 | 0.30 | 0.48 | 30's | 131 | 4.96 | 5.67 | 28.12 | 1.14 |
| | | 1.69 | 2.38 | 3.94 | 6.67 | 10.0 | 0.13 | 3.46 | 4.23 | 5.11 | 9.27 | 0.88 |
| 2 | **C1RB** Control | 11.02 | 17.32 | 190.9 | 0.60 | 0.75 | 30s | 209 | 6.61 | 10.4 | 68.72 | 1.57 |
| | - CV% | 1.54 | 2.60 | 4.12 | 5 | 5.33 | 0.13 | 1.97 | 4.69 | 5.38 | 9.93 | 1.27 |
| | Chemical Pretreated - CV% | 12.2 | 16.93 | 206.54 | 0.54 | 0.70 | 30's | 197 | 6.59 | 9.14 | 60.23 | 1.39 |
| | | 4.10 | 2.42 | 6.44 | 5.56 | 5.00 | 0.13 | 2.03 | 3.95 | 4.60 | 5.00 | 2.16 |
| | Bio Pretreated -CV% | 12.6 | 18.9 | 238.11 | 0.56 | 0.73 | 30's | 203 | 7.06 | 10.6 | 74.67 | 1.5 |
| | | 1.51 | 1.32 | 2.85 | 5.36 | 5.00 | 0.13 | 1.97 | 4.26 | 4.44 | 5.00 | 0.67 |
| | Chemical Pretreated, Bio Polished - CV% | 12.2 | 18.11 | 220.94 | 0.56 | 0.67 | 30's | 191 | 6.83 | 10.1 | 69.29 | 1.48 |
| | | 1.56 | 1.10 | 2.71 | 5.36 | 5.71 | 0.07 | 1.85 | 4.25 | 4.14 | 8.33 | 0.68 |
| | Bio Pretreated, Bio Polished - CV% | 13.39 | 18.9 | 253.04 | 0.56 | 0.71 | 30's | 197 | 7.5 | 10.6 | 79.35 | 1.41 |
| | | 3.73 | 2.38 | 5.97 | 5.36 | 5.48 | 0.07 | 2.09 | 3.74 | 4.73 | 8.3 | 2.13 |
| 3 | **C2SJ** Control | 13.39 | 20.47 | 274.13 | 0.28 | 0.50 | 30's | 141 | 3.75 | 5.73 | 21.49 | 1.53 |
| | CV% | 1.19 | 2.20 | 3.26 | 10.71 | 8.00 | 0.13 | 2.84 | 8.27 | 8.90 | 17.04 | 1.31 |
| | Chemical Pretreated - CV% | 16.14 | 16.93 | 273.24 | 0.28 | 0.46 | 30's | 133 | 4.52 | 4.74 | 21.42 | 1.05 |
| | | 2.54 | 1.89 | 4.22 | 10.71 | 5.00 | 0.10 | 2.38 | 7.98 | 9.28 | 5.00 | 0.95 |
| | Bio Pretreated -CV% | 15.75 | 18.11 | 285.24 | 0.30 | 0.48 | 30's | 138 | 4.73 | 5.43 | 25.67 | 1.15 |
| | | 3.30 | 2.48 | 5.61 | 10.00 | 5.00 | 0.10 | 2.29 | 8.69 | 7.37 | 5.00 | 1.74 |
| | Chemical Pretreated, Bio Polished - CV% | 16.14 | 18.9 | 305.01 | 0.29 | 0.44 | 30's | 130 | 4.68 | 5.48 | 25.65 | 1.17 |
| | | 0.68 | 2.59 | 3.15 | 10.34 | 6.52 | 0.13 | 3.08 | 9.19 | 9.12 | 18.16 | 1.71 |
| | Bio Pretreated, Bio Polished - CV% | 16.54 | 18.9 | 312.57 | 0.30 | 0.46 | 30's | 135 | 4.96 | 5.67 | 28.13 | 1.14 |
| | | 3.63 | 1.69 | 5.32 | 10.0 | 6.25 | 0.13 | 2.96 | 9.07 | 8.64 | 17.42 | 1.75 |
| 4 | **C2RB** Control | 10.24 | 18.11 | 185.5 | 0.54 | 0.73 | 30's | 190 | 5.53 | 9.78 | 54.08 | 1.77 |
| | CV% | 1.86 | 2.71 | 4.48 | 3.70 | 5.48 | 0.13 | 1.86 | 2.53 | 3.78 | 6.32 | 1.13 |
| | Chemical Pretreated - CV% | 12.6 | 16.14 | 203.39 | 0.54 | 0.69 | 30's | 181 | 6.8 | 8.72 | 59.31 | 1.28 |
| | | 2.78 | 2.23 | 4.67 | 3.70 | 5.00 | 0.07 | 2.10 | 2.21 | 3.67 | 5.00 | 1.56 |
| | Bio Pretreated -CV% | 13.39 | 18.9 | 253.0 | 0.56 | 0.71 | 30's | 184 | 7.5 | 10.6 | 79.35 | 1.41 |
| | | 1.79 | 2.75 | 44.50 | 5.36 | 5.00 | 0.10 | 1.72 | 5.20 | 5.10 | 5.00 | 1.42 |
| | Chemical Pretreated, Bio Polished - CV% | 12.6 | 19.69 | 248.03 | 0.56 | 0.67 | 30's | 177 | 7.06 | 11 | 77.78 | 1.56 |
| | | 1.98 | 2.08 | 3.97 | 5.36 | 2.90 | 0.13 | 2.56 | 5.24 | 4.45 | 9.64 | 0.64 |
| | Bio Pretreated, Bio Polished - CV% | 13.39 | 18.90 | 253.04 | 0.56 | 0.69 | 30's | 182 | 7.5 | 10.6 | 79.35 | 1.41 |
| | | 2.69 | 1.06 | 3.76 | 3.57 | 4.23 | 0.17 | 1.95 | 2.00 | 2.36 | 4.13 | 1.42 |

The chemical pretreated fabrics were comparatively thinner and lower in weight than the bio pretreated fabrics before and after bio polishing. The loop length was constant with an initial decrease after pretreatment. Spencer (2001), states that a wet relaxation treatment was sufficient to relieve the stored strains and the agitation during washing and tumble drying should facilitate the process of achieving a dimensionally stable fabric. The loop shape factor also decreased when compared to the control after pretreatment and bio polishing. The same trend was noticed in all the single jersey samples.

In the case of rib fabrics, there was an increase in the wales per centimeter and a marginal increase was seen in the courses per centimeter after bio polishing. A gradual decrease in thickness and mass was noticed between the chemical and bio pretreated samples and the control rib fabrics knitted with carded and combed yarns. The loop length remained constant with an initial decrease after pretreatment. Higgins *et al.* (2003), state that wetting with agitation would bring all the loops to a state where they do not have any tendency to change in shape or in properties and fabric tightness factor. A substantial reduction in weight and thickness was noticed in the chemical pretreated and bio polished samples when compared with the enzyme pretreated and bio polished samples. Most of the rib samples had a stable loop length after enzymatic pretreatment and bio polishing whereas the chemical pretreated samples exhibited a reduction in loop length.

**Lycra Cotton**

The geometrical properties of lycra cotton single jersey and rib knitted with carded yarns (LC1SJ, LC1RB) and lycra cotton single jersey and rib knitted with combed yarns (LC2SJ and LC2RB) are given in Table XXIV.

From Table XXIV, it may be understood that the increase in the wales per centimeter after pretreatment and bio polishing in the lycra cotton single jersey was marginal in both the fabrics knitted with carded and combed yarns. A decrease in courses per centimeter was noticed in the single jersey fabrics knitted with carded and combed yarns, when compared to their controls. No definite trend was seen in the behaviour of loop length after pretreatment and bio polishing. An overall reduction, in weight and thickness, was seen in the pretreated and bio polished samples. A reduction in value was also noticed in the loop shape factor of all the single jersey fabrics, in comparison with their controls. Wang and Hu (2007) state that the loop shape factor is a function of the measure of the ratio of the width to the length of the loop. This ratio is affected by fabric distortion as such distortion may cause increase or decrease of corresponding parameters.

## TABLE XXIV
## GEOMETRICAL PROPERTIES OF LYCRA COTTON WEFT KNITS

| S. No. | Sample Particulars | Wales per cm | Courses per cm | Stitch Density ($cm^2$) | Loop Length (cm) | Thickness (mm) | Ne (Tex) | Mass ($g/m^2$) | Geometrical Constants | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Kw / Uw | Kc / Uc | Ks / Us | Loop Shape Factor |
| 1 | **LC1SJ** Control | 16 | 23.2 | 371.2 | 0.3 | 0.65 | 30's | 197 | 4.8 | 6.96 | 33.41 | 1.45 |
| | (CV%) | 0.13 | 0.22 | 0.15 | 16.67 | 40.0 | 0.13 | 2.30 | 15.0 | 15.32 | 29.8 | 5.0 |
| | Chemical Pretreated - CV% | 16 | 20 | 320 | 0.32 | 0.63 | 30's | 186 | 5.12 | 6.4 | 32.77 | 1.25 |
| | | 0.25 | 0.35 | 0.54 | 9.38 | 63.45 | 0.17 | 1.7 | 8.2 | 8.28 | 16.38 | 0.24 |
| | Bio Pretreated -CV% | 16.8 | 20.8 | 349.44 | 0.32 | 0.64 | 30's | 191 | 5.37 | 6.66 | 35.78 | 1.24 |
| | | 0.30 | 0.15 | 0.46 | 15.63 | 54.65 | 0.17 | 1.34 | 7.1 | 16.97 | 33.39 | 0.06 |
| | Chemical Pretreated, Bio Polished - CV% | 16.4 | 19.2 | 314.88 | 0.3 | 0.6 | 30's | 182 | 4.92 | 5.76 | 28.34 | 1.17 |
| | | 0.24 | 0.26 | 0.51 | 16.67 | 58.33 | 0.13 | 2.26 | 4.71 | 18.23 | 35.49 | 0.11 |
| | Bio Pretreated, Bio Polished - CV% | 16.8 | 20.8 | 349.44 | 0.28 | 0.62 | 30's | 188 | 4.70 | 5.82 | 27.4 | 1.24 |
| | | 0.42 | 0.24 | 0.59 | 14.29 | 48.39 | 0.14 | 2.41 | 14.65 | 14.41 | 28.62 | 0.23 |
| 2 | **LC1RB** Control | 12 | 20 | 240 | 0.62 | 0.95 | 30's | 245 | 7.44 | 12.4 | 92.26 | 1.67 |
| | (CV%) | 0.25 | 0.10 | 0.15 | 3.23 | 16.84 | 0.07 | 1.68 | 2.42 | 2.66 | 5.07 | 5.0 |
| | Chemical Pretreated - CV% | 12.4 | 20 | 248 | 0.6 | 0.91 | 30's | 231 | 7.44 | 12 | 89.28 | 1.61 |
| | | 0.32 | 0.10 | 0.37 | 3.33 | 43.96 | 0.07 | 1.73 | 2.8 | 2.75 | 5.57 | 0.27 |
| | Bio Pretreated -CV% | 13.6 | 20.8 | 282.88 | 0.64 | 0.93 | 30's | 238 | 8.70 | 13.31 | 115.87 | 1.53 |
| | | 0.15 | 0.15 | 0.30 | 6.67 | 37.63 | 0.13 | 1.45 | 7.6 | 7.61 | 15.12 | 0.07 |
| | Chemical Pretreated, Bio Polished - CV% | 12 | 19.2 | 230.4 | 0.62 | 0.88 | 30's | 226 | 7.44 | 11.90 | 88.57 | 1.6 |
| | | 0.33 | 0.21 | 0.55 | 6.45 | 39.77 | 0.13 | 1.77 | 7.53 | 7.47 | 14.89 | 0.18 |
| | Bio Pretreated, Bio Polished - CV% | 12.8 | 19.2 | 245.76 | 0.56 | 0.9 | 30's | 234 | 7.17 | 10.75 | 77.07 | 1.5 |
| | | 0.16 | 0.21 | 0.31 | 10.71 | 22.22 | 0.13 | 1.28 | 10.32 | 10.33 | 20.5 | 0.07 |
| 3 | **LC2SJ** Control | 14.8 | 20 | 296 | 0.27 | 0.51 | 30's | 136 | 3.10 | 5.4 | 21.58 | 1.35 |
| | (CV%) | 0.20 | 0.15 | 0.11 | 18.52 | 15.61 | 0.13 | 2.94 | 16.75 | 16.87 | 32.9 | 5.0 |
| | Chemical Pretreated - CV% | 16 | 20 | 320 | 0.3 | 0.48 | 30's | 129 | 4.8 | 6 | 28.8 | 1.25 |
| | | 0.25 | 0.10 | 0.35 | 6.67 | 56.25 | 0.13 | 2.45 | 7.71 | 7.5 | 15.2 | 0.15 |
| | Bio Pretreated -CV% | 16.8 | 20.8 | 349.44 | 0.28 | 0.49 | 30's | 132 | 4.70 | 5.82 | 27.4 | 1.24 |
| | | 0.18 | 0.14 | 0.27 | 20.0 | 55.1 | 0.10 | 1.93 | 18.45 | 18.59 | 36.1 | 0.15 |
| | Chemical Pretreated, Bio Polished - CV% | 16.4 | 23.2 | 380.48 | 0.3 | 0.46 | 30's | 126 | 4.92 | 6.96 | 34.24 | 1.42 |
| | | 0.18 | 0.26 | 0.39 | 13.33 | 58.7 | 0.09 | 2.51 | 12.8 | 12.93 | 25.41 | 0.09 |
| | Bio Pretreated, Bio Polished - CV% | 16.8 | 20.8 | 349.44 | 0.29 | 0.47 | 30's | 130 | 4.87 | 6.03 | 29.39 | 1.24 |
| | | 0.12 | 0.14 | 0.24 | 10.34 | 53.19 | 0.13 | 2.43 | 8.83 | 8.96 | 17.71 | 0.08 |
| 4 | **LC2RB** Control | 11.2 | 18.4 | 206.08 | 0.54 | 0.75 | 30's | 204 | 6.048 | 9.94 | 60.09 | 1.64 |
| | (CV%) | 0.18 | 0.43 | 0.43 | 9.26 | 13.67 | 0.17 | 1.74 | 9.92 | 10.36 | 20.1 | 5.0 |
| | Chemical Pretreated - CV% | 12 | 18.4 | 220.8 | 0.62 | 0.71 | 30's | 194 | 7.44 | 11.41 | 84.88 | 1.53 |
| | | 0.33 | 0.33 | 0.67 | 3.23 | 26.76 | 0.13 | 1.96 | 3.9 | 3.94 | 7.88 | 0.14 |
| | Bio Pretreated -CV% | 13.6 | 20.8 | 282.88 | 0.64 | 0.73 | 30's | 198 | 8.70 | 13.31 | 115.87 | 1.53 |
| | | 0.59 | 0.10 | 0.66 | 4.84 | 45.21 | 0.10 | 1.75 | 5.22 | 4.81 | 9.95 | 0.53 |
| | Chemical Pretreated, Bio Polished - CV% | 12.8 | 18 | 230.4 | 0.6 | 0.68 | 30's | 190 | 7.68 | 10.8 | 82.94 | 1.41 |
| | | 0.16 | 0.17 | 0.29 | 6.67 | 48.53 | 0.05 | 1.66 | 7.25 | 7.31 | 14.55 | 0.05 |
| | Bio Pretreated, Bio Polished - CV% | 12.8 | 19.2 | 245.76 | 0.58 | 0.71 | 30's | 195 | 7.42 | 11.14 | 82.67 | 1.5 |
| | | 0.47 | 0.16 | 0.66 | 3.45 | 40.85 | 0.14 | 1.31 | 2.96 | 2.87 | 5.87 | 0.33 |

In the case of rib fabrics a very marginal increase in wales per centimeter and a marginal decrease in courses per centimeter was noticed indicating that the dimensional

stability of the lycra cotton rib fabrics were good. A decrease in loop length was noticed in the bio pretreated and bio polished samples, when compared to their controls. A gradual reduction was also noticed in the loop shape factor. The reduction in weight and thickness was comparatively lower in the enzyme pretreated and bio polished samples when compared to the chemical pretreated counter parts. Mahapatra (2007) explains that use of highly alkaline chemicals, not only remove the non cellulosic impurities from the cotton but also breaks down the cellulose, leading to reduction in fabric thickness, heavy strength loss and weight loss in the fabric.

### 4.4.2. Tests after Pretreatment and Bio Polishing

The tests carried out after pretreatment and bio polishing are the pH of Fabric, Absorbency, Weight, Bursting Strength, Degree of Polymerization, Residual Alkali, Whiteness and Yellowness Index, Comfort Properties [Air Permeability, $q_{max,}$ Thermal Conductivity and Wicking], Low Stress Mechanical Properties [Tensile, Shear, Bending, Compression, Fabric Weight and Thickness and Surface], and Effluent Estimation [Measurement of Effluent pH, Colour, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)]. The statistical calculations for ANOVA are given in Appendix IX. The results of the tests done after pretreatment and bio polishing are given below.

**❋ pH of Fabric, Absorbency, Weight and Bursting Strength**

**100% Cotton**

The pH of Fabric, Absorbency, Weight and Bursting Strength of cotton weft knits are presented in Table XXV and Figure 8. The analysis of variance for all the above properties are presented in Table XXVa.

**pH of Fabric** [100% cotton]

The pH of fabric is an important indicator of the acidity or alkalinity of the fabric that has to undergo successive treatments in processing; pH 7 indicates neutrality of fabric, above pH 7 indicates alkalinity and below pH 7 represents acidity. From Table XXV, neutral pH (7) was noticed in the bio pretreated samples C1SJ and C2RB. The chemical pretreated and bio polished samples exhibited higher pH values than the bio pretreated and bio polished samples. This may be due to the alkaline pretreatment that preceded the bio polishing process. The acidity or alkalinity, if present beyond certain limits will affect the quality of the fabric. This measure is used as an indicator to determine whether the fabric is strong enough for storage or further processing treatments to reach the end product.

## TABLE XXV

## pH OF FABRIC, ABSORBENCY, WEIGHT AND BURSTING STRENGTH OF COTTON WEFT KNITS

| Test | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Bio Polished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| pH of Fabric | C1SJ | 6.5 | 7.2 | 10.76 | 7 | 7.69 | 7.7 | 18.46 | 7.3 | 12.30 |
| | C1RB | 6.6 | 7.3 | 10.60 | 6.9 | 4.54 | 7.5 | 13.63 | 7.3 | 10.60 |
| | C2SJ | 6.8 | 7.3 | 7.35 | 6.8 | 0 | 7.5 | 10.29 | 7.2 | 5.88 |
| | C2RB | 6.3 | 7.3 | 15.87 | 7 | 11.11 | 7.5 | 19.04 | 7.3 | 15.87 |
| Absorbency (seconds) | C1SJ | - | 8 | - | 3 | - | 3 | - | 1.5 | - |
| | C1RB | - | 5 | - | 4 | - | 3 | - | **<1** | - |
| | C2SJ | - | 3 | - | **2** | - | 4 | - | 1.5 | - |
| | C2RB | - | 11 | - | 5 | - | 2 | - | **<1** | - |
| Weight (gm/sq m) | C1SJ | 138 | 131 | -5.07 | 135 | -2.17 | 127 | -3.05 | 131 | -2.9 |
| | C1RB | 209 | 197 | -5.74 | 203 | -2.87 | 191 | -3.04 | 197 | -2.95 |
| | C2SJ | 141 | 133 | -5.67 | 138 | **-2.12** | 130 | -2.25 | 135 | -2.17 |
| | C2RB | 190 | 181 | -5.26 | 184 | -3.15 | 177 | -2.21 | 182 | **-1.08** |
| Bursting Strength ($Kg/cm^2$) | C1SJ | 6.4 | 5.75 | -10.15 | 6.1 | -4.68 | 5.2 | -18.75 | 5.9 | -7.81 |
| | C1RB | 6.4 | 5.86 | -8.43 | 6.2 | -3.12 | 5.4 | -15.62 | 6 | -6.25 |
| | C2SJ | 7 | 6.2 | -11.42 | 6.7 | -4.28 | 5.8 | -17.14 | 6.57 | -6.14 |
| | C2RB | 6.7 | 6.1 | -8.95 | 6.5 | **-2.98** | 5.6 | -16.41 | 6.3 | **-5.97** |

From Table XXVa, the structures, processes and bio polishing effects in the main effects and yarn /structure in 2 way interactions represented significant effect on pH, at 1% level.

**Absorbency:** [100% cotton]

Absorbency of the fabric is rated as good if less time is taken by the water droplet to completely penetrate into the fabric. Table XXV reveals that the time taken for complete absorption is less in all the bio pretreated samples when compared to the samples that have been chemically pretreated, indicating good absorbency. Sample C2SJ (2 seconds) exhibited the least absorbency time after bio pretreatment. It may also be noted that after bio polishing, both the chemical and bio pretreated samples exhibited very good absorbency. Samples C1RB and C2RB (<1 second) recorded lowest absorbency time values after bio pretreatment and bio polishing. Choudhury (2006), states that the pectic substances in the primary wall of the cotton fibre, act as adhesive, binding the wax to the cotton fibre. When these substances are removed by pretreatment, greater absorbency results.

**TABLE XXVa**

**ANALYSIS OF VARIANCE FOR pH OF FABRIC, ABSORBENCY, WEIGHT AND BURSTING STRENGTH OF COTTON WEFT KNITS**

| Effects | Source of Variation | pH of Fabric | Absorbency | Fabric Weight | Bursting Strength |
|---|---|---|---|---|---|
| | | F Value | F Value | F Value | F Value |
| Main Effects | Yarns | 0.144 | 0.285 | 1.318 | **11.980**** |
| | Structures | **11.537**** | 3.298 | 0.207 | **23.945**** |
| | Processes | **20.480**** | **30.859**** | **34.707**** | **26.887**** |
| | Bio Polishing | **20.626**** | **37.078**** | **23.894**** | 3.570 |
| 2- way Interactions | Yarn /Structure | **32.927**** | **10.271**** | 0.856 | **8.076**** |
| | Yarn /Process | 0.027 | 0.285 | 0.004 | **7.952**** |
| | Yarn/ Polishing | 0.305 | 0.000 | 1.132 | **14.308**** |
| | Structure/Process | 0.223 | 0.103 | 0.574 | **13.760**** |
| | Structure/ Polishing | 0.239 | **8.947**** | 0.088 | **9.468**** |
| | Process/Polishing | 0.285 | 1.929 | 0.074 | 0.934 |
| 3- way Interactions | Yarn / Structure / Process | 0.193 | **4.565*** | 0.531 | **10.673**** |
| | Yarn / Structure/ Polishing | 0.077 | **13.980**** | 0.072 | **7.371**** |
| | Yarn / Process / Polishing | 0.297 | 0.000 | 0.074 | **11.698**** |
| | Structure/Process/ Polishing | 0.320 | 0.046 | 0.074 | **11.339**** |
| 4- way Interactions | Yarn / Structure / Process / Polishing | 0.789 | **7.133**** | 0.074 | **9.032**** |

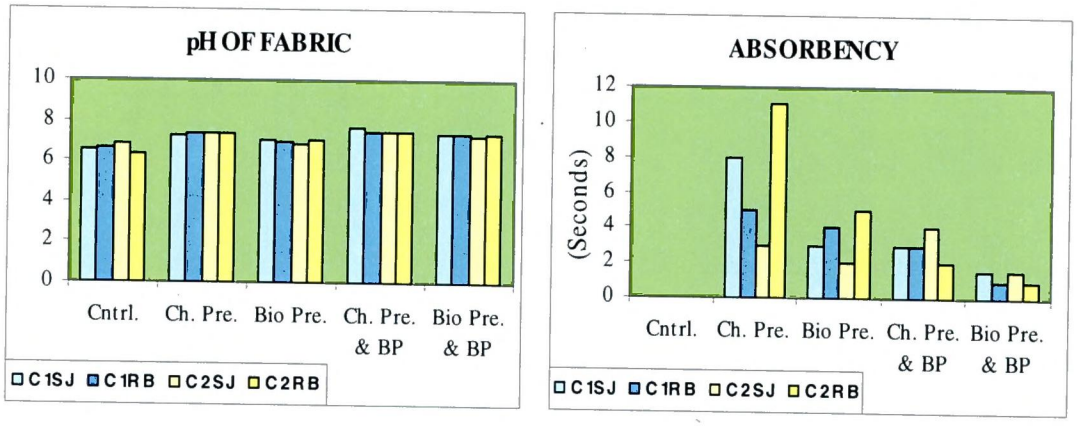
** Significant at 1% level * Significant at 5% level

The statistical Table XXVa reveals that the processes and bio polishing effects in main effects, Yarn /Structure and Structure/ Polishing in 2-way interactions, Yarn / Structure / Process (5% level) and Yarn / Structure / Polishing in 3-way interactions and Yarn / Structure/ Process / Polishing in 4-way effects expressed significant effect on absorbency at 1% level.

**Weight:** [100% cotton]

Table XXV highlights the fact that the weight of bio pretreated samples was higher than the chemical pretreated samples. After bio pretreatment sample C2SJ recorded the lowest weight loss of 2.12 %. Patra [2003] explains that enzymes are selective in action and cause no degradation of cellulose. Moreover the amount of wax removed is less which results in lower weight loss, improved hand yet has excellent absorbency. Bio preparation causes less weight and strength loss than caustic scouring.

# pH OF FABRIC, ABSORBENCY, FABRIC WEIGHT AND BURSTING STRENGTH OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



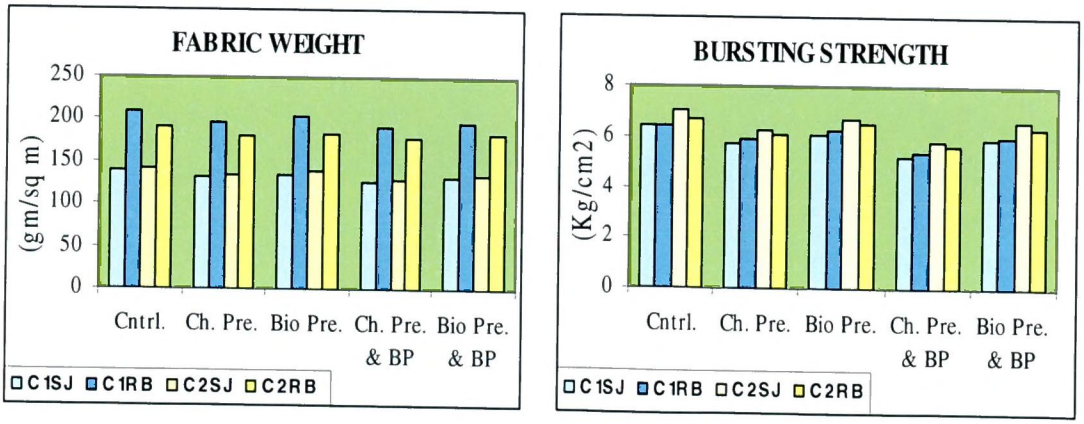




**FIGURE 8**

After bio polishing, further loss in weight was noted in all the samples. This may be due to the fact that bio polishing treatment removes the micro fibrils in the cotton fibre resulting in weight loss but ensures a smooth surface. Among the bio polished samples, C2RB recorded the lowest weight loss of 1.08%.

The ANOVA Table XXVa reveals that the processes and bio polishing effects in main effects had a significant effect on fabric weight at 1% level.

**Bursting Strength:** [100% cotton]

Table XXV shows loss of strength in all samples after pretreatment and subsequent bio polishing. The bio pretreated samples have higher strength when compared to the chemical pretreated samples. The lowest loss of strength was noted in the sample C2RB (2.98 %) and after bio pretreatment with bio polishing (5.97%). This may be due to the fact that chemical scouring has an adverse effect on the fabric as the cellulose is degraded substantially. The percentage strength loss was higher in the case of chemical pretreated samples after the bio polishing treatment.

The statistical Table XXVa highlights that, except for bio polishing effect in main effects and Process/Polishing in 2-way interactions, all the parameters analysed, showed significant effect on bursting strength at 1% level.

**❋ pH of Fabric, Absorbency, Weight and Bursting Strength**

**Lycra cotton**

The pH of Fabric, Absorbency, Weight and Bursting Strength of lycra cotton weft knits are presented in Table XXVI and Figure 9. The analysis of variance for the above mentioned properties of lycra cotton weft knits are represented in Table XXVIa.

**pH of Fabric :** [Lycra cotton]

After pretreatment all the samples exihibited values above 7 and after bio polishing there is a slight increase when compared to their control. The chemical pretreated samples before and after bio polishing record higher values than the bio pretreated counter parts. The values near the ideal pH was found in the samples LC1SJ and LC2RB with 7.3 after bio pretreatment and samples LC1SJ and LC1RB were closest to the neutral pH with 7.5 after bio pretreatment plus bio polishing.

## TABLE XXVI

## pH OF FABRIC, ABSORBENCY, WEIGHT AND BURSTING STRENGTH OF LYCRA COTTON WEFT KNITS

| Test | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| pH of Fabric | LC1SJ | 6.8 | 7.5 | 10.29 | **7.3** | 7.35 | 7.8 | 14.70 | **7.5** | 10.29 |
| | LC1RB | 6.8 | 7.4 | 8.82 | 7.4 | 8.82 | 7.8 | 14.70 | **7.5** | 10.29 |
| | LC2SJ | 6.9 | 7.6 | 10.14 | 7.5 | 8.69 | 8 | 15.94 | 7.6 | 10.14 |
| | LC2RB | 7.2 | 7.7 | 6.94 | **7.3** | 1.38 | 8.1 | 12.5 | 7.7 | 6.94 |
| Absorbency (seconds) | LC1SJ | - | 3 | - | **<1** | - | 2 | - | **<1** | - |
| | LC1RB | - | 3 | - | 2 | - | 2 | - | **<1** | - |
| | LC2SJ | - | 1 | - | **<1** | - | 1 | - | **<1** | - |
| | LC2RB | - | 1 | - | **<1** | - | 1 | - | **<1** | - |
| Weight (gm/sq m) | LC1SJ | 197 | 183 | -7.10 | 190 | -3.55 | 176 | -10.65 | 184 | **-6.59** |
| | LC1RB | 245 | 232 | -5.30 | 236 | -3.67 | 222 | -9.38 | 227 | -7.34 |
| | LC2SJ | 136 | 125 | -8.08 | 132 | **-2.94** | 121 | -11.02 | 127 | -6.61 |
| | LC2RB | 204 | 186 | -8.82 | 196 | -3.92 | 179 | -12.25 | 189 | -7.35 |
| Bursting Strength ($Kg/cm^2$) | LC1SJ | 5.4 | 5.00 | -7.40 | 5.58 | **3.33** | 4.40 | -18.51 | 5.32 | **-1.48** |
| | LC1RB | 6.1 | 4.58 | -24.91 | 4.875 | -20.08 | 4.44 | -27.21 | 4.63 | -24.09 |
| | LC2SJ | 5.6 | 4.62 | -17.5 | 4.95 | -11.60 | 4.75 | -15.17 | 4.80 | -14.28 |
| | LC2RB | 6.6 | 4.81 | -27.12 | 6 | -9.09 | 5.00 | -24.24 | 5.62 | -14.84 |

The ANOVA Table XXVIa revealed that the yarn and processes in main effects and yarn/structure in 2-way interactions have significant effect at 5% level; the structures and bio polishing effect in the main effects have significant effect on the pH of fabric at 1% level.

**Absorbency:** [Lycra cotton]

Table XXVI highlights good absorbency values after both chemical and bio pretreatment indicating that the fabrics are very suitable for the subsequent finishing treatments. After bio polishing the absorbency has improved in both chemical and bio pretreated samples. The lowest absorbency time (<1 second)was noted in all bio pretreated samples except LC1RB whereas all the bio pretreated and bio polished lycra cotton weft knits exhibited lowest values of less than one second.

The statistical analysis in Table XXVIa reveals that processes and bio polishing in main effects and yarn/process in 2- way interactions have significant effect at 5% level, while yarns in main effects had significant effect on absorbency at 1% level.

**TABLE XXVIa**

**ANALYSIS OF VARIANCE FOR pH OF FABRIC, ABSORBENCY, WEIGHT AND BURSTING STRENGTH OF LYCRA COTTON WEFT KNITS**

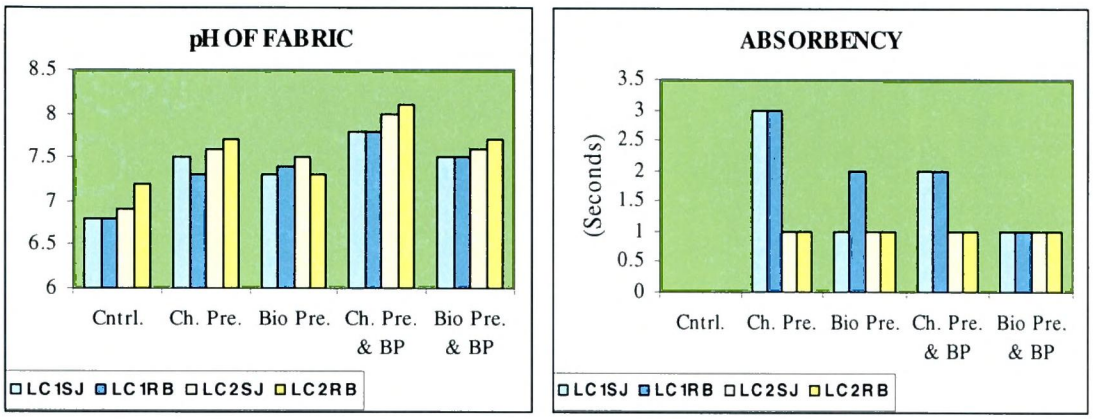
| Effects | Source of Variation | pH of Fabric | Absorbency | Fabric Weight | Bursting Strength |
|---|---|---|---|---|---|
| | | F Value | F Value | F Value | F Value |
| Main Effects | Yarns | **4.04*** | **25**** | **5.084*** | 0.095 |
| | Structures | **7.82**** | 0 | 0.201 | 3.065 |
| | Processes | **4.662*** | **6.250*** | **87.304**** | **37.390**** |
| | Bio Polishing | **7.705**** | **6.250*** | **71.999**** | **4.842*** |
| 2- way Interactions | Yarn /Structure | **6.191*** | 0.000 | 3.214 | **35.038**** |
| | Yarn /Process | 0.000 | **6.250*** | **6.060*** | 0.007 |
| | Yarn/ Polishing | 0.379 | 6.250 | 0.071 | 2.619 |
| | Structure/Process | 0.813 | 0 | 1.269 | 0.180 |
| | Structure/ Polishing | 0.081 | 0 | 0.182 | 0.147 |
| | Process/Polishing | 0.146 | 0 | 0.003 | 0.856 |
| 3- way Interactions | Yarn / Structure / Process | 0.001 | 0 | 1.628 | **10.013**** |
| | Yarn / Structure / Polishing | 0.352 | 0 | 0.077 | 0.686 |
| | Yarn / Process / Polishing | 1.344 | 0 | 0.253 | 2.485 |
| | Structure / Process / Polishing | 0.702 | 0 | 0.038 | 0.919 |
| 4- way Interactions | Yarn / Structure / Process / Polishing | 3.107 | 0 | 0.065 | 0.143 |

** Significant at 1% level * Significant at 5% level

**Weight :** [Lycra cotton]

Table XXVI highlights that the fabric weight was higher in the case of bio pretreated samples with bio polishing than the chemical pretreated ones. The minimum weight loss recorded after bio pretreatment and after subsequent bio polishing was found in sample LC2SJ (2.94%) and in sample LC1SJ (6.59%). Ammayappan *et al.* (2003) state that the weight loss is directly proportionately to the concentration of sodium hydroxide and the processing time. The chemical formulation reveals higher concentration and time for scouring when compared to the bio pretreatment procedure leading to higher weight loss in the chemical pretreated and bio polished samples.

# pH OF FABRIC, ABSORBENCY, FABRIC WEIGHT AND BURSTING STRENGTH OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



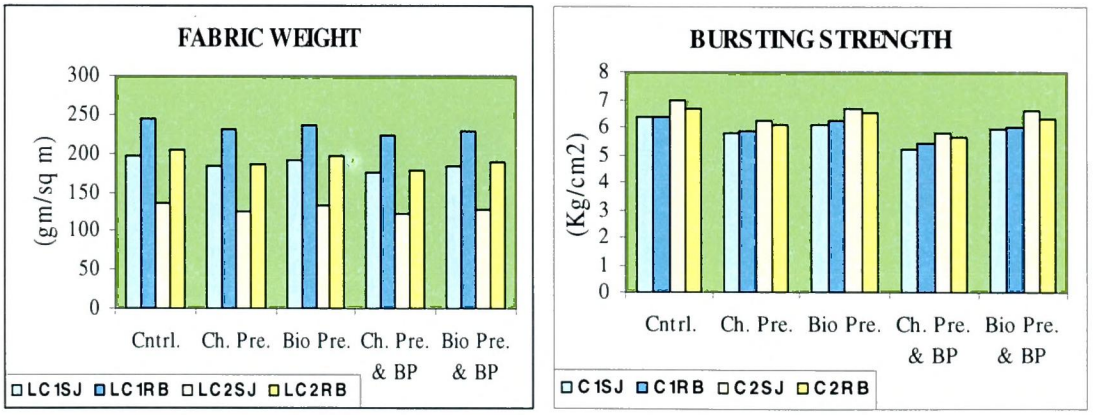




**FIGURE 9**

The ANOVA Table XXVIa highlights that processes and bio polishing in main effects showed significant effect at 1% level; yarns in main effects and yarn /process in 2-way interactions exhibited significant effect on fabric weight at 5% level.

**Bursting Strength:** [Lycra cotton]

Table XXVI reveals a reduction of strength of all samples after pretreatment and bio polishing when compared to their controls. The percentage strength loss was higher in the chemical pretreated samples highlighting the negative effect of chemicals on the fabric. The lowest difference in strength was observed in the sample LC1SJ (3.33%) after bio pretreatment and (1.48%) after bio pretreatment and bio polishing. Churi and Khadilkar (2005), explain that the absence of strong alkali in the liquor prevents the risk of oxycellulose formation and hence the strength loss is less when enzymes are used in processing.

From the ANOVA Table XXVIa, it may be observed that processes in main effects, yarn /structure in 2-way interactions and yarn /structure /process in 3-way interactions showed significant effect on bursting strength at 1% level while bio polishing in main effects exhibited significant effect at 5% level.

❋ **Degree of Polymerization, Residual Alkali, Whiteness And Yellowness Index 100% Cotton**

The Degree of Polymerization, Residual Alkali, Whiteness Index and Yellowness Index of cotton weft knits are given in Table XXVII and Figure 10.The analysis of variance for the properties mentioned above are given in Table XXVIIa.

**Degree of Polymerization:** [100% cotton]

The degree of polymerization values suggest the amount of cellulose degradation in numerical terms. Abdel-Halim *et al.* (2007), state that the conventional alkali scouring destroys some of the cellulosic chains of the fibre resulting in lower degree of polymerization. The table XXVII reveals higher values in the case of bio pretreated samples with and without bio polishing, suggesting that the degradation percentage is less when compared to the chemical pretreated counter parts. Sample C2RB recorded the lowest loss percentage of 4.5 after bio pretreatment and 5.65 after subsequent bio polishing.

## TABLE XXVII

## DEGREE OF POLYMERIZATION, RESIDUAL ALKALI, WHITENESS INDEX AND YELLOWNESS INDEX OF COTTON WEFT KNITS

| Test | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Degree of Polymerization | C1SJ | 2802 | 2499 | -10.81 | 2642 | -5.71 | 2292 | -18.20 | 2437 | -13.02 |
| | C1RB | 2870 | 2605 | -9.23 | 2726 | -5.01 | 2449 | -14.66 | 2633 | -8.25 |
| | C2SJ | 3020 | 2733 | -9.50 | 2859 | -5.33 | 2588 | -14.30 | 2759 | -8.64 |
| | C2RB | 3412 | 3104 | -9.02 | 3258 | **-4.51** | 3005 | -11.92 | 3219 | **-5.65** |
| Residual Alkali (ppm) | C1SJ | - | 1000 | - | 490 | - | 845 | - | 335 | - |
| | C1RB | - | 1055 | - | **450** | - | 870 | - | 350 | - |
| | C2SJ | - | 965 | - | 475 | - | 800 | - | 345 | - |
| | C2RB | - | 945 | - | 456 | - | 825 | - | **327** | - |
| Whiteness Index | C1SJ | 8 | 71 | 787.5 | 55 | 587.5 | **68** | 750 | 55 | 587.5 |
| | C1RB | 10 | 70 | 600 | 50 | 400 | 65 | 550 | 48 | 380 |
| | C2SJ | 6 | **74** | 1133.33 | 60 | 900 | **68** | 1033.33 | 59 | 883.33 |
| | C2RB | 9 | 70 | 677.77 | 52 | 477.77 | 66 | 633.33 | 50 | 455.55 |
| Yellowness Index | C1SJ | 29 | 5 | -82.75 | 5 | -82.75 | 9 | -68.96 | 8 | -72.41 |
| | C1RB | 30 | 5 | -83.33 | 6 | -80 | 11 | -63.33 | 11 | -63.33 |
| | C2SJ | 24 | **3** | -87.5 | 4 | -83.33 | **6** | -75 | 7 | -70.83 |
| | C2RB | 32 | 6 | -81.25 | 6 | -81.25 | 10 | -68.75 | 10 | -68.75 |

From the ANOVA Table XXVIIa, it is seen that except yarn /process in 2-way interactions, all other parameters showed significant effect on degree of polymerization of cotton weft knits, at 1% level.

**Residual Alkali:** [100% cotton]

Table XXVII indicates that residual alkali after pretreatment was high in chemical pretreated samples since a high dose of alkali was used in the chemical scouring process. Among the treated samples, the bio pretreated sample C1RB recorded the lowest residual alkali value of 450 ppm and the bio pretreated bio polished sample C2RB represented a low residual alkali value of 327 ppm.

The analysis of variance Table XXVIIa revealed that all the parameters analyzed had significant effect on residual alkali at 1% level.

## TABLE XXVIIa

## ANALYSIS OF VARIANCE FOR DEGREE OF POLYMERIZATION, RESIDUAL ALKALI, WHITENESS INDEX AND YELLOWNESS INDEX OF COTTON WEFT KNITS

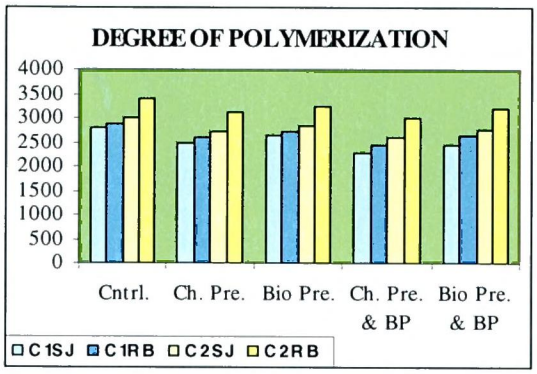
| Effects | Source of Variation | Degree of Polymerization | Residual Alkali | Whiteness Index | Yellowness Index |
|---|---|---|---|---|---|
| | | F Value | F Value | F Value | F Value |
| Main Effects | Yarns | **5925.326**** | **1387.584**** | **705.016**** | **77.102**** |
| | Structures | **6852.093**** | **11.113**** | **1812.035**** | **222.214**** |
| | Processes | **39800.204**** | **349200.189**** | **653.013**** | **2421.924**** |
| | Bio Polishing | **29148.419**** | **27254.643**** | **24.759**** | **13.324**** |
| 2- way Interactions | Yarn /Structure | **354.291**** | **159.013**** | **249.403**** | 0.010 |
| | Yarn /Process | 1.883 | **953.130**** | 0.240 | **23.028**** |
| | Yarn/ Polishing | **2906.995**** | **54.643**** | 1.683 | **14.079**** |
| | Structure/Process | **38.997**** | **453.971**** | 0.001 | **30.964**** |
| | Structure/ Polishing | **2352.573**** | **105.903**** | 0.090 | 0.475 |
| | Process/Polishing | **702.034**** | **258.845**** | **8.766**** | **9.072**** |
| 3 - way Interactions | Yarn / Structure / Process | **8.371**** | **83.382**** | 0.050 | **30.964**** |
| | Yarn / Structure / Polishing | **88.649**** | **9.265**** | 1.992 | **45.067**** |
| | Yarn / Process / Polishing | **22.261**** | **73.130**** | 0.424 | **9.072**** |
| | Structure / Process / Polishing | **132.082**** | **35.315**** | 1.378 | 0.003 |
| 4- way Interactions | Yarn / Structure / Process / Polishing | **79.449**** | **349.601**** | 0.841 | 0.003 |

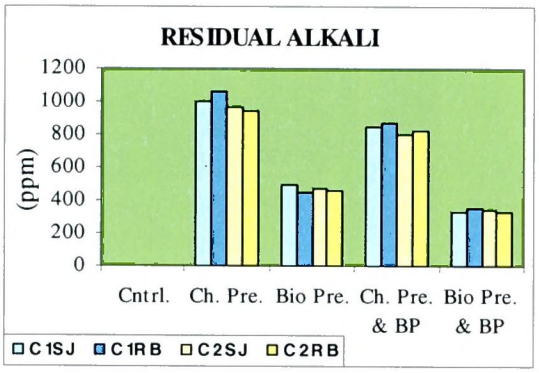
** Significant at 1% level * Significant at 5% level

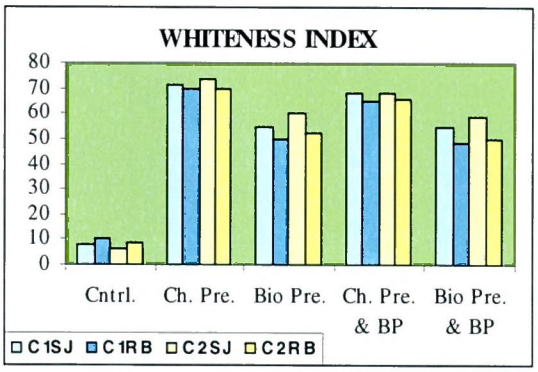
**Whiteness Index:** [100% cotton]

From the Table XXVII it is seen that the chemically pretreated samples have a high degree of whiteness index when compared to the bio pretreated fabrics. After bio polishing the whiteness index has reduced in both the chemical and bio pretreated samples. Presa and Tavcer (2009), narrate that after alkaline scouring, the fibres swelled, became smoother and free from non-cellulosic impurities having a higher degree of whiteness whereas the bio scoured samples had lower degrees of whiteness. The chemical pretreated sample C2SJ recorded the maximum value of 74 and the chemical pretreated and bio polished samples C1SJ and C2SJ presented values of 68.

# DEGREE OF POLYMERIZATION, RESIDUAL ALKALI, WHITENESS INDEX AND YELLOWNESS INDEX OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



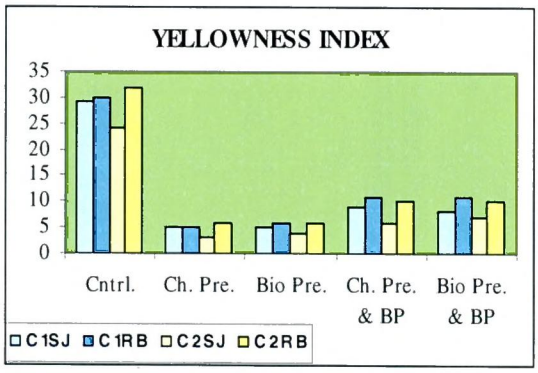




**FIGURE 10**

The ANOVA Table XXVIIa reveals that all the factors analysed in main effects and yarn /structure and process /polishing in 2-way interactions represented a significant effect on the whiteness index at 1% level.

**Yellowness Index:** [100% cotton]

Table XXVII reveals that the yellowness index was higher in the case of bio pretreated samples. The lowest yellowness index values was observed in sample C2SJ with 3 and 6 after chemical pretreatment and subsequent bio polishing. These values highlight the fact that enzymatic treatments produce a lower whiteness index and higher yellow index in comparison with chemical treatments.

The ANOVA Table XXVIIa shows that except structure /polishing in 2-way interactions, structure /process /polishing in 3-way interactions and yarn / structure /process /polishing in 4-way interactions, all other factors exhibited a significant effect at 1% level, with regard to yellowness index.

❋ **Degree of Polymerization, Residual Alkali, Whiteness Index and Yellowness Index Lycra Cotton**

Table XXVIII and Figure 11 presents the Degree of Polymerization, Residual Alkali, Whiteness and Yellowness Index of Lycra cotton weft knits. The analysis of variance for all the above mentioned properties are given in Table XXVIIIa.

**Degree of Polymerization:** [Lycra cotton]

Table XXVIII indicates a reduction in values after pretreatment and bio polishing. The percentage reduction was higher in the case of chemical pretreated samples, with or without bio polishing, than the bio pretreated samples. The bio pretreated sample LC2RB recorded the highest value of 3202 and after bio polishing the same sample showed 3135 indicating that the bio treatments were mild and do not degrade the fibres in the samples.

From the statistical Table XXVIIIa, it is seen that all the parameters statistically analysed in main effects, 2-way interactions and 4-way interactions had a significant effect on degree of polymerization at 1% level, while Yarn / Structure / Polishing in 3-way interactions had significant effect at 5% level.

## TABLE XXVIII

## DEGREE OF POLYMERIZATION, RESIDUAL ALKALI, WHITENESS INDEX AND YELLOWNESS INDEX OF LYCRA COTTON WEFT KNITS

| Test | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Bio Polished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Degree of Polymerization | LC1SJ | 2851 | 2457 | -13.81 | 2613 | -8.34 | 2417 | -15.22 | 2565 | -10.03 |
| | LC1RB | 2894 | 2569 | -11.23 | 2678 | -7.46 | 2527 | -12.68 | 2655 | -8.25 |
| | LC2SJ | 3135 | 2774 | -11.51 | 2935 | -6.37 | 2686 | -14.32 | 2864 | -8.64 |
| | LC2RB | 3395 | 3052 | -10.10 | **3202** | -5.68 | 2990 | -11.92 | **3135** | -7.65 |
| Residual Alkali (ppm) | LC1SJ | - | 1205 | - | 973 | - | 513 | - | 350 | - |
| | LC1RB | - | 1113 | - | 985 | - | 499 | - | 375 | - |
| | LC2SJ | - | 1050 | - | **908** | - | 501 | - | 380 | - |
| | LC2RB | - | 1032 | - | 929 | - | 512 | - | **347** | - |
| Whiteness Index | LC1SJ | 3 | 58 | 1833.3 | 58 | 1833.3 | 56 | 1766.6 | 59 | 1866.6 |
| | LC1RB | 2 | 59 | 2850 | 61 | 2950 | 61 | 2950 | 59 | 2850 |
| | LC2SJ | 6 | 60 | 900 | 54 | 800 | 59 | 883.3 | 60 | 900 |
| | LC2RB | 1 | 62 | 6100 | **65** | 6400 | 62 | 6100 | **64** | 6300 |
| Yellowness Index | LC1SJ | 31 | 8 | -74.19 | 8 | -74.19 | 8 | -74.19 | 8 | -74.19 |
| | LC1RB | 33 | 8.5 | -74.24 | 8 | -75.75 | 8 | -75.75 | 9 | -72.72 |
| | LC2SJ | 29 | 7 | -75.86 | 9 | -68.96 | 8 | -72.41 | 7 | -75.86 |
| | LC2RB | 36 | 7 | -80.55 | **6** | -83.33 | 7 | -80.55 | **6** | -83.33 |

**Residual Alkali:** [Lycra cotton]

A low residual value in the fabric is an important requirement in apparel exports. The residual alkali values were found to be higher in the chemical pretreated samples when compared to the bio pretreated samples. The lowest residual alkali values was recorded in bio pretreated sample LC2SJ with 908 ppm. The bio pretreated bio polished sample LC2RB with 347 ppm was the lowest value recorded among the bio polished samples, showing that bio treatments are beneficial, since the presence of higher residual value may have a negative effect on the skin of the person wearing the finished garment.

From the statistical Table XXVIIIa, it may be observed that all the parameters analysed showed significant effect on residual alkali at 1% level.

## TABLE XXVIIIa

## ANALYSIS OF VARIANCE FOR DEGREE OF POLYMERIZATION, RESIDUAL ALKALI, WHITENESS INDEX AND YELLOWNESS INDEX OF LYCRA COTTON WEFT KNITS

| Effects | Source of Variation | Degree of Polymerization | Residual Alkali | Whiteness Index | Yellowness Index |
|---|---|---|---|---|---|
| | | F Value | F Value | F Value | F Value |
| Main Effects | Yarns | **2775.474**** | **2822.432**** | **537.273**** | **161.996**** |
| | Structures | **4178.022**** | **174.414**** | **3950.961**** | **326.674**** |
| | Processes | **34883.049**** | **501340.631**** | 1.595 | 0.087 |
| | Bio Polishing | **4784.118**** | **31254.144**** | 0.015 | 0.922 |
| 2- way Interactions | Yarn /Structure | **125.715**** | **56.306**** | **1750.297**** | **268.128**** |
| | Yarn /Process | **10.030**** | **2918.919**** | 0.599 | 3.238 |
| | Yarn/ Polishing | **296.953**** | **303.063**** | 0.002 | **6.079*** |
| | Structure/Process | **501.252**** | **98.108**** | 1.396 | **13.838**** |
| | Structure/ Polishing | **105.837**** | **428.919**** | 0.134 | **6.079*** |
| | Process/Polishing | **14.092**** | **23.063**** | 0.041 | **8.299**** |
| 3- way Interactions | Yarn / Structure / Process | 2.895 | **303.063**** | 2.790 | **27.304**** |
| | Yarn / Structure / Polishing | **4.414*** | **493.333**** | 0.280 | 0.922 |
| | Yarn / Process / Polishing | 0.009 | **292.703**** | 0.081 | **54.711**** |
| | Structure /Process / Polishing | 1.454 | **493.333**** | 1.595 | **54.711**** |
| 4- way Inter ctions | Yarn / Structure / Process / Polishing | **62.744**** | **7.297**** | 0.041 | **8.299**** |

** Significant at 1% level * Significant at 5% level

**Whiteness Index:** [Lycra cotton]

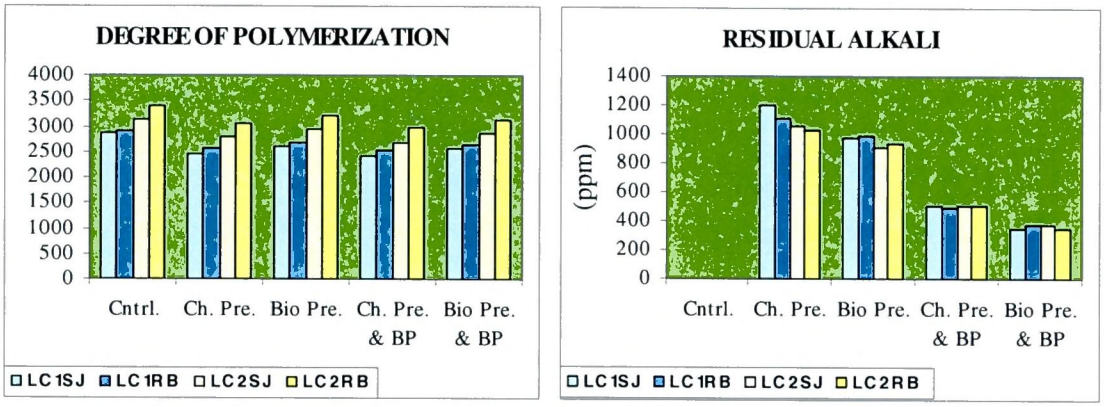
Table XXVIII shows improvement in whiteness index among all the treated samples when compared to their control. Higher whiteness index has an important bearing on the final colouration of fabrics. Bio pretreated sample LC2RB recorded the highest whiteness index of 65 and 64 after pretreatment and bio polishing respectively.

From the ANOVA Table XXVIIIa yarns and structures in main effects and yarn /structure in 2-way interactions have significant effect on the whiteness index at 1% level.

**Yellowness Index:** [Lycra cotton]

From Table XXVIII all the samples showed reduction in yellowness index, after pretreatment and bio polishing, when compared to their controls. Lowest yellowness index

# DEGREE OF POLYMERIZATION, RESIDUAL ALKALI, WHITENESS INDEX AND YELLOWNESS INDEX OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



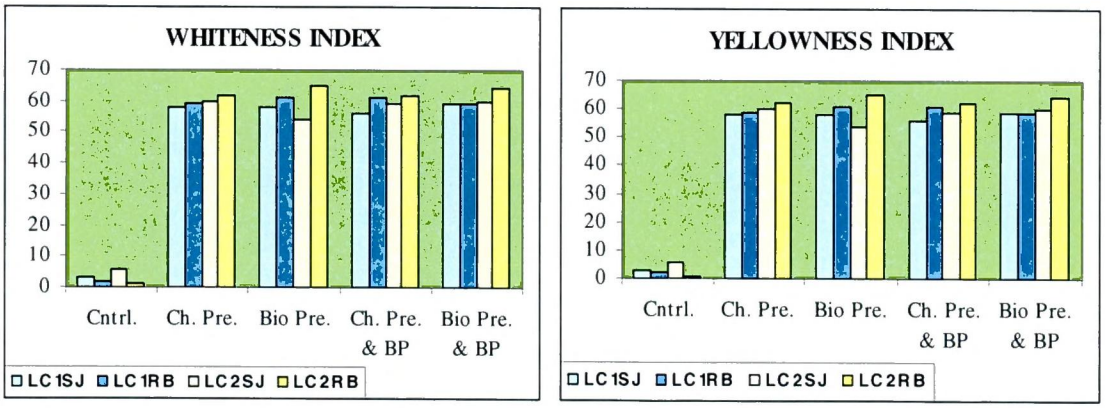




**FIGURE 11**

was observed in enzyme pretreated sample LC2RB with a value of 6 after pretreatment and subsequent bio polishing.

From Table XXVIIIa yarns and structures in main effects, yarn/structure, structure /process and process/polishing in 2-way interactions, all the parameters in 3-way interactions (except Yarn / Structure / Polishing) and 4-way interaction factors exhibited significant effect on the yellowness index at 1% level, while yarn /polishing and structure / polishing in 2-way interactions, exhibited significant effect at 5% level.

### ❋ Comfort properties - 100% Cotton

Comfort properties, which include Air permeability, $q_{max}$ and Thermal Conductivity, are presented in Table XXIX and Figure 12. The analysis of variance for the above mentioned comfort properties of 100% cotton weft knits are given in Table XXIXa.

**TABLE XXIX**

**COMFORT PROPERTIES OF COTTON WEFT KNITS**

| Test | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Air Permeability ($cm^3/sec/cm^2$) | C1SJ | 77.21 | 43.1 | -44.17 | 46.09 | -40.30 | 46.23 | -40.12 | 49.49 | -35.90 |
| | C1RB | 63.66 | 52.96 | **-16.80** | 47.18 | -25.88 | 58.17 | **-8.62** | 49.7 | -21.92 |
| | C2SJ | 85.28 | 52.89 | -37.98 | 40.26 | -52.79 | 59.91 | -29.74 | 46.85 | -45.06 |
| | C2RB | 70.6 | 46.3 | -34.41 | 42.55 | -39.73 | 48.37 | -31.32 | 44.28 | -37.28 |
| $q_{max}$ ($w/cm^2$) | C1SJ | 0.00312 | **0.00379** | 21.47 | 0.00350 | 12.17 | **0.004293** | 37.59 | 0.003889 | 24.64 |
| | C1RB | 0.00301 | 0.00377 | 25.24 | 0.00341 | 13.28 | 0.004285 | 42.35 | 0.003802 | 26.31 |
| | C2SJ | 0.00298 | 0.00374 | 25.50 | 0.00363 | 21.81 | 0.003929 | 31.84 | 0.004024 | 35.03 |
| | C2RB | 0.00285 | 0.00360 | 26.31 | 0.00356 | 24.91 | 0.004024 | 41.19 | 0.003857 | 35.33 |
| Thermal Conductivity | C1SJ | 0.0515 | 0.0470 | -5.04 | 0.0495 | -3.88 | 0.0520 | 11.84 | 0.0555 | 7.76 |
| | C1RB | 0.0687 | **0.0650** | -12.22 | 0.0648 | -5.67 | **0.0697** | -2.32 | 0.0672 | -2.18 |
| | C2SJ | 0.0517 | 0.0472 | -8.70 | 0.0520 | 0.58 | 0.0528 | 2.12 | 0.0572 | 10.63 |
| | C2RB | 0.0606 | 0.0604 | -0.33 | 0.0641 | 5.77 | 0.0683 | 14.19 | 0.0688 | 13.53 |

**Air Permeability :** [100% cotton]

From Table XXIX it is seen that all samples showed a marked decrease in air permeability when compared to their respective controls. This may be due to the change in

the dimensions of the fabric after pretreatment. Tyagi and Gupta (2009), state that swelling of the fibres during enzymatic scouring and bleaching increase the compactness of the knit structures. After bio polishing there was a slight increase in air permeability which may be due to the absence of short fibrils that are removed by the bio polishing treatment. The minimum loss in air permeability values were noted in chemically pretreated sample C1RB (16.8%) and after subsequent bio polishing, the same sample exhibited a value of 8.62%.

The ANOVA Table XXIXa highlights that, apart from yarn/polishing in 2-way interactions, all the parameters studied showed significant effect on air permeability at 1% level.

**TABLE XXIXa**

**ANALYSIS OF VARIANCE OF COMFORT PROPERTIES OF COTTON WEFT KNITS**

| Effects | Source of Variation | Air Permeability | Q Max | Thermal Conductivity |
|---|---|---|---|---|
| | | F Value | F Value | F Value |
| Main Effects | Yarns | **8820.330**** | **4.180*** | **26.915**** |
| | Structures | **19079.176**** | 1.761 | 3.644 |
| | Processes | **4866.589**** | **9.435**** | **10.479**** |
| | Bio Polishing | **2777.385**** | **29.217**** | **53.592**** |
| 2- way Interactions | Yarn /Structure | **6587.956**** | 0.013 | **12.157**** |
| | Yarn /Process | **1145.826**** | **5.091*** | 2.878 |
| | Yarn/ Polishing | 0.868 | 0.554 | 0.993 |
| | Structure/Process | **207.350**** | 0.438 | **6.961**** |
| | Structure/Polishing | **74.986**** | 0.157 | 1.231 |
| | Process/Polishing | **37.318**** | 0.080 | 0.554 |
| 3- way Interactions | Yarn / Structure / Process | **3868.420**** | 0.007 | 0.221 |
| | Yarn / Structure/ Polishing | **321.145**** | 0.047 | 1.188 |
| | Yarn / Process/ Polishing | **13.187**** | 0.298 | 0.215 |
| | Structure / Process/ Polishing | **32.724**** | 0.387 | 0.955 |
| 4- way Inter actions | Yarn / Structure / Process / Polishing | **33.378**** | 0.368 | 0.006 |

** Significant at 1% level * Significant at 5% level

**$q_{max}$ :** [100% cotton]

$q_{max}$ reflects the instantaneous warm / cool feeling sensed when there is an initial contact of the fabric with the surface of the skin. An increase in values are noted in the Table XXIX from their control, indicating rapid movement of heat from the skin to fabric resulting in a cooler feeling. The chemical pretreated sample C2RB exhibited highest increase of 26.31% among the pretreated samples. After bio polishing, the chemical pretreated and bio polished sample C1RB showed a maximum increase of 42.35%.This may be due to the higher loss in weight and thickness of the chemical pretreated fabrics leading to the cooler feeling when compared to the bio pretreated samples.

From the ANOVA Table XXIXa, it may be understood that processes and bio polishing effects in main effects were significant at 1% level and yarns in main effects and yarn /process in 2-way interactions had significant effect on $q_{max}$ at 5% level.

**Thermal Conductivity :** [100% cotton]

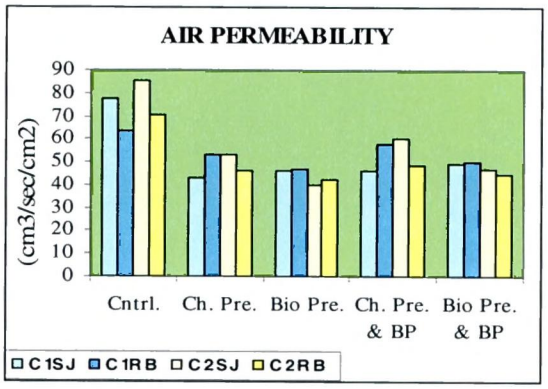
Table XXIX reveals that all the samples showed decreased thermal conductivity values than their control whereas bio polished samples showed increased values. The thermal properties of a textile fabric depends, to a great extent, on the air trapped within it. When the amount of fibre increases, the amount of entrapped air decreases. After pretreatment the yarns move closer due to shrinkage leading to lesser entrapped air. The thermal conductivity of the fibres are more than the thermal conductivity of the entrapped air. After bio polishing short fibrils are removed, leading to a mild increase in values. In general heavier fabrics like rib have higher values due to their knit structure than the single jersey fabrics. Of all the treated samples, the highest values were recorded in the chemically pretreated sample C1RB with 0.0650 and 0.0697 after pretreatment and bio polishing respectively.

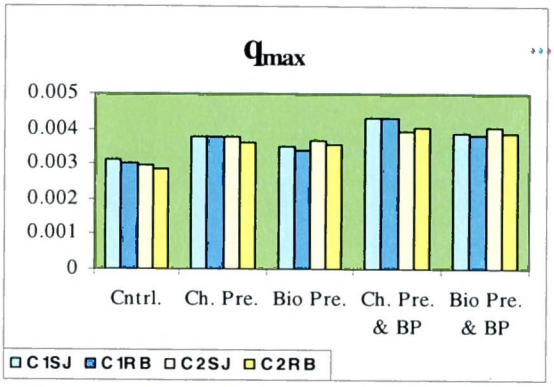
ANOVA Table XXIXa shows that yarns, process and bio polishing in main effects and yarn /structure and structure /process in 2-way interactions exhibited significant effect on the thermal conductivity values at 1% level.

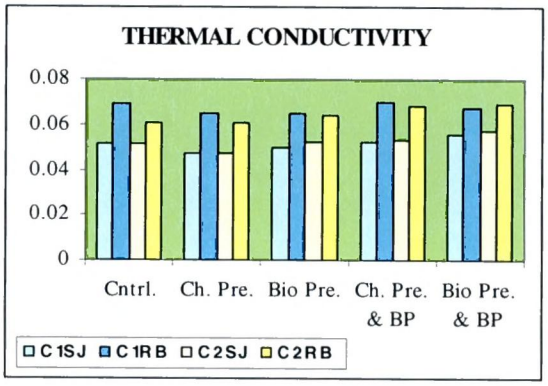
**Wicking** : [100% cotton]

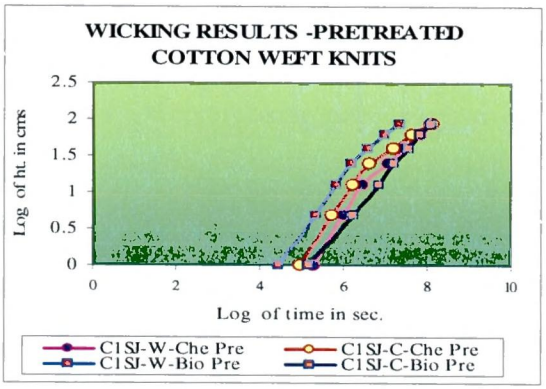
Table XXX gives the correlation coefficients, constant and slope values of cotton weft knits, obtained by linear regression analysis. The log value of height and the log value of time in seconds of cotton weft knits after pretreatment and bio polishing are given in Appendix 8.

# AIR PERMEABILITY, $q_{max}$, THERMAL CONDUCTIVITY AND WICKING RESULTS OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIOPOLISHING



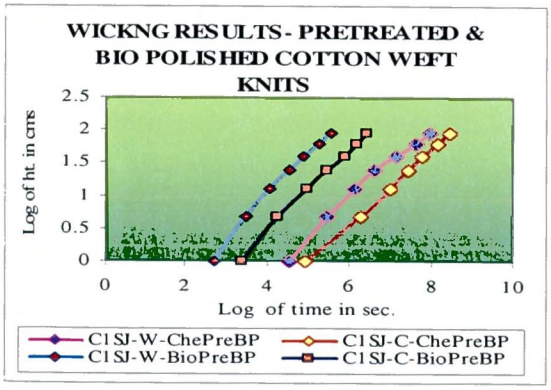




**FIGURE 12**

Table XXX shows the highest slope values of 0.8912 and 0.8693 were noted in sample C1RB in the wale direction, after bio pretreatment and subsequent bio polishing. A majority of the bio pretreated samples (about 75%) and the bio pretreated and bio polished samples (about 87.5%), exhibited higher slope values when compared to the respective chemical pretreated and chemical pretreated, bio polished samples. The greater the slope value, the better is the wickability. The correlation coefficient values in all samples was positive and ranged from 0.976 to 0.999 indicating good correlation between the two parameters analyzed namely log of height verses log of time. Presa and Tavcer (2008), state that during bio scouring cracks appear in the cuticle that enabled the water to penetrate into the fibres causing increased absorbency. This change in the fibre has enabled better wicking properties in the enzyme pretreated cotton weft knits.

**TABLE XXX**

**REGRESSION ANALYSIS FOR WICKING OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING**

**Model : log (ht) = constant + b. log (time)**

| | **Chemical Pretreated** | | | **Bio Pretreated** | | |
|---|---|---|---|---|---|---|
| | **Correlation** | **Constant (a)** | **Slope (b)** | **Correlation** | **Constant (a)** | **Slope (b)** |
| C1SJ-W | 0.988 | -3.3514 | 0.6648 | 0.991 | -2.9727 | 0.6879 |
| C | 0.976 | -2.8272 | 0.6085 | 0.999 | -3.4574 | 0.6695 |
| C1RB-W | 0.997 | -4.1282 | 0.7886 | 0.999 | -5.0604 | **0.8912** |
| C | 0.999 | -1.8757 | 0.4141 | 0.991 | -2.8149 | 0.5676 |
| C2SJ-W | 0.999 | -2.0923 | 0.5025 | 0.999 | -2.717 | 0.5851 |
| C | 0.999 | -4.1331 | 0.6766 | 0.996 | -3.3358 | 0.6135 |
| C2RB- W | 0.997 | -5.6416 | 0.8718 | 0.978 | -3.33 | 0.6422 |
| C | 0.991 | -4.1733 | 0.6851 | 0.999 | -3.7014 | 0.6447 |
| | **Chemical Pretreated & Bio Polished** | | | **Bio Pretreated & Bio Polished** | | |
| | **Correlation** | **Constant (a)** | **Slope (b)** | **Correlation** | **Constant (a)** | **Slope (b)** |
| C1SJ-W | 0.991 | -2.3985 | 0.5568 | 0.994 | -1.7092 | 0.6714 |
| C | 0.999 | -2.806 | 0.563 | 0.978 | -1.4415 | 0.4876 |
| C1RB-W | 0.993 | -2.3237 | 0.5953 | 0.996 | -3.3877 | **0.8693** |
| C | 0.998 | -1.7718 | 0.5719 | 0.995 | -2.8414 | 0.6233 |
| C2SJ-W | 0.988 | -1.726 | 0.6199 | 0.996 | -3.0384 | 0.6642 |
| C | 0.999 | -3.4146 | 0.7474 | 0.995 | -4.0998 | 0.7478 |
| C2RB- W | 0.997 | -1.9811 | 0.6532 | 0.992 | -2.7177 | 0.7506 |
| C | 0.985 | -1.9255 | 0.6066 | 0.996 | -2.7043 | 0.6902 |

## ❋ Comfort Properties - Lycra Cotton

The comfort properties namely Air permeability, $q_{max}$ and Thermal Conductivity of Lycra Cotton weft knits are presented in Table XXXI and Figure 13. The Analysis of Variance for the above mentioned comfort properties are given in Table XXXIa.

**Air Permeability:** [Lycra Cotton]

Table XXXI reveals that after pretreatment a reduction in air permeability was noticed in all the samples when compared to their controls. The loss percentage was higher in the case of rib structures when compared to the single jersey fabrics. Baltakyte and Petrulyte (2008), state that when the fabric surface was wetted by water, the fibres swelled transversally reducing the size of the pores in the fabric. A mixed trend in values was noticed after bio polishing, when compared to their originals. After pretreatment, minimum loss was noted in bio pretreated sample LC1SJ with 19.50%. After bio polishing, chemical pretreated and bio polished sample LC2SJ exhibited a minimum loss of 13.74%.

The ANOVA Table XXXIa reveals that apart from the parameter structure /process in 2-way interactions, all the parameters analyzed revealed significant influence on air permeability at 1% level.

**$q_{max}$ :** [Lycra Cotton]

Table XXXI shows a substantial increase in values in all the samples after pretreatment and subsequent bio polishing. Kan and Yuen (2006), explain that a higher value of $q_{max}$ denotes that there is a more rapid movement of heat from the skin to the fabric surface which will provide a cooler feeling. Higher values are found in single jersey samples highlighting that single jersey knits are cooler than rib structures. Among all the treated samples, the highest increase in values were recorded in sample LC2SJ(30.74%) after chemical pretreatment and the same sample after bio polishing showed a maximum increase of 46.1%.

From ANOVA Table XXXIa, it is seen that yarns and bio polishing in main effects expressed significant differences at 1% level while processes in main effects and yarn /process in 2-way interactions exhibited significant effect at 5% level.

## TABLE XXXI

## COMFORT PROPERTIES OF LYCRA COTTON WEFT KNITS

| Test | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Air Permeability ($cm^3/sec/cm^2$) | LC1SJ | 35.95 | 16.08 | -55.24 | 28.93 | -19.50 | 18.38 | -48.87 | 15.81 | -56.02 |
| | LC1RB | 74.07 | 23.03 | -68.90 | 26.85 | -63.74 | 22.48 | -69.65 | 24.01 | -67.58 |
| | LC2SJ | 35.88 | **20.11** | -43.93 | 21.99 | -38.70 | **30.95** | -13.74 | 20.67 | -42.39 |
| | LC2RB | 98.38 | 52.40 | -46.72 | 46.36 | -52.86 | 44.21 | -55.06 | 49.7 | -49.48 |
| Q max (w/cm2) | LC1SJ | 0.00301 | 0.00353 | 17.27 | 0.00351 | 16.61 | 0.004008 | 33.15 | 0.004008 | 33.15 |
| | LC1RB | 0.00296 | 0.00337 | 13.85 | 0.0032 | 8.10 | 0.003644 | 23.10 | 0.003798 | 28.31 |
| | LC2SJ | 0.00277 | **0.0036** | 30.74 | 0.00333 | 20.21 | **0.004047** | 46.10 | 0.003868 | 39.63 |
| | LC2RB | 0.00268 | 0.00357 | 30.73 | 0.00307 | 12.45 | 0.004001 | 46.05 | 0.003728 | 36.55 |
| Thermal Conductivity | LC1SJ | 0.071 | 0.0581 | **-18.16** | 0.0567 | -20.14 | 0.0622 | -12.39 | 0.0636 | -10.42 |
| | LC1RB | 0.0881 | 0.0698 | -20.77 | 0.0655 | -25.65 | 0.0752 | -14.64 | 0.0756 | -14.18 |
| | LC2SJ | 0.0701 | 0.0557 | -20.54 | 0.0535 | -23.68 | 0.0614 | -12.41 | 0.0612 | -12.69 |
| | LC2RB | 0.0742 | 0.0606 | -18.32 | 0.0602 | -18.86 | 0.0671 | **-9.56** | 0.0647 | -12.80 |

**Thermal Conductivity:** [Lycra Cotton]

Table XXXI shows an overall reduction in values in all the samples when compared to their controls. After pretreatment the fabrics undergo shrinkage and the thickness of the fabrics increase thereby having an impact on thermal conductivity of the fabrics. This situation can be explained by the amount of entrapped air in the fabric structure. Morton and Hearle (2002), state that as the weight increases, the amount of fibre in the unit area increases and the amount of air layer decreases. The thermal conductivity values of fibres are higher than the thermal conductivity of entrapped air. So heavier fabrics that contain less still air (like rib and interlock) have higher thermal conductivity values. It can be noted that the thermal conductivity values of all the samples increased marginally after bio polishing when compared to the pretreated samples. Of all the treated samples, minimum loss of 18.16% was noticed in chemical pretreated sample LC1SJ and in chemical pretreated and bio polished sample LC2RB with 9.56%.

**TABLE XXXIa**

**ANALYSIS OF VARIANCE OF COMFORT PROPERTIES OF LYCRA COTTON WEFT KNITS**

| Effects | Source of Variation | Air Permeability | $q_{max}$ | Thermal Conductivity |
|---|---|---|---|---|
| | | F Value | F Value | F Value |
| Main Effects | Yarns | **6038.092**** | **25.246**** | 0.961 |
| | Structures | **12850.139**** | 1.340 | 0.327 |
| | Processes | **74.538**** | **4.351*** | 2.318 |
| | Bio Polishing | **90.726**** | **56.866**** | **77.081**** |
| 2- way Interactions | Yarn /Structure | **327.597**** | 2.981 | **9.792**** |
| | Yarn /Process | **1898.212**** | **4.909*** | 0.132 |
| | Yarn/ Polishing | **1681.791**** | 0.785 | 0.013 |
| | Structure/Process | 1.163 | 0.917 | 0.391 |
| | Structure/ Polishing | **18.750**** | 0.000 | 0.082 |
| | Process/Polishing | **2466.661**** | 0.012 | 1.528 |
| 3- way Interactions | Yarn / Structure / Process | **1038.575**** | 0.892 | 0.285 |
| | Yarn / Structure / Polishing | **1724.266**** | 0.100 | 0.701 |
| | Yarn / Process / Polishing | **301.135**** | 1.299 | 1.427 |
| | Structure / Process / Polishing | **3873.864**** | 0.025 | 0.297 |
| 4- way Interactions | Yarn / Structure / Process / Polishing | **17.921**** | 0.899 | 0.826 |

** Significant at 1% level * Significant at 5% level

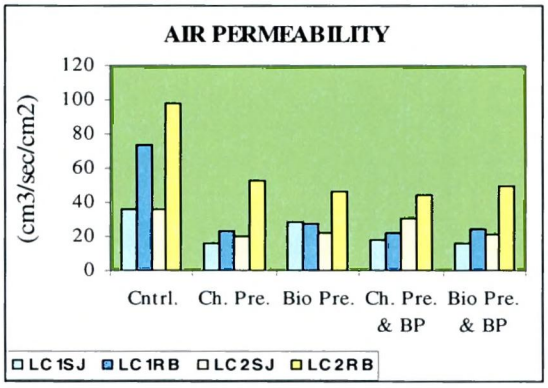
From the statistical analysis Table XXXIa, bio polishing in main effects and yarn /structure in 2-way interactions exhibited significant effect on thermal conductivity at 1% level.

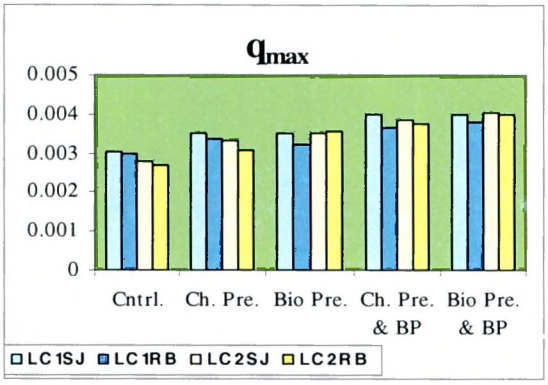
**Wicking** [Lycra Cotton]

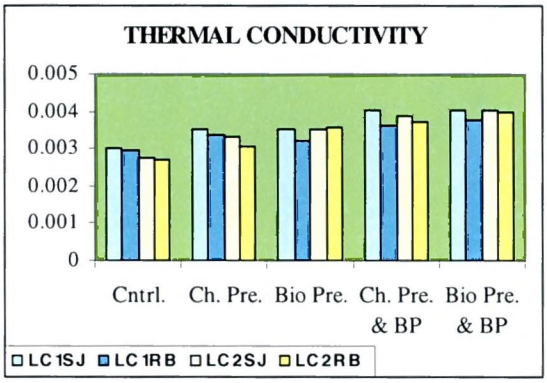
Table XXXII gives the correlation coefficients, constant and slope values of lycra cotton weft knits, obtained by linear regression analysis. The log value of time in seconds of lycra cotton weft knits after pretreatment and bio polishing are given in Appendix 8.

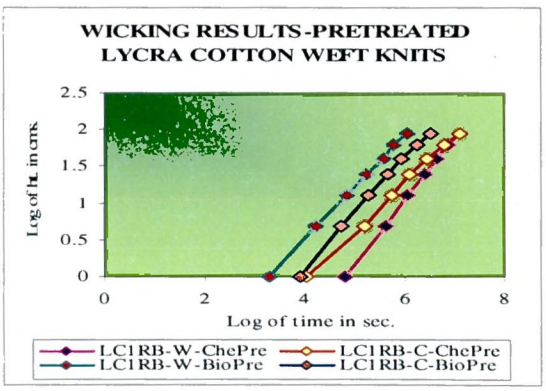
From the regression analysis Table XXXII, it may be noted that among the pretreated samples, the highest slope value was recorded in bio pretreated sample LC1RB (0.868) in the wale direction. A majority (about 93.75%) of the bio pretreated samples exhibited greater

# WICKING RESULTS OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIOPOLISHING



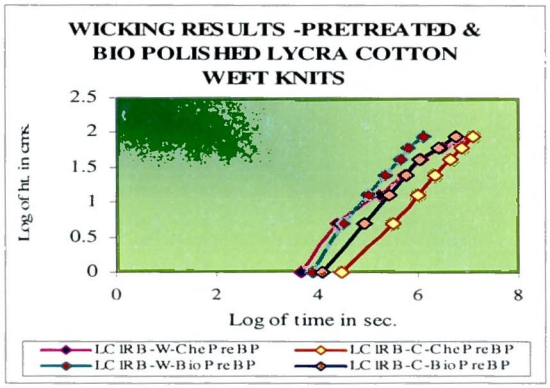




**FIGURE 13**

slope values than the chemical pretreated samples, indicating greater absorbency in the bio pretreated samples.

**TABLE XXXII**

**REGRESSION ANALYSIS FOR WICKING OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING**
**Model : log (ht) = constant + b. log (time)**

| | Chemical Pretreated | | | Bio Pretreated | | |
|---|---|---|---|---|---|---|
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope (b) |
| LC1SJ-W | 0.999 | -2.082 | 0.626 | 0.998 | -1.979 | 0.662 |
| C | 0.998 | -2.406 | 0.673 | 0.999 | -2.472 | 0.728 |
| LC1RB-W | 0.988 | -2.060 | 0.659* | 0.999 | -4.178 | **0.868** |
| C | 0.998 | -2.651 | 0.654 | 0.997 | -2.829 | 0.738 |
| LC2SJ-W | 0.994 | -2.248 | 0.679 | 0.997 | -2.257 | 0.720 |
| C | 0.997 | -2.974 | 0.751 | 0.995 | -2.376 | 0.720* |
| LC2RB- W | 0.985 | -1.926 | 0.568 | 0.991 | -3.236 | 0.860 |
| C | 0.999 | -3.369 | 0.749 | 0.995 | -2.993 | 0.749 |
| | **Chemical Pretreated & Bio Polished** | | | **Bio Pretreated & Bio Polished** | | |
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope (b) |
| LC1SJ-W | 0.997 | -1.709 | 0.623 | 0.999 | -1.593 | 0.628 |
| C | 0.996 | -1.823 | 0.628 | 0.999 | -1.798 | 0.635 |
| LC1RB-W | 0.997 | -1.930 | 0.589 | 0.997 | -2.066 | 0.674 |
| C | 0.997 | -3.223 | 0.781 | 0.998 | -1.723 | 0.614 |
| LC2SJ-W | 0.997 | -2.082 | 0.684 | 0.986 | -1.724 | 0.658 |
| C | 0.995 | -1.731 | 0.627 | 0.997 | -2.054 | 0.671 |
| LC2RB- W | 0.996 | -1.848 | 0.635 | 0.998 | -3.737 | 0.839 |
| C | 0.999 | -3.217 | 0.791 | 0.997 | -4.042 | **0.850** |

After bio polishing, it was noted that the bio pretreated, bio polished sample LC2RB (0.850), showed the highest slope value, in the course direction. After bio polishing a majority (about 87.5%) of the bio pretreated, bio polished samples exhibited higher slope values than the chemical pretreated, bio polished samples highlighting the fact that the type of pretreatment has an impact on the wickability of the samples. The correlation coefficient

values in all samples was positive ranged from 0.985 to 0.999 indicating good correlation between the log of height verses log of time.

**❋ Low Stress Mechanical Properties (KES)**

The level of changes in the low stress properties of cotton and lycra cotton weft knitted fabrics comprising of single jersey and rib in cotton and lycra cotton, knitted with carded and combed yarns, in response to bio and chemical pretreatment and subsequent bio polishing were analyzed by the Kawabata Evaluation System. The goals of the study are to define the level of changes in mechanical and surface properties, translate property differences into handle quality differences and comfort and ascertain the statistical significance of the resulting changes to find out the influence of the treatments.

**✶ Tensile Properties - 100 % Cotton**

The Tensile Properties studied include Linearity of Load (LT), Tensile Energy (WT), Tensile Resilience (RT) and Extensibility (EMT). The Tensile Properties of cotton weft knitted fabrics, measured by the KES-FB1 system, are shown in Table XXXIII and Figure 14. The results of the statistical analysis of tensile properties are given in Table XXXIIIa.

The Linearity of Load (LT) represents the linearity of load extension curve and values below 1.0 indicate that the stress strain curve falls above a $45^0$ straight line. From the Table XXXIII, it is clear that all the pretreated and bio polished samples showed reduction in LT values when compared to their controls, indicating that there is more flexibility in the fabric after pretreatment and bio polishing. Of all the treated samples, the highest loss percentage (16.85) was observed in bio pretreated sample C1RB in the course direction and in bio pretreated, bio polished sample C1SJ (19.3) in the wale direction. Kavitha *et al.* (2006), explains that increasing LT values show that the stress strain curves become more linear.

From the ANOVA Table XXXIIIa, it may be noted that bio polishing (5% level) in main effects and in 2-way interactions structure/polishing (5% level) and yarn /structure (1% level) were significant in the wale direction. In the course direction, yarns, structures (1% level) and bio polishing (5% level) in main effects and yarn /structure, process/polishing (1% level) and yarn/process, structure/polishing, (5% level) in 2-way interactions, exhibited significant effect on the Linearity of Load of cotton weft knits, after pretreatment and bio polishing.

## TABLE XXXIII
## TENSILE PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Tensile Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Bio Polished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Linearity of Load (LT) | W | 0.995 | 0.912 | -8.34 | 0.878 | -11.76 | 0.823 | -17.29 | 0.803 | **-19.3** |
| | C | 0.967 | 0.887 | -8.27 | 0.837 | -13.44 | 0.784 | -18.92 | 0.818 | -15.41 |
| | C1SJ | 0.982 | 0.9 | -8.35 | 0.857 | -12.73 | 0.803 | -18.11 | 0.811 | -17.36 |
| | W | 0.993 | 0.885 | -10.9 | 0.913 | -8.056 | 0.909 | -8.459 | 0.941 | -5.237 |
| | C | 0.932 | 0.831 | -10.8 | 0.775 | **-16.85** | 0.811 | -12.98 | 0.815 | -12.55 |
| | C1RB | 0.963 | 0.858 | -10.9 | 0.844 | -12.45 | 0.86 | -10.7 | 0.878 | -8.827 |
| | W | 0.835 | 0.785 | -5.99 | 0.79 | -5.389 | 0.742 | -11.14 | 0.737 | -11.74 |
| | C | 0.858 | 0.807 | -5.94 | 0.857 | -0.117 | 0.778 | -9.324 | 0.825 | -3.846 |
| | C2SJ | 0.847 | 0.796 | -6.02 | 0.824 | -2.715 | 0.76 | -10.27 | 0.781 | -7.792 |
| | W | 1.021 | 0.929 | -9.01 | 0.895 | -12.34 | 0.882 | -13.61 | 0.863 | -15.48 |
| | C | 0.901 | 0.82 | -8.99 | 0.78 | -13.43 | 0.747 | -17.09 | 0.827 | -8.213 |
| | C2RB | 0.961 | 0.874 | -9.05 | 0.837 | -12.9 | 0.815 | -15.19 | 0.845 | -12.07 |
| Tensile Energy (WT) [gf·cm/cm$^2$] | W | 0.97 | 1.28 | 31.96 | 1.43 | 47.423 | 1.5 | 54.639 | 1.22 | 25.773 |
| | C | 3.48 | 4.58 | 31.61 | 4.94 | 41.954 | 4.76 | 36.782 | 4.94 | 41.954 |
| | C1SJ | 2.23 | 2.93 | 31.39 | 3.18 | 42.601 | 3.13 | 40.359 | 3.08 | 38.117 |
| | W | 0.96 | 1.25 | 30.21 | 1.56 | **62.5** | 1.46 | 52.083 | 1.35 | 40.625 |
| | C | 5.881 | 7.62 | 29.57 | 9.43 | 60.347 | 7.46 | 26.849 | 8.44 | 43.513 |
| | C1RB | 3.423 | 4.43 | 29.42 | 5.49 | 61.423 | 4.46 | 30.295 | 4.89 | 42.857 |
| | W | 1.07 | 1.28 | 19.63 | 1.53 | 42.991 | 1.29 | 20.561 | 1.3 | 21.495 |
| | C | 3.56 | 4.26 | 19.66 | 5.32 | 49.438 | 5.12 | 43.82 | 5.64 | 58.427 |
| | C2SJ | 2.32 | 2.77 | 19.4 | 3.43 | 47.845 | 3.2 | 37.931 | 3.47 | 49.569 |
| | W | 0.94 | 1.36 | 44.68 | 1.4 | 48.936 | 1.47 | 56.383 | 1.51 | **60.64** |
| | C | 5.84 | 8.41 | 44.01 | 9.09 | 55.651 | 8.66 | 48.288 | 8.93 | 52.911 |
| | C2RB | 3.39 | 4.88 | 44.34 | 5.24 | 54.572 | 5.07 | 52.335 | 5.22 | 53.982 |
| Tensile Resilience (RT) [%] | W | 12.6 | 15.77 | 25.16 | 27.35 | **117.06** | 27.98 | 122.06 | 33.6 | **166.67** |
| | C | 30.78 | 38.52 | 25.15 | 37.05 | 20.37 | 34.52 | 12.151 | 36.86 | 19.753 |
| | C1SJ | 21.7 | 27.15 | 25.12 | 32.2 | 48.387 | 31.25 | 44.009 | 35.23 | 62.35 |
| | W | 24.3 | 25.61 | 5.391 | 28.85 | 18.724 | 32.28 | 32.84 | 32.6 | 34.156 |
| | C | 22.53 | 23.75 | 5.415 | 25.88 | 14.869 | 24.12 | 7.0573 | 22.67 | 0.6214 |
| | C1RB | 23.42 | 24.68 | 5.38 | 27.37 | 16.866 | 28.2 | 20.41 | 27.64 | 18.019 |
| | W | 24.03 | 29.67 | 23.47 | 27.45 | 14.232 | 30.12 | 25.343 | 28.46 | 18.435 |
| | C | 31.8 | 39.25 | 23.43 | 37.59 | 18.208 | 34.75 | 9.2767 | 37.24 | 17.107 |
| | C2SJ | 27.92 | 34.46 | 23.42 | 32.52 | 16.476 | 32.44 | 16.189 | 32.85 | 17.658 |
| | W | 21.89 | 22.92 | 4.705 | 32.86 | 50.114 | 29.26 | 33.668 | 28.5 | 30.196 |
| | C | 24.07 | 25.21 | 4.736 | 22.76 | -5.442 | 22.84 | -5.11 | 23.17 | -3.739 |
| | C2RB | 22.98 | 24.06 | 4.7 | 27.81 | 21.018 | 26.05 | 13.359 | 25.83 | 12.402 |
| Extensibility (EMT) [%] | W | 5.22 | 5.68 | 8.812 | 6.52 | 24.904 | 7.31 | 40.038 | 6.07 | 16.284 |
| | C | 18.98 | 20.65 | 8.799 | 23.6 | 24.341 | 24.3 | 28.03 | 24.15 | 27.239 |
| | C1SJ | 12.09 | 13.15 | 8.768 | 15.06 | 24.566 | 15.8 | 30.687 | 15.11 | 24.979 |
| | W | 5.05 | 5.66 | 12.08 | 6.84 | 35.446 | 6.4 | 26.733 | 5.76 | 14.059 |
| | C | 32.74 | 36.7 | 12.1 | 47.65 | **45.54** | 36.75 | 12.248 | 41.5 | 26.756 |
| | C1RB | 18.9 | 21.18 | 12.06 | 27.74 | 46.772 | 21.58 | 14.18 | 23.63 | 25.026 |
| | W | 5.81 | 6.54 | 12.56 | 7.76 | 33.563 | 6.95 | 19.621 | 7.05 | 21.343 |
| | C | 18.76 | 21.1 | 12.47 | 24.85 | 32.463 | 26.3 | 40.192 | 27.35 | 45.789 |
| | C2SJ | 12.29 | 13.82 | 12.45 | 16.31 | 32.71 | 16.63 | 35.313 | 17.2 | 39.951 |
| | W | 4.74 | 5.86 | 23.63 | 6.27 | 32.278 | 6.68 | 40.928 | 7 | **47.68** |
| | C | 33.27 | 41.1 | 23.53 | 46.65 | 40.216 | 46.4 | 39.465 | 43.25 | 29.997 |
| | C2RB | 19.01 | 23.48 | 23.51 | 26.46 | 39.19 | 26.54 | 39.611 | 25.13 | 32.194 |

The Tensile Energy (WT) values represent the tensile energy per unit area, that is, the area under load elongation curve. Higher value of WT corresponds to higher extensibility. Naujokaitytė and Strazdienė (2007), explain that when Tensile Energy WT or the work done by the extension upto a maximum force increases, fabrics became more stretchable and more energy is needed to reach the same tensile load. The chemical and bio pretreated samples exhibit an increase in values with regard to their controls. The highest percentage increase of 62.5% was noticed in the bio pretreated sample C1RB in the wale direction among the pretreated samples. Among the bio polished samples, bio pretreated and bio polished sample C2RB showed a maximum increase of 60.64%.

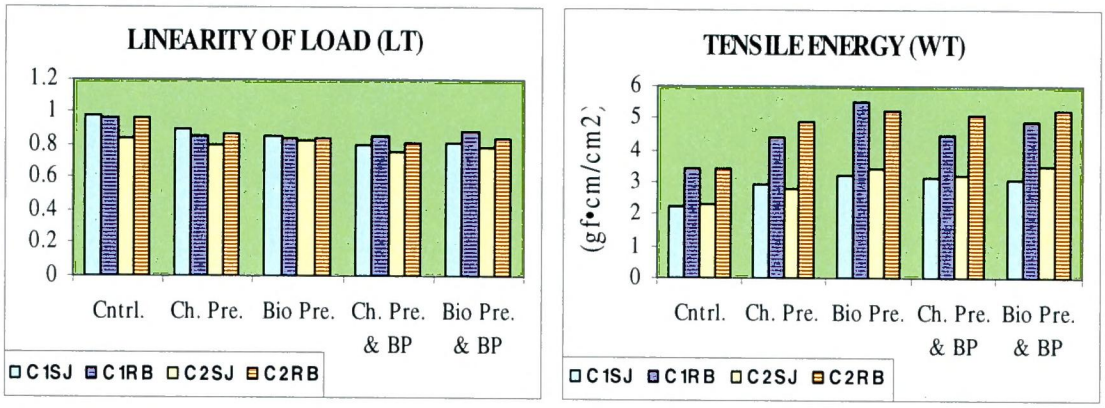
**TABLE XXXIIIa**
**ANALYSIS OF VARIANCE OF TENSILE PROPERTIES OF COTTON WEFT KNITS**

| Tensile Properties | | Linearity of Load (LT) | | Tensile Energy (WT) | | Tensile Resilience (RT) | | Extensibility (EMT) | |
|---|---|---|---|---|---|---|---|---|---|
| Effects | Source of Variation | Wales | Courses | Wales | Courses | Wales | Courses | Wales | Courses |
| Main Effects (F Value) | Yarns | 0.147 | **19.996**** | **7.989**** | **819.16**** | **27.604**** | 1.272 | **822.60**** | **36974.84**** |
| | Structures | 0.426 | **7.356**** | **154.74**** | **323.79**** | **24.400**** | **9.33**** | **900.08**** | **1180.05**** |
| | Processes | 0.144 | 0.809 | **14.47**** | **3520.26**** | **8.341**** | 0.000 | **491.23**** | **62141.34**** |
| | Bio Polishing | **6.394*** | **4.678*** | 0.134 | **94.994**** | **11.142**** | 1.423 | **546.65**** | **14250.36**** |
| 2- way Interactions (F Value) | Yarn /Structure | **11.15**** | **10.959**** | **57.68**** | **106.779**** | **37.872**** | 0.457 | **1014.79**** | **516.94**** |
| | Yarn /Process | 0.232 | **5.897*** | **5.756*** | 1.228 | **4.187*** | 0.084 | **357.20**** | **6949.56**** |
| | Yarn/ Polishing | 0.439 | 0.003 | 0.029 | **554.760**** | **8.090**** | 0.005 | **39.47**** | **13720.92**** |
| | Structure/ Process | 0.271 | 1.300 | 3.041 | 3.342 | 1.084 | 0.073 | **35.34**** | **2045.75**** |
| | Structure/ Polishing | **4.468*** | **4.026*** | **16.473**** | **731.130**** | 2.699 | 0.038 | **21.09**** | **40073.86**** |
| | Process/ Polishing | 0.030 | **8.815**** | **109.13**** | **396.327**** | 2.986 | 0.257 | **2732.99**** | **39788.76**** |
| 3- way Interactions (F Value) | Yarn / Structure / Process | 1.910 | 0.097 | **22.36**** | **830.514**** | **8.626**** | 0.078 | **191.22**** | **19090.18**** |
| | Yarn / Structure / Polishing | 2.220 | 1.240 | **18.09**** | **10.900**** | 3.027 | 0.022 | **1310.09**** | **460.08**** |
| | Yarn / Process / Polishing | 0.016 | 0.052 | **38.51**** | 1.942 | 0.043 | 0.457 | **868.32**** | **31.46**** |
| | Structure / Process / Polishing | 0.019 | 1.456 | **4.731*** | 0.145 | 0.068 | 0.512 | **130.20**** | **1940.28**** |
| 4-way Inter actions (F Value) | Yarn / Structure / Process / Polishing | 0.093 | 2.830 | **4.266*** | **67.284**** | 1.993 | 0.414 | **53.429**** | **237.95**** |

** Significant at 1% level  * Significant at 5% level

The statistical Table XXXIIIa reveals that bio polishing in main effects and yarn/ polishing, structure/process in 2-way interactions were not significant in the wale direction. Yarn / process in 2-way interactions, structure/process/polishing in 3-way interactions and

# TENSILE PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



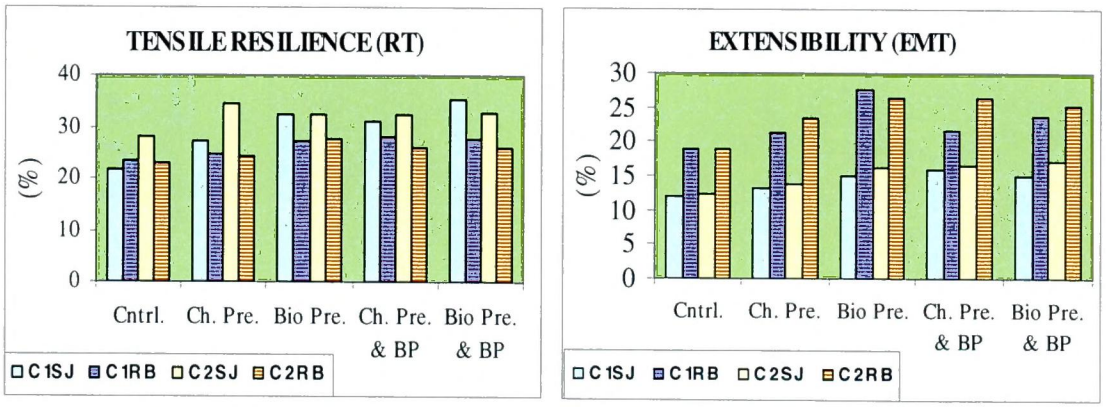




**FIGURE 14**

yarn/structure/process/polishing showed significant difference at 5% level. The rest of the parameters analyzed showed significant difference at 1% level in the wale direction. In the course direction, except for yarn/process, structure/process in 2-way interactions and yarn/process/polishing, structure/ process/polishing in 3-way interactions, all the other parameters exhibited significant effect at 1% level.

All the treated samples showed increased Tensile Resilience (RT) values when compared to their controls. Single jersey structures record more resilience when compared to the rib structures. The percentage increase is more after bio polishing in most of the samples indicating increased smoothness and recovery. The highest increase, among the pretreated samples, was noticed in the bio pretreated sample C1SJ (117.06%) in the wale direction. After bio polishing treatment, the same sample exhibited maximum increase of 166.67%. Karmakar (1999) states that after bio polishing the Tensile Resilience RT is increased indicating that the fabrics became less stiff, easier to stretch and looser in structure.

From the ANOVA Table XXXIIIa, all the parameters in main effects, yarn /structure, yarn/polishing, yarn/process (5% level) in 2-way interactions and yarn / structure/process in 3-way interactions had significant effect on Tensile Resilience, at 1% level in the wale direction. In the course direction, structures in main effects exhibited significant effect on tensile resilience at 1% level.

EMT is extensibility under a load of 500 g/cm2. It can be noted that the samples made from the combed yarns had good extensibility. This may be attributed to the yarn strength to withstand greater extension. The bio polished samples recorded higher values showing greater extension. Among the treated samples, bio pretreated sample C1RB in the course direction exhibited a maximum increase of 45.54% and bio pretreated and bio polished sample C2RB showed the highest increase of 47.68% in the wale direction. According to Behera and Ajay (2001), larger the EMT value, the greater will be the wearing comfort.

The ANOVA Table XXXIIIa revealed significant effect on extensibility in all the parameters analyzed at 1% level in both the wale and course directions.

**✶ Tensile Properties - Lycra Cotton**

The Tensile Properties namely Linearity of Load (LT), Tensile Energy (WT), Tensile Resilience (RT) and Extensibility (EMT) of lycra cotton weft knitted fabrics, measured by the KES-FB1 system, are given in Table XXXIV and Figure 15. The results of the statistical analysis of tensile properties are given in Table XXXIVa.

## TABLE XXXIV
## TENSILE PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Tensile Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Linearity of Load (LT) | W | 1.02 | 0.927 | -9.118 | 0.899 | -11.86 | 0.834 | -18.24 | 0.841 | -17.54 |
| | C | 0.987 | 0.907 | -8.105 | 0.93 | -5.775 | 0.87 | -11.85 | 0.929 | -5.876 |
| | LC1SJ | 1.008 | 0.917 | -9.028 | 0.915 | -9.226 | 0.852 | -15.48 | 0.9 | -10.71 |
| | W | 1.07 | 0.939 | -12.24 | 0.948 | -11.4 | 0.944 | -11.78 | 0.928 | -13.27 |
| | C | 1.099 | 0.982 | -10.65 | 0.968 | -11.92 | 0.896 | **-18.47** | 0.957 | -12.92 |
| | LC1RB | 1.084 | 0.96 | -11.44 | 0.958 | -11.62 | 0.92 | -15.13 | 0.942 | -13.1 |
| | W | 0.99 | 0.925 | -6.566 | 0.843 | **-14.84** | 0.877 | -11.41 | 0.878 | -11.31 |
| | C | 1.004 | 0.958 | -4.582 | 0.879 | -12.45 | 0.872 | -13.15 | 0.933 | -7.072 |
| | LC2SJ | 0.997 | 0.941 | -5.617 | 0.811 | -18.66 | 0.875 | -12.24 | 0.908 | -8.927 |
| | W | 0.995 | 0.911 | -8.442 | 0.875 | -12.06 | 0.961 | -3.417 | 0.88 | -11.56 |
| | C | 0.931 | 0.856 | -8.056 | 0.927 | -0.43 | 0.932 | 0.1074 | 0.855 | -8.163 |
| | LC2RB | 0.962 | 0.883 | -8.212 | 0.901 | -6.341 | 0.946 | -1.663 | 0.868 | -9.771 |
| Tensile Energy (WT) [gf·cm/cm$^2$] | W | 3.48 | 4.1 | 17.82 | 3.53 | 1.437 | 2.81 | -19.25 | 3.18 | -8.621 |
| | C | 6.504 | 8.38 | 28.84 | 8.58 | 31.92 | 8.3 | 27.614 | 9.59 | **47.45** |
| | LC1SJ | 4.992 | 6.24 | 25 | 6.05 | 21.19 | 5.56 | 11.378 | 6.39 | 28.005 |
| | W | 2.63 | 2.7 | 2.662 | 3.59 | **36.50** | 3.22 | 22.433 | 3.49 | 32.7 |
| | C | 14.74 | 16.6 | 12.62 | 20.35 | 38.06 | 16.6 | 12.619 | 20.8 | 41.113 |
| | LC1RB | 8.685 | 9.65 | 11.11 | 12.17 | 40.13 | 9.91 | 14.105 | 12.15 | 39.896 |
| | W | 4.722 | 4.97 | 5.252 | 2.62 | -44.52 | 3.88 | -17.83 | 3.71 | -21.43 |
| | C | 7.816 | 8.81 | 12.72 | 7.92 | 1.331 | 8.72 | 11.566 | 9.19 | 17.579 |
| | LC2SJ | 6.269 | 6.89 | 9.906 | 5.27 | -15.94 | 6.3 | 0.4945 | 6.45 | 2.8872 |
| | W | 2.353 | 3.14 | 33.45 | 2.8 | 19 | 2.76 | 17.297 | 2.47 | 4.9724 |
| | C | 13.19 | 17.6 | 33.43 | 18.95 | 43.67 | 18.5 | 40.25 | 2.35 | -82.18 |
| | LC2RB | 7.77 | 10.37 | 33.46 | 10.88 | 40.03 | 11.43 | 47.104 | 2.41 | -68.98 |
| Tensile Resilience (RT) | W | 29.34 | 39.26 | 33.81 | 39.71 | 35.3 | 40.93 | 39.5 | 45.27 | 54.29 |
| | C | 29.9 | 39.74 | 32.91 | 43.32 | **44.9** | 44.1 | 47.49 | 46.4 | 55.18 |
| | LC1SJ | 29.62 | 39.5 | 33.36 | 41.52 | 40.2 | 42.51 | 43.52 | 45.83 | 54.73 |
| | W | 34.41 | 38.35 | 11.44 | 37.87 | 10 | 33.82 | -1.73 | 39.25 | 14.05 |
| | C | 28.39 | 31.43 | 10.72 | 36.68 | 29.2 | 33.4 | 17.66 | 30.65 | 7.975 |
| | LC1RB | 31.4 | 34.89 | 11.11 | 37.27 | 18.7 | 33.61 | 7.038 | 34.95 | 11.31 |
| | W | 30.74 | 42.26 | 37.46 | 32.82 | 6.75 | 43.56 | 41.68 | 49.88 | **62.24** |
| | C | 30.92 | 42.22 | 36.57 | 40.4 | 30.7 | 44.16 | 42.84 | 48.53 | 56.98 |
| | LC2SJ | 30.83 | 42.24 | 37.01 | 36.61 | 18.8 | 43.86 | 42.26 | 49.2 | 59.59 |
| | W | 33.53 | 38.22 | 13.98 | 34.65 | 3.33 | 38.38 | 14.45 | 43.33 | 29.21 |
| | C | 30.71 | 34.78 | 13.27 | 38.65 | 25.9 | 30.9 | 0.631 | 38.17 | 24.31 |
| | LC2RB | 32.12 | 36.5 | 13.64 | 36.65 | 14.1 | 34.64 | 7.846 | 40.75 | 26.87 |
| Extensibility (EMT) [%] | W | 15.29 | 17.7 | 15.74 | 15.7 | 2.66 | 13.5 | -11.7 | 14.6 | -4.54 |
| | C | 32.24 | 36.95 | 14.63 | 36.9 | 14.5 | 38.15 | 18.35 | 41.3 | 28.12 |
| | LC1SJ | 23.76 | 27.32 | 14.98 | 26.3 | 10.7 | 25.83 | 8.712 | 27.95 | 17.64 |
| | W | 9.674 | 11.5 | 18.88 | 16.85 | **74.2** | 13.65 | 41.1 | 15.05 | **55.58** |
| | C | 57.59 | 67.65 | 17.46 | 84.05 | 45.9 | 74.15 | 28.74 | 86.9 | 50.88 |
| | LC1RB | 33.63 | 39.57 | 17.66 | 50.45 | 50 | 43.9 | 30.54 | 50.97 | 51.56 |
| | W | 16.45 | 21.5 | 30.69 | 14.1 | -14 | 17.7 | 7.593 | 16.9 | 2.73 |
| | C | 28.43 | 36.8 | 29.45 | 36.05 | 26.8 | 40 | 40.7 | 39.4 | 38.59 |
| | LC2SJ | 22.44 | 29.15 | 29.9 | 25.08 | 11.8 | 28.85 | 28.57 | 28.15 | 25.45 |
| | W | 9.696 | 13.8 | 42.32 | 12.8 | 32 | 11.5 | 18.6 | 11.25 | 16.02 |
| | C | 58.52 | 82.3 | 40.63 | 81.9 | 39.9 | 87.8 | 50.03 | 11 | -81.2 |
| | LC2RB | 34.11 | 48.05 | 40.87 | 47.35 | 38.8 | 49.65 | 45.56 | 11.13 | -67.4 |

# TENSILE PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

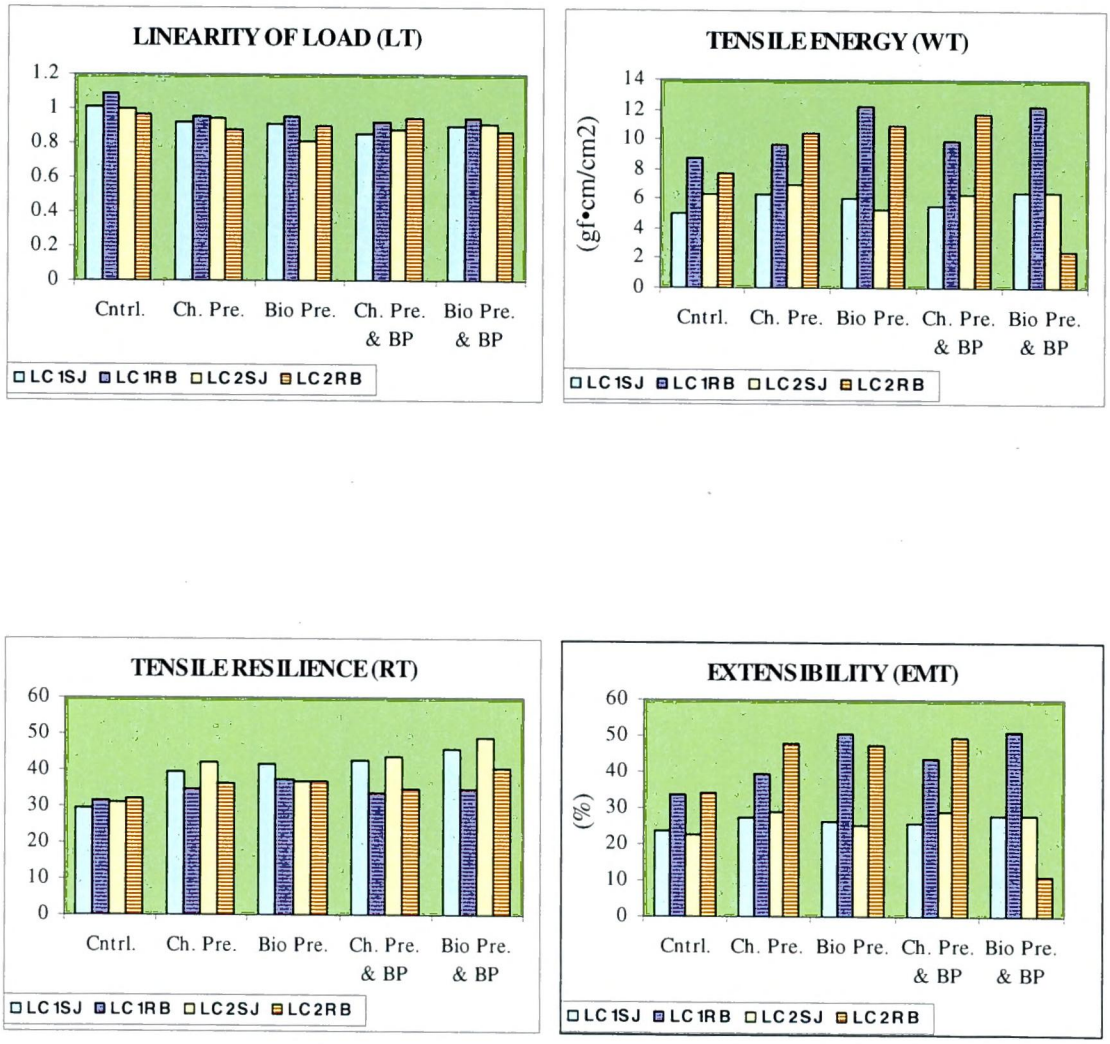



**FIGURE 15**

The Table XXXIV reveals that decrease in the Linearity of load (LT) values was observed among all the pretreated and bio polished samples when compared to their respective controls. Among the pretreated samples, maximum decrease was noticed in bio pretreated sample LC2SJ in the wale direction, with a loss of 14.84%. After bio polishing, chemical pretreated and bio polished sample LC1RB showed a maximum loss of 18.47% in the course direction.

In the wale direction, the analysis of variance Table XXXIVa highlights that the structures (5% level) and processes in main effects, the yarn/process and yarn/polishing in 2-way interactions and structure/process/polishing in 3-way interactions exhibited significant effect on Linearity of Load of the lycra cotton weft knits at 1% level. In the course direction, yarns in main effects, yarn/structure in 2-way interactions, structure/process/polishing in 3-way interactions and yarns/structure/process/polishing in 4-way interactions showed significant effect at 1% level.

The Tensile Energy (WT) values have increased indicating good flexibility in all the treated samples. The highest increase of 36.50% was noticed in bio pretreated sample LC1RB in wale direction among the pretreated samples. Among the bio polished samples, a maximum increase of 47.45% was observed in bio pretreated, bio polished sample LC1SJ in the course direction.

The ANOVA Table XXXIVa highlighted that all the parameters analysed had a significant effect on the Tensile Energy of lycra cotton weft knits at 1% level in both the wale and course directions.

The Tensile Resilience (RT) values of all the treated samples showed an increase in values compared to their controls, indicating that the fabrics had lost their initial stiffness. Of all the treated samples, bio pretreated sample LC1SJ recorded the highest increase of 44.9% in the course direction and bio pretreated, bio polished sample LC2SJ recorded an increase of 62.24% in the wale direction.

From the ANOVA Table XXXIVa structures and bio polishing in main effects, yarn/polishing (5% level) and process/polishing in 2-way effects indicated significant differences at 1% level on the Tensile Resilience of lycra cotton weft knits in the wale direction. In the course direction, structures in main effects, structure/polishing in 2-way interactions exhibited significant differences at 1% level with regard to the Tensile Resilience of lycra cotton weft knits.

## TABLE XXXIVa
## ANALYSIS OF VARIANCE OF TENSILE PROPERTIES OF LYCRA COTTON WEFT KNITS

| Tensile Properties | | Linearity of Load (LT) | | Tensile Energy (WT) | | Tensile Resilience (RT) | | Extensibility (EMT) | |
|---|---|---|---|---|---|---|---|---|---|
| Effects | Source of Variation | Wales | Courses | Wales | Courses | Wales | Courses | Wales | Courses |
| Main Effects (F Value) | Yarns | 1.912 | 12.88** | 1251.95** | 21383.74** | 0.125 | 0.154 | 4397.22** | 20229.18** |
| | Structures | 6.668* | 0.034 | 8410.45** | 585.12** | 37.83** | 32.62** | 101185.15** | 6153.7** |
| | Processes | 10.38** | 1.314 | 80.65** | 3104.81** | 0.492 | 3.660 | 1.835 | 104601.52** |
| | Bio Polishing | 0.013 | 3.039 | 669.1** | 5068.01** | 8.34** | 0.576 | 8210.07** | 54378.27** |
| 2- way Interactions (F Value) | Yarn /Structure | 2.170 | 23.65** | 140.81** | 1477.57** | 1.420 | 0.099 | 15414.56** | 422789.1** |
| | Yarn /Process | 10.70** | 2.879 | 2041.91** | 43647.08** | 1.092 | 0.177 | 22301.39** | 694100.10** |
| | Yarn/ Polishing | 8.88** | 1.255 | 29.94** | 11190.04** | 4.03* | 0.042 | 302.22** | 267880.45** |
| | Structure/ Process | 0.290 | 0.106 | 959.46** | 8222.84** | 0.123 | 0.202 | 17639.14** | 132938.28** |
| | Structure/ Polishing | 0.605 | 0.024 | 35.83** | 16846.71** | 3.647 | 5.074* | 30.11** | 330793.24** |
| | Process/ Polishing | 3.783 | 0.926 | 152.33** | 12160.52** | 9.28** | 0.001 | 1036.57** | 286209.52** |
| 3- way Interactions (F Value) | Yarn / Structure / Process | 0.759 | 0.342 | 169.03** | 23266.6** | 0.212 | 1.039 | 2083.52** | 506337.35** |
| | Yarn / Structure / Polishing | 2.198 | 0.942 | 695.95** | 11529.30** | 0.000 | 0.039 | 7191.82** | 319844.15** |
| | Yarn / Process / Polishing | 1.151 | 1.969 | 412.03** | 22431.69** | 1.729 | 2.774 | 6509.52** | 319615.71** |
| | Structure / Process / Polishing | 11.75** | 9.07** | 1377.86** | 31817.74** | 0.389 | 0.741 | 12156.84** | 388682.85** |
| 4-way Inter ctions (F Value) | Yarn / Structure / Process / Polishing | 2.387 | 13.908** | 54.04** | 22816.29** | 0.717 | 0.154 | 1147.147** | 236017.73** |

** Significant at 1% level  * Significant at 5% level

The Extensibility (EMT) readings of all the treated samples showed an increase when compared to their controls, emphasizing the fact that the extensibility has increased. The maximum increase of 74.2% was noticed in bio pretreated sample LC1RB in the wale way and the same sample after bio polishing exhibited an increase of 55.58%, among all the treated samples

The ANOVA Table XXXIVa showed that all the parameters analyzed exhibited significant differences at 1% level in both wale and course directions, except for processes in main effects in the wale direction, with respect to extensibility EMT.

### ✶ Shear Properties - 100% Cotton

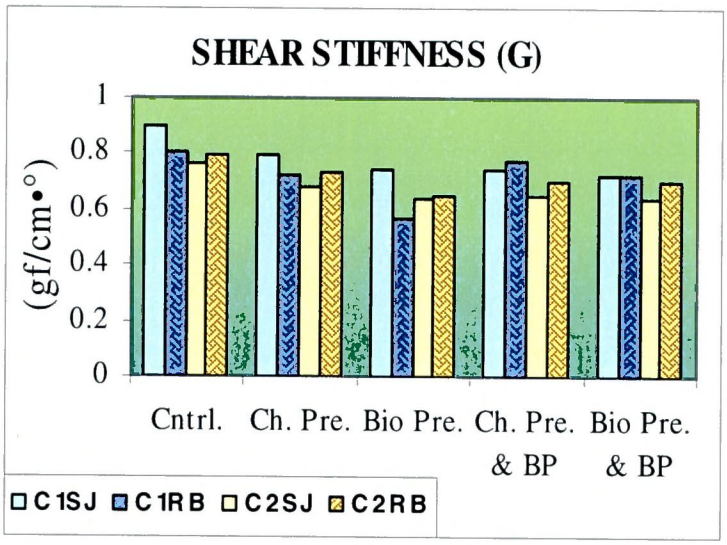
The Table XXXV and Figure 16 presents the Shear Properties.

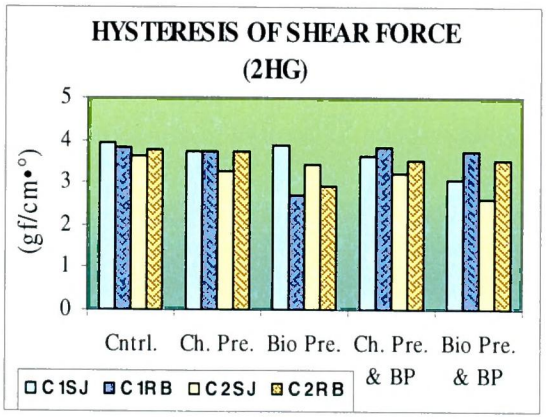
## TABLE XXXV

## SHEAR PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Shear Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Shear Stiffness (G) [gf/cm·°] | W | 0.903 | 0.88 | -2.5 | 0.8 | -11 | 0.77 | -14.7 | 0.79 | -12.5 |
| | C | 0.909 | 0.71 | -21.9 | 0.68 | -25 | 0.71 | -21.9 | 0.64 | **-29.6** |
| | C1SJ | 0.9 | 0.79 | -12.2 | 0.74 | -18 | 0.74 | -17.8 | 0.72 | -21.05 |
| | W | 0.767 | 0.78 | 1.739 | 0.66 | -14 | 0.78 | 1.739 | 0.75 | -2.17 |
| | C | 0.833 | 0.66 | -20.8 | 0.48 | -42 | 0.76 | -8.8 | 0.7 | -16 |
| | C1RB | 0.8 | 0.72 | -10 | 0.55 | -28 | 0.77 | -3.75 | 0.72 | -10 |
| | W | 0.694 | 0.71 | 2.375 | 0.62 | -11 | 0.69 | -0.51 | 0.67 | -3.39 |
| | C | 0.815 | 0.64 | -21.5 | 0.67 | -18 | 0.62 | -24 | 0.61 | -25.2 |
| | C2SJ | 0.76 | 0.68 | -10.5 | 0.64 | -16 | 0.65 | -14.5 | 0.64 | -15.8 |
| | W | 0.69 | 0.73 | 5.797 | 0.66 | -4.3 | 0.73 | 5.797 | 0.73 | 5.797 |
| | C | 0.901 | 0.74 | -17.9 | 0.63 | **-28.5** | 0.66 | -26.7 | 0.67 | -25.6 |
| | C2RB | 0.79 | 0.73 | -7.59 | 0.65 | -16.4 | 0.7 | -16.24 | 0.7 | -11.4 |
| Hysteresis of Shear Force 0.5 degree (2HG) [gf/cm·°] | W | 3.556 | 3.46 | -2.7 | 3.73 | 4.9 | 3.61 | 1.523 | 2.95 | -17 |
| | C | 4.284 | 3.96 | -7.57 | 3.99 | **-7.79** | 3.59 | -16.2 | 3.13 | -26.9 |
| | C1SJ | 3.92 | 3.71 | -5.14 | 3.86 | -6.35 | 3.6 | -8.86 | 3.04 | -22.4 |
| | W | 2.65 | 2.65 | 0 | 2.76 | 4.15 | 3.05 | 15.09 | 2.88 | 8.679 |
| | C | 5.04 | 4.76 | -5.55 | 2.6 | -48 | 4.61 | -8.52 | 4.57 | -9.32 |
| | C1RB | 3.85 | 3.71 | -3.64 | 2.68 | -30 | 3.83 | -0.52 | 3.72 | -3.38 |
| | W | 3.061 | 2.84 | -7.23 | 3.14 | 2.57 | 3.31 | 8.122 | 2.6 | -15.1 |
| | C | 4.219 | 3.7 | -12.3 | 3.71 | -12 | 3.15 | -25.3 | 2.63 | **-37.7** |
| | C2SJ | 3.64 | 3.27 | -10.2 | 3.43 | -5.8 | 3.23 | -11.3 | 2.61 | -26.4 |
| | W | 2.819 | 2.85 | 1.095 | 2.15 | -24 | 2.94 | 4.287 | 2.65 | -6 |
| | C | 4.781 | 4.57 | -4.41 | 3.71 | -22 | 4.07 | -14.9 | 4.38 | -8.38 |
| | C2RB | 3.8 | 3.71 | -2.37 | 2.93 | -23 | 3.51 | -7.63 | 3.51 | -7.63 |
| Hysteresis of Shear Force 5 degree (2HG5) [gf/cm·°] | W | 3.838 | 3.46 | -9.85 | 3.44 | -10.37 | 3.53 | -8.023 | 3.2 | -16.62 |
| | C | 4.391 | 3.77 | -14.1 | 3.81 | -13.23 | 3.64 | -17.1 | 3.1 | **-29.40** |
| | C1SJ | 4.12 | 3.62 | -11.97 | 3.63 | -11.89 | 3.58 | -13.11 | 3.2 | -23.01 |
| | W | 2.964 | 2.79 | -5.86 | 2.69 | -9.23 | 3.11 | 4.9424 | 3.08 | 3.9301 |
| | C | 4.876 | 4.35 | -10.8 | 2.62 | **-28.8** | 4.3 | -11.82 | 4.19 | -14.08 |
| | C1RB | 3.92 | 3.57 | -8.93 | 3.17 | -19.01 | 3.71 | -5.357 | 3.63 | -7.398 |
| | W | 3.067 | 2.83 | -7.73 | 2.91 | -5.123 | 3.08 | 0.4201 | 2.59 | -15.56 |
| | C | 4.084 | 3.56 | -12.8 | 3.69 | -9.649 | 3.18 | -22.14 | 2.7 | -33.89 |
| | C2SJ | 3.57 | 3.19 | -10.6 | 3.3 | -7.563 | 3.13 | -11.28 | 2.64 | -26.05 |
| | W | 3.064 | 2.9 | -5.36 | 2.22 | -27.55 | 3 | -2.1 | 2.78 | -9.28 |
| | C | 4.836 | 4.34 | -10.2 | 3.51 | -27.41 | 3.86 | -20.18 | 3.96 | -18.11 |
| | C2RB | 3.95 | 3.62 | -8.35 | 2.87 | -27.34 | 3.43 | -13.16 | 3.37 | -14.68 |

# SHEAR PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



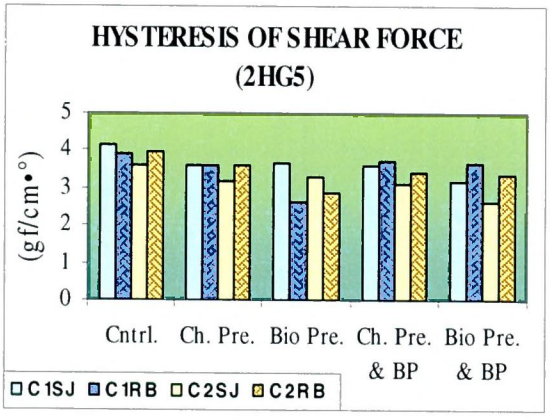




**FIGURE 16**

The shear properties measured by the KES-FB1 are Shear Stiffness (G), Hysteresis of Shear Force (2HG) and (2HG5) of cotton weft knits, after pretreatment and bio polishing. The results of the statistical analysis for shear properties of cotton weft knits are represented in Table XXXVa.

**TABLE XXXVa**

**ANALYSIS OF VARIANCE OF SHEAR PROPERTIES OF COTTON WEFT KNITS**

| Shear Properties | | Shear Stiffness (G) | | Hysteresis of Shear Force (2HG) | | Hysteresis of Shear Force (2HG5) | |
|---|---|---|---|---|---|---|---|
| **Effects** | **Source of Variation** | **Wales** | **Courses** | **Wales** | **Courses** | **Wales** | **Courses** |
| **Main Effects (F Value)** | Yarns | **18.847**** | 0.012 | **242.832**** | **16.809**** | **62.040**** | 0.684 |
| | Structures | **18.319**** | 0.000 | **77.272**** | **137.539**** | **69.442**** | **25.662**** |
| | Processes | **17.209**** | **21.762**** | **363.090**** | **1548.582**** | **441.338**** | **1224.066**** |
| | Bio Polishing | 1.053 | 3.376 | **40.214**** | **198.660**** | **209.824**** | **77.927**** |
| **2- way Interactions (F Value)** | Yarn /Structure | 0.056 | **4.518*** | **277.965**** | **689.213**** | **420.035**** | **56.536**** |
| | Yarn /Process | 0.000 | **10.114**** | **118.553**** | **234.865**** | **119.239**** | **144.862**** |
| | Yarn/ Polishing | 1.622 | **23.671**** | **26.677**** | **467.885**** | 0.010 | **590.828**** |
| | Structure/Process | 0.328 | **8.885**** | **16.148**** | **282.874**** | **17.724**** | **318.292**** |
| | Structure/ Polishing | **6.010**** | **21.519**** | **349.237**** | **2969.421**** | **380.209**** | **1603.944**** |
| | Process/Polishing | **11.700**** | 2.907 | **289.888**** | **469.133**** | **12.033**** | **187.355**** |
| **3- way Interactions (F Value)** | Yarn / Structure / Process | 2.189 | 0.280 | **88.177**** | **303.245**** | **59.998**** | **132.540**** |
| | Yarn / Structure / Polishing | 2.329 | **14.426**** | **18.996**** | **132.815**** | 2.902 | **65.901**** |
| | Yarn / Process / Polishing | 0.042 | 0.071 | **31.781**** | **90.828**** | 0.641 | **90.687**** |
| | Structure / Process / Polishing | 0.003 | **12.527**** | **379.527**** | **2125.375**** | **270.525**** | **1503.480**** |
| **4- way Interactions (F Value)** | Yarn / Structure / Process / Polishing | 0.002 | 0.028 | **97.238**** | **70.314**** | **74.821**** | **31.798**** |

** Significant at 1% level  * Significant at 5% level

From Table XXXV, it is evident that there is an overall decrease of values in Shear Stiffness and Hysteresis of Shear at 0.5 and 5 degrees, among all the treated samples when compared with their respective controls. The Shear Stiffness (G) values reduced after pretreatment and bio polishing. Dingra *et al.* (1989), state that after scouring there is a reduction in shear values and hysteresis indicating the inter yarn pressures have reduced, whereas the unfinished fabric have high values. This attributes better draping qualities to the fabric. Among the treated samples, the maximum loss of 28.5% was recorded in bio

pretreated sample C2RB in the course direction and the bio pretreated, bio polished sample C1SJ showed a maximum loss of 29.6% in the course direction.

From the statistical Table XXXVa, it is clear that yarns, structures and processes in main effects and structure/polishing and process/polishing in 2-way interactions showed significant differences at 1% level in the wale direction. In the course direction, processes in main effects, yarn/structure/polishing, structure/ process/polishing in 3-way interactions and except for process/polishing and yarn/structure in 2-way interactions, all parameters showed significant effect on Shear Stiffness at 1% level. In 2-way interactions, yarn/structure showed significant effect at 5% level.

In the case of Shear Hysteresis at 0.5 and 5 degree angles, it can be understood that there is an overall decrease in values in both the chemical and bio pretreated samples. Table XXXV highlights that after bio polishing there is a further reduction in values showing that the recovery from shear deformation is better than their controls. It can also be noted that the single jersey fabrics in all cases exihibited lower value than the rib structures among both chemical and bio pretreated samples and the subsequent bio polished samples. Senthilkumar and Jambagi (2008), state that shear properties are mainly influenced by the surface characteristics of the knitted materials. After bio polishing the surface fibres are removed which has resulted in improved softness leading to the reduction of Shear Hysteresis values when compared to the untreated fabrics.

Among the pretreated samples, the maximum loss of 7.79% was observed in bio pretreated sample C1SJ in the course direction with regard to Hysteresis of Shear Force (2HG). Bio pretreated, bio polished sample C2SJ in the course direction, exhibited a maximum loss of 37.7%, among the bio polished samples. In the case of Hysteresis of Shear Force (2HG5), lowest values were recorded in bio pretreated sample C1RB in the course direction with a loss of 28.8% while maximum loss of 29.4% was noted in sample bio pretreated, bio polished samples C1SJ, in the course direction.

From the ANOVA Table XXXVa, it can be understood that all the parameters analyzed showed a significant effect on Hysteresis of Shear Force (2HG) of cotton weft knits at 1% level, in both wale and course directions. With regard to Hysteresis of Shear Force (2HG5) of cotton weft knits, apart from yarns/polishing in 2-way interactions, yarn/structure/polishing and yarn/process/polishing in 3-way interactions, all other factors showed significant differences at 1% level, in the wale direction. In the course direction,

apart from yarns in main effects, all the parameters showed significant difference at 1% level.

✶ **Shear Properties - Lycra Cotton**

Shear Properties which include Shear Stiffness (G), Hysteresis of Shear Force (2HG) and (2HG5) of pretreated and bio polished lycra cotton weft knits are presented in Table XXXVI and Figure 17. The results of the statistical analysis of shear properties of lycra cotton weft knits are represented in Table XXXVIa.

From the Table XXXVI, it is evident that all the treated samples showed reduction in Shear Stiffness and Hysteresis of Shear values, at 0.5 and 5 degrees, when compared with their controls, indicating that the fabrics have relaxed and the draping quality of the samples have been enhanced. Nalankilli (1998) narrates that treatment with cellulase enzymes is known to defuzz, soften and improve the visual appearance of apparel knit fabrics thereby avoiding pilling. This softening has led to the reduction of values.

Among the pretreated samples, the lowest Shear Stiffness value was recorded in bio pretreated sample LC2SJ with a loss of 39.1% in the course direction. Among the bio polished samples, bio pretreated, bio polished sample LC1RB registered a loss of 40.1% in the course direction.

The statistical analysis Table XXXVIa reveals that in the wale direction the yarns, structures and processes in the main effects and yarn/structure in 2-way interactions showed significant effect on Shear Stiffness at 1% level and yarn/ structure/process/polishing in 4-way interactions showed significant effect at 5% level. In the course direction, yarns, structures and bio polishing in main effects, yarn/structure, process/polishing (5% level) in 2-way interactions and yarn/ structure, process/structure and process/polishing (5% level) in 3-way interactions showed significant effect on Shear Stiffness at 1% level.

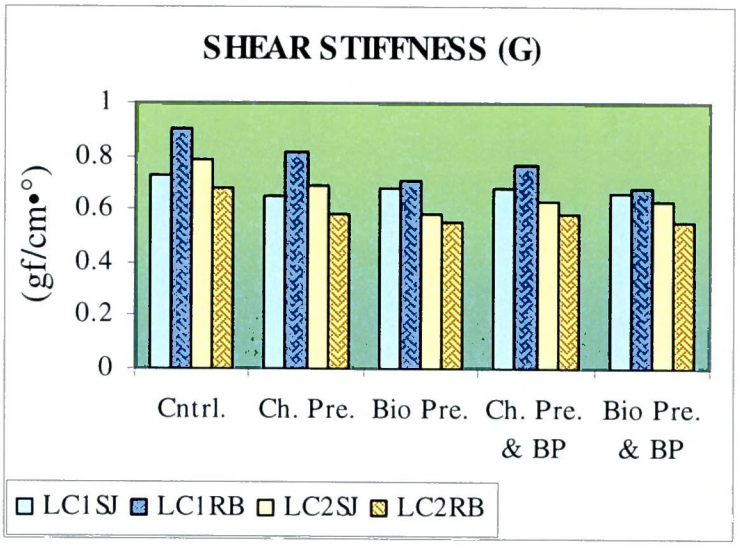
The lowest Shear Hysteresis value (2HG) was recorded in the bio pretreated sample LC1RB with a loss of 30% in the course direction, among the pretreated samples. Among the bio polished samples, bio pretreated, bio polished sample LC2SJ recorded a maximum loss of 30.4% in the course direction.

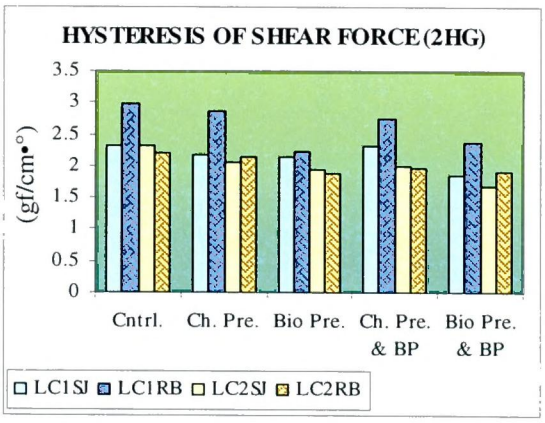
## TABLE XXXVI

## SHEAR PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Shear Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Shear Stiffness (G) [gf/cm·°] | W | 0.652 | 0.67 | 2.688 | 0.74 | 13.4 | 0.76 | 16.48 | 0.69 | 5.753 |
| | C | 0.808 | 0.63 | -22 | 0.63 | -22 | 0.61 | -24.5 | 0.64 | -20.7 |
| | LC1SJ | 0.73 | 0.65 | -11 | 0.68 | -6.8 | 0.68 | -6.85 | 0.66 | -9.59 |
| | W | 0.855 | 0.87 | 1.769 | 0.78 | -8.8 | 0.86 | 0.599 | 0.81 | -5.25 |
| | C | 0.934 | 0.76 | -18.6 | 0.64 | -31 | 0.68 | -27.2 | 0.56 | **-40.1** |
| | LC1RB | 0.9 | 0.82 | -8.89 | 0.71 | -21 | 0.77 | -14.4 | 0.68 | -24.4 |
| | W | 0.656 | 0.66 | 0.663 | 0.61 | -7 | 0.67 | 2.188 | 0.64 | -2.39 |
| | C | 0.936 | 0.73 | -22 | 0.57 | **-39.10** | 0.59 | -37 | 0.61 | -34.8 |
| | LC2SJ | 0.79 | 0.69 | -12.7 | 0.59 | -27 | 0.63 | -20.3 | 0.63 | -20.3 |
| | W | 0.627 | 0.62 | -1.1 | 0.59 | -5.9 | 0.66 | 5.281 | 0.62 | -1.1 |
| | C | 0.733 | 0.54 | -26.3 | 0.51 | -30 | 0.51 | -30.4 | 0.49 | -33.2 |
| | LC2RB | 0.68 | 0.58 | -14.7 | 0.55 | -19 | 0.58 | -14.7 | 0.55 | -19.1 |
| Hysteresis of Shear Force 0.5 degree (2HG) [gf/cm·°] | W | 2.402 | 2.34 | -2.57 | 2.4 | -0.1 | 2.34 | -2.57 | 1.75 | -27.1 |
| | C | 2.249 | 2.01 | -10.6 | 1.85 | -18 | 2.28 | 1.381 | 1.96 | -12.8 |
| | LC1SJ | 2.32 | 2.17 | -6.47 | 2.13 | -8.2 | 2.31 | -0.43 | 1.86 | -19.8 |
| | W | 2.808 | 2.8 | -0.27 | 2.29 | -18 | 2.84 | 1.151 | 2.42 | -13.8 |
| | C | 3.122 | 2.91 | -6.79 | 2.19 | **-30** | 2.66 | -14.8 | 2.33 | -25.4 |
| | LC1RB | 2.97 | 2.86 | -3.7 | 2.24 | -25 | 2.75 | -7.41 | 2.38 | -19.9 |
| | W | 2.088 | 1.96 | -6.15 | 1.91 | -8.5 | 2.1 | 0.558 | 1.6 | -23.4 |
| | C | 2.5 | 2.15 | -14 | 1.94 | -22 | 1.91 | -23.6 | 1.74 | **-30.4** |
| | LC2SJ | 2.3 | 2.06 | -10.4 | 1.93 | -16 | 2.01 | -12.6 | 1.67 | -27.4 |
| | W | 1.874 | 1.92 | 2.464 | 1.81 | -3.4 | 2.08 | 11 | 1.8 | -3.94 |
| | C | 2.526 | 2.36 | -6.58 | 1.98 | -22 | 1.89 | -25.2 | 2 | -20.8 |
| | LC2RB | 2.2 | 2.14 | -2.73 | 1.89 | -14 | 1.98 | -10 | 1.9 | -13.6 |
| Hysteresis of Shear Force 5 degree (2HG5) [gf/cm·°] | W | 2.846 | 2.59 | -8.99 | 2.55 | -10 | 2.89 | 1.556 | 2.15 | -24.4 |
| | C | 2.454 | 2.07 | -15.7 | 1.92 | -22 | 2.15 | -12.4 | 1.94 | -21 |
| | LC1SJ | 2.65 | 2.33 | -12.1 | 2.24 | -15 | 2.52 | -4.91 | 2.04 | -23 |
| | W | 3.365 | 3.17 | -5.79 | 2.54 | -25 | 3.29 | -2.23 | 2.65 | -21.2 |
| | C | 3.215 | 2.85 | -11.4 | 2.14 | **-33** | 2.58 | -19.8 | 2.14 | **-33.4** |
| | LC1RB | 3.29 | 3.01 | -8.51 | 2.34 | -29 | 2.93 | -10.9 | 2.39 | -27.4 |
| | W | 2.375 | 2.22 | -6.51 | 2.11 | -11 | 2.45 | 3.176 | 1.92 | -19.1 |
| | C | 2.474 | 2.13 | -13.9 | 1.91 | -23 | 1.82 | -26.4 | 1.77 | -28.5 |
| | LC2SJ | 2.43 | 2.18 | -10.3 | 2.01 | -17 | 2.14 | -11.9 | 1.85 | -23.9 |
| | W | 2.094 | 2.04 | -2.58 | 1.91 | -8.8 | 2.26 | 7.929 | 2 | -4.49 |
| | C | 2.466 | 2.2 | -10.8 | 1.85 | -25 | 1.75 | -29 | 1.81 | -26.6 |
| | LC2RB | 2.28 | 2.12 | -7.02 | 1.88 | -18 | 2.01 | -11.8 | 1.91 | -16.2 |

# SHEAR PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



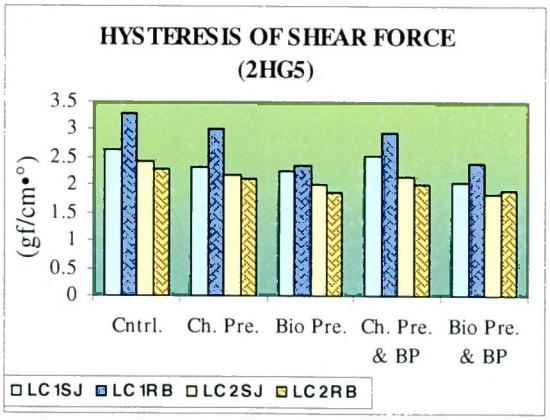




**FIGURE 17**

The statistical analysis Table XXXVIa reveals that except for structure/process in 2-way interactions, yarn/process/polishing in 3-way interactions, the rest of the parameters analysed showed significant differences at 1% level in the wale direction; yarn/process in 2-way interactions showed significant differences at 5% level in the wale direction. In the course direction, except for yarn/structure/ process/polishing in 4-way interactions and structure/process in 2-way interactions, the rest of the samples showed significant differences at 1% level and structure/process in 2-way interactions showed significant differences at 5% level.

**TABLE XXXVIa**
**ANALYSIS OF VARIANCE OF SHEAR PROPERTIES OF LYCRA COTTON WEFT KNITS**

| Shear Properties | | Shear Stiffness (G) | | Hysteresis of Shear Force (2HG) | | Hysteresis of Shear Force (2HG5) | |
|---|---|---|---|---|---|---|---|
| **Effects** | **Source of Variation** | **Wales** | **Courses** | **Wales** | **Courses** | **Wales** | **Courses** |
| **Main Effects (F Value)** | Yarns | **7.15**** | **20.79**** | **70.88**** | **172.11**** | **220.01**** | **17.48**** |
| | Structures | **11.59**** | 1.546 | **133.54**** | **32.27**** | **15.1**** | **62.75**** |
| | Processes | **8.46**** | **18.49**** | **705.8**** | **489.70**** | **908.6**** | **458.53**** |
| | Bio Polishing | 3.549 | **9.99**** | **30.13**** | **36.38**** | **29.09**** | **154.08**** |
| **2- way Interactions (F Value)** | Yarn /Structure | **15.73**** | **16.01**** | **122.05**** | **211.81**** | **102.8**** | **64.52**** |
| | Yarn /Process | 0.261 | 0.033 | **4.348*** | **63.36**** | **28.41**** | **66.13**** |
| | Yarn/ Polishing | 0.414 | 0.079 | **29.35**** | **178.25**** | **12.85**** | **97.63**** |
| | Structure/Process | 1.262 | 3.214 | 2.06 | **4.53*** | 0.300 | **41.32**** |
| | Structure/ Polishing | 0.009 | 1.762 | **163.54**** | **31.89**** | **40.82**** | **17.19**** |
| | Process/Polishing | 1.261 | **6.138*** | **200.02**** | **52.1**** | **176.41**** | **74.4**** |
| **3- way Interactions (F Value)** | Yarn / Structure / Process | 1.623 | **13.82**** | **18.54**** | **21.14**** | **25.80**** | **35.19**** |
| | Yarn / Structure / Polishing | 0.421 | 2.724 | **19.41**** | **30.57**** | 0.57 | **9.99**** |
| | Yarn / Process / Polishing | 1.784 | 3.175 | 3.087 | **18.27**** | 0.07 | **26.40**** |
| | Structure / Process / Polishing | 2.479 | **4.937*** | **123.14**** | **104.78**** | **94.86**** | **36.39**** |
| **4- way Interactions (F Value)** | Yarn / Structure / Process / Polishing | **5.082*** | 2.329 | **21.319**** | 0.245 | **12.187**** | 0.102 |

** Significant at 1% level  * Significant at 5% level

Of all the treated samples, the lowest Shear Hysteresis value (2HG5) was noticed in bio pretreated sample LC1RB with a loss of 33% in the course direction which after subsequent bio polishing recorded a loss of 33.4% in the course direction.

The ANOVA Table XXXVIa reveals that except for the factors structure/process in 2-way interactions, yarn/structure/polishing and yarn/process/polishing in 3-way interactions, significant differences was noticed for the rest of the parameters at 1% level in the wale direction. In the course direction, except for yarn/ structure/process/polishing in 4-way interactions, the rest of the parameters exhibited significant effect on the Shear Hysteresis value (2HG5) of the lycra cotton weft knits at 1% level.

**✶ Bending Properties - 100% Cotton**

The Table XXXVII and Figure 18 present the Bending Properties namely Bending Rigidity (B) and Hysteresis of Bending Movement (2HB) of cotton weft knits after pretreatment and bio polishing. The results of the statistical analysis of bending properties of cotton weft knits are represented in Table XXXVIIa.

Table XXXVII reveals a reduction of Bending Rigidity values in all the treated samples after pretreatment and subsequent bio polishing. The bio pretreated sample C2SJ exhibited the highest loss percentage of 74.55% in the course direction and the same sample after bio polishing showed the maximum loss of 70.92% in the course direction.

The ANOVA Table XXXVIIa reveals that yarns, structures and bio polishing in main effects and yarn/structure and structure/polishing in 2-way interactions, yarn /structure/process and yarn/structure/polishing in 3-way interactions showed significant effect on Bending Rigidity at 1% level, while yarn/process/polishing in 3-way interactions presents significant difference at 5% level in the wale direction. In the course direction, yarn/structure in 2-way interactions presented significant effect on the Bending Rigidity at 1% level.

The Hysteresis of Bending Movement (2HB) reflects the recovery of the fabric after bending. The smaller the values of 2HB, the better the fabric bending recovery will be, states Kan (2008). It can be noted that there is an overall reduction in values in all samples after pretreatment and bio polishing. This may be due to the removal of the waxes and impurities after the pretreatment and the removal of the short fibrils after bio polishing, which makes the fabric more flexible and pliable. Among the treated samples, the bio pretreated sample C1RB in the course direction showed the maximum loss of 65.09% while the highest loss percentage of 63.83%, after bio polishing, was seen in sample C2SJ in the course direction.

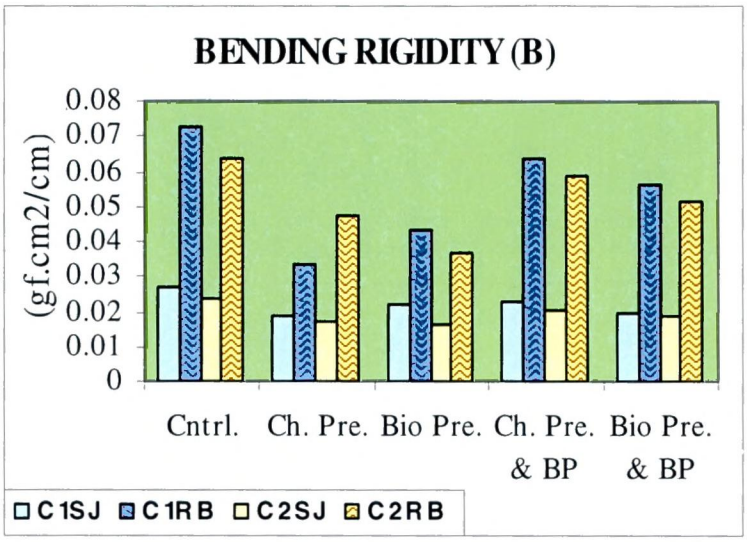
## TABLE XXXVII

## BENDING PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Bending Properties | Sample | Control | Chemical Pretreated | % Gain / Loss over Control | Bio Pretreated | % Gain / Loss over Control | Chemical Pretreated& Bio Polished | % Gain / Loss over Control | Bio Pretreated & Bio Polished | % Gain / Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Bending Rigidity (B) [gf.cm2/cm] | W | 0.035 | 0.0312 | -9.75 | 0.0314 | -9.174 | 0.0334 | -3.388 | 0.0283 | -18.14 |
| | C | 0.019 | 0.0066 | -66 | 0.0123 | -36.69 | 0.0128 | -34.12 | 0.0107 | -44.93 |
| | C1SJ | 0.027 | 0.0189 | -30 | 0.0218 | -19.26 | 0.0231 | -14.44 | 0.0195 | -27.78 |
| | W | 0.108 | 0.0537 | -50.3 | 0.071 | -34.31 | 0.1126 | 4.1866 | 0.0992 | -8.212 |
| | C | 0.038 | 0.0128 | -66.4 | 0.0148 | -61.2 | 0.0144 | -62.25 | 0.0142 | -62.77 |
| | C1RB | 0.073 | 0.0332 | -54.5 | 0.0429 | -41.23 | 0.0635 | -13.01 | 0.0567 | -22.33 |
| | W | 0.023 | 0.0242 | 3.51 | 0.0265 | 13.348 | 0.0278 | 18.909 | 0.0299 | 27.891 |
| | C | 0.025 | 0.0107 | -56.8 | 0.0063 | **-74.55** | 0.0133 | -46.28 | 0.0072 | **-70.92** |
| | C2SJ | 0.024 | 0.0174 | -27.5 | 0.0164 | -31.67 | 0.0206 | -14.17 | 0.0185 | -22.92 |
| | W | 0.099 | 0.0806 | -18.6 | 0.0588 | -40.64 | 0.1006 | 1.5576 | 0.0875 | -11.67 |
| | C | 0.029 | 0.014 | -51.6 | 0.0146 | -49.56 | 0.0167 | -42.3 | 0.0146 | -49.56 |
| | C2RB | 0.064 | 0.0473 | -26.1 | 0.0367 | -42.66 | 0.0587 | -8.281 | 0.0511 | -20.16 |
| Hysteresis of Bending movement (2HB) [gf.cm/cm] | W | 0.05 | 0.0386 | -22.6 | 0.0485 | -2.698 | 0.0455 | -8.717 | 0.0421 | -15.54 |
| | C | 0.03 | 0.013 | -56.9 | 0.0145 | -51.92 | 0.0144 | -52.25 | 0.017 | -43.62 |
| | C1SJ | 0.04 | 0.0258 | -35.5 | 0.0315 | -21.25 | 0.03 | -25 | 0.0296 | -26 |
| | W | 0.153 | 0.0883 | -42.4 | 0.1073 | -30.02 | 0.056 | -63.39 | 0.2094 | 36.569 |
| | C | 0.039 | 0.0155 | -59.9 | 0.0135 | **-65.09** | 0.0187 | -51.64 | 0.0236 | -38.97 |
| | C1RB | 0.096 | 0.0519 | -45.9 | 0.0604 | -37.08 | 0.039 | 57.50 | 0.1165 | 21.354 |
| | W | 0.03 | 0.0255 | -14.7 | 0.0279 | -6.652 | 0.0286 | -4.31 | 0.0369 | 23.46 |
| | C | 0.026 | 0.0104 | -60.4 | 0.0156 | -40.61 | 0.0159 | -39.47 | 0.0095 | **-63.83** |
| | C2SJ | 0.028 | 0.0179 | -36.1 | 0.0217 | -22.5 | 0.0223 | -20.36 | 0.0232 | -17.14 |
| | W | 0.22 | 0.1394 | -36.8 | 0.0811 | -63.21 | 0.1944 | -11.8 | 0.1288 | -41.56 |
| | C | 0.036 | 0.0157 | -56.3 | 0.0158 | -56.05 | 0.0193 | -46.32 | 0.0159 | -55.77 |
| | C2RB | 0.128 | 0.0775 | -39.5 | 0.0485 | -62.14 | 0.1068 | -16.63 | 0.0724 | -43.48 |

The statistical Table XXXVIIa reveals that except for yarns in main effects, structure/process and structure/polishing in 2-way interactions and yarn/structure/ polishing in 3 -way interactions, all other factors showed significant differences at 1% level in the wale direction. In the course direction, yarn/process/polishing in 3 -way interactions, exhibited significant effect on Hysteresis of Bending Movement (2HB) at 1% level.

# BENDING PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



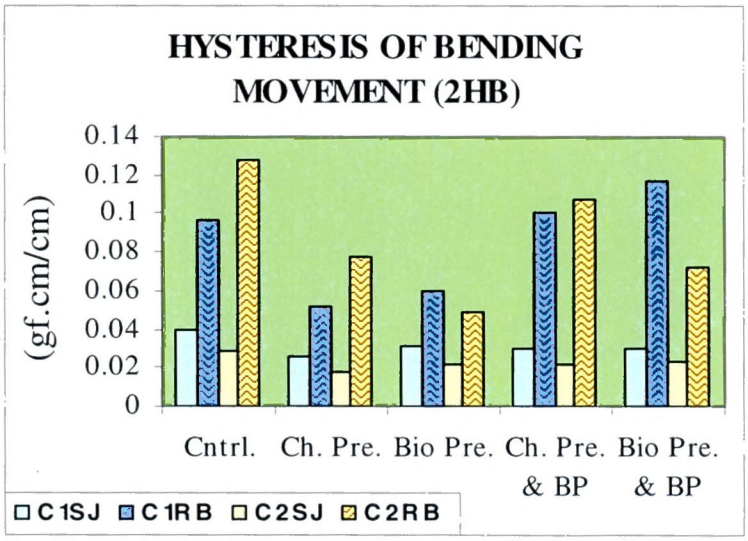




**FIGURE 18**

**TABLE XXXVIIa**

**ANALYSIS OF VARIANCE OF BENDING PROPERTIES OF COTTON WEFT KNITS**

| Bending Properties | | Bending Rigidity (B) | | Hysteresis of Bending movement (2HB) | |
|---|---|---|---|---|---|
| **Effects** | **Source of Variation** | **Wales** | **Courses** | **Wales** | **Courses** |
| **Main Effects (F Value)** | Yarns | **31.781**** | 0.144 | 1.259 | 0.019 |
| | Structures | **58.735**** | 0.239 | **205.472**** | 0.861 |
| | Processes | 1.218 | 0.377 | **70.129**** | 0.069 |
| | Bio Polishing | **43.116**** | 1.718 | **49.605**** | 3.885 |
| **2- way Interactions (F Value)** | Yarn /Structure | **16.287**** | **11.868**** | **24.419**** | 0.002 |
| | Yarn /Process | 0.057 | 3.429 | **121.936**** | 1.559 |
| | Yarn/ Polishing | 0.004 | 0.009 | **17.632**** | 1.962 |
| | Structure/Process | 2.344 | 0.349 | 4.354 | 0.149 |
| | Structure/ Polishing | **18.029**** | 0.471 | 2.900 | 1.454 |
| | Process/Polishing | 2.203 | 2.707 | **43.586**** | 1.393 |
| **3- way Interactions (F Value)** | Yarn / Structure / Process | **8.986**** | 1.779 | **195.187**** | 0.004 |
| | Yarn / Structure / Polishing | **7.204**** | 0.195 | 0.779 | 0.093 |
| | Yarn / Process / Polishing | **4.596*** | 0.645 | **20.158**** | **7.340**** |
| | Structure / Process / Polishing | 0.023 | 0.733 | **56.216**** | 3.065 |
| **4- way Interactions (F Value)** | Yarn / Structure / Process / Polishing | 0.912 | 0.975 | **109.565**** | 0.558 |

** Significant at 1% level * Significant at 5% level

### ✶ Bending Properties - Lycra Cotton

The Bending Properties namely Bending Rigidity (B), Hysteresis of Bending Movement (2HB) of lycra cotton weft knits after pretreatment and bio polishing, measured by KES-FB2 system, are given in Table XXXVIII and Figure 19. The results of the statistical analysis of Bending properties of lycra cotton weft knits are represented in Table XXXVIIIa

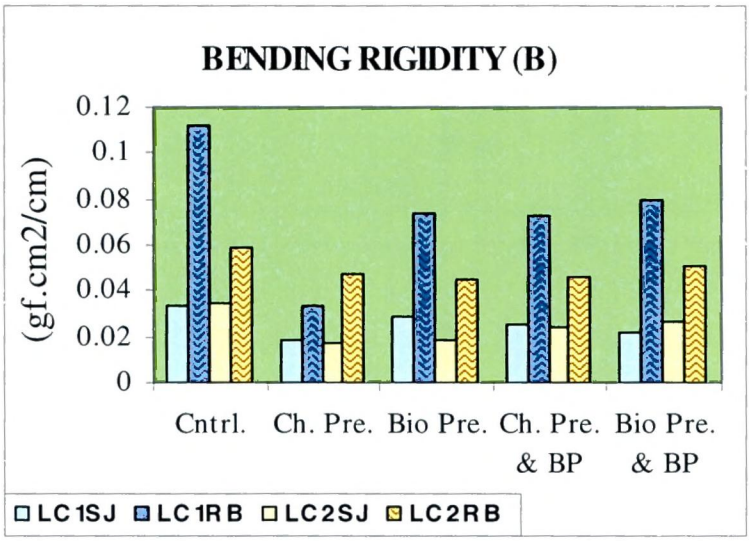
## TABLE XXXVIII

## BENDING PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Bending Properties | Sample | Control | Chemical Pretreated | % Gain / Loss over Control | Bio Pretreated | % Gain / Loss over Control | Chemical Pretreated& Bio Polished | % Gain / Loss over Control | Bio Pretreated & Bio Polished | % Gain / Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Bending Rigidity (B) [gf.cm2/cm] | W | 0.044 | 0.031 | -29.33 | 0.036 | -19.13 | 0.029 | -33.63 | 0.028 | -36.35 |
| | C | 0.021 | 0.007 | -69.24 | 0.021 | -1.184 | 0.02 | -8.642 | 0.016 | -27.29 |
| | LC1SJ | 0.033 | 0.019 | -42.38 | 0.029 | -13.11 | 0.025 | -25.3 | 0.022 | -33.54 |
| | W | 0.17 | 0.054 | -68.48 | 0.105 | -38.48 | 0.104 | -38.77 | 0.118 | -31.02 |
| | C | 0.053 | 0.013 | -75.84 | 0.044 | -17.53 | 0.041 | -21.87 | 0.043 | -19.04 |
| | LC1RB | 0.112 | 0.033 | -70.22 | 0.074 | -33.45 | 0.073 | -34.71 | 0.08 | -28.07 |
| | W | 0.039 | 0.024 | -37.88 | 0.033 | -16.32 | 0.03 | -22.73 | 0.038 | -2.198 |
| | C | 0.032 | 0.011 | -66.19 | 0.005 | **-85.78** | 0.019 | -41.54 | 0.016 | **-51.02** |
| | LC2SJ | 0.035 | 0.017 | -50.57 | 0.019 | -47.44 | 0.024 | -30.97 | 0.027 | -23.86 |
| | W | 0.09 | 0.081 | -10.64 | 0.071 | -21.28 | 0.071 | -21.5 | 0.082 | -9.42 |
| | C | 0.027 | 0.014 | -48.91 | 0.019 | -32.49 | 0.022 | -21.54 | 0.021 | -23.37 |
| | LC2RB | 0.059 | 0.047 | -19.56 | 0.045 | -23.81 | 0.046 | -21.6 | 0.051 | -12.59 |
| Hysteresis of Bending Movement (2HB) [gf.cm/cm] | W | 0.087 | 0.039 | -55.83 | 0.049 | -44.51 | 0.046 | -47.94 | 0.042 | -51.83 |
| | C | 0.043 | 0.013 | -69.63 | 0.015 | -66.12 | 0.014 | -66.36 | 0.017 | -60.28 |
| | LC1SJ | 0.065 | 0.026 | -60.37 | 0.032 | -51.61 | 0.027 | -58.06 | 0.03 | -54.53 |
| | W | 0.278 | 0.088 | -68.26 | 0.107 | -61.43 | 0.018 | **-93.4** | 0.209 | -24.73 |
| | C | 0.061 | 0.016 | -74.42 | 0.014 | -77.72 | 0.019 | -69.14 | 0.024 | -61.05 |
| | LC1RB | 0.169 | 0.052 | -69.36 | 0.06 | -64.34 | 0.101 | -40.32 | 0.117 | -31.23 |
| | W | 0.084 | 0.026 | -69.55 | 0.028 | -66.68 | 0.029 | -65.85 | 0.037 | -55.93 |
| | C | 0.048 | 0.01 | **-78.44** | 0.016 | -67.66 | 0.016 | -67.03 | 0.01 | -80.3 |
| | LC2SJ | 0.066 | 0.018 | -72.8 | 0.022 | -67.02 | 0.022 | -66.11 | 0.023 | -64.74 |
| | W | 0.174 | 0.139 | -20.05 | 0.081 | -53.49 | 0.194 | 11.489 | 0.129 | -26.13 |
| | C | 0.031 | 0.016 | -48.97 | 0.016 | -48.64 | 0.019 | -37.27 | 0.016 | -48.32 |
| | LC2RB | 0.103 | 0.078 | -24.39 | 0.049 | -52.68 | 0.107 | 4.1951 | 0.072 | -29.37 |

The treated samples showed decreased values in Bending Rigidity as well as Hysteresis of Bending Movement indicating that the samples have become flexible. After pretreatment the knitted fabrics undergo relaxation and there is a reduction in inter fibre and inter yarn friction leading to increased yarn mobility within the structure. Among the pretreated samples, the maximum loss in Bending Rigidity was noticed in the bio pretreated sample LC2SJ (85.78%) in the course direction. After bio polishing the loss percentage, when compared with their respective controls, decreased showing 51.02% as the highest loss percentage in bio pretreated, bio polished sample LC2SJ, in the course direction.

# BENDING PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



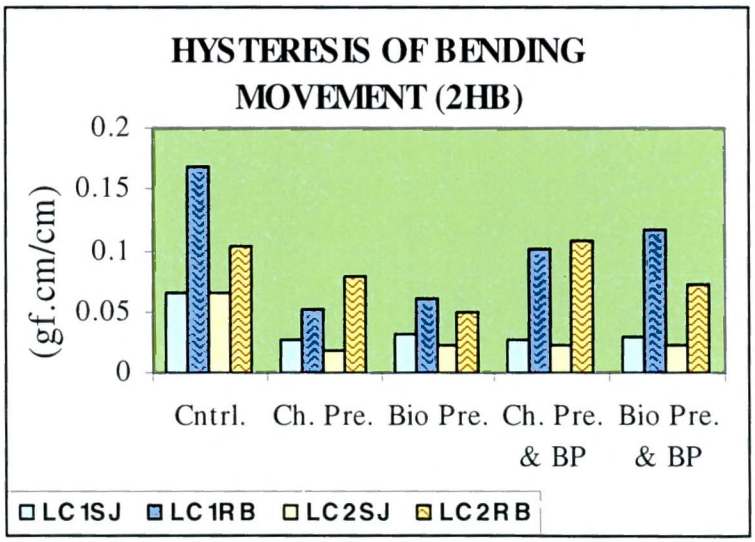




**FIGURE 19**

**TABLE XXXVIIIa**

**ANALYSIS OF VARIANCE OF BENDING PROPERTIES OF LYCRA COTTON WEFT KNITS**

| Bending Properties | | Bending Rigidity (B) | | Hysteresis of Bending movement (2HB) | |
|---|---|---|---|---|---|
| **Effects** | **Source of Variation** | **Wales** | **Courses** | **Wales** | **Courses** |
| **Main Effects (F Value)** | Yarns | **83.212**** | **15.069**** | **146.356**** | **10.375**** |
| | Structures | **5.464*** | **6.205*** | **202.875**** | **18.506**** |
| | Processes | **29.922**** | **8.323**** | **8.053**** | 0.107 |
| | Bio Polishing | **6.731*** | **30.693**** | **103.991**** | 3.274 |
| **2- way Interactions (F Value)** | Yarn /Structure | **20.449**** | **23.084**** | **694.944**** | **35.684**** |
| | Yarn /Process | 0.024 | **13.544**** | **287.105**** | 1.562 |
| | Yarn/ Polishing | 0.793 | 0.049 | **55.285**** | 0.787 |
| | Structure/Process | 0.628 | 2.959 | 2.802 | 0.610 |
| | Structure/ Polishing | 3.776 | 0.080 | **45.826**** | 1.310 |
| | Process/Polishing | 0.756 | **20.967**** | **34.422**** | 0.990 |
| **3- way Interactions (F Value)** | Yarn / Structure/ Process | **18.125**** | 0.714 | **329.276**** | 0.020 |
| | Yarn / Structur / Polishing | **26.669**** | 1.105 | **16.059**** | 0.049 |
| | Yarn / Process / Polishing | **11.147**** | **14.527**** | **26.197**** | **5.339*** |
| | Structure / Process/ Polishing | 1.116 | 0.000 | **64.232**** | 1.361 |
| **4- way Interactions (F Value)** | Yarn / Structure / Process / Polishing | **4.091**** | 3.497 | **114.360**** | 0.087 |

** Significant at 1% level * Significant at 5% level

From the statistical Table XXXVIIIa, it may be observed that, in the wale direction, yarns, processes, structures and polishing (5% level) in main effects, yarn /structure in 2-way interactions, yarn/structure/process, yarn/structure/polishing and yarn/process/polishing in 3-way interactions and yarn/structure/process /polishing in 4-way interactions exhibited significant effect on Bending Rigidity of lycra cotton weft knits at 1% level in the wale way. In the course direction, structures (5% level) and all other factors in main effects, yarn/structure, yarn/process and process/polishing in 2-way interactions and yarn/process /polishing in 3-way interactions, exhibited significant differences at 1% level.

Of all the pretreated samples, the highest loss of 78.44% was seen in the chemical pretreated sample LC2SJ in the course direction with regard to Hysteresis of Bending Movement (2HB). Among the bio polished samples, chemical pretreated and bio polished sample LC1RB showed 93.4% in the wale direction. This may be attributed to decrease in thickness after chemical pretreatment leading to lower values in Hysteresis of Bending Movement.

From the ANOVA Table XXXVIIIa, apart from structure/process in 2-way interactions, all other factors analyzed showed significant effect on Hysteresis of Bending Movement at 1% level in the wale direction. In the course direction, yarns, structures in main effects, yarn/structure in 2-way interactions and yarn /process/polishing (5% level) in 3-way interactions, showed significant differences at 1% level.

**✶ Compression Properties - 100% Cotton**

The Compression Properties includes Linearity of Compression (LC), Compression Energy (WC), Compressional Resilience (RC) and Percentage Compression. The compression properties of cotton weft knits after pretreatment and bio polishing, measured by the KES-FB3 system, are given in Table XXXIX and Figure 20. The results of the statistical analysis of Compression properties of cotton weft knits are presented in Table XXXIXa.

From Table XXXIX, it is understood that the Linearity of Compression values of all the treated samples have decreased after pretreatment when compared to their controls. The percentage reduction is higher in the case of the chemical pretreated fabrics than the bio pretreated fabrics. After bio polishing there is a further reduction in values indicating that the fabrics have become soft. Paramanik and Patil (2009) express that compression is related to the thickness values of the fabric. Linearity of Compression (LC), Compression Energy (WC), Thickness at 0.5 gf/cm$^2$ (To) and Thickness at 5 gf/cm$^2$ (Tm) are related to the softness of the fabric. Lower values of LC and WC and higher values of difference in To and Tm indicate softness.

The maximum loss was recorded in the chemical pretreated sample C1SJ with 12.89% among the pretreated samples. With regard to bio polished samples, the highest loss was noted in chemical pretreated and bio polished sample C2RB with 20.66%. Linearity of Compression is based on fabric thickness and chemical pretreated fabrics are thinner than their bio counter parts, indicating lower values.

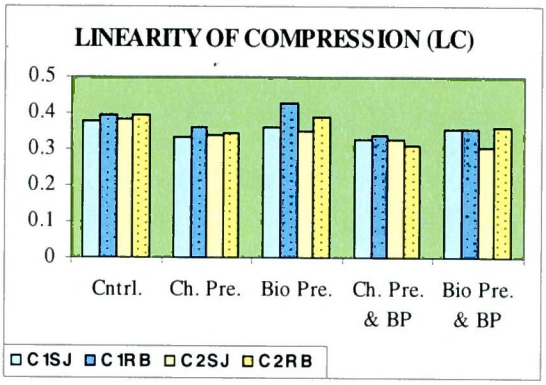
**TABLE XXXIX**
**COMPRESSION PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING**

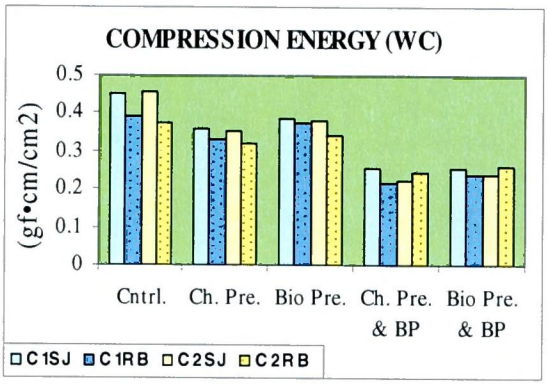
| Compression Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Linearity of Compression (LC) | C1SJ | 0.38 | 0.331 | **-12.89** | 0.36 | -5.26 | 0.329 | -13.42 | 0.354 | -6.84 |
| | C1RB | 0.396 | 0.36 | -9.09 | 0.43 | 8.58 | 0.338 | -14.64 | 0.357 | -9.84 |
| | C2SJ | 0.386 | 0.339 | -12.17 | 0.35 | -9.32 | 0.326 | -15.54 | 0.307 | -20.46 |
| | C2RB | 0.392 | 0.344 | -12.24 | 0.391 | -0.25 | 0.311 | **-20.66** | 0.363 | -7.39 |
| Compression Energy (WC) [gf·cm/cm2] | C1SJ | 0.45 | 0.36 | -20 | 0.388 | -13.77 | 0.254 | -43.55 | 0.255 | -43.33 |
| | C1RB | 0.39 | 0.334 | -14.35 | 0.376 | -3.58 | 0.216 | -44.61 | 0.241 | -38.20 |
| | C2SJ | 0.458 | 0.353 | **-22.92** | 0.38 | -17.03 | 0.223 | **-51.31** | 0.24 | -47.59 |
| | C2RB | 0.375 | 0.322 | -14.13 | 0.344 | -8.26 | 0.242 | -35.46 | 0.262 | -30.13 |
| Compression Resilience (RC) [ %] | C1SJ | 30.12 | 35.72 | 18.59 | 37.15 | 23.33 | 36 | 19.52 | 34.39 | 14.17 |
| | C1RB | 25.58 | 38.03 | **48.67** | 32.79 | 28.18 | 36.7 | **43.47** | 35.07 | 37.09 |
| | C2SJ | 29.35 | 38.22 | 30.22 | 38.28 | 30.42 | 39.11 | 33.25 | 35.71 | 21.66 |
| | C2RB | 27.98 | 36.13 | 29.12 | 38.19 | 36.49 | 34.97 | 24.98 | 31.4 | 12.22 |
| Percentage Compression [ %] | C1SJ | 44.42 | 45.28 | **1.94** | 41.51 | -6.55 | 37.68 | -15.17 | 34.76 | -21.75 |
| | C1RB | 32.51 | 32.49 | -0.1 | 28.62 | -12 | 25.27 | -22.27 | 24.98 | -23.16 |
| | C2SJ | 45.65 | 45.56 | -0.2 | 43.24 | -5.28 | 36.58 | -19.87 | 38.04 | -16.67 |
| | C2RB | 33.26 | 33.19 | -0.2 | 28.64 | -13.9 | 29.12 | **-12.45** | 26.63 | -19.93 |

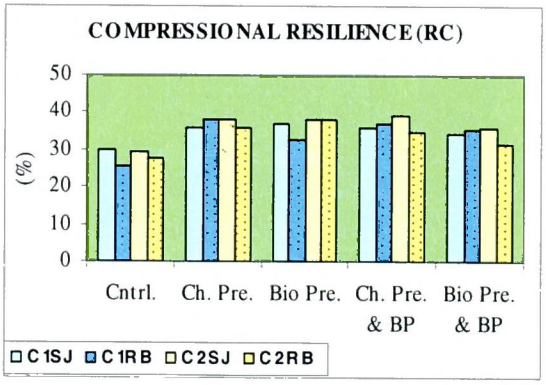
The statistical Table XXXIXa reveals that yarns in main effects and structure /process in 2-way interactions had significant differences at 5% level while processes and polishing in main effects showed significant differences at 1% level.

The Compressional Energy (WC) also shows a decrease in values and the percentage reduction was higher in the chemical pretreated fabrics when compared to the bio pretreated samples. This may be attributed to the difference in thickness between the chemical and bio pretreated samples. After bio polishing, a further reduction was noted which highlights that the thickness of the fabrics are reduced after bio polishing and they become smoother. Sun and Stylios (2005), state that higher WC values correspond to higher compressibility of the fabrics. As the thickness of the fabric increases the work of compression increases, hence the values are low after bio polishing. Among the treated samples, the maximum loss was noticed in chemical pretreated sample C2SJ before and after bio polishing with 22.92% and 51.31% respectively.

# COMPRESSION PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



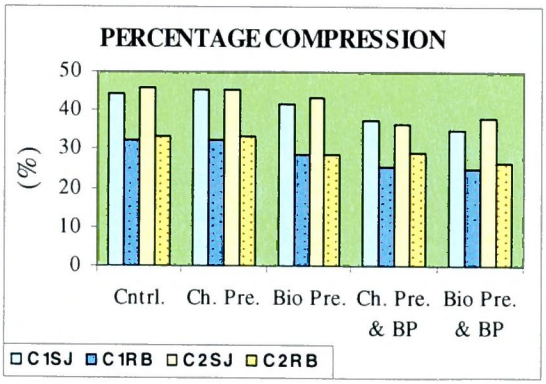




**FIGURE 20**

## TABLE XXXIXa

## ANALYSIS OF VARIANCE OF COMPRESSION PROPERTIES OF COTTON WEFT KNITS

| Compression Properties | | Linearity of Compression (LC) | Compression Energy (WC) | Compressional Resilience (RC) | Percentage Compression |
|---|---|---|---|---|---|
| Effects | Source of Variation | | | | |
| Main Effects (F Value) | Yarns | **4.621*** | 0.065 | 0.310 | 0.174 |
| | Structures | 3.550 | **11.118**** | **6.882*** | 0.656 |
| | Processes | **13.793**** | 4.383 | 2.824 | 4.086 |
| | Bio Polishing | **12.139**** | **107.594**** | 2.157 | **20.872**** |
| 2- way Interactions (F Value) | Yarn /Structure | 0.048 | 2.129 | **12.901**** | 0.207 |
| | Yarn /Process | 0.702 | 0.018 | 0.165 | 0.036 |
| | Yarn/ Polishing | 0.061 | 0.556 | 1.266 | 0.422 |
| | Structure/Process | **4.875*** | 0.337 | 0.593 | 0.457 |
| | Structure/ Polishing | 2.025 | 0.035 | 0.167 | 0.215 |
| | Process/Polishing | 1.606 | 0.380 | 1.123 | 1.184 |
| 3- way Interactions (F Value) | Yarn / Structure / Process | 1.399 | 0.186 | 1.500 | 0.732 |
| | Yarn / Structure / Polishing | 1.670 | 1.681 | 1.732 | 0.304 |
| | Yarn / Process / Polishing | 0.213 | 0.130 | 1.863 | 0.004 |
| | Structure / Process / Polishing | 0.030 | 0.024 | 0.364 | 0.078 |
| 4-way Inter actions (F Value) | Yarn / Structure / Process / Polishing | 1.677 | 0.000 | 1.528 | 0.197 |

** Significant at 1% level * Significant at 5% level

The statistical analysis Table XXXIXa reveals that structures and polishing in main effects showed significant effect on Compression Energy WC at 1% level.

The RC values of the treated samples, show an increase indicating that the recovery after compression was better when compared to their controls. The chemical pretreated values exhibit higher values when compared to the bio pretreated samples. Compression measurements give an indication of the resilience and fullness of knitted fabrics. When Compressional Resilience is higher, the recovery percentage after compression is also high, narrate Kane *et al.*(2007). Among the treated samples, the chemical pretreated sample C1RB exhibited a maximum increase of 48.67% while the same sample after bio polishing showed an increase of 43.47% showing good recovery from compression.

From the ANOVA Table XXXIXa structures in main effects and yarn /structure in 2-way interactions exhibited significant effect on Compressional Resilience at 5% and 1% levels respectively.

About 87.5% of the samples showed reduced values in Percentage Compression after pretreatment, when compared to their controls. The Table XXXIX highlights a substantial reduction in values after bio polishing indicating lower compressibility due to consolidation factor or tightening of the structure. The chemical pretreated sample C1SJ showed an increase in compression value (1.94%) among the pretreated samples. The higher the percentage compression values, the higher the fabric compressibility. Among the bio polished samples, chemical pretreated and bio polished sample C2RB exhibited minimum loss in compression values with 12.45%.

The statistical Table XXXIXa reveals that polishing in main effects, showed significant effect on percentage compression at 1% level.

**✶ Compression Properties - Lycra Cotton**

The Compression Properties includes Linearity of Compression (LC), Compression Energy (WC), Compressional Resilience (RC) and Percentage Compression. The Table XL and Figure 21 gives the Compression properties of lycra cotton weft knits after pretreatment and bio polishing. The results of the statistical analysis of compression properties of lycra cotton weft knits are presented in Table XLa.

From the Table XL it is clear that the Compression properties of the lycra cotton weft knits show a reduction in the case of Linearity of Compression (LC) and Compression Energy (WC) when compared with their controls. Reduction of values indicate that the softness of the fabrics have increased. Among the treated samples, the maximum reduction was observed in the bio pretreated sample LC2RB with 35.01% and the same sample showed the highest loss of 36.14% after subsequent bio polishing.

The ANOVA Table XLa reveals that at 5% level, processes in main effects and yarn/process in 2-way interactions and at 1% level, yarns in main effects, yarn /structure, yarn/polishing and process/polishing in 2-way interactions and yarn /structure/process in 3-way interactions exhibited significant effect on Linearity of Compression of lycra cotton weft knits.

## TABLE XL

## COMPRESSION PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

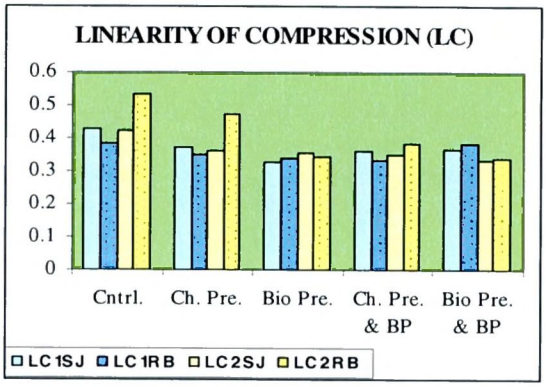
| Compression Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Linearity of Compression (LC) | LC1SJ | 0.426 | 0.371 | -12.91 | 0.327 | -23.23 | 0.361 | -15.25 | 0.365 | -14.31 |
| | LC1RB | 0.385 | 0.35 | -9.09 | 0.34 | -11.68 | 0.336 | -12.72 | 0.384 | -0.25 |
| | LC2SJ | 0.425 | 0.361 | -15.05 | 0.353 | -16.94 | 0.35 | -17.64 | 0.334 | -21.41 |
| | LC2RB | 0.534 | 0.473 | -11.42 | 0.347 | **-35.01** | 0.381 | -28.65 | 0.341 | **-36.14** |
| Compression Energy (WC) [gf·cm/cm2] | LC1SJ | 0.469 | 0.363 | -22.60 | 0.344 | -26.65 | 0.235 | -49.89 | 0.253 | -46.05 |
| | LC1RB | 0.552 | 0.455 | -17.57 | 0.448 | -18.84 | 0.211 | **-61.77** | 0.263 | -52.35 |
| | LC2SJ | 0.51 | 0.376 | -26.27 | 0.354 | **-30.58** | 0.268 | -47.45 | 0.261 | -48.82 |
| | LC2RB | 0.45 | 0.362 | -19.55 | 0.399 | -11.33 | 0.278 | -38.22 | 0.287 | -36.22 |
| Compressiona Resilience (RC) [ %] | LC1SJ | 27.89 | 34.87 | 25.02 | 38.2 | 36.96 | 35.49 | 27.24 | 33.01 | 18.35 |
| | LC1RB | 24.21 | 32.28 | 33.33 | 38.5 | 59.02 | 36.31 | 49.97 | 32.88 | 35.81 |
| | LC2SJ | 23.48 | 33.55 | 42.88 | 38.14 | **62.43** | 30.88 | 31.51 | 35.14 | 49.65 |
| | LC2RB | 24.24 | 35.65 | 47.07 | 38.33 | 58.12 | 34.28 | 41.41 | 39.91 | **64.64** |
| Percentage Compression [ %] | LC1SJ | 34.07 | 37.42 | 9.83 | 39.61 | 16.3 | 29.97 | -12.03 | 30.65 | -10.04 |
| | LC1RB | 31.78 | 33.61 | 5.76 | 33.8 | 6.36 | 22.61 | -28.85 | 21.37 | -32.76 |
| | LC2SJ | 35.86 | 45.15 | **25.9** | 39.37 | 9.79 | 34.34 | -4.239 | 33.09 | -7.724 |
| | LC2RB | 25.25 | 28.18 | 11.6 | 27.54 | 9.07 | 26.2 | **3.76** | 26.19 | 3.723 |

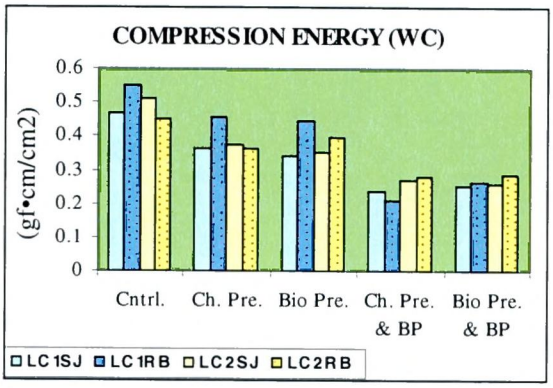
A similar trend was noticed in the WC values which further emphasize that the treated samples have become soft after the process when compared to their controls. When the fabrics are smooth the work of compression decreases. Among the treated samples, the maximum loss of 30.58% was observed in bio pretreated sample LC2SJ and in the chemical pretreated, bio polished sample LC1RB with 61.77%.

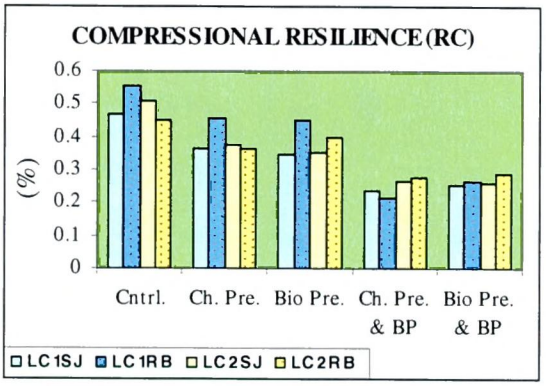
From the statistical Table XLa, it may be understood that at 5% level, yarns, structures in main effects and yarn/polishing in 2-way interactions, and at 1% level, polishing in main effects and yarn/structure in 2-way interactions showed significant effect on the Compressional Energy of lycra cotton weft knits.

An overall increase was noted in the Compressional Resilience values of treated samples when compared to their controls. After pretreatment the values were higher in the bio pretreated samples showing that the recovery from compression was good. Among the

# COMPRESSION PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



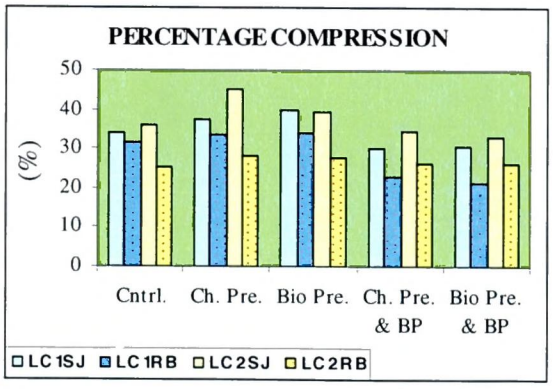




**FIGURE 21**

pretreated samples, a maximum increase of 62.43% was recorded in bio pretreated sample LC2SJ. After bio polishing, maximum increase of 64.64% was observed in bio pretreated, bio polished sample LC2RB, indicating that the combed yarns LC2 exhibited greater Compressional Resilience due to the yarn structure.

The ANOVA Table XLa shows that yarns (1% level), structures and processes (at 5% level) in main effects exhibited significant effect on Compressional Resilience of lycra cotton weft knits.

**TABLE XLa**

**ANALYSIS OF VARIANCE OF COMPRESSION PROPERTIES OF LYCRA COTTON WEFT KNITS**

| Compression Properties | | Linearity of Compression (LC) | Compression Energy (WC) | Compressional Resilience (RC) | Percentage Compression |
|---|---|---|---|---|---|
| **Effects** | **Source of Variation** | | | | |
| **Main Effects (F Value)** | Yarns | **33.443**** | **4.187*** | **8.117**** | **16.511**** |
| | Structures | 0.329 | **5.433*** | **5.877*** | 4.197 |
| | Processes | **6.411*** | 0.469 | **4.846*** | 0.507 |
| | Bio Polishing | 0.595 | **129.587**** | 1.383 | **58.161**** |
| **2- way Interactions (F Value)** | Yarn /Structure | **25.385**** | **8.510**** | 1.356 | **5.848*** |
| | Yarn /Process | **6.755*** | 0.035 | 2.132 | 1.298 |
| | Yarn/ Polishing | **7.717**** | **5.176*** | 0.000 | **6.491*** |
| | Structure/Process | 0.186 | 1.775 | 0.017 | 0.049 |
| | Structure/Polishing | 0.495 | 3.726 | 0.785 | 0.138 |
| | Process/Polishing | **8.023**** | 0.705 | 1.613 | 0.067 |
| **3- way Interactions (F Value)** | Yarn / Structure / Process | **9.746**** | 0.171 | 0.091 | 1.440 |
| | Yarn / Structure / Polishing | 0.764 | 2.177 | 0.149 | **6.276*** |
| | Yarn / Process / Polishing | 0.715 | 1.440 | 3.303 | 1.008 |
| | Structure / Process / Polishing | 2.315 | 0.122 | 0.019 | 0.181 |
| **4-way Interactions (F Value)** | Yarn / Structure / Process / Polishing | 0.982 | 0.431 | 0.688 | 0.177 |

** Significant at 1% level * Significant at 5% level

Of all the treated samples, highest Percentage Compression values were noticed in chemical pretreated sample LC2SJ (25.9%) and in chemical pretreated, bio polished sample LC2RB (3.76%) due to the difference in weight and thickness between chemical and bio pretreated samples.

The ANOVA Table XLa revealed significant differences between yarns and bio polishing in main effects at 1% level and yarn/structure, yarn/polishing in 2-way interactions and yarn/structure /polishing in 3-way interactions at 5% level.

**Fabric Thickness and Weight - 100 % cotton**

The Fabric Thickness and Weight of cotton weft knitted fabrics, measured by the KES-FB3 system, are shown in Table XLI and Figure 22. The results of the statistical analysis for Fabric Thickness and Weight of cotton weft knits are represented in Table XLIa.

**TABLE XLI**

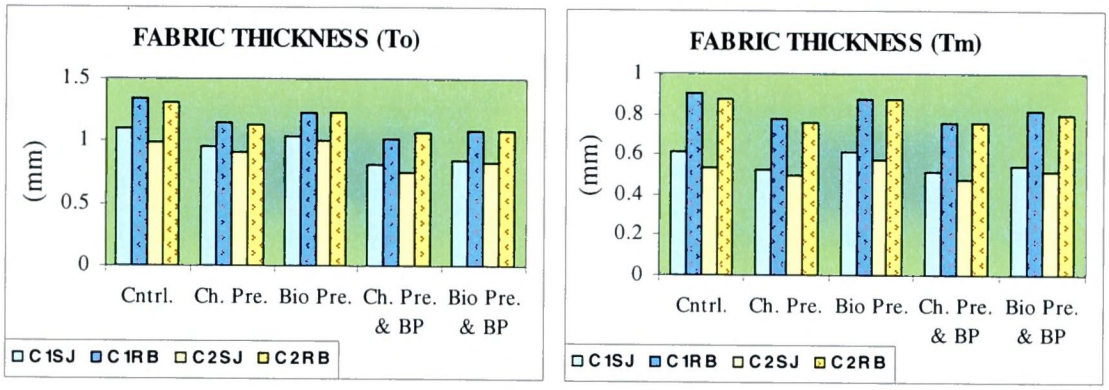
**FABRIC THICKNESS AND WEIGHT OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING**

| | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Fabric Thickness (To mm) | C1SJ | 1.103 | 0.963 | -12.69 | 1.043 | -5.43 | 0.82 | -25.65 | 0.84 | -23.84 |
| | C1RB | 1.338 | 1.148 | -14.20 | 1.223 | -8.59 | 1.017 | -23.99 | 1.089 | -18.60 |
| | C2SJ | 0.988 | 0.913 | -7.59 | 1.006 | **1.82** | 0.749 | -24.19 | 0.828 | **-16.19** |
| | C2RB | 1.302 | 1.13 | -13.21 | 1.229 | -5.60 | 1.068 | -17.97 | 1.089 | -16.35 |
| Fabric Thickness at max. pressure (Tm mm) | C1SJ | 0.613 | 0.527 | -14.02 | 0.61 | -0.48 | 0.511 | -16.63 | 0.548 | -10.60 |
| | C1RB | 0.903 | 0.775 | -14.17 | 0.873 | -3.32 | 0.76 | -15.83 | 0.817 | -9.52 |
| | C2SJ | 0.537 | 0.497 | -7.44 | 0.571 | **6.33** | 0.475 | -11.54 | 0.513 | **-4.46** |
| | C2RB | 0.869 | 0.755 | -13.11 | 0.877 | 0.92 | 0.757 | -12.88 | 0.799 | -8.05 |
| Fabric Weight ($mg/cm^2$) | C1SJ | 16.68 | 15.17 | -9.05 | 16.47 | **-1.25** | 14.83 | -11.09 | 15.56 | -6.71 |
| | C1RB | 24.55 | 21.22 | -13.56 | 23.32 | -5.01 | 22.16 | -9.73 | 23.04 | -6.15 |
| | C2SJ | 15.97 | 14.01 | -12.27 | 15.75 | -1.37 | 14.24 | -10.83 | 15.51 | **-2.88** |
| | C2RB | 23.57 | 21.97 | -6.78 | 23.12 | -1.90 | 21.55 | -8.57 | 22.77 | -3.39 |

**Fabric Thickness** [100% Cotton]

Table XLI reveals substantial reduction in Fabric Thickness in a majority of the treated samples after pretreatment and bio polishing. It is observed that the loss percentage is greater in chemical pretreated samples when compared to the bio pretreated samples. Bio pretreated sample C2SJ showed a marginal increase in thickness by 1.82% which may be due to shrinkage after the process, while all other samples showed a decrease in fabric thickness (To). The minimum loss percentage of 16.19 was noticed in bio pretreated, bio polished sample C2SJ, among the bio polished samples. With regards to Fabric Thickness at

# FABRIC THICKNESS AND WEIGHT OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



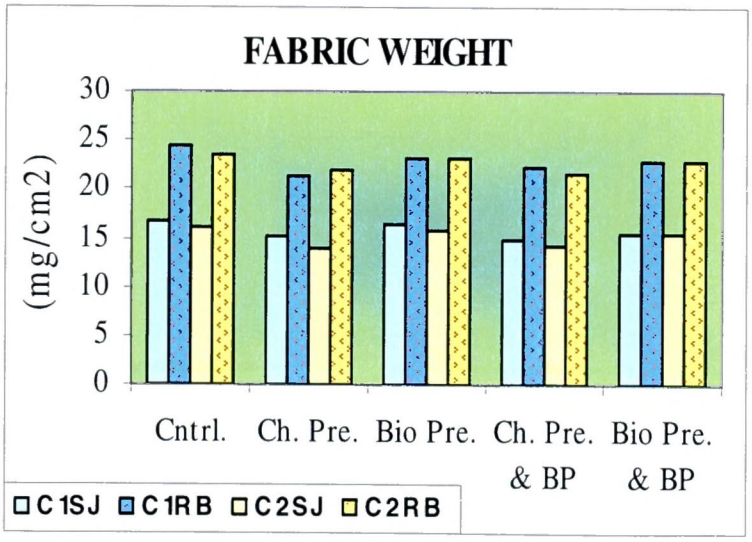




**FIGURE 22**

processes and polishing in main effects and process /polishing in 2-way interactions show significant differences at 1% level.

**Fabric Weight** [100% Cotton]

From Table XLI it may be noted that the weight of all the samples reduced after pretreatment and subsequent bio polishing. Among the treated samples, the minimum weight loss of 1.25% was noticed in bio pretreated sample C1SJ and in the bio pretreated, bio polished sample C2SJ with 2.88%. Manickam and Ganeshprasad (2004) state that the traditional scouring using sodium hydroxide at boiling condition is highly unspecific in action and removes the primary wall to a greater extent than required, resulting in thickness and weight reduction.

The statistical analysis Table XLIa showed that apart from structures in main effects and yarn/polishing in 2-way interactions, all other parameters showed significant effect on fabric weight at 1% level.

✶ **Fabric Thickness and Weight - Lycra Cotton**

The Fabric Thickness and Weight of cotton weft knitted fabrics, measured by the KES-FB3 system, are shown in Table XLII and Figure 23. The results of the statistical analysis for Fabric Thickness and Weight of lycra cotton weft knits are represented in Table XLIIa.

**Fabric Thickness** [Lycra Cotton]

From the Table XLII the lycra cotton weft knits exhibited decrease in thickness and weight after pretreatment and bio polishing when compared to their controls. Among the treated samples, the minimum loss in thickness was observed in bio pretreated sample LC2SJ with 1.06% and in bio pretreated and bio polished sample LC2RB with 8.24%. In the bio polishing treatment, the cellulase enzyme eliminates the superficial micro fibrils by the controlled hydrolysis of cellulose leading to a reduction in thickness and weight. With regards to Fabric Thickness at maximum pressure (Tm), the minimum loss percentage of 4.75 was observed in bio pretreated sample LC2RB and the same sample after bio polishing showed a minimum loss of 9.4%, among the treated samples.

With respect to Fabric Thickness (To), the ANOVA Table XLIIa reveals significant differences in all parameters analysed at 1% level except for yarn /process/polishing in 3-way interactions. In the case of Fabric Thickness at maximum pressure (Tm), the statistical

results highlight that except for yarn /structure in 2-way interactions, the rest of the parameters showed significant effect at 1% level.

**TABLE XLII**

**FABRIC WEIGHT AND THICKNESS OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING**

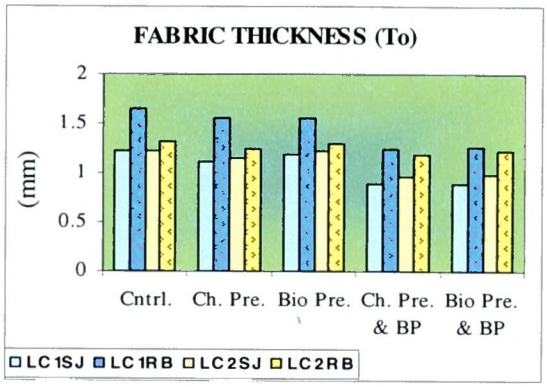
| | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Fabric Thickness (To mm) | LC1SJ | 1.23 | 1.109 | -9.84 | 1.189 | -3.33 | 0.881 | -28.4 | 0.894 | -27.3 |
| | LC1RB | 1.655 | 1.547 | -6.53 | 1.562 | -5.62 | 1.243 | -24.9 | 1.259 | -23.9 |
| | LC2SJ | 1.227 | 1.154 | -5.95 | 1.214 | **-1.06** | 0.958 | -21.9 | 0.973 | -20.7 |
| | LC2RB | 1.323 | 1.249 | -5.59 | 1.3 | -1.74 | 1.187 | -10.3 | 1.214 | **-8.24** |
| Fabric Thickness at max. pressure (Tm mm) | LC1SJ | 0.811 | 0.694 | -14.43 | 0.718 | -11.47 | 0.617 | -23.92 | 0.62 | -23.55 |
| | LC1RB | 1.129 | 1.027 | -9.035 | 1.034 | -8.415 | 0.962 | -14.79 | 0.99 | -12.31 |
| | LC2SJ | 0.787 | 0.633 | -19.57 | 0.736 | -6.48 | 0.629 | -20.08 | 0.651 | -17.28 |
| | LC2RB | 0.989 | 0.897 | -9.302 | 0.942 | **-4.75** | 0.876 | -11.43 | 0.896 | **-9.40** |
| Fabric Weight ($mg/cm^2$) | LC1SJ | 20.7 | 19.14 | -7.54 | 19.17 | -7.39 | 17.56 | -15.2 | 18.02 | -12.9 |
| | LC1RB | 30.28 | 27.53 | -9.08 | 28.09 | -7.23 | 26.82 | -11.4 | 26.95 | -11 |
| | LC2SJ | 21.96 | 16.84 | -23.3 | 19.61 | -10.7 | 18.65 | -15.1 | 18.98 | -13.6 |
| | LC2RB | 24.06 | 22.7 | -5.65 | 23.31 | **-3.12** | 22.37 | -7.02 | 22.57 | **-6.19** |

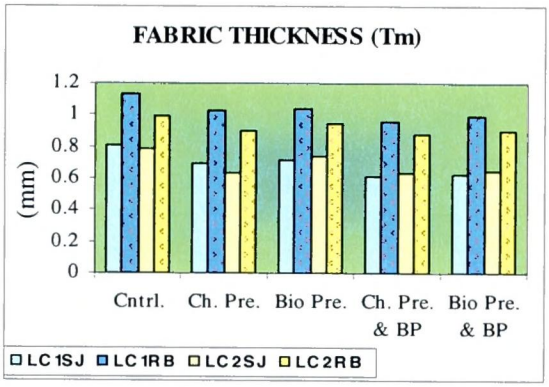
**Fabric Weight** [Lycra cotton]

Table XLII highlights that there is a reduction in weight in all the samples after pretreatment and subsequent bio polishing. Of all the treated samples, the minimum weight loss of 3.12% was observed in bio pretreated sample LC2RB and after bio polishing the same sample exhibited a minimum weight loss of 6.19%. Patra and Arora (2006) narrate that the weight loss in the enzyme pretreated samples is less than that of the alkali pretreated fabrics, due to the small percentage of wax remaining in the fabric.

From the statistical Table XLIIa, it may be noted that all the factors analyzed show significant differences, with regard to Fabric Weight, at 1% level.

# FABRIC THICKNESS AND WEIGHT OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



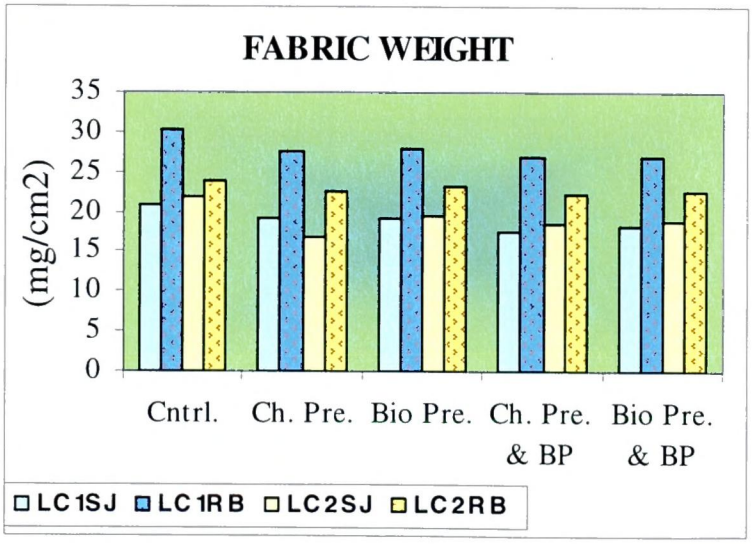




**FIGURE 23**

**TABLE XLIIa**

**ANALYSIS OF VARIANCE OF FABRIC THICKNESS AND WEIGHT OF LYCRA COTTON WEFT KNITS**

| Fabric Thickness & Fabric Weight | | Fabric Thickness (To) | Fabric Thickness (Tm) | Fabric Weight |
|---|---|---|---|---|
| **Effects** | **Source of Variation** | | | |
| **Main Effects (F Value)** | Yarns | **6399.684**** | **337.520**** | **55.372**** |
| | Structures | **2174.471**** | **2879.427**** | **13654.919**** |
| | Processes | **996.278**** | **730.803**** | **3305.365**** |
| | Bio Polishing | **34401.286**** | **2130.310**** | **2278.245**** |
| **2- way Interactions (F Value)** | Yarn /Structure | **546.981**** | 0.075 | **8927.393**** |
| | Yarn /Process | **14.358**** | **224.967**** | **1112.347**** |
| | Yarn/ Polishing | **2274.035**** | **151.456**** | **2760.824**** |
| | Structure/Process | **75.549**** | **79.718**** | **792.913**** |
| | Structure/ Polishing | **1985.767**** | **237.256**** | **50.744**** |
| | Process/Polishing | **255.953**** | **160.807**** | **997.738**** |
| **3- way Interactions (F Value)** | Yarn / Structure / Process | **64.862**** | **72.243**** | **767.250**** |
| | Yarn / Structure / Polishing | **748.457**** | **47.829**** | **1927.685**** |
| | Yarn / Process / Polishing | 0.019 | **128.047**** | **1225.136**** |
| | Structure / Process / Polishing | **117.412**** | **130.669**** | **235.733**** |
| **4-way Inter actions (F Value)** | Yarn / Structure / Process / Polishing | **28.934**** | **9.626**** | **1124.011**** |

** Significant at 1% level  * Significant at 5% level

### ✶ Surface Properties - 100 % Cotton

The Surface Properties include Coefficient of Friction (MIU), Mean Deviation of MIU – (MMD) and Geometrical Roughness (SMD). The Surface Properties of cotton weft knitted fabrics measured by the KES-FB4 system are shown in Table XLIII and Figure 24. The results of the statistical analysis are given in Table XLIIIa.

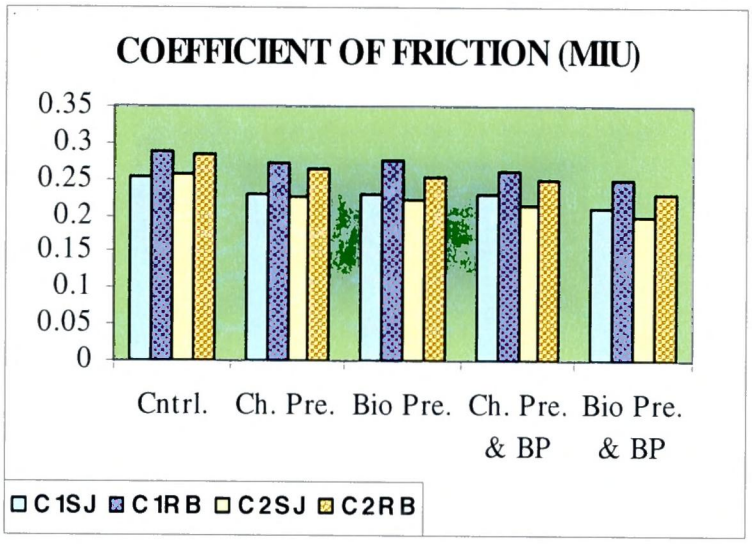
From the Table XLIII, it is clear that an increase in Coefficient of Friction MIU was noticed in a majority of the pretreated samples in the wale direction. In the course direction, a reduction is noticed in Coefficient of Friction MIU when compared to their controls. Sun and Stylios (2005), explain that the Coefficient of Friction MIU is determined by the ease with which two surfaces slide against each other. It is the ratio of the force required to slide the surfaces to the force perpendicular to the surfaces. A higher value of MIU corresponds to greater friction or resistance and drag.

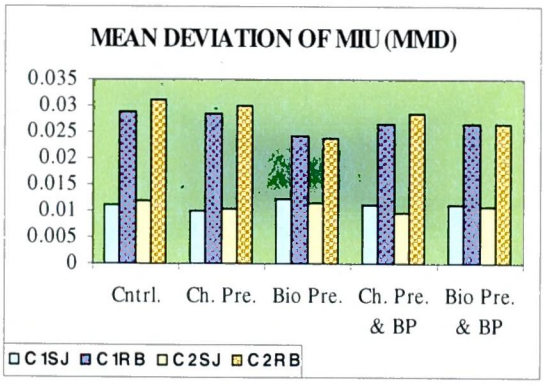
## TABLE XLIII

## SURFACE PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Coefficient of Friction ( MIU) | W | 0.149 | 0.226 | 52.19 | 0.233 | 56.9 | 0.23 | 54.88 | 0.207 | 39.39 |
| | C | 0.358 | 0.235 | -34.4 | 0.226 | -36.94 | 0.228 | -36.38 | 0.21 | -41.4 |
| | C1SJ | 0.254 | 0.231 | -9.06 | 0.229 | -9.843 | 0.229 | -9.843 | 0.209 | -17.7 |
| | W | 0.139 | 0.226 | 62.25 | 0.228 | 63.682 | 0.225 | 61.529 | 0.212 | 52.2 |
| | C | 0.438 | 0.319 | -27.1 | 0.322 | -26.44 | 0.292 | -33.3 | 0.283 | -35.4 |
| | C1RB | 0.288 | 0.272 | -5.56 | 0.275 | -4.514 | 0.259 | -10.07 | 0.247 | -14.2 |
| | W | 0.155 | 0.226 | 45.93 | 0.219 | 41.407 | 0.214 | 38.178 | 0.194 | 25.26 |
| | C | 0.357 | 0.228 | -36.2 | 0.222 | **-37.84** | 0.215 | -39.8 | 0.199 | **-44.3** |
| | C2SJ | 0.256 | 0.227 | -11.3 | 0.221 | -13.67 | 0.215 | -16.02 | 0.197 | -23 |
| | W | 0.134 | 0.217 | 61.63 | 0.208 | 54.922 | 0.212 | 57.901 | 0.188 | 40.03 |
| | C | 0.436 | 0.311 | -28.6 | 0.301 | -30.92 | 0.285 | -34.59 | 0.27 | -38 |
| | C2RB | 0.285 | 0.264 | -7.37 | 0.254 | -10.88 | 0.249 | -12.63 | 0.229 | -19.6 |
| Mean Deviation of MIU – (MMD) | W | 0.002 | 0.0104 | 455.9 | 0.013 | 594.92 | 0.0116 | 520.09 | 0.0119 | 536.1 |
| | C | 0.021 | 0.0100 | -52.38 | 0.0113 | -45.49 | 0.0106 | -48.86 | 0.0104 | -49.8 |
| | C1SJ | 0.011 | 0.0099 | -12.4 | 0.0122 | 7.9646 | 0.0111 | -1.77 | 0.0111 | -1.77 |
| | W | 0.001 | 0.0109 | 803.8 | 0.0118 | 878.47 | 0.0109 | 803.84 | 0.0105 | 770.7 |
| | C | 0.057 | 0.0461 | -19.7 | 0.0368 | -35.88 | 0.042 | -26.82 | 0.0422 | -26.5 |
| | C1RB | 0.029 | 0.0285 | -2.73 | 0.0243 | -17.06 | 0.0264 | -9.898 | 0.0264 | -9.9 |
| | W | 0.003 | 0.0113 | 287.7 | 0.0136 | 366.67 | 0.009 | 208.82 | 0.012 | 311.8 |
| | C | 0.021 | 0.0098 | -53.8 | 0.0099 | **-52.89** | 0.0104 | -50.94 | 0.0099 | **-53.3** |
| | C2SJ | 0.012 | 0.0105 | -12.5 | 0.0117 | -2.5 | 0.0097 | -19.17 | 0.0109 | -9.17 |
| | W | 0.002 | 0.0115 | 486.3 | 0.0103 | 425.1 | 0.0083 | 323.14 | 0.0103 | 425.1 |
| | C | 0.06 | 0.0482 | -19.8 | 0.0371 | -38.3 | 0.0488 | -18.85 | 0.0425 | -29.3 |
| | C2RB | 0.031 | 0.0299 | -3.86 | 0.0237 | -23.79 | 0.0285 | -8.36 | 0.0264 | -15.1 |
| Geometrical Roughness (SMD) [ µm ] | W | 7.431 | 4.82 | -35.1 | 3.93 | **-47.11** | 6.4 | -13.88 | 6.19 | -16.7 |
| | C | 6.225 | 3.95 | -37 | 3.59 | -42.33 | 4.97 | -20.16 | 3.01 | **-51.6** |
| | C1SJ | 6.828 | 4.37 | -36 | 3.76 | -44.93 | 5.69 | -16.67 | 4.6 | -34.15 |
| | W | 4.791 | 4.12 | -14 | 3.51 | -26.74 | 4.18 | -12.75 | 4.03 | -15.9 |
| | C | 20.97 | 17.58 | -16.2 | 16.17 | -22.89 | 17.9 | -14.64 | 17.05 | -18.7 |
| | C1RB | 12.88 | 10.85 | -15.8 | 9.84 | -23.6 | 11.04 | -14.29 | 10.54 | -18.2 |
| | W | 5.547 | 4.92 | -11.3 | 3.35 | -39.61 | 4.78 | -13.82 | 4.81 | -13.3 |
| | C | 4.553 | 3.88 | -14.8 | 2.78 | -38.94 | 3.67 | -19.4 | 3.23 | -29.1 |
| | C2SJ | 5.05 | 4.4 | -12.9 | 3.06 | -39.41 | 4.22 | -16.44 | 4.02 | -20.4 |
| | W | 4.632 | 3.93 | -15.2 | 2.92 | -36.96 | 4.42 | -4.575 | 4.13 | -10.8 |
| | C | 20.4 | 16.86 | -17.4 | 16.33 | -19.95 | 17.43 | -14.56 | 15.13 | -25.8 |
| | C2RB | 12.51 | 10.39 | -16.9 | 9.62 | -23.1 | 10.92 | -12.71 | 9.63 | -23 |

# SURFACE PROPERTIES OF COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



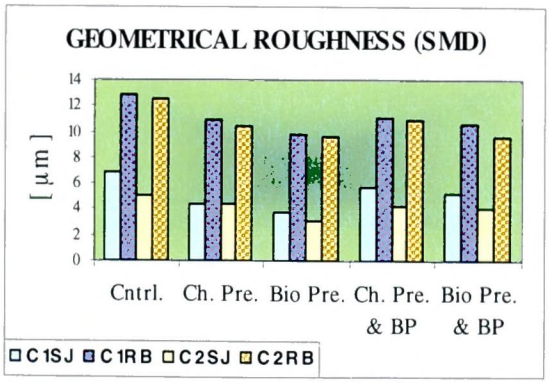




**FIGURE 24**

Among the treated samples, the lowest readings were recorded in the bio pretreated sample C2SJ in the course direction, with a loss of 37.84% and after bio polishing the same sample recorded a loss of 44.3% in the course direction, indicating that bio polishing has smoothened the fabric and reduced friction.

**TABLE XLIIIa**

**ANALYSIS OF VARIANCE OF SURFACE PROPERTIES OF COTTON WEFT KNITS**

| Surface Properties | | Coefficient of Friction (MIU) | | Mean Deviation of MIU – (MMD) | | Geometrical Roughness (SMD) | |
|---|---|---|---|---|---|---|---|
| Effects | Source of Variation | Wales | Courses | Wales | Courses | Wales | Courses |
| Main Effects (F Value) | Yarns | **123.022**** | **67.097**** | **30.742**** | 0.056 | **9.633**** | 1.586 |
| | Structures | **232.701**** | **502.047**** | **19.537**** | **35.623**** | **20.864**** | **70.167**** |
| | Processes | **77.742**** | **79.923**** | 0.507 | 1.414 | **53.650**** | **46.419**** |
| | Bio Polishing | **101.991**** | **368.006**** | 0.515 | 0.275 | **110.762**** | **10.382**** |
| 2- way Interactions (F Value) | Yarn /Structure | **13.920**** | 0.138 | **7.424**** | 0.094 | **7.786**** | **15.671**** |
| | Yarn /Process | **11.548**** | 1.644 | 0.001 | 0.516 | **4.540*** | 3.223 |
| | Yarn/ Polishing | **5.091*** | 0.511 | 0.081 | 0.091 | 0.077 | **7.998**** |
| | Structure/Process | 0.405 | **8.042**** | 0.161 | 2.258 | 0.013 | **5.322*** |
| | Structure/ Polishing | 1.267 | **24.981**** | 0.081 | 0.044 | **5.099*** | **7.378**** |
| | Process/Polishing | **53.827**** | **15.629**** | 0.011 | 0.146 | **28.590**** | 0.049 |
| 3- way Interactions (F Value) | Yarn / Structure / Process | 2.124 | **6.089*** | 0.005 | 0.004 | 0.004 | 1.674 |
| | Yarn / Structure / Polishing | 0.151 | **5.902*** | 0.033 | 0.026 | **19.746**** | 1.458 |
| | Yarn / Process / Polishing | 2.716 | 0.315 | 0.549 | 0.000 | **4.713*** | 0.686 |
| | Structure / Process / Polishing | 0.901 | 0.377 | 0.044 | 1.198 | 1.184 | 1.670 |
| 4- way Interactions (F Value) | Yarn / Structure / Process / Polishing | 3.115 | 0.652 | 0.069 | 0.252 | 1.356 | **8.353**** |

** Significant at 1% level * Significant at 5% level

In the wale direction, the ANOVA Table XLIIIa reveals that significant differences were noticed in all parameters of main effects and 2-way interactions at 1% level except for yarn/polishing, structure/polishing and process /polishing. Yarn/polishing in 2 way interactions was significant at 5% level with regard to Coefficient of Friction MIU. In the course direction, all the factors in main effects, structure/process, structure/polishing and

process / polishing in 2-way interactions were significant at 1% level while yarn / structure / process and yarn/structure /polishing in 3-way interactions were significant at 5% level.

A similar trend was seen in Mean Deviation of MIU (MMD), with bio pretreated sample C2SJ recording a maximum loss of 52.89% in the course direction. After bio polishing the above mentioned sample recorded the maximum loss of 53.3% in the course direction.

From the statistical Table XLIIIa, yarns and structures in main effects and yarn /structure in 2-way interactions showed significant differences at 1% level in the wale direction and in the course direction, structures in main effects showed significant differences at 1% level.

A reduction in Geometrical Roughness SMD values, was observed in the treated samples when compared to their controls. Lower values were recorded after bio polishing indicating that the short fibrils have been removed by the enzyme treatment and the samples have been rendered even and smooth, than the untreated samples. Kan and Yuen (2006), express that the SMD also shows the evenness characteristics of the fabric surface. The greater the SMD value, the less even will be the fabric surface. The maximum loss of 47.11% was noticed in the bio pretreated sample C1SJ in the wale direction and after bio polishing the same sample revealed a maximum loss of 51.6% in the course direction, among the treated samples.

From the ANOVA Table XLIIIa, it is evident that in the wale direction, at 1% level, all parameters in main effects, yarn/structure and process/polishing in 2-way interactions and yarn/structure/polishing in 3-way interactions showed significant differences with regard to Geometrical Roughness, while yarn/process and structure/polishing in 2-way interactions and yarn/process/polishing in 3-way interactions exhibited significant differences at 5% level. In the course direction except for yarns, all other factors in main effects, yarn/structure, yarn/polishing and structure/polishing in 2-way interactions and yarn/structure/process /polishing in 4-way interactions exhibited significant differences at 1% level; at 5% level, structure/process in 2-way interactions exhibited significant differences with regard to Geometrical Roughness in the course direction.

✶ **Surface Properties - Lycra Cotton**

The Surface Properties include Coefficient of Friction (MIU), Mean Deviation of MIU – (MMD) and Geometrical Roughness (SMD). The Surface Properties of lycra cotton weft

knitted fabrics, measured by the KES-FB4 system, are shown in Table XLIV and Figure 25. The results of the statistical analysis of surface properties are given in Table XLIVa.

From the Table XLIV, it is evident that a majority of the pretreated and bio polished samples showed reduction in Coefficient of Friction MIU when compared to their controls. Among the treated samples, maximum loss of 24.04% was observed in bio pretreated sample LC1RB in the course direction and bio pretreated, bio polished sample LC1SJ exhibited a loss of 24.51% in the course direction.

From the statistical Table XLIVa, it is seen that apart from processes and polishing in main effects, yarn/structure in 2-way interactions and yarn / structure / process and yarn/structure/polishing in 3-way interactions, the rest of the factors exhibited significant effect at 1% level while structure/polishing in 2-way interactions and yarn/structure/process/polishing in 4-way interactions showed significant effect at 5% level. In the course direction, yarns, processes and polishing in main effects, yarn/structure, yarn/polishing and process/polishing in 2-way interactions, yarn/structure/process, structure/process /polishing and yarn/process/polishing showed significant differences at 1% level.

Mean Deviation of MIU (MMD) also showed the same trend as Coefficient of Friction. Of all the treated samples, a maximum reduction of 33.05% in bio pretreated sample LC2SJ in the course direction and after bio polishing, the same sample exhibited maximum loss of 43.98% in the wale direction.

From the ANOVA Table XLIVa, in the wale direction, yarn/structure in 2-way interactions and in the course direction, structures in main effects exhibited significant effect at 1% level.

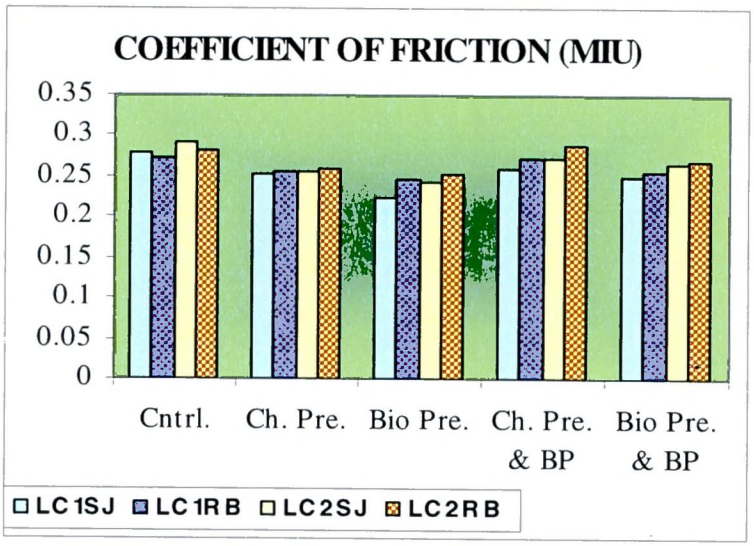
The pretreated and bio polished samples exhibited a substantial reduction in Geometrical Roughness SMD, when compared to their controls, indicating that the surface friction had reduced in all the treated samples. Ramkumar (2002), states that enzyme treated fabrics showed lower values in Geometrical Roughness than the untreated fabrics, showing that the enzyme treated fabrics are smoother. Of all the treated samples, bio pretreated sample LC2SJ exhibited the maximum reduction of 38.04% in the wale direction while bio pretreated, bio polished sample LC1RB showed a maximum loss of 39.18% in the course direction.

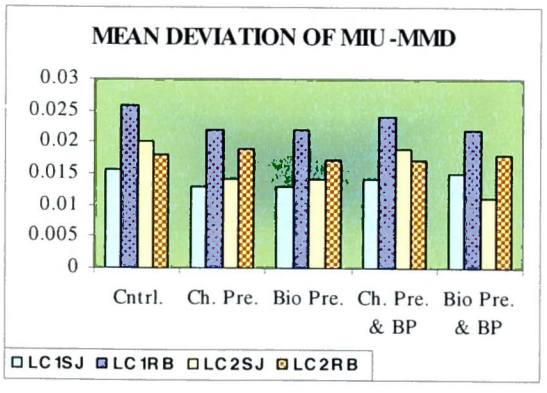
## TABLE XLIV

## SURFACE PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING

| Surface Properties | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Coefficient of Friction MIU | W | 0.2679 | 0.251 | -6.306 | 0.226 | -15.64 | 0.246 | -8.172 | 0.253 | -5.559 |
| | C | 0.2901 | 0.253 | -12.79 | 0.246 | -15.2 | 0.273 | -5.897 | 0.219 | **-24.51** |
| | LC1SJ | 0.279 | 0.252 | -9.677 | 0.236 | -15.42 | 0.26 | -6.81 | 0.25 | -10.39 |
| | W | 0.2287 | 0.223 | -2.51 | 0.26 | 13.67 | 0.264 | 15.41 | 0.223 | -2.51 |
| | C | 0.3173 | 0.287 | -9.538 | 0.241 | **-24.04** | 0.279 | -12.06 | 0.291 | -8.277 |
| | LC1RB | 0.273 | 0.255 | -6.593 | 0.246 | -9.89 | 0.272 | -0.366 | 0.257 | -5.861 |
| | W | 0.2912 | 0.265 | -9.007 | 0.237 | -18.62 | 0.228 | -21.71 | 0.259 | -11.07 |
| | C | 0.2896 | 0.246 | -15.06 | 0.246 | -15.06 | 0.316 | 9.1037 | 0.272 | -6.088 |
| | LC2SJ | 0.291 | 0.256 | -12.03 | 0.242 | -16.84 | 0.272 | -6.529 | 0.265 | -8.935 |
| | W | 0.234 | 0.224 | -4.261 | 0.252 | 7.707 | 0.236 | 0.8681 | 0.224 | -4.261 |
| | C | 0.3269 | 0.291 | -10.99 | 0.254 | -22.31 | 0.343 | 4.9116 | 0.315 | -3.653 |
| | LC2RB | 0.281 | 0.258 | -8.185 | 0.253 | -9.964 | 0.289 | 2.847 | 0.27 | -3.915 |
| Mean Deviation of MIU - MMD | W | 0.0164 | 0.015 | -10.9 | 0.014 | -12.73 | 0.017 | 4.3557 | 0.017 | 2.5249 |
| | C | 0.0148 | 0.012 | -21.69 | 0.012 | -22.37 | 0.011 | -23.04 | 0.013 | -12.92 |
| | LC1SJ | 0.0156 | 0.013 | -16.03 | 0.013 | -17.31 | 0.014 | -8.974 | 0.015 | -5.128 |
| | W | 0.0179 | 0.016 | -10.79 | 0.015 | -18.04 | 0.014 | -21.39 | 0.014 | -21.94 |
| | C | 0.0338 | 0.028 | -18.01 | 0.029 | -13.86 | 0.034 | 1.5317 | 0.03 | -10.01 |
| | LC1RB | 0.0258 | 0.022 | -15.5 | 0.022 | -15.12 | 0.024 | -6.202 | 0.022 | -13.95 |
| | W | 0.0218 | 0.016 | -24.69 | 0.015 | -29.29 | 0.026 | 18.929 | 0.012 | **-43.98** |
| | C | 0.0182 | 0.012 | -31.95 | 0.012 | **-33.05** | 0.012 | -33.05 | 0.011 | -41.28 |
| | LC2SJ | 0.02 | 0.014 | -28 | 0.014 | -31 | 0.019 | -5 | 0.011 | -43 |
| | W | 0.011 | 0.013 | 18.24 | 0.011 | 0.047 | 0.011 | 0.9564 | 0.013 | 20.05 |
| | C | 0.0247 | 0.026 | 3.994 | 0.023 | -5.313 | 0.023 | -6.527 | 0.022 | -10.57 |
| | LC2RB | 0.0179 | 0.019 | 8.38 | 0.017 | -3.911 | 0.017 | -4.469 | 0.018 | -1.676 |
| Geometrical Roughness SMD [ µm ] | W | 9.62 | 8.15 | -15.29 | 8.8 | -8.53 | 8.47 | -11.96 | 8.66 | -9.99 |
| | C | 5.08 | 4.29 | -15.54 | 3.49 | -31.29 | 4.2 | -17.31 | 4.44 | -12.6 |
| | LC1SJ | 7.35 | 6.22 | -15.37 | 6.14 | -16.46 | 6.34 | -13.74 | 6.55 | -10.9 |
| | W | 13.7 | 10.45 | -23.55 | 9.53 | -30.28 | 13.32 | -2.553 | 12.53 | -8.33 |
| | C | 11.1 | 8.45 | -23.67 | 7.77 | -29.82 | 8.78 | -20.69 | 6.75 | **-39.18** |
| | LC1RB | 12.4 | 9.45 | -23.61 | 8.65 | -30.07 | 11.05 | -10.67 | 9.64 | -23.75 |
| | W | 11.2 | 8.53 | -23.96 | 7.85 | **-38.04** | 10.75 | -4.17 | 11.28 | 0.56 |
| | C | 6.28 | 4.76 | -24.15 | 3.94 | -37.22 | 4.59 | -26.86 | 5.21 | -17 |
| | LC2SJ | 8.74 | 6.64 | -24.03 | 5.45 | -37.64 | 7.67 | -12.24 | 8.24 | -5.72 |
| | W | 8.81 | 7.41 | -15.9 | 6.35 | -27.93 | 7.74 | -12.16 | 8.72 | -1.04 |
| | C | 10.7 | 8.98 | -16.08 | 8.71 | -18.6 | 10.15 | -5.144 | 9.6 | -10.3 |
| | LC2RB | 9.75 | 8.19 | -16 | 7.53 | -22.77 | 8.95 | -8.205 | 9.16 | -6.05 |

# SURFACE PROPERTIES OF LYCRA COTTON WEFT KNITS AFTER PRETREATMENT AND BIO POLISHING



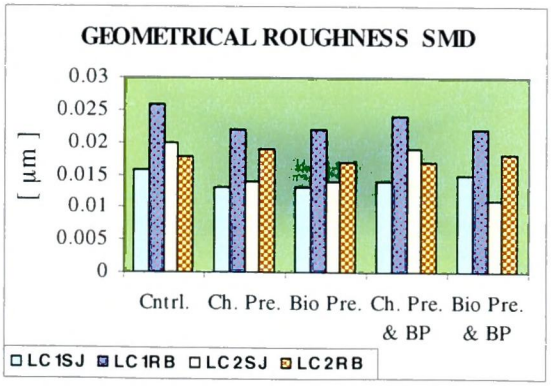




**FIGURE 25**

From the statistical Table XLIVa, it can be understood that in the wale direction, polishing in main effects, yarn/structure, process/polishing and yarn/polishing in 2-way interactions, yarn/structure/process, yarn/process/polishing and yarn /structure/polishing in 3-way interactions showed significant effect at 1% level. In the course direction, structures, processes, polishing in main effects, yarn /structure and process/polishing in 2-way interactions and structure/process/polishing in 3-way interactions showed significant effect at 1% level.

**TABLE XLIVa**

**ANALYSIS OF VARIANCE OF SURFACE PROPERTIES OF LYCRA COTTON WEFT KNITS**

| SURFACE PROPERTIES | | Coefficient of Friction (MIU) | | Mean Deviation of MIU – (MMD) | | Geometrical Roughness (SMD) | |
|---|---|---|---|---|---|---|---|
| Effects | Source of Variation | Wales | Courses | Wales | Courses | Wales | Courses |
| Main Effects (F Value) | Yarns | **152.474**** | **321.397**** | 0.358 | 0.803 | 2.163 | 3.294 |
| | Structures | **924.084**** | 0.027 | 0.997 | **10.319**** | 2.480 | **13.458**** |
| | Processes | 0.023 | **505.512**** | 1.514 | 0.123 | 3.613 | **8.711**** |
| | Bio Polishing | 0.263 | **1068.675**** | 0.491 | 0.000 | **328.653**** | **44.691**** |
| 2- way Interactions (F Value) | Yarn /Structure | 0.019 | **9.928**** | **7.105**** | 3.333 | **14.224**** | **59.324**** |
| | Yarn /Process | **17.070**** | 1.259 | 0.762 | 0.294 | 0.783 | 0.521 |
| | Yarn/ Polishing | **30.819**** | **165.893**** | 0.079 | 0.762 | **36.183**** | 0.761 |
| | Structure/Process | **7.430**** | 3.578 | 1.123 | 0.464 | 2.981 | 0.001 |
| | Structure/ Polishing | **4.248*** | 0.271 | 1.471 | 0.042 | 3.168 | 0.156 |
| | Process/Polishing | **23.078**** | **7.710**** | 0.031 | 0.001 | **26.717**** | **22.535**** |
| 3- way Interactions (F Value) | Yarn / Structure / Process | 0.045 | **25.482**** | 1.090 | 0.058 | **16.16**** | 0.791 |
| | Yarn / Structure / Polishing | 1.459 | 2.175 | 0.054 | 0.418 | **86.863**** | 0.565 |
| | Yarn / Process / Polishing | **41.036**** | **124.288**** | 0.285 | 0.006 | **38.528**** | 0.327 |
| | Structure / Process / Polishing | **444.989**** | **129.444**** | 2.130 | 0.092 | 1.852 | **17.422**** |
| 4- way Interactions (F Value) | Yarn / Structure / Process / Polishing | **4.837*** | 0.490 | 2.176 | 0.744 | 0.037 | 1.160 |

** Significant at 1% level * Significant at 5% level

### ❋ Effluent Estimation - 100% Cotton

The Table XLV and Figure 26 show the effluent load after bio and chemical pretreatment processes and bio polishing of Cotton Weft knits in comparison with the norms prescribed by the Tamil Nadu Pollution Control Board and Central Pollution Control Board for effluent discharge. The parameters analyzed include pH of Effluent, Colour, Total

Dissolved Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). The 't' test results are also given in the Table XLV.

**TABLE XLV**

**EFFLUENT PARAMETERS AFTER PRETREATMENT AND BIO POLISHING OF COTTON WEFT KNITS**

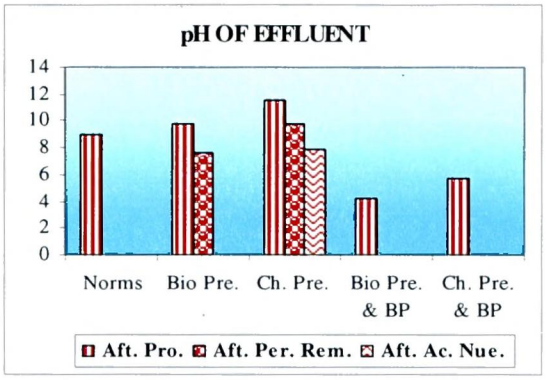
| S. No | Processes undertaken | Parameters Analyzed | Norms+ | Chemical Pretreatment | | Bio Pretreatment | |
|---|---|---|---|---|---|---|---|
| | | | | Values | % Gain / Loss over Norms | Values | % Gain/ Loss over Norms |
| 1. | After Pretreatment | pH at 30° C | 9 | 11.49 | 27.66 | 9.84** | 9.33 |
| | After Peroxide killing | | | 9.79 | 8.77 | 7.62** | -15.33 |
| | After neutralization | | | 7.92 | -12 | - | - |
| | #After Bio polishing | | | 5.67 | -37 | 4.23** | -53 |
| 2. | After Pretreatment | Colour (Hazen) | 0 | 400 | - | 207** | - |
| | After Peroxide killing | | | 85 | - | 47** | - |
| | After neutralization | | | 100 | - | - | - |
| | After Bio polishing | | | 14 | - | 13 | - |
| 3. | After Pretreatment | TDS (mg/l) | 2100 | 6000 | 185.71 | 5776** | 175.04 |
| | After Peroxide killing | | | 1880 | -10.47 | 616** | -70.66 |
| | After neutralization | | | 1276 | -39.23 | - | - |
| | After Bio polishing | | | 1823 | -13.19 | 1614** | -23.14 |
| 4. | After Pretreatment | TSS (mg/l) | 100 | 490 | 390 | 476** | 376 |
| | After Peroxide killing | | | 284 | 184 | 120** | 20 |
| | After neutralization | | | 108 | 8 | - | - |
| | After Bio polishing | | | 219 | 119 | 206** | 106 |
| 5. | After Pretreatment | COD (mg/l) | 250 | 4614 | 1745.6 | 2637** | 954.8 |
| | After Peroxide killing | | | 773 | 209.2 | 406** | 62.4 |
| | After neutralization | | | 1528 | 511.2 | - | - |
| | After Bio polishing | | | 1925 | 670 | 1875** | 650 |
| 6. | After Pretreatment | BOD (mg/l) | 30 | 1491 | 4870 | 207** | 590 |
| | After Peroxide killing | | | 280 | 833.33 | 30** | 0 |
| | After neutralization | | | 296 | 886.66 | - | - |
| | After Bio polishing | | | 300 | 900 | 281** | 836.66 |

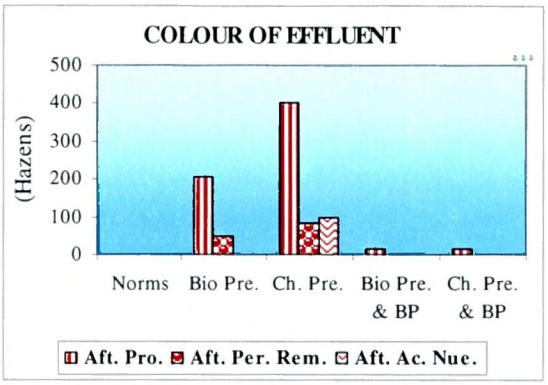
** Significant at 1% level * Significant at 5% level

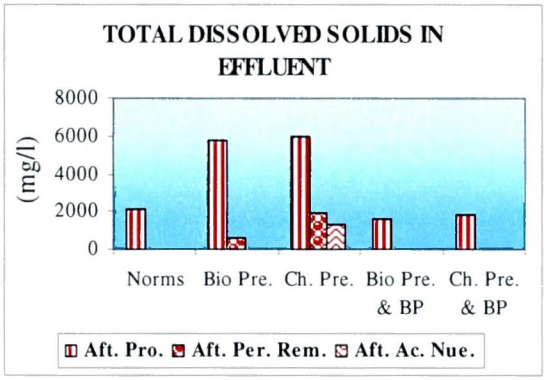
# Bio polishing is optional; has been carried out for both bio pretreated and chemical pretreated samples.

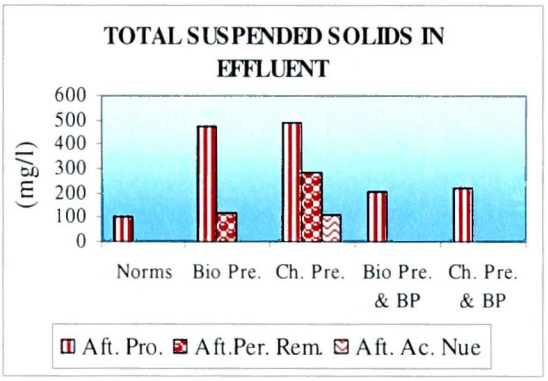
+ Norms prescribed by Tamil Nadu Pollution Control Board and Central Pollution Control Board for effluent discharge.

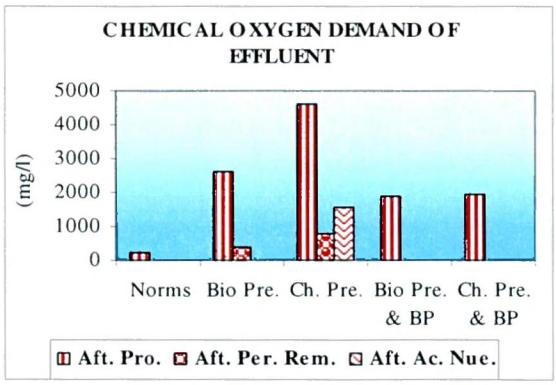
# EFFLUENT ESTIMATION AFTER PRETREATMENT AND BIOPOLISHING OF COTTON WEFT KNITS



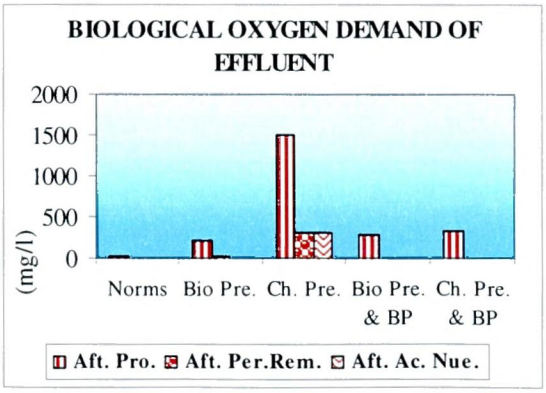




**FIGURE 26**

The Table XLV highlights the fact that the effluent load after bio pretreatment was lower when compared to the effluent released after chemical pretreatment. The deviation from the norms, prescribed by the government, is lower in all the above mentioned parameters, after each process, in the case of the bio pretreatment than chemical pretreatment. The effluent load after bio polishing treatment also shows a similar trend as the effluent load after bio pretreatment. Partiban and Kumar (2005), state that the textile effluent contains chemicals that are non-biodegradable and their removal before discharging the water is essential. The polluted water is harmful for the fauna and flora due to high temperature, odours, turbidity, colours and toxic chemicals.

Statistical analysis based on 't' test proved that the differences were significant at 1% level in all parameters except for the aspect colour in the effluent after bio polishing.

❋ **Effluent Estimation - Lycra Cotton**

The Table XLVI and Figure 27 show the effluent estimation after bio and chemical pretreatment and bio polishing of Lycra Cotton weft knits in comparison with the norms prescribed by the State and Central Pollution Control Boards. The parameters analyzed include pH of Effluent, Colour, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). The results of the 't' test are also given in the Table XLVI.

The effluent released after chemical pretreatment was high in all the above mentioned parameters when compared with the effluent parameters after each process in bio pretreatment and bio polishing. Sharma (2008) expresses that hazardous chemicals result in an increase in COD, BOD and TDS in the waste waters causing a polluted environment. The effluent released after bio pretreatment showed reduced effluent load indicating that the bio pretreatment caused less pollution to the environment.

Statistical analysis based on 't' test proved that the differences were significant at 1% level in all parameters except for the aspect colour in the effluent after bio polishing. Thus it may be understood that the effluent discharged after enzymatic treatment is substantially less in terms of effluent load which is beneficial for the processing industry.

## TABLE XLVI
## EFFLUENT PARAMETERS AFTER PRETREATMENT AND BIO POLISHING OF LYCRA COTTON WEFT KNITS

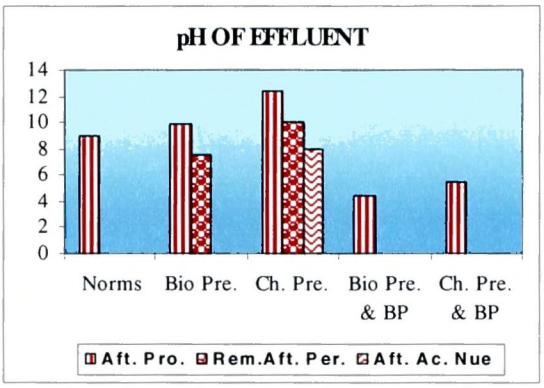
| S. No | Processes undertaken | Property analyzed | Norms | Chemical Pretreatment | | Bio Pretreatment | |
|---|---|---|---|---|---|---|---|
| | | | | Values | % Gain / Loss over Norms | Values | % Gain/ Loss over Norms |
| 1. | After Pretreatment | pH at 30° C | 9 | 12.4 | 37.77 | 9.87** | 9.66 |
| | After Peroxide killing | | | 10.02 | 11.33 | 7.52** | -16.44 |
| | After neutralization | | | 7.95 | -11.66 | - | |
| | After Bio polishing | | | 5.48 | -39.11 | 4.44** | -50.66 |
| 2. | After Pretreatment | Colour (Hazen) | 0 | 445 | - | 217** | - |
| | After Peroxide killing | | | 93 | - | 49** | - |
| | After neutralization | | | 115 | - | - | - |
| | After Bio polishing | | | 17 | - | 15 | - |
| 3. | After Pretreatment | TDS (mg/l) | 2100 | 6675 | 217.85 | 5732** | 172.95 |
| | After Peroxide killing | | | 1895 | -9.76 | 591** | -71.85 |
| | After neutralization | | | 1289 | -38.61 | - | |
| | After Bio polishing | | | 1912 | -8.95 | 1603** | -23.66 |
| 4. | After Pretreatment | TSS (mg/l) | 100 | 503 | 403 | 471** | 371 |
| | After Peroxide killing | | | 312 | 212 | 113** | 13 |
| | After neutralization | | | 107 | 7 | - | |
| | After Bio polishing | | | 229 | 129 | 203** | 103 |
| 5. | After Pretreatment | COD (mg/l) | 250 | 4664 | 1765.6 | 2653** | 961.2 |
| | After Peroxide killing | | | 850 | 240 | 416** | 66.4 |
| | After neutralization | | | 1537 | 514.8 | - | |
| | After Bio polishing | | | 1978 | 691.2 | 1884** | 653.6 |
| 6. | After Pretreatment | BOD (mg/l) | 30 | 1505 | 4916.66 | 211** | 603.33 |
| | After Peroxide killing | | | 308 | 926.66 | 33** | 10 |
| | After neutralization | | | 320 | 966.66 | - | |
| | After Bio polishing | | | 341 | 1036.66 | 287** | 856.66 |

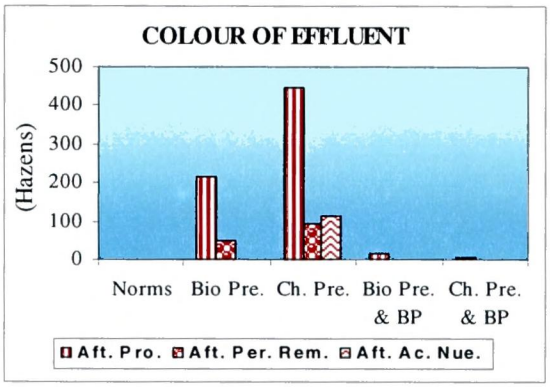
** Significant at 1% level  * Significant at 5% level

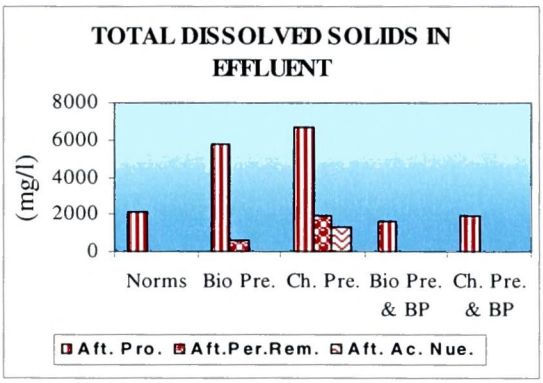
*Bio polishing is optional; has been carried out for both bio pretreated and chemical pretreated samples.

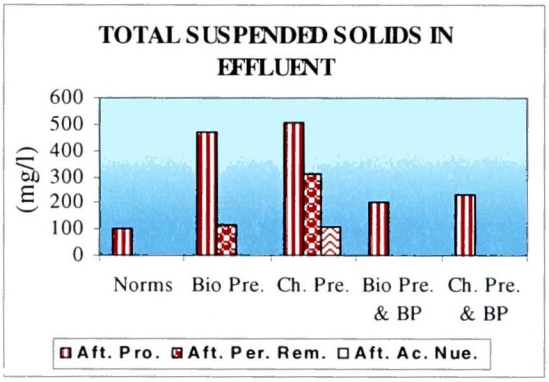
+ Norms prescribed by Tamil Nadu Pollution Control Board and Central Pollution Control Board for effluent discharge

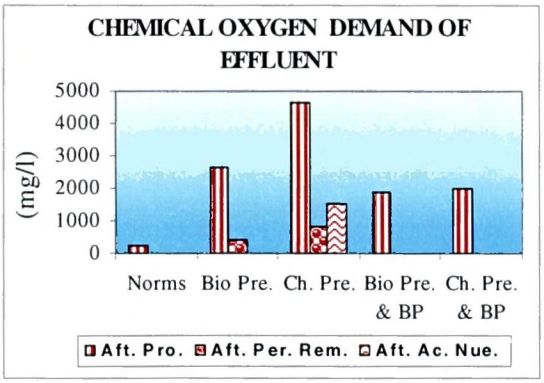
# EFFLUENT ESTIMATION AFTER PRETREATMENT AND BIOPOLISHING OF LYCRA COTTON WEFT KNITS



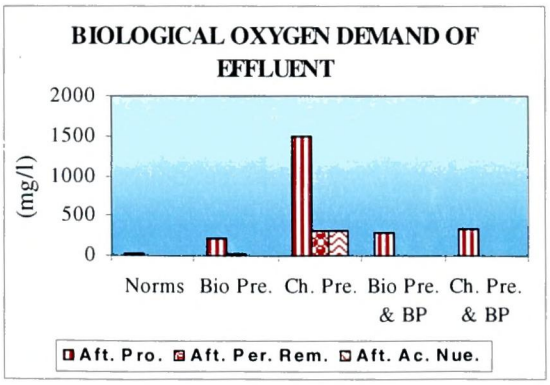




**FIGURE 27**

### 4.4.3. Tests after Dyeing and Wear

The tests namely Skewness, Bursting Strength, Abrasion Resistance, Flexural Rigidity, Drape, Pilling, Air Permeability, Wicking, Dimensional Stability, Colour Fastness and Instrumental Colour measurement was carried out after dyeing and wear study of 100% cotton and lycra cotton weft knits. The results are presented as follows:

✶ **Skewness - 100% Cotton**

The skewness of cotton weft knits after dyeing and wear along with the F values, are presented in Table XLVII and Figure 28.

**TABLE XLVII**

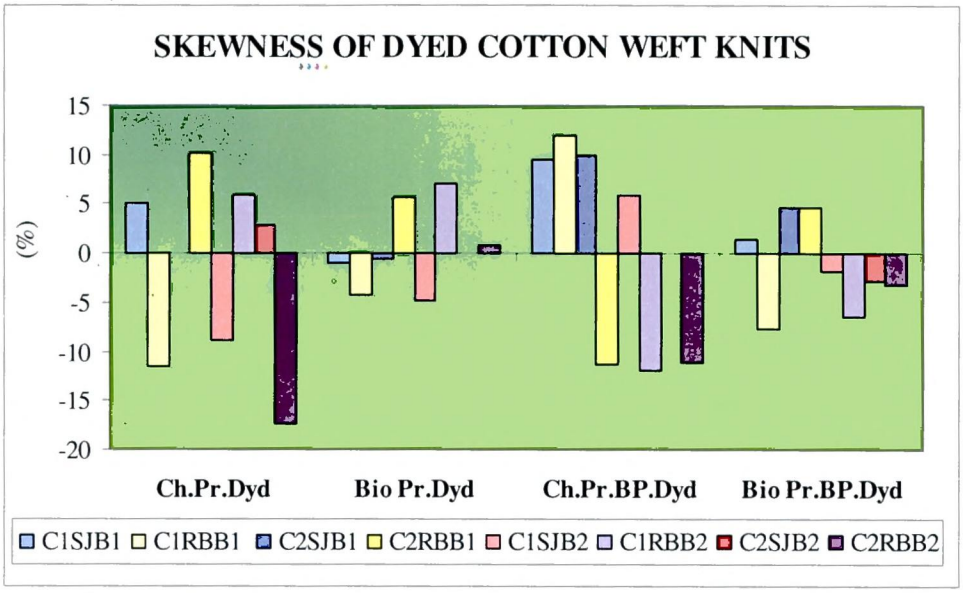
**SKEWNESS OF COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in (%) | Sample | Chemical Pretreated & Dyed | Chemical Pretreated & Dyed after wear | Bio pretreated & Dyed | Bio pretreated & Dyed after wear | Chemical Pretreated Bio polished& Dyed | Chemical Pretreated Bio polished& Dyed after wear | Bio pretreated, Bio Polished & Dyed | Bio pretreated, Bio Polished & Dyed after wear |
|---|---|---|---|---|---|---|---|---|---|
| After dyeing and wear | C1SJB1 | 5.1 | 5.8 | -0.9 | 4.14 | 9.55 | 3.89 | **1.43** | 2.39 |
| | C1RBB1 | -11.6 | -15.1 | -4.3 | -8 | 12 | -5.5 | -7.7 | -3.2 |
| | C2SJB1 | **0** | 4.23 | **-0.6** | 3.15 | 10 | 2.53 | 4.68 | **1.01** |
| | C2RBB1 | 10.2 | -11.5 | 5.79 | -7.6 | -11.2 | -4.6 | 4.59 | -2.1 |
| | C1SJB2 | -8.82 | 4.97 | -4.9 | 3.67 | 5.97 | 3.74 | **-1.8** | 1.03 |
| | C1RBB2 | 5.88 | -6.01 | 7.11 | -4.2 | -11.9 | -4.13 | -6.5 | -2.1 |
| | C2SJB2 | 2.9 | 9.66 | **0** | **2.76** | **0** | 2.14 | -2.9 | **0** |
| | C2RBB2 | -17.4 | -4.08 | **0.76** | **-2.7** | -11.1 | -2.63 | -3.2 | **-0.5** |
| F –values | C1SJ | 1210.709** | | 307.133** | | 169.807** | | 79.674** | |
| | C1RB | 4553.827** | | 732.943** | | 3997.028** | | 1035.432** | |
| | C2SJ | 742.889** | | 79.435** | | 604.937** | | 206.863** | |
| | C2RB | 5107.272** | | 915.728** | | 1040.770** | | 281.902** | |

** Significant at 1% level * Significant at 5% level

From Table XLVII, it is clear that there is a mixed response of positive skewness indicating skewness to the left in the wale direction and negative skewness indicating skewness to the right in the course direction in a majority of the samples. The zero value

# SKEWNESS OF COTTON WEFT KNITS AFTER DYEING AND WEAR



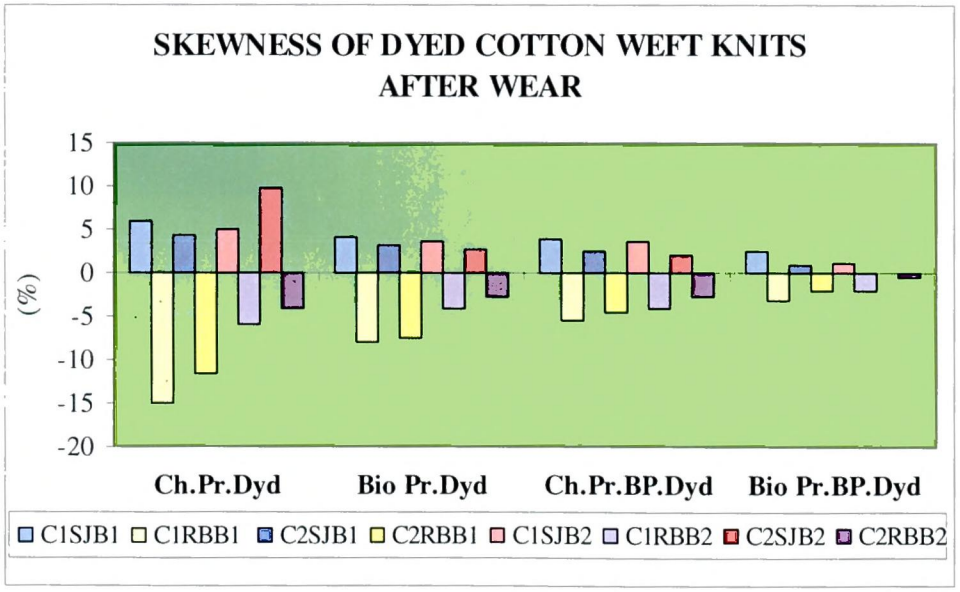




**FIGURE 28**

shows that the fabric is stable. Zero values have been observed in chemical pretreated and dyed sample C2SJB1, in bio pretreated and dyed sample C2SJB2 and in chemical pretreated, bio polished and dyed sample C2SJB2. The lowest positive and negative values among the pretreated and dyed samples were found in the bio pretreated and dyed samples C2RBB2 with (0.76%) and C2SJB1 with (-0.6%) respectively. The lowest positive and negative values among the pretreated, bio polished and dyed samples were found in the bio pretreated, bio polished and dyed samples C1SJB1 with (1.43%) and C1SJB2 with (-1.8%) respectively.

After wear, zero value was observed in bio pretreated, bio polished and dyed sample C2SJB2. The lowest positive and negative values among the pretreated and dyed samples were found in the bio pretreated and dyed samples C2SJB2 with (2.76%) and C2RBB2 with (-2.7%) respectively. The lowest positive and negative values among the pretreated, bio polished and dyed samples were found in the bio pretreated, bio polished and dyed samples C2SJB1 with (1.01%) and C2RBB2 with (-0.5%) respectively. The table highlights the fact that bio pretreated with and without bio polishing after dyeing and wear presents lower skewness values when compared with their chemical counterparts. Moreover the lowest values were observed in the fabrics knitted with combed yarns. Royan (2001), explains that a close relationship exists between twist and spirality and combed yarns with higher twist have led to low spirality or skewness.

All the samples, statistically analyzed with one-way ANOVA, showed significant differences after the dyeing and wear with respect to skewness at 1% level.

✶ **Skewness - Lycra Cotton**

The skewness of lycra cotton weft knits after dyeing and wear and the ANOVA results, are presented in Table XLVIII and Figure 29.

From Table XLVIII, it is evident that a few of the samples exhibited zero values after dyeing and wear showing that the fabrics had no skewness and were stable. Zero values were noted in chemical pretreated and dyed sample LC2SJB1, bio pretreated and dyed sample LC2RBB2 and in bio pretreated, bio polished and dyed samples LC1SJB2, LC2SJB2 and LC2RBB2. The lowest positive and negative values among the pretreated and dyed samples were found in the chemical pretreated and dyed samples LC2SJB2 with (0.73%) and LC2RBB1with (-1.46%) and in bio pretreated and dyed sample LC1SJB2 (-1.46%). The lowest positive and negative values among the pretreated, bio polished and dyed samples

were found in the bio pretreated, bio polished and dyed sample LC1SJB1 with (0.87%) and chemical pretreated, bio polished and dyed sample LC2SJB2 with (-0.74 %).

**TABLE XLVIII**

**SKEWNESS OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR**

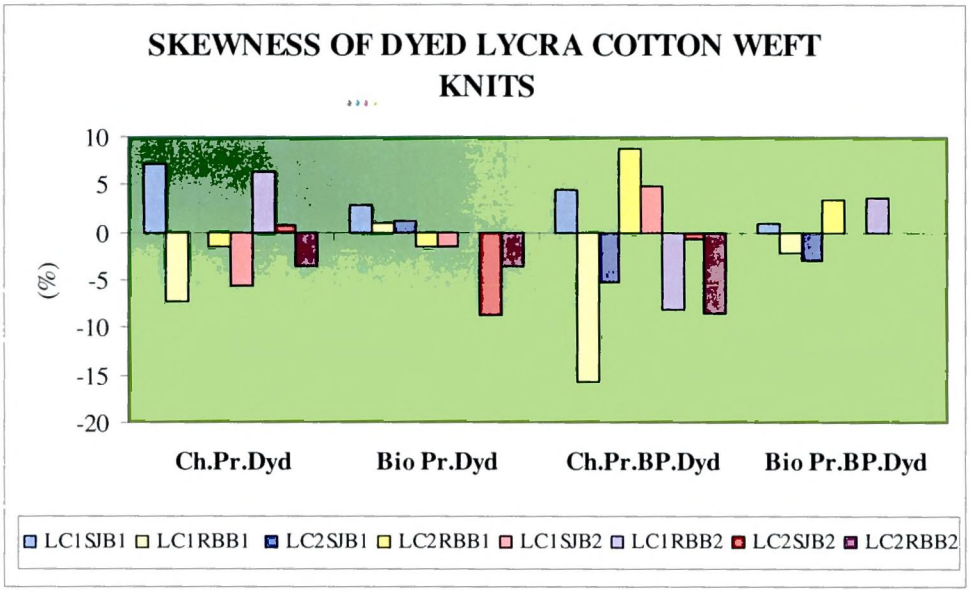
| Units in (%) | Sample | Chemical Pretreated & Dyed | Chemical Pretreated & Dyed after wear | Bio pretreated & Dyed | Bio pretreated & Dyed after wear | Chemical Pretreated Bio polished& Dyed | Chemical Pretreated Bio polished& Dyed after wear | Bio pretreated, Bio Polished & Dyed | Bio pretreated, Bio Polished & Dyed after wear |
|---|---|---|---|---|---|---|---|---|---|
| After dyeing and wear | LC1SJB1 | 7.09 | 3.42 | 2.84 | 1.50 | 4.38 | 2.28 | **0.87** | **0.85** |
| | LC1RBB1 | -7.36 | -2.92 | 0.90 | -2.84 | -15.66 | 2.50 | -2.07 | -2.86 |
| | LC2SJB1 | **0.00** | 10.07 | 1.16 | **1.40** | -5.23 | 4.26 | -2.92 | -1.40 |
| | LC2RBB1 | **-1.46** | **0.00** | -1.47 | -2.86 | 8.70 | -7.51 | 3.52 | -1.39 |
| | LC1SJB2 | -5.71 | 5.48 | **-1.46** | -2.78 | 4.88 | 1.38 | **0.00** | 1.38 |
| | LC1RBB2 | 6.24 | -2.86 | **0.00** | -3.63 | -8.14 | -9.66 | 3.54 | **-0.70** |
| | LC2SJB2 | **0.73** | 2.19 | -8.70 | **-0.59** | **-0.74** | 6.33 | **0.00** | 0.90 |
| | LC2RBB2 | -3.57 | -5.02 | -3.52 | -1.96 | -8.57 | -3.48 | **0.00** | **0.00** |
| F –values | LC1SJ | 684.342** | | 145.837** | | 57.820** | | 21.222** | |
| | LC1RB | 1088.292** | | 194.969** | | 2407.309** | | 245.119** | |
| | LC2SJ | 480.935** | | 628.245** | | 841.861** | | 118.875** | |
| | LC2RB | 226.420** | | 52.939** | | 1938.944** | | 121.684** | |

** Significant at 1% level * Significant at 5% level

After wear, zero values were observed in chemical pretreated and dyed sample LC2RBB1 and in bio pretreated, bio polished and dyed sample LC2RBB2. The lowest positive and negative values among the pretreated and dyed samples were found in the bio pretreated, and dyed samples LC2SJB1 with (1.40%) and in LC2SJB2 with (-0.59 %). The lowest positive and negative values among the pretreated, bio polished and dyed samples were found in the bio pretreated, bio polished and dyed sample LC1SJB1 with (0.85%) and in LC1RBB2 with (-0.70 %).

All the samples, statistically analyzed with one-way ANOVA, showed significant differences after the dyeing and wear with respect to skewness at 1% level.

# SKEWNESS OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



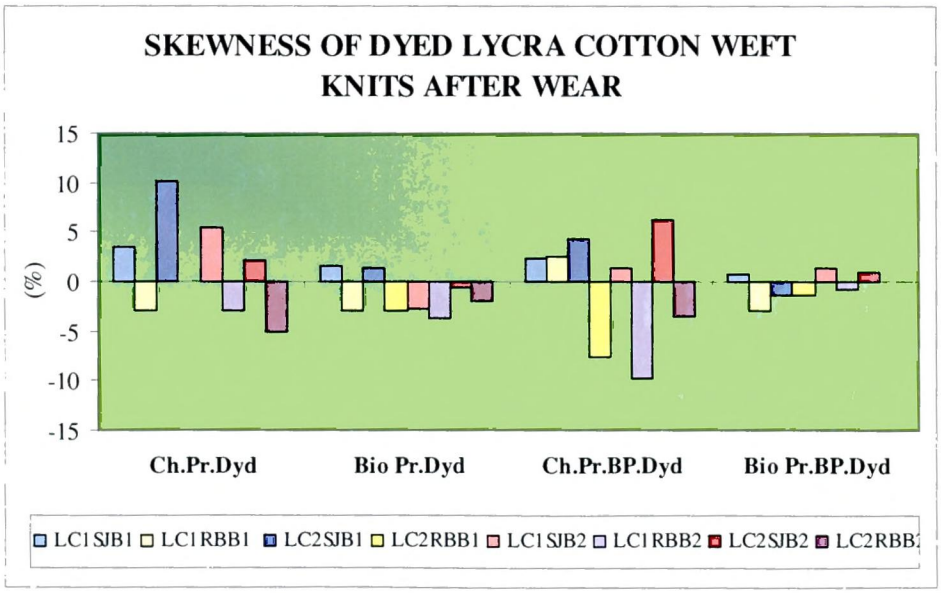




**FIGURE 29**

## ✶ Bursting Strength - 100% Cotton

The bursting strength of cotton weft knits after dyeing and wear along with the F values, are presented in Table XLIX and Figure 30.

**TABLE XLIX**

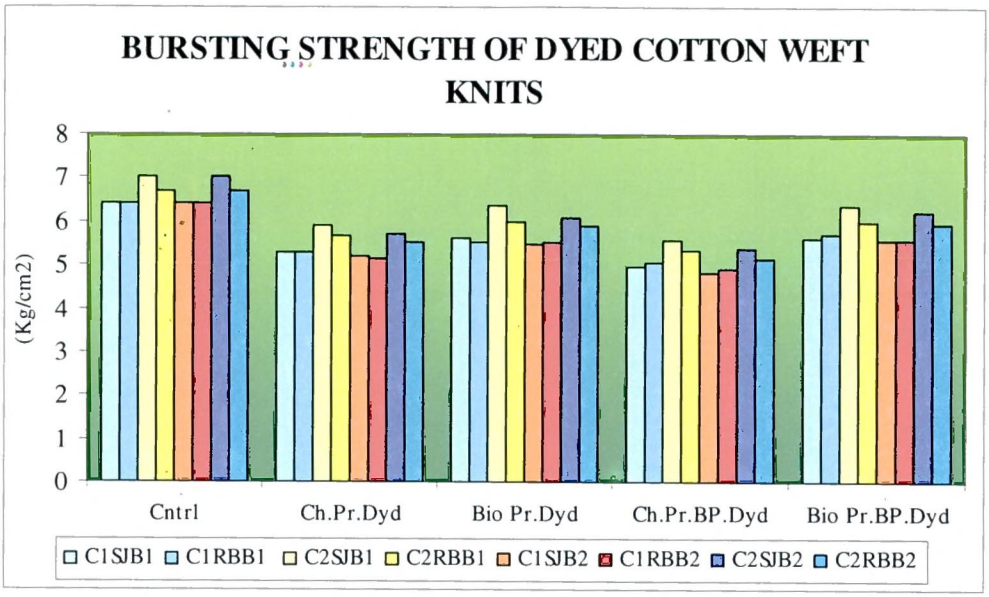
**BURSTING STRENGTH OF COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in ($Kg/cm^2$) | Sample | Control | Chemical Pretreated & Dyed | % Gain/ Loss over Control | Bio Pretreated & Dyed | % Gain/ Loss over Control | Chemical Pretreated, Bio polished & Dyed | % Gain/ Loss over Control | Bio Pretreated, Bio polished & Dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | C1SJB1 | 6.4 | 5.29 | -17.34 | 5.6 | -12.5 | 4.94 | -22.81 | 5.60 | -12.5 |
| | C1RBB1 | 6.4 | 5.28 | -17.5 | 5.5 | -14.06 | 5.07 | -20.78 | 5.70 | -10.94 |
| | C2SJB1 | 7 | 5.89 | -15.86 | 6.36 | **-9.14** | 5.56 | -20.57 | 6.37 | **-9** |
| | C2RBB1 | 6.7 | 5.67 | -15.37 | 5.98 | -10.75 | 5.32 | -20.6 | 6.01 | -10.3 |
| | C1SJB2 | 6.4 | 5.18 | -19.06 | 5.49 | -14.22 | 4.8 | -25 | 5.55 | -13.28 |
| | C1RBB2 | 6.4 | 5.16 | -19.38 | 5.50 | -14.06 | 4.91 | -23.28 | 5.59 | -12.66 |
| | C2SJB2 | 7 | 5.7 | -18.57 | 6.10 | -12.86 | 5.39 | -23 | 6.24 | -10.86 |
| | C2RBB2 | 6.7 | 5.5 | -17.91 | 5.90 | -11.94 | 5.15 | -23.13 | 5.96 | -11.04 |
| After Wear | C1SJB1 | 6.4 | 4.8 | -25 | 5.40 | -15.63 | 4.2 | -34.38 | 5.2 | -18.75 |
| | C1RBB1 | 6.4 | 5.14 | -19.69 | 5.79 | **-9.53** | 4.8 | -25 | 5.5 | -14.06 |
| | C2SJB1 | 7 | 4.93 | -29.57 | 6.02 | -14 | 4.63 | -33.86 | 6.11 | -12.71 |
| | C2RBB1 | 6.7 | 5.23 | -21.94 | 5.82 | -13.13 | 5.02 | -25.07 | 5.85 | **-12.69** |
| | C1SJB2 | 6.4 | 4.4 | -31.25 | 5.28 | -17.5 | 4.1 | -35.94 | 5.25 | -17.97 |
| | C1RBB2 | 6.4 | 5.03 | -21.41 | 5.53 | -13.59 | 4.4 | -31.25 | 5.34 | -16.56 |
| | C2SJB2 | 7 | 4.8 | -31.43 | 5.57 | -20.43 | 4.4 | -37.14 | 6.02 | -14 |
| | C2RBB2 | 6.7 | 5.67 | -15.37 | 5.65 | -15.67 | 4.93 | -26.42 | 5.72 | -14.63 |
| F Values | C1SJ | | 7.168** | | 1.361 | | 5.109** | | 1.558 | |
| | C1RB | | 4.696** | | 4.286** | | 5.648** | | 2.287 | |
| | C2SJ | | 17.242** | | 5.585** | | 13.44** | | 1.621 | |
| | C2RB | | 4.437** | | 1.742 | | 31.782** | | 1.651 | |

** Significant at 1% level * Significant at 5% level

Table XLIX reveals a reduction in bursting strength in all the samples after dyeing and wear when compared to their controls. Minimum loss was noted in bio pretreated, without and with bio polishing and dyed sample C2SJB1 with 9.143% and 9% respectively. It can be observed that all the samples that were bio pretreated, without and with bio polishing after dyeing and wear showed higher values than the chemical pretreated

# BURSTING STRENGTH OF COTTON WEFT KNITS AFTER DYEING AND WEAR



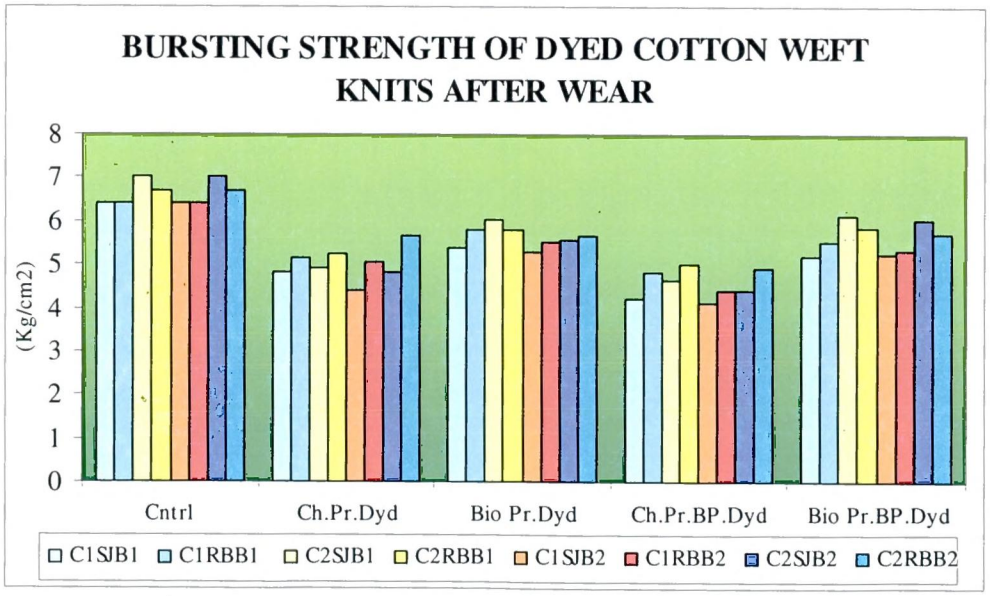




**FIGURE 30**

counterparts. Cortex *et al.* (2002), explain that alkaline scouring causes substantial reduction in bursting strength, which is attributed to higher weight loss and a possible oxidative damage during scouring. Enzyme scouring shows very little deterioration in strength which is due to the surface layer breakage and cleavage due to enzyme treatment. This may be the reason for the lower values in chemical pretreated and dyed samples with regard to bursting strength.

After wear, a minimum loss of 9.531% and 12.69% was observed in bio pretreated and dyed sample C1RBB1 and in bio pretreated, bio polished and dyed sample C2RBB1 respectively.

The statistical analysis reveals that bio pretreated and dyed samples C1SJ and C2RB and all the samples namely C1SJ, C1RB, C2SJ and C2RB which had been bio pretreated, bio polished and dyed did not show significant difference with respect to bursting strength. The remaining samples exhibited significant differences at 1% level.

✶ **Bursting Strength - Lycra Cotton**

The bursting strength of lycra cotton weft knits after dyeing and wear are presented in Table L and Figure 31.

From Table L it is evident that all the treated samples showed reduction in bursting strength when compared to their controls. A minimum loss of 4.63% and 3.39% was observed in bio pretreated and dyed sample LC1SJB1 and in bio pretreated, bio polished and dyed sample LC2SJB1 respectively.

After wear, minimum loss of 0.92% and 14.28% was noted in bio pretreated and dyed sample LC1SJB1 and in bio pretreated, bio polished and dyed sample LC2SJB2 respectively.

The statistical analysis reveals that chemical pretreated and dyed samples LC1SJ, LC2SJ and LC2RB, bio pretreated and dyed samples LC1SJ and LC2SJ, did not show significant differences with regard to bursting strength. Bio pretreated and dyed sample LC1RB, bio pretreated, bio polished and dyed samples LC1SJ and LC2SJ showed significant difference at 5% level with respect to bursting strength.

Apart from the above mentioned samples, the remaining samples exhibited significant differences at 1% level with respect to bursting strength.

TABLE L

BURSTING STRENGTH OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR

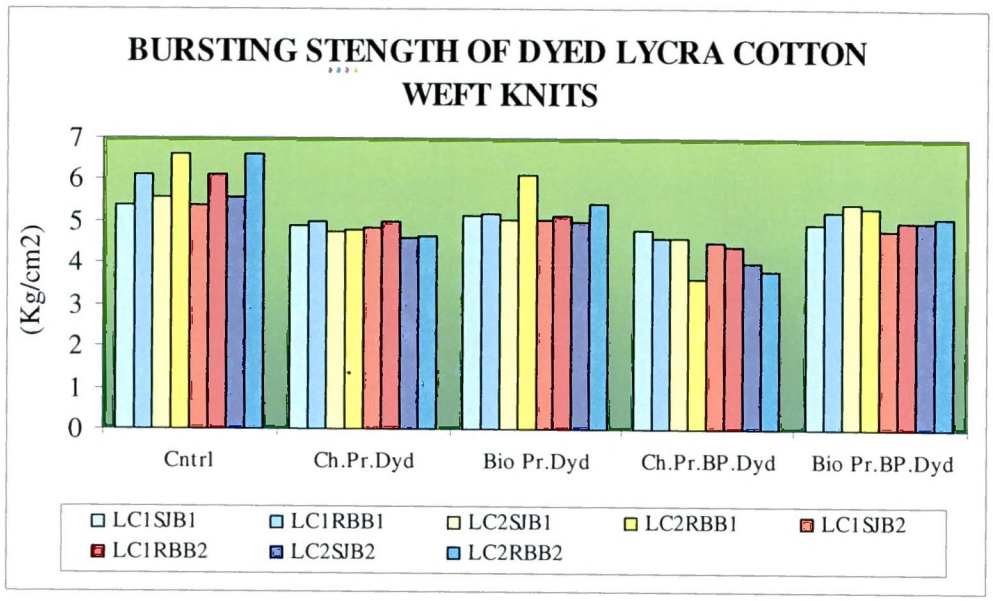
| Units in ($Kg/cm^2$) | Sample | Control | Chemical Pretreated & Dyed | % Gain/ Loss over Control | Bio Pretreated & Dyed | % Gain/ Loss over Control | Chemical Pretreated, Bio Polished & Dyed | % Gain/ Loss over Control | Bio Pretreated, Bio Polished & Dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | LC1SJB1 | 5.4 | 4.90 | -9.26 | 5.15 | **-4.63** | 4.80 | -11.11 | 4.95 | -8.33 |
| | LC1RBB1 | 6.1 | 5.00 | -18.03 | 5.20 | -14.75 | 4.60 | -24.59 | 5.25 | -13.93 |
| | LC2SJB1 | 5.6 | 4.75 | -15.17 | 5.04 | -10 | 4.60 | -17.85 | 5.41 | **-3.39** |
| | LC2RBB1 | 6.6 | 4.80 | -27.27 | 6.10 | -7.57 | 3.60 | -45.45 | 5.35 | -18.93 |
| | LC1SJB2 | 5.4 | 4.85 | -10.2 | 5.05 | -6.481 | 4.50 | -16.66 | 4.80 | -11.11 |
| | LC1RBB2 | 6.1 | 5.01 | -17.86 | 5.15 | -15.57 | 4.40 | -27.86 | 5.00 | -18.03 |
| | LC2SJB2 | 5.6 | 4.60 | -17.85 | 5.00 | -10.71 | 4.00 | -28.57 | 5.00 | -10.71 |
| | LC2RBB2 | 6.6 | 4.65 | -29.54 | 5.45 | -17.42 | 3.80 | -42.42 | 5.10 | -22.72 |
| After Wear | LC1SJB1 | 5.4 | 4.75 | -12.03 | 5.35 | **-0.92** | 3.9 | -27.77 | 4.2 | -22.22 |
| | LC1RBB1 | 6.1 | 4.23 | -30.65 | 4.60 | -24.59 | 3.35 | -45.08 | 4.1 | -32.78 |
| | LC2SJB1 | 5.6 | 4.80 | -14.28 | 5.32 | -5 | 4 | -28.57 | 4.5 | -19.64 |
| | LC2RBB1 | 6.6 | 4.5 | -31.81 | 4.8 | -27.27 | 3.4 | -48.48 | 4.3 | -34.84 |
| | LC1SJB2 | 5.4 | 4.8 | -11.11 | 5 | -7.40 | 3.9 | -27.77 | 4.6 | -14.81 |
| | LC1RBB2 | 6.1 | 4.2 | -31.14 | 4.8 | -21.31 | 3.7 | -39.34 | 4 | -34.42 |
| | LC2SJB2 | 5.6 | 4.85 | -13.39 | 5.25 | -6.25 | 4.1 | -26.78 | 4.8 | **-14.28** |
| | LC2RBB2 | 6.6 | 4.38 | -33.63 | 4.95 | -25 | 3.9 | -40.90 | 4.41 | -33.18 |
| F –values | LC1SJ | | 0.221 | | 0.719 | | 3.078** | | 3.305* | |
| | LC1RB | | 5.749** | | 2.847* | | 12.07** | | 11.172** | |
| | LC2SJ | | 0.468 | | 0.829 | | 4.548** | | 3.866* | |
| | LC2RB | | 1.326 | | 5.923** | | 12.518** | | 11.845** | |

** Significant at 1% level * Significant at 5% level

### ✶ Abrasion Resistance -100% Cotton

The abrasion resistance of cotton weft knits after dyeing and wear and the ANOVA results are given in Table LI and Figure 32.

# BURSTING STRENGTH OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



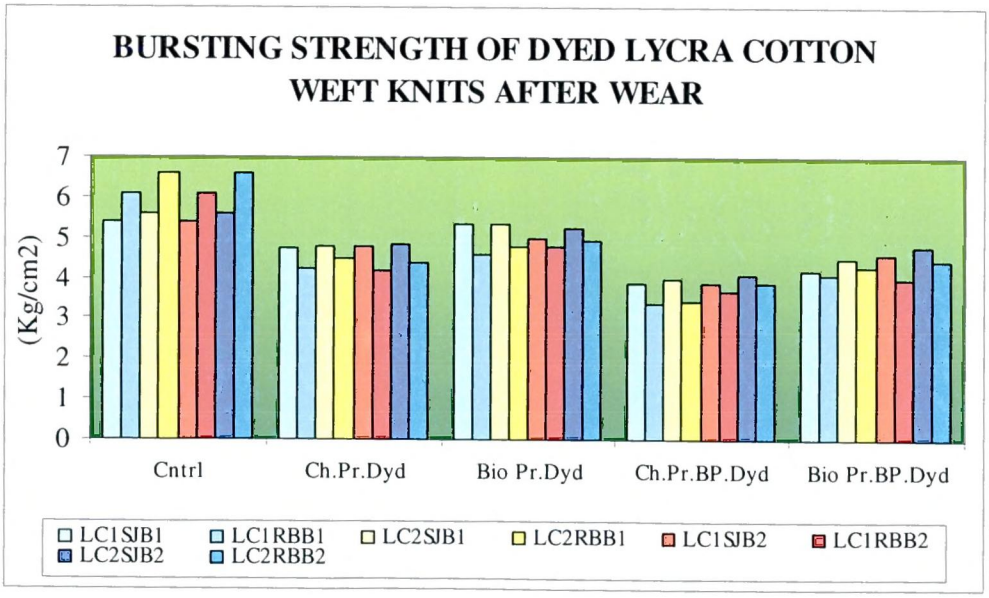




**FIGURE 31**

## TABLE LI

## ABRASION RESISTANCE OF COTTON WEFT KNITS AFTER DYEING AND WEAR

| Units in (%) | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Biopolished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | C1SJB1 | 2.5 | 5.5 | 120 | 3.7 | **48** | 6.5 | 160 | 3.9 | **56** |
| | C1RBB1 | 2.63 | 6.6 | 150.9 | 4 | 52.09 | 7.2 | 173.8 | 4.3 | 63.5 |
| | C2SJB1 | 1.9 | 5.3 | 179 | 3.5 | 84.21 | 6.33 | 233.2 | 3.6 | 89.47 |
| | C2RBB1 | 2 | 6 | 200 | 3.9 | 94.99 | 6.9 | 245 | 4.1 | 105 |
| | C1SJB2 | 2.5 | 5.8 | 132 | 3.8 | 52 | 6.89 | 175.6 | 4.45 | 78 |
| | C1RBB2 | 2.63 | 6.4 | 143.4 | 4.1 | 55.89 | 7.52 | 185.9 | 4.68 | 77.95 |
| | C2SJB2 | 1.9 | 5.4 | 184.2 | 3.6 | 89.47 | 6.54 | 244.2 | 4.18 | 120 |
| | C2RBB2 | 2 | 6.2 | 210 | 4 | 100 | 7.33 | 266.5 | 4.23 | 111.5 |
| After Wear | C1SJB1 | 2.5 | 4.1 | 64 | 1.6 | **-36** | 4.23 | 69.2 | 2.17 | -13.2 |
| | C1RBB1 | 2.63 | 4.6 | 74.9 | 2.01 | -23.6 | 4.35 | 65.4 | 2.25 | -14.4 |
| | C2SJB1 | 1.9 | 3.6 | 89.47 | 1.4 | -26.3 | 4.15 | 118.4 | 1.15 | **-39.5** |
| | C2RBB1 | 2 | 4 | 100 | 2 | 0 | 4.18 | 109 | 1.99 | -0.5 |
| | C1SJB2 | 2.5 | 4.35 | 74 | 1.99 | -20.4 | 4.5 | 80 | 2.19 | -12.4 |
| | C1RBB2 | 2.63 | 4.78 | 81.75 | 2.1 | -20.2 | 5 | 90.11 | 2.32 | -11.8 |
| | C2SJB2 | 1.9 | 4.3 | 126.3 | 1.55 | -18.4 | 4.25 | 123.7 | 2.11 | 11.05 |
| | C2RBB2 | 2 | 4.55 | 127.5 | 2.23 | 11.5 | 5.1 | 155 | 2.09 | 4.5 |
| F values | C1SJ | | 14.063** | | 11.569** | | 54.571** | | 14.872** | |
| | C1RB | | 27.074** | | 30.137** | | 128.395** | | 30.355** | |
| | C2SJ | | 20.419** | | 74.188** | | 81.528** | | 25.600** | |
| | C2RB | | 44.517** | | 13.007** | | 112.693** | | 32.745** | |

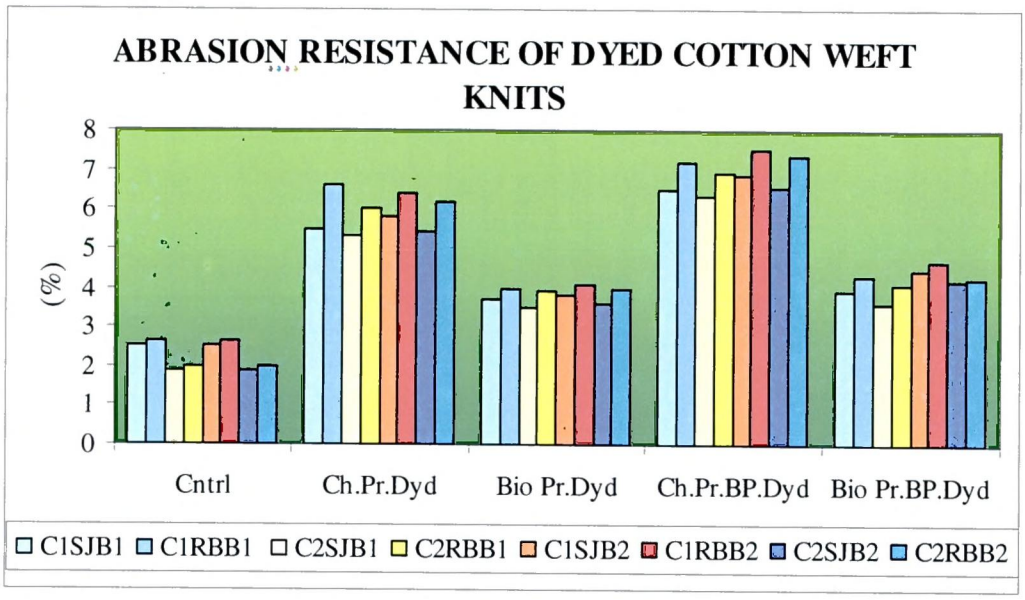
** Significant at 1% level * Significant at 5% level

From the Table LI it is seen that all the samples showed a loss in weight due to abrasion, the lower the loss percentage, the greater is the ability of the fabric to withstand wear and tear.

After dyeing, the minimum loss of 48% was noted in bio pretreated sample C1SJB1 and after bio polishing the same sample recorded a value of 56% as the minimum loss. After wear, shrinkage had occurred and the loss percentage was below the original samples showing 36% and 39.5% in bio pretreated sample C1SJB1and bio pretreated, bio polished sample C2SJB1 respectively. In general, higher abrasion was noticed in samples knitted with carded yarns and dyed in dark colour, which may be due to the yarn structure and the percentage of chemicals and dyes involved in producing the dark blue colour.

Statistical analysis with one-way ANOVA, showed significant differences in all the samples, after the dyeing and wear with respect to abrasion resistance at 1% level.

# ABRASION RESISTANCE OF COTTON WEFT KNITS AFTER DYEING AND WEAR



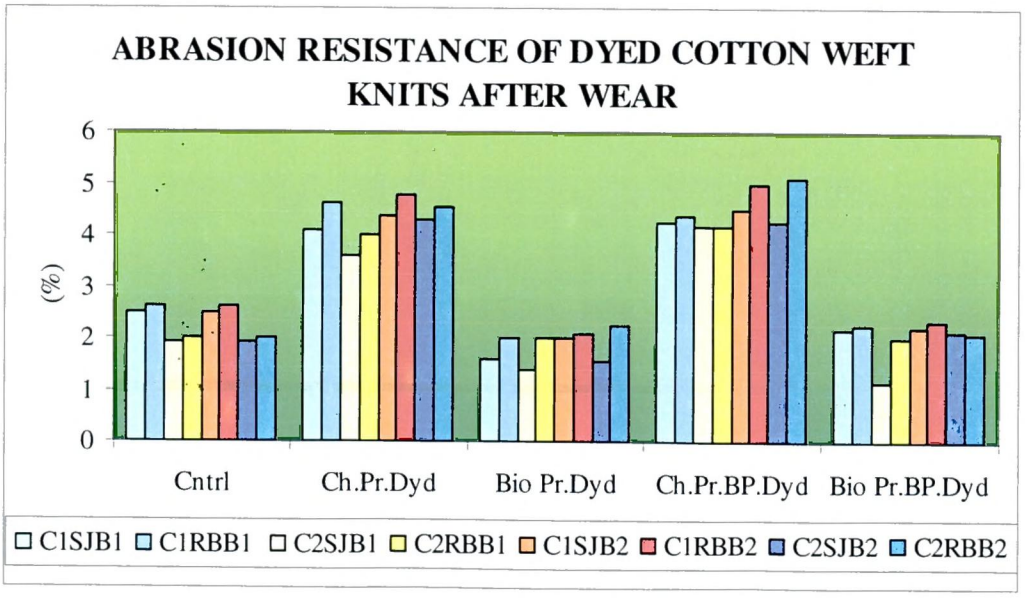




**FIGURE 32**

## ✶ Abrasion Resistance - Lycra Cotton

The abrasion resistance of lycra cotton weft knits after dyeing and wear are presented in Table LII and Figure 33. The F values for one way ANOVA are also given below.

**TABLE LII**

**ABRASION RESISTANCE OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in (%) | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated Bio Polished | % Gain/ Loss over Control | Bio Pretreated, Bio Polished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | LC1SJB1 | 2.3 | 5.29 | 129.8 | 3.73 | 62.37 | 9.3 | 304.4 | 3.72 | 61.7 |
| | LC1RBB1 | 2.46 | 4.51 | 83.02 | 3.48 | **41.26** | 5.97 | 142.4 | 3.7 | **50.2** |
| | LC2SJB1 | 1.79 | 5.9 | 228.9 | 3.33 | 85.5 | 7.73 | 331.2 | 3.5 | 95.12 |
| | LC2RBB1 | 1.95 | 4.07 | 108.9 | 4.43 | 127.5 | 7.58 | 289.6 | 3.7 | 90.17 |
| | LC1SJB2 | 2.3 | 7.33 | 218.6 | 4.74 | 106.2 | 9.26 | 302.6 | 4.52 | 96.38 |
| | LC1RBB2 | 2.46 | 4.97 | 101.8 | 4.25 | 72.54 | 6.36 | 158.3 | 4.76 | 93.36 |
| | LC2SJB2 | 1.79 | 6.48 | 261.2 | 3.98 | 121.8 | 8.7 | 384.8 | 4.54 | 153 |
| | LC2RBB2 | 1.95 | 6.83 | 250.8 | 3.9 | 100.4 | 8.84 | 354 | 4.81 | 147.4 |
| After wear | LC1SJB1 | 2.3 | 2.18 | -5.22 | 1.72 | -25.2 | 2.22 | -3.38 | 1.77 | -23 |
| | LC1RBB1 | 2.46 | 2.25 | -8.64 | 1.8 | -26.9 | 2.48 | 0.793 | 1.85 | **-24.9** |
| | LC2SJB1 | 1.79 | 2.16 | 20.15 | 1.11 | **-38.3** | 2.31 | 28.78 | 1.51 | -15.8 |
| | LC2RBB1 | 1.95 | 2.22 | 14.19 | 1.31 | -32.6 | 2.58 | 32.57 | 1.83 | -5.97 |
| | LC1SJB2 | 2.3 | 3.51 | 52.61 | 2.18 | -5.19 | 4.05 | 76.09 | 3.75 | 63.04 |
| | LC1RBB2 | 2.46 | 3.77 | 53.08 | 2.25 | -8.64 | 4.21 | 70.95 | 3.86 | 56.74 |
| | LC2SJB2 | 1.79 | 3.46 | 93.07 | 2.13 | 18.75 | 4.41 | 145.6 | 3.92 | 118.5 |
| | LC2RBB2 | 1.95 | 3.68 | 88.91 | 2.29 | 17.67 | 4.82 | 147.6 | 3.99 | 105 |
| F values | LC1SJ | | 93.813** | | 16.522** | | 160.25** | | 17.719** | |
| | LC1RB | | 45.312** | | 33.38** | | 95.77** | | 31.249** | |
| | LC2SJ | | 86.321** | | 95.226** | | 274.827** | | 27.692** | |
| | LC2RB | | 66.441** | | 19.195** | | 258.776** | | 58.781** | |

** Significant at 1% level * Significant at 5% level

From the Table LII, it is clear that after dyeing all the samples showed an increase in percentage loss due to abrasion, when compared with their controls. The lowest loss was observed in bio pretreated, dyed sample LC1RBB1 with 41.26% and the same sample after bio polishing and dyeing showed 50.2% as minimum loss. Higher abrasion values were seen in single jersey samples, due to the lower weight and thickness of these samples and samples dyed with darker shade (B2) which may be due to the chemical formulation used for the dark shade. In general, the bio polished samples showed higher values since a loss of short fibrils in the cotton weakens the fabric.

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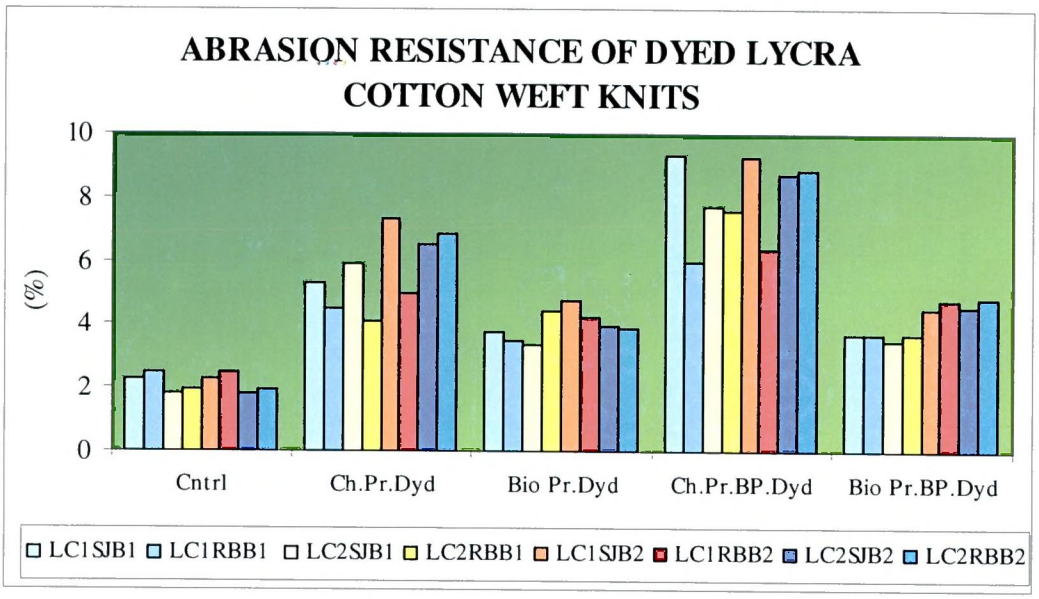


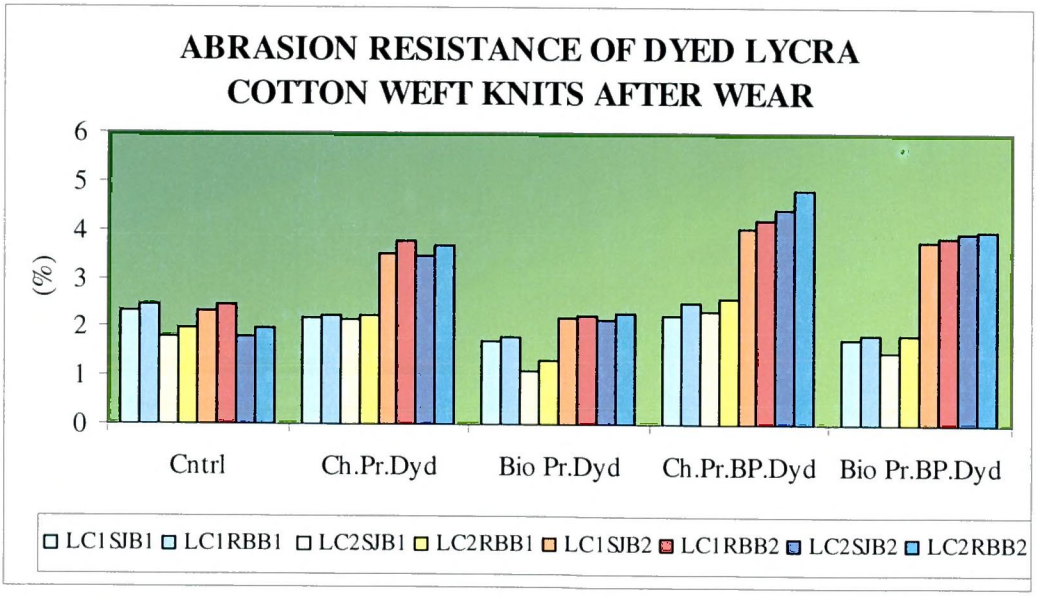




**FIGURE 33**

After wear, there was a decrease in the values indicating higher strength due to the closeness of the knitted structure which occurs after the washing process. The bio pretreated dyed sample LC2SJB1 and the bio pretreated, bio polished, dyed sample LC1RBB1 showed minimum loss of 38.3% and 24.9% respectively, when compared to their controls.

All the samples, statistically analyzed with one-way ANOVA, showed significant differences after dyeing and wear, with their controls, with respect to abrasion resistance, at 1% level.

✶ **Flexural Rigidity - 100% cotton**

The flexural rigidity values of cotton weft knits after dyeing and wear, along with the F values, are presented in Table LIII and Figure 34.

The Table LIII reveals that the flexural rigidity of all the samples decreased after dyeing when compared to their controls. Lowest values were noted in bio pretreated and dyed sample C2RBB1 in the course direction with 70.7% loss and after bio polishing, the chemical pretreated sample C2SJB1, in the course direction showed a loss in flexural rigidity by 74.06%. Blanchard *et al.* (2000), state that cellulase enzyme breaks cellulose to form glucose which is accompanied with loss in fabric thickness, tensile strength and weight. This may be the reason for the reduction of values after bio polishing.

After wear, a majority of the samples showed reduction in flexural rigidity in comparison with their controls. Maximum loss in flexural rigidity was noticed in chemical pretreated, dyed sample C1SJB2 in the wale direction and in the chemical pretreated, bio polished and dyed sample C1RBB1 in the wale direction with loss of 44.1% and 68.35% respectively.

The statistical analysis revealed significant differences in all the samples after dyeing and wear, with their originals, with respect to flexural rigidity at 1% level in both the wale and course directions.

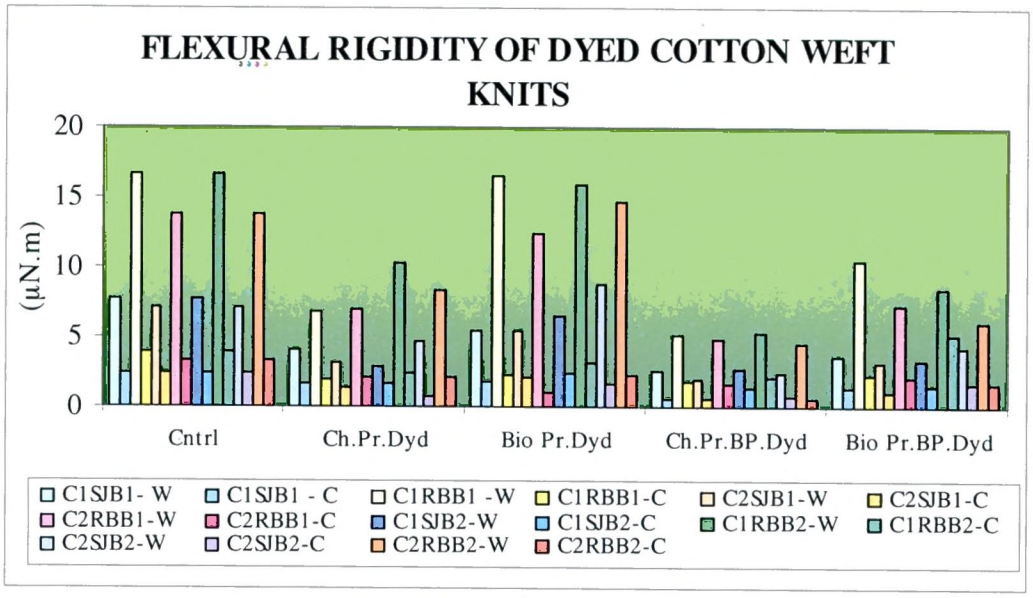
## TABLE LIII

## FLEXURAL RIGIDITY OF COTTON WEFT KNITS AFTER DYEING AND WEAR

| Units in (μN.m) | Sample | Control | Chemical Pretreated | % Gain/ Loss over Control | Bio Pretreated | % Gain/ Loss over Control | Chemical Pretreated & Bio Polished | % Gain/ Loss over Control | Bio Pretreated Bio Polished | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After dyeing | C1SJB1- W | 7.76 | 4.09 | -47.3 | 5.45 | -29.8 | 2.58 | -66.77 | 3.69 | -52 |
| | C1SJB1 - C | 2.4 | 1.63 | -32.1 | 1.76 | -26.7 | 0.68 | -71.67 | 1.39 | -42 |
| | C1RBB1 -W | 16.65 | 6.75 | -59.5 | 16.5 | -0.9 | 5.1 | -69.37 | 10.5 | -37 |
| | C1RBB1-C | 3.91 | 2.03 | -48.1 | 2.31 | -40.9 | 1.88 | -51.92 | 2.22 | -43 |
| | C2SJB1-W | 7.16 | 3.15 | -56 | 5.38 | -24.9 | 2.04 | -71.52 | 3.21 | -55 |
| | C2SJB1-C | 2.39 | 1.39 | -41.8 | 2.11 | -11.7 | 0.62 | **-74.06** | 1 | -58 |
| | C2RBB1-W | 13.82 | 6.9 | -50.1 | 12.5 | -9.56 | 4.85 | -64.91 | 7.21 | -48 |
| | C2RBB1-C | 3.38 | 2.13 | -37 | 0.99 | **-70.7** | 1.71 | -49.41 | 2.19 | -35 |
| | C1SJB2-W | 7.76 | 2.89 | -62.8 | 6.47 | -16.7 | 2.8 | -63.94 | 3.32 | -57 |
| | C1SJB2-C | 2.4 | 1.66 | -30.8 | 2.39 | -0.42 | 1.38 | -42.5 | 1.48 | -38 |
| | C1RBB2-W | 16.65 | 10.3 | -38.1 | 15.9 | -4.5 | 5.25 | -68.47 | 8.47 | -49 |
| | C1RBB2-C | 3.91 | 2.39 | -38.9 | 3.18 | -18.7 | 2.15 | -45.01 | 5.22 | 33.5 |
| | C2SJB2-W | 7.16 | 4.67 | -34.8 | 8.73 | 21.9 | 2.39 | -66.63 | 4.18 | -42 |
| | C2SJB2-C | 2.39 | 0.72 | -69.9 | 1.72 | -28 | 0.71 | -70.29 | 1.6 | -33 |
| | C2RBB2-W | 13.82 | 8.27 | -40.2 | 14.7 | 6.36 | 4.55 | -67.08 | 6.08 | -56 |
| | C2RBB2-C | 3.38 | 2.11 | -37.6 | 2.33 | -31.1 | 0.59 | -82.54 | 1.68 | -50 |
| After Wear | C1SJB1- W | 7.76 | 5.36 | -31 | 6.34 | -18.3 | 3.38 | -56.47 | 5.33 | -31 |
| | C1SJB1 - C | 2.4 | 1.84 | -23.3 | 2.27 | -5.42 | 1.67 | -30.42 | 2.12 | -12 |
| | C1RBB1 -W | 16.65 | 9.5 | -42.9 | 20.8 | 24.92 | 5.27 | **-68.35** | 9.1 | -45 |
| | C1RBB1-C | 3.91 | 2.81 | -28.1 | 3.35 | -14.3 | 2.29 | -41.43 | 2.69 | -31 |
| | C2SJB1-W | 7.16 | 4.19 | -41.5 | 7.16 | -0.03 | 6.51 | -9.102 | 3.64 | -49 |
| | C2SJB1-C | 2.39 | 2.02 | -15.5 | 2.36 | -1.26 | 1.31 | -45.19 | 1.89 | -21 |
| | C2RBB1-W | 13.82 | 8.58 | -37.9 | 14.3 | 3.466 | 12.6 | -8.834 | 7.82 | -43 |
| | C2RBB1-C | 3.38 | 3.13 | -7.4 | 2.76 | -18.3 | 2.31 | -31.66 | 2.7 | -20 |
| | C1SJB2-W | 7.76 | 4.34 | **-44.1** | 8.4 | 8.186 | 7.57 | -2.504 | 4.51 | -42 |
| | C1SJB2-C | 2.4 | 1.99 | -17.1 | 3.62 | 50.83 | 1.64 | -31.67 | 2.21 | -7.9 |
| | C1RBB2-W | 16.65 | 12.4 | -25.5 | 21.8 | 30.93 | 10.6 | -36.34 | 10.9 | -35 |
| | C1RBB2-C | 3.91 | 3.37 | -13.8 | 5.47 | 39.9 | 2.44 | -37.6 | 2.91 | -26 |
| | C2SJB2-W | 7.16 | 5.91 | -17.5 | 10.8 | 50.8 | 8.82 | 23.15 | 5.49 | -23 |
| | C2SJB2-C | 2.39 | 1.52 | -36.4 | 2.14 | -10.5 | 1.39 | -41.84 | 1.96 | -18 |
| | C2RBB2-W | 13.82 | 9.61 | -30.5 | 20.9 | 51.22 | 10.5 | -24.03 | 9.3 | -33 |
| | C2RBB2-C | 3.38 | 2.8 | -17.2 | 5.31 | 57.1 | 2.04 | -39.64 | 3.23 | -4.4 |
| F values | C1SJ-W | | 2393.14** | | 3062.884** | | 31.37** | | 1806.878** | |
| | C1RB-W | | 15663.73** | | 75331.9** | | 32616.3** | | 7259.779** | |
| | C2SJ-W | | 6731.942** | | 21754.91** | | 37254.48** | | 5391.585** | |
| | C2RB-W | | 5655.843** | | 51432.69** | | 69673.07** | | 13453.89** | |
| | C1SJ-C | | 31.461** | | 717.368** | | 194.46** | | 318.125** | |
| | C1RB-C | | 6618.4** | | 6714.154** | | 1346.423** | | 2729.982** | |
| | C2SJ-C | | 4350.275** | | 263.483** | | 715.416** | | 738.959** | |
| | C2RB-C | | 293.053** | | 4367.935** | | 952.063** | | 1467.686** | |

**W – wales, C –Courses] [** Significant at 1% level * Significant at 5% level**

# FLEXURAL RIGIDITY OF COTTON WEFT KNITS AFTER DYEING AND WEAR



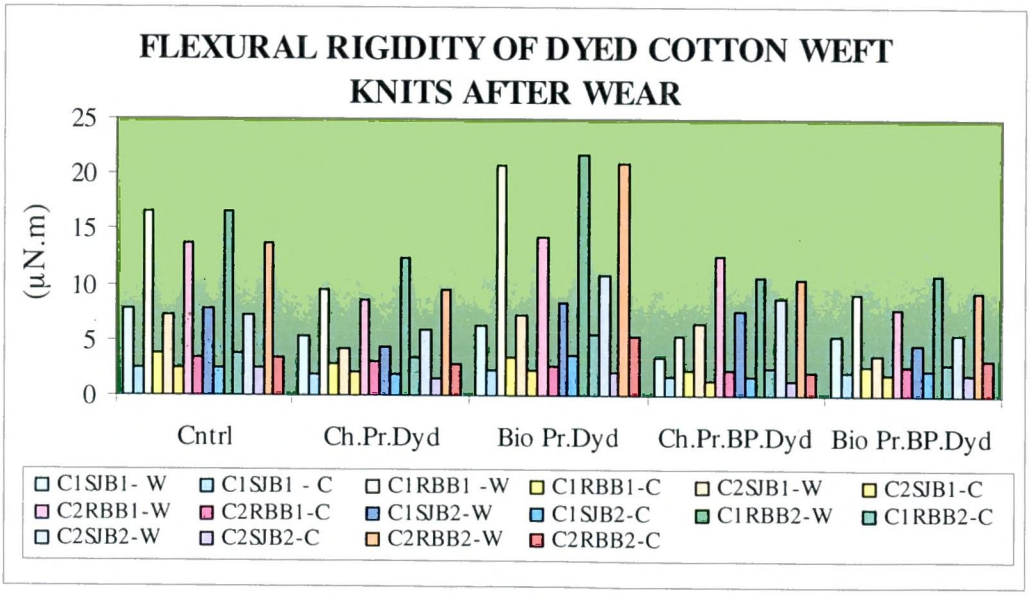




**FIGURE 34**

### ✶ Flexural Rigidity - Lycra Cotton

The flexural rigidity values of lycra cotton weft knits after dyeing and wear, along with the one way ANOVA values, are presented in Table LIV and Figure 35.

From the Table LIV, it is clear that there is a marked decrease in flexural rigidity after dyeing. The maximum decrease in values was recorded in chemical pretreated and dyed sample LC1SJB1 in the course direction with 79.95% and chemical pretreated, bio polished and dyed sample LC2SJB1 in the wale direction with 82.8%. This maybe attributed to the greater thickness values of the bio pretreated samples, when compared to the chemical pretreated samples.

After wear, a majority of the samples recorded decrease in flexural rigidity when compared to their controls. The chemical pretreated, dyed sample LC1SJB2 in the wale direction, recorded a maximum decrease of 65.86% and chemical pretreated, bio polished and dyed sample LC2SJB2 in the course direction showed a maximum loss of 70.7%.

It may be noted from the Table LIV, that all the samples statistically analyzed with one-way ANOVA, recorded significant effect on flexural rigidity after dyeing and wear, in both the wale and course directions, at 1% level.

## TABLE LIV
## FLEXURAL RIGIDITY OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR

| Units in (μN.m) | Sample | Control | Chemical Pretreated Dyed | % Gain/ Loss over Control | Bio Pretreated Dyed | % Gain/ Loss over Control | Chemical Pretreated & Bio Polished Dyed | % Gain/ Loss over Control | Bio Pretreated & Bio Polished Dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After dyeing | LC1SJB1- W | 15.23 | 5.82 | -61.79 | 8.41 | -44.8 | 4.67 | -69.3 | 8.78 | -42.35 |
| | LC1SJB1 - C | 4.44 | 0.89 | **-79.95** | 4.09 | -7.88 | 1.54 | -65.3 | 11.6 | 161 |
| | LC1RBB1 -W | 12.88 | 9.86 | -23.45 | 12.7 | -1.4 | 9.32 | -27.6 | 7.44 | -42.24 |
| | LC1RBB1-C | 6.74 | 4.53 | -32.79 | 5.83 | -13.5 | 3.41 | -49.4 | 4.91 | -27.15 |
| | LC2SJB1-W | 8.31 | 4.92 | -40.79 | 2.82 | -66.1 | 1.43 | **-82.8** | 9.37 | 12.8 |
| | LC2SJB1-C | 4.5 | 2.81 | -37.56 | 4.53 | 0.667 | 5.74 | 27.56 | 8.25 | 83.3 |
| | LC2RBB1-W | 8.99 | 6.51 | -27.59 | 6.15 | -31.6 | 5.40 | -39.9 | 5.72 | -36.37 |
| | LC2RBB1-C | 5.03 | 2.73 | -45.73 | 3.33 | -33.8 | 1.98 | -60.6 | 2.68 | -46.72 |
| | LC1SJB2-W | 15.23 | 7.74 | -49.18 | 12.9 | -15.3 | 3.90 | -74.4 | 5.58 | -63.36 |
| | LC1SJB2-C | 4.44 | 1.49 | -66.44 | 6.41 | 44.37 | 2.03 | -54.3 | 5.82 | 31.1 |
| | LC1RBB2-W | 12.88 | 11.35 | -11.88 | 7.83 | -39.2 | 11.07 | -14.1 | 9.73 | -24.46 |
| | LC1RBB2-C | 6.74 | 4.66 | -30.86 | 5.31 | -21.2 | 5.81 | -13.8 | 4.98 | -26.11 |
| | LC2SJB2-W | 8.31 | 3.82 | -54.03 | 3.34 | -59.8 | 3.68 | -55.7 | 3.84 | -53.79 |
| | LC2SJB2-C | 4.5 | 3.47 | -22.89 | 4.17 | -7.33 | 2.87 | -36.2 | 1.83 | -59.33 |
| | LC2RBB2-W | 8.99 | 10.86 | 20.8 | 6.39 | -28.9 | 9.02 | 0.334 | 7.66 | -14.79 |
| | LC2RBB2-C | 5.03 | 3.33 | -33.8 | 2.61 | -48.1 | 3.18 | -36.8 | 1.98 | -60.64 |
| After Wear | LC1SJB1- W | 15.23 | 8.23 | -45.92 | 12.7 | -16.6 | 10.11 | -33.6 | 8.17 | -46.36 |
| | LC1SJB1 - C | 4.44 | 6.64 | 49.55 | 6.15 | 38.51 | 9.03 | 103.4 | 5.35 | 20.5 |
| | LC1RBB1 -W | 12.88 | 11.34 | -11.96 | 28 | 117.4 | 16.2 | 25.78 | 17.8 | 38.2 |
| | LC1RBB1-C | 6.74 | 5.83 | -13.5 | 8.96 | 32.94 | 5.76 | -14.5 | 7.38 | 9.496 |
| | LC2SJB1-W | 8.31 | 7.169 | -13.73 | 5.17 | -37.8 | 4.029 | -51.5 | 3.24 | -61.01 |
| | LC2SJB1-C | 4.5 | 3.77 | -16.22 | 4.54 | 0.889 | 2.82 | -37.3 | 3.56 | -20.89 |
| | LC2RBB1-W | 8.99 | 7.90 | -12.12 | 15.6 | 73.53 | 10.21 | 13.57 | 14.1 | 56.84 |
| | LC2RBB1-C | 5.03 | 3.89 | -22.66 | 4.82 | -4.17 | 3.6 | -28.4 | 4.29 | -14.71 |
| | LC1SJB2-W | 15.23 | 5.20 | **-65.86** | 15.3 | 0.46 | 5.123 | -66.4 | 7.66 | -49.7 |
| | LC1SJB2-C | 4.44 | 4.79 | 7.88 | 6.65 | 49.77 | 4.81 | 8.333 | 2.41 | -45.72 |
| | LC1RBB2-W | 12.88 | 30.9 | 139.9 | 39.2 | 204.3 | 19.98 | 55.12 | 14.9 | 15.68 |
| | LC1RBB2-C | 6.74 | 10.7 | 58.75 | 13.3 | 97.33 | 9.26 | 37.39 | 3.5 | -48.07 |
| | LC2SJB2-W | 8.31 | 4.32 | -48.01 | 6.48 | -22 | 4.418 | -46.8 | 3.04 | -63.42 |
| | LC2SJB2-C | 4.5 | 2.47 | -45.11 | 4.31 | -4.22 | 1.32 | **-70.7** | 1.62 | -64 |
| | LC2RBB2-W | 8.99 | 22.72 | 152.7 | 21.1 | 134.7 | 14.65 | 62.96 | 12 | 33.48 |
| | LC2RBB2-C | 5.03 | 8.14 | 61.83 | 7.64 | 51.89 | 6.18 | 22.86 | 1.84 | -63.42 |
| F values | LC1SJ-W | | 28832.29** | | 24302.68** | | 24.421** | | 7826.293** | |
| | LC1RB-W | | 362083.7** | | 598572.9** | | 402649.6** | | 148683.1** | |
| | LC2SJ-W | | 13055.8** | | 11114.56** | | 4576.785** | | 32434.21** | |
| | LC2RB-W | | 317413.1** | | 270118.9** | | 31850.71** | | 70435.82** | |
| | LC1SJ-C | | 6738.666** | | 3164.216** | | 61.477** | | 15446.46** | |
| | LC1RB-C | | 29763.27** | | 233246.6** | | 7889.821** | | 4861.8** | |
| | LC2SJ-C | | 1711.328** | | 16388.46** | | 18704.28** | | 15008.57** | |
| | LC2RB-C | | 10110.48** | | 3672.955** | | 14978.2** | | 6833.161** | |

W – wales, C –Courses] [** Significant at 1% level * Significant at 5% level

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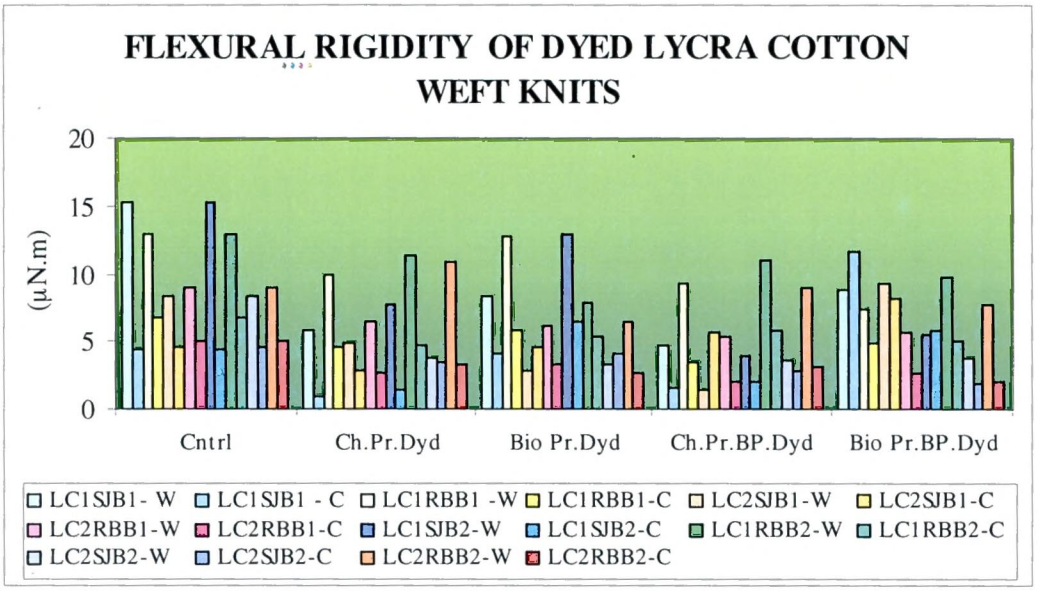


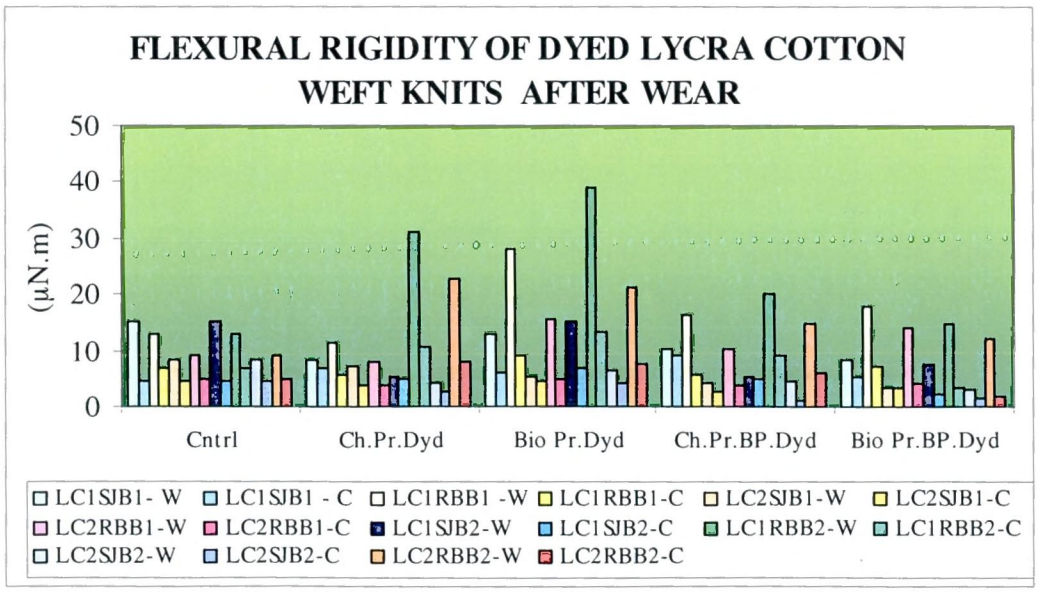




**FIGURE 35**

### ✶ Drape Coefficient - 100% Cotton

The drape coefficient of cotton weft knits after dyeing and wear and the one way ANOVA values, are presented in Table LV and Figure 36.

**TABLE LV**

**DRAPE COEFFICIENT OF COTTON WEFT KNITS AFTER DYEING AND WEAR**

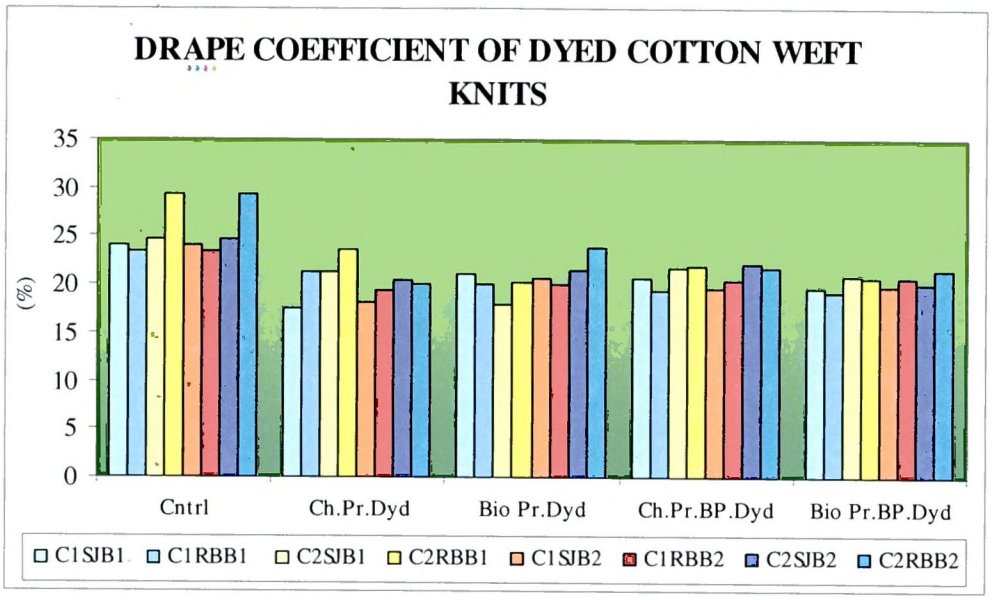
| Units in (%) | Sample | Control | Chemical Pretreated & Dyed | % Gain/ Loss over Control | Bio Pretreated & Dyed | % Gain/ Loss over Control | Chemical Pretreated, Bio Polished &Dyed | % Gain/ Loss over Control | Bio Pretreated, Bio Polished & Dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | C1SJB1 | 24.08 | 17.52 | -27.22 | 21.03 | -12.65 | 20.56 | -14.62 | 19.67 | -18.35 |
| | C1RBB1 | 23.38 | 21.31 | -8.83 | 19.99 | -14.48 | 19.38 | -17.08 | 19.21 | -17.86 |
| | C2SJB1 | 24.63 | 21.23 | -13.77 | 17.97 | -27.03 | 21.78 | -11.56 | 20.82 | -15.5 |
| | C2RBB1 | 29.31 | 23.53 | -19.7 | 20.14 | -31.28 | 21.87 | -25.4 | 20.61 | **-29.67** |
| | C1SJB2 | 24.08 | 18.08 | -24.92 | 20.75 | -13.82 | 19.70 | -18.17 | 19.80 | -17.8 |
| | C1RBB2 | 23.38 | 19.32 | -17.34 | 20.05 | -14.22 | 20.53 | -12.15 | 20.57 | -12 |
| | C2SJB2 | 24.63 | 20.41 | -17.13 | 21.55 | -12.51 | 22.16 | -10.02 | 20.08 | -18.5 |
| | C2RBB2 | 29.31 | 20.07 | **-31.52** | 23.85 | -18.6 | 21.73 | -25.83 | 21.52 | -26.6 |
| After Wear | C1SJB1 | 24.08 | 26.98 | 12.04 | 21.48 | -13.40 | 23.04 | -4.29 | 22.30 | -7.36 |
| | C1RBB1 | 23.37 | 22.43 | -4.016 | 20.13 | -13.87 | 26.33 | 12.66 | 20.48 | -12.39 |
| | C2SJB1 | 24.62 | 19.96 | -18.96 | 21.71 | -11.82 | 22.25 | -9.65 | 22.94 | -6.83 |
| | C2RBB1 | 29.30 | 25.61 | -12.62 | 23.40 | **-20.14** | 23.17 | -20.95 | 23.48 | -19.9 |
| | C1SJB2 | 24.08 | 27.82 | 15.53 | 20.60 | -14.47 | 22.09 | -8.26 | 21.11 | -12.33 |
| | C1RBB2 | 23.37 | 20.34 | -12.99 | 20.19 | -13.61 | 27.91 | 19.39 | 19.45 | -16.78 |
| | C2SJB2 | 24.62 | 22.38 | -9.119 | 22.03 | -10.54 | 22.64 | -8.05 | 22.12 | -10.2 |
| | C2RBB2 | 29.30 | 24.27 | -17.19 | 24.77 | -15.49 | 24.48 | -16.46 | 23.09 | **-21.2** |
| F –values | C1SJ | | 520.078** | | 9.585** | | 86.801** | | 14.677** | |
| | C1RB | | 29.324** | | 9.494** | | 725.690** | | 80.625** | |
| | C2SJ | | 82.722** | | 48.979** | | 124.544** | | 53.208** | |
| | C2RB | | 368.351** | | 74.811** | | 177.682** | | 62.126** | |

** Significant at 1% level * Significant at 5% level

Table LV reveals a reduction in drape coefficient in all the treated samples after dyeing and wear, when compared with their controls. The lower the value more graceful will be the folds of fabric when draped. Thilagavathy and Natrajan (2003) state that dyeing decreases the value of drape coefficient. Better drape coefficient is due to the basic fibre fineness, the processing involved and the resultant lower bending rigidity, state Ramakrishnan *et al.* (2009). After dyeing, the maximum loss of 31.52% and 29.67% were observed in chemical pretreated and dyed sample C2RBB2 and in bio pretreated, bio polished and dyed sample C2RBB1 respectively.

After wear, bio pretreated dyed sample C2RBB1 and bio pretreated, bio polished and dyed sample C2RBB2 showed maximum loss of 20.14% and 21.2% respectively. In all the

# DRAPE COEFFICIENT OF COTTON WEFT KNITS AFTER DYEING AND WEAR



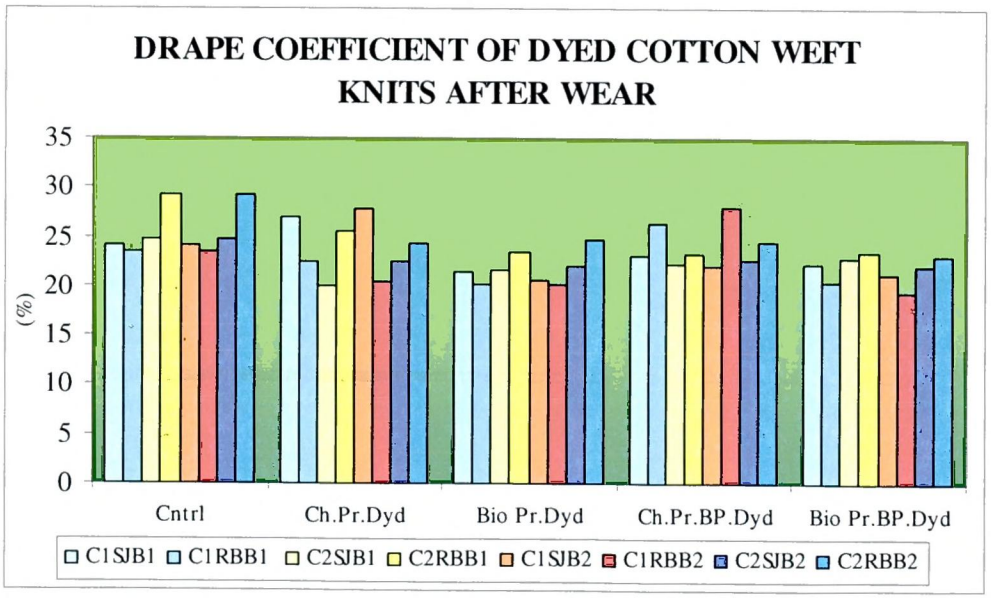




**FIGURE 36**

above mentioned samples it may be noticed that the combed yarn and the rib structure have the lowest values when compared to their controls.

All the samples, statistically analyzed with one-way ANOVA, showed significant differences, after the dyeing and wear with respect to drape coefficient at 1% level.

✶ **Drape Coefficient - Lycra Cotton**

The drape coefficient of lycra cotton weft knits after dyeing and wear and the F values, are presented in Table LVI and Figure 37.

**TABLE LVI**

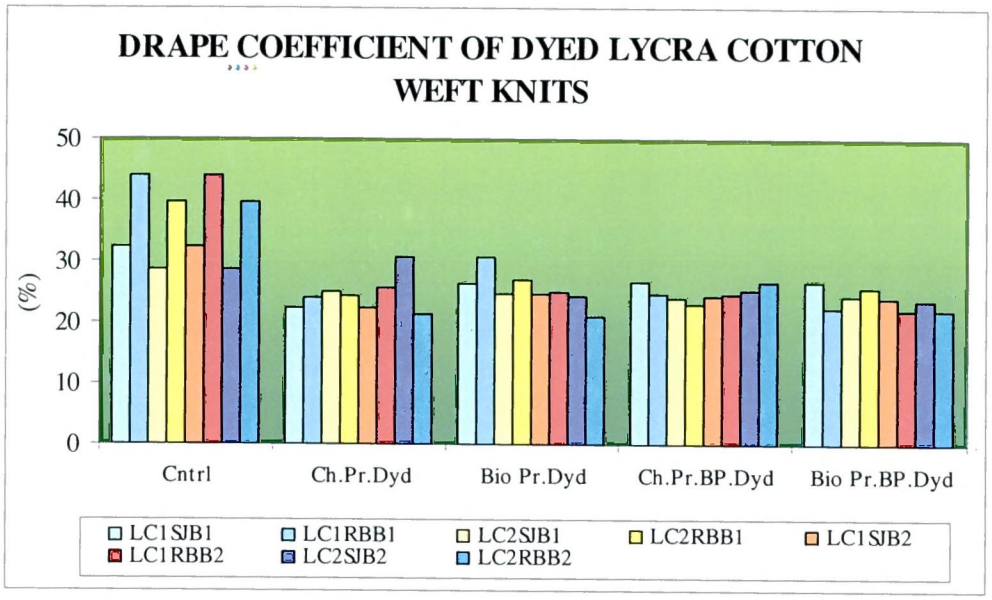
**DRAPE COEFFICIENT OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in (%) | Sample | Control | Chemical Pretreated & dyed | % Gain/ Loss over Control | Bio Pretreated & dyed | % Gain/ Loss over Control | Chemical Pretreated, Bio Polished & dyed | % Gain/ Loss over Control | Bio Pretreated, Bio polished & dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | LC1SJB1 | 32.3 | 22.25 | -31.11 | 26.41 | -18.24 | 26.58 | -17.71 | 26.76 | -17.15 |
| | LC1RBB1 | 43.87 | 23.84 | -45.66 | 30.76 | -29.88 | 24.59 | -43.95 | 22.32 | -49.12 |
| | LC2SJB1 | 28.75 | 25.14 | -12.56 | 24.58 | -14.5 | 23.99 | -16.56 | 24.34 | -15.35 |
| | LC2RBB1 | 39.7 | 24.17 | -39.12 | 27.14 | -31.64 | 22.94 | -42.22 | 25.81 | -34.99 |
| | LC1SJB2 | 32.3 | 22.37 | -30.74 | 24.76 | -23.34 | 24.33 | -24.67 | 24.02 | -25.63 |
| | LC1RBB2 | 43.87 | 25.65 | -41.53 | 24.89 | -43.26 | 24.58 | -43.97 | 22.06 | **-49.72** |
| | LC2SJB2 | 28.75 | 30.73 | 6.88 | 24.33 | -13.47 | 25.36 | -11.79 | 23.81 | -17.18 |
| | LC2RBB2 | 39.7 | 21.33 | -46.27 | 21.08 | **-46.9** | 26.76 | -32.59 | 21.86 | -44.94 |
| After Wear | LC1SJB1 | 32.3 | 21.88 | -32.26 | 29.31 | -9.257 | 27.26 | -15.6 | 24.42 | -24.4 |
| | LC1RBB1 | 43.87 | 27.06 | -38.32 | 22.86 | **-47.90** | 23.88 | -45.57 | 22.9 | **-47.81** |
| | LC2SJB1 | 28.75 | 24.72 | -14.02 | 27.28 | -5.113 | 24.61 | -14.41 | 24.83 | -13.64 |
| | LC2RBB1 | 39.7 | 21.15 | -46.73 | 23.87 | -39.87 | 24.54 | -38.18 | 24.03 | -39.47 |
| | LC1SJB2 | 32.3 | 23.76 | -26.43 | 26.3 | -18.58 | 25.4 | -21.38 | 28.73 | -11.06 |
| | LC1RBB2 | 43.87 | 40.31 | -8.126 | 31.18 | -28.92 | 31.16 | -28.97 | 26.68 | -39.18 |
| | LC2SJB2 | 28.75 | 32.64 | 13.53 | 29.48 | 2.522 | 26.47 | -7.93 | 28.47 | -0.957 |
| | LC2RBB2 | 39.7 | 33.12 | -16.57 | 26.72 | -32.69 | 37.8 | -4.786 | 23.73 | -40.22 |
| F –values | LC1SJ | | 106.182** | | 61.207** | | 42.747** | | 65.861** | |
| | LC1RB | | 1945.808** | | 331.042** | | 1305.124** | | 81.020** | |
| | LC2SJ | | 721.172** | | 309.231** | | 61.520** | | 138.429** | |
| | LC2RB | | 1462.677** | | 131.757** | | 1096.065** | | 75.406** | |

** Significant at 1% level * Significant at 5% level

From Table LVI, it may be understood that a decrease in drape coefficient is seen in all the samples after dyeing and wear, in comparison with their controls. The maximum loss was noticed in bio pretreated and dyed sample LC2RBB2 with 46.9% and in bio pretreated, bio polished and dyed sample LC1RBB2 with 49.72%.

# DRAPE COEFFICIENT OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



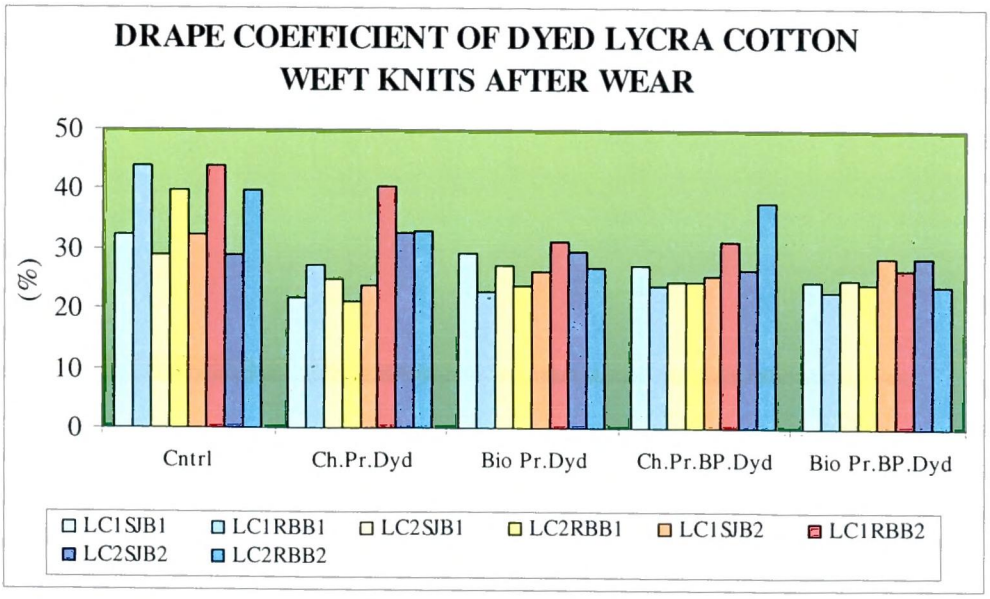




**FIGURE 37**

After wear, the bio pretreated and dyed sample LC1RBB1showed a maximum loss of 47.9% and the same sample after bio polishing and dyeing showed a maximum loss of 47.81%.

All the samples, statistically analyzed with one-way ANOVA, showed significant differences after the dyeing and wear with respect to drape coefficient at 1% level.

✶ **Pilling - 100% Cotton**

The ratings of the pilling tests of cotton weft knits after dyeing and wear are presented in Table LVII and Figure 38.

**TABLE LVII**

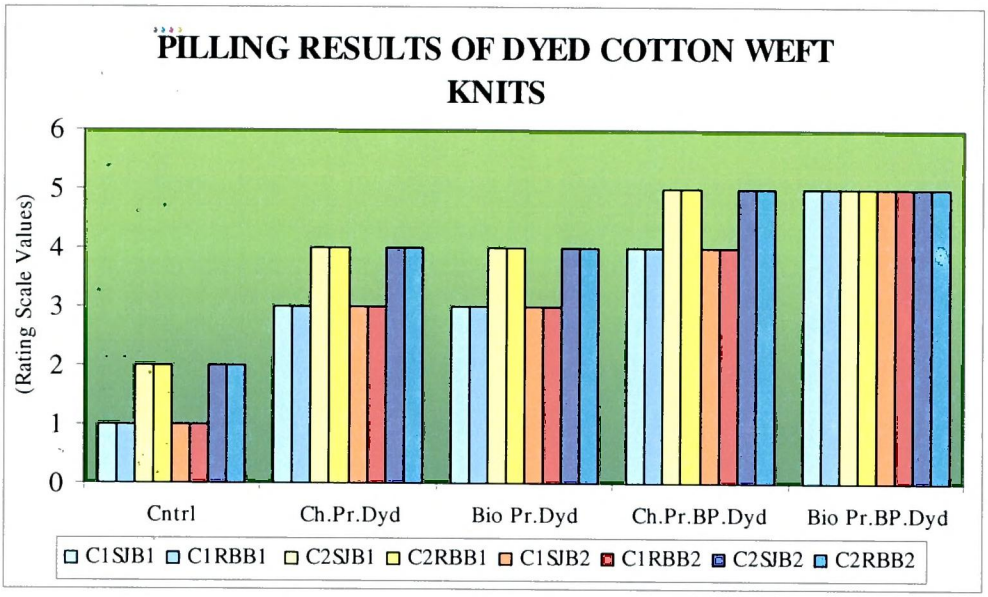
**PILLING EVALUATION OF COTTON WEFT KNITS AFTER DYEING AND WEAR**

| | Sample | Chemical Pretreated & Dyed | Chemical Pretreated & Dyed after wear | Bio Pretreated & Dyed | Bio Pretreated & Dyed after wear | Chemical Pretreated, Bio polished& Dyed | Pretreated, Bio polished& Dyed after wear | Bio Pretreated, Bio Polished & Dyed | Bio Pretreated, Bio Polished & Dyed after wear |
|---|---|---|---|---|---|---|---|---|---|
| After Dyeing & Wear | C1SJB1 | 3 | 2 | 3 | 2 | 4 | 4 | 5 | 5 |
| | C1RBB1 | 3 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| | C2SJB1 | 4 | 3 | 4 | 4 | 5 | 5 | 5 | 5 |
| | C2RBB1 | 4 | 3 | 4 | 4 | 5 | 5 | 5 | 5 |
| | C1SJB2 | 3 | 2 | 3 | 2 | 4 | 4 | 5 | 5 |
| | C1RBB2 | 3 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| | C2SJB2 | 4 | 3 | 4 | 4 | 5 | 5 | 5 | 5 |
| | C2RBB2 | 4 | 3 | 4 | 3 | 5 | 5 | 5 | 5 |

Pilling ratings as per photographic standards. No.1= Very severe pilling;
No. 2= severe pilling; No.3 = Moderate Pilling; No.4 = Slight Pilling; No.5 = No Pilling.

Table LVII reveals that the bio pretreated, bio polished samples exhibited no pilling (5) after dyeing and wear. The samples made from the carded yarns exhibited lower ratings than the fabrics made from combed yarns. Booth (2002) explains that pilling occurs due to the migration of fibres from the constituent yarns in the fabric. During spinning, the combing process removes the short fibres and prevents the migration of fibres in the combed yarns. The bio polished and dyed fabrics exhibited better ratings (4 and 5) when compared to the fabrics that have not been bio polished (3 and 4). Mangovska *et al.* (2004) state that the visual surface pill rating of alkaline scoured and bleached fabrics were lower than enzymatic scoured knit fabric after pretreatment and laundering.

# PILLING RESULTS OF COTTON WEFT KNITS AFTER DYEING AND WEAR



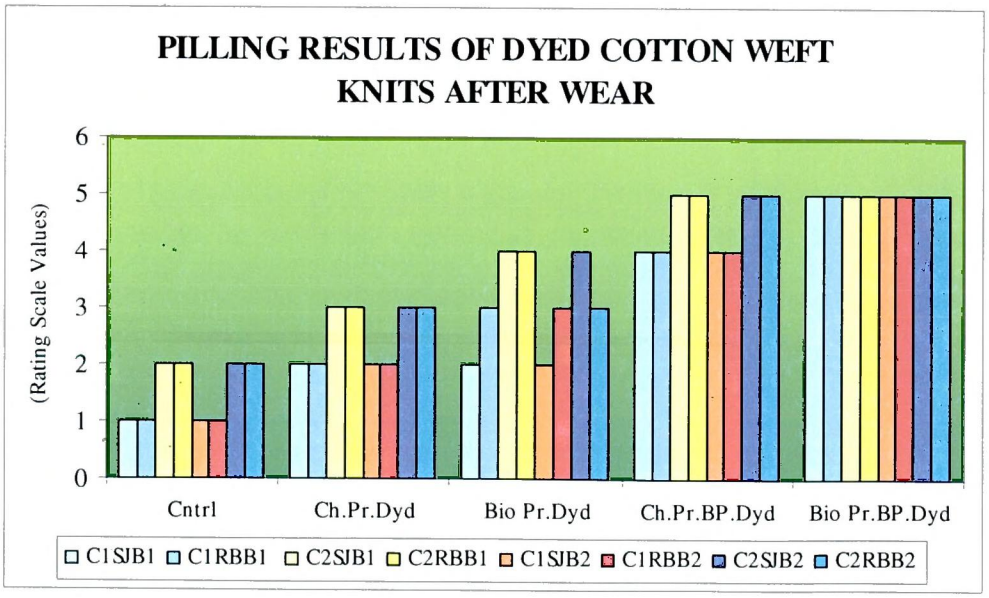




**FIGURE 38**

After wear, chemical pretreated and dyed samples exhibited severe pilling (2) to moderate pilling (3) while the bio pretreated and dyed samples showed severe(2) – moderate(3) - slight pilling(4). The chemical/bio pretreated and bio polished samples exhibited slight (4) to no pilling (5) in the rating scale value indicating that bio polished treatment has modified the surface of the knitted fabric.

✶ **Pilling - Lycra Cotton**

The ratings of the pilling tests of lycra cotton weft knits after dyeing and wear are presented in Table LVIII and Figure 39.

**TABLE LVIII**

**PILLING EVALUATION OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR**

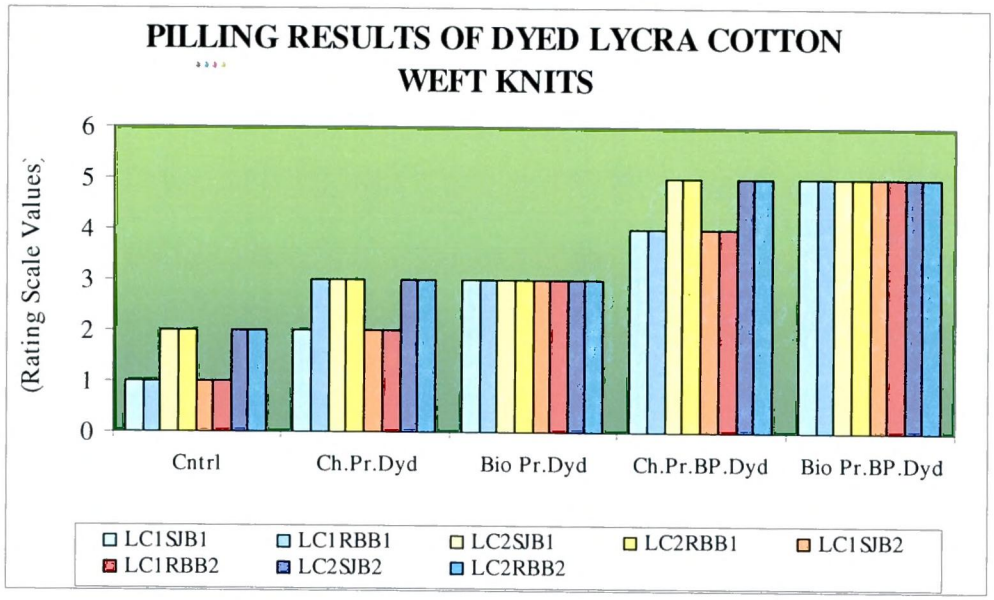
| | Sample | Chemical Pretreated & Dyed | Chemical Pretreated & Dyed after wear | Bio pretreated & Dyed | Bio pretreated & Dyed after wear | Chemical Pretreated Bio polished& Dyed | Chemical Pretreated Bio polished& Dyed after wear | Bio pretreated, Bio Polished & Dyed | Bio pretreated, Bio Polished & Dyed after wear |
|---|---|---|---|---|---|---|---|---|---|
| After Dyeing & Wear | LC1SJB1 | 3 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| | LC1RBB1 | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 5 |
| | LC2SJB1 | 4 | 3 | 4 | 3 | 5 | 5 | 5 | 5 |
| | LC2RBB1 | 4 | 3 | 4 | 3 | 5 | 5 | 5 | 5 |
| | LC1SJB2 | 3 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| | LC1RBB2 | 3 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| | LC2SJB2 | 4 | 3 | 4 | 3 | 5 | 5 | 5 | 5 |
| | LC2RBB2 | 4 | 3 | 4 | 3 | 5 | 5 | 5 | 5 |

Pilling ratings as per photographic standards. No.1= Very severe pilling; No. 2= severe pilling; No.3 = Moderate Pilling; No.4 = Slight Pilling; No.5 = No Pilling.

From Table LVIII it is clear that the bio polished samples are rated as the best in both chemical and bio pretreated, dyed and washed samples. Karmakar (1999) states that cellulase treatments removes the small fibre ends found in the yarn surface which eventually lead to pilling on the fabric surface.

The samples made from carded yarns were rated as moderate pilling (3) while those made from the combed yarns were rated as slight pilling (4). This may be due to the presence of short fibres in the carded yarns which were loosened during the wearing action of the pilling tester to produce a number of pills. The combed yarns showed better pilling ratings as the short fibres are combed and removed during the combing process in spinning.

# PILLING RESULTS OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



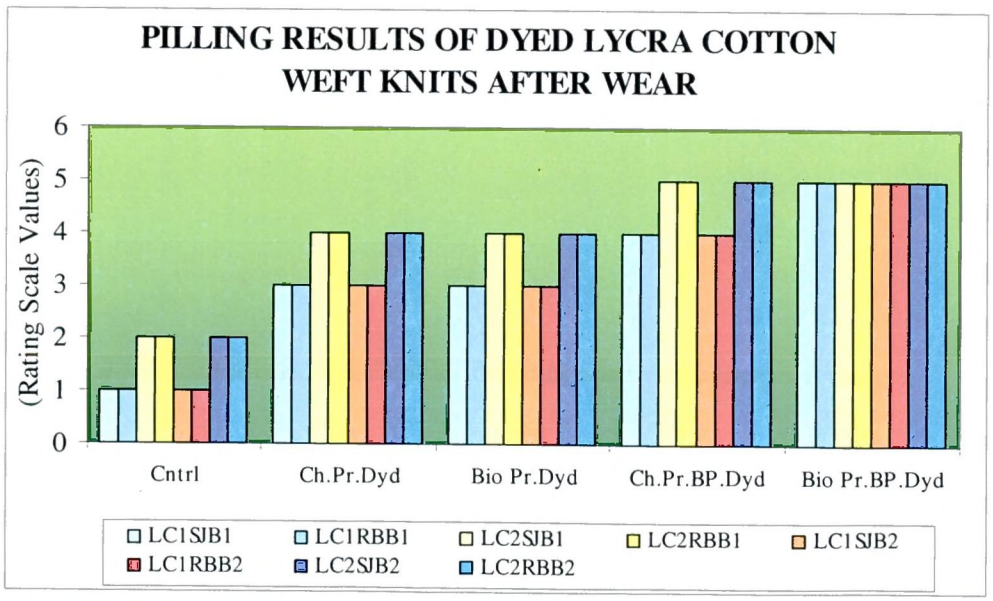




**FIGURE 39**

After wear there is a slight reduction in the ratings ranging from severe pilling (2) to moderate pilling (3) in the chemical pretreated and dyed samples and moderate pilling (3) in the bio pretreated and dyed samples. The chemical pretreated, bio polished and dyed samples after wear, exhibited slight (4) to no pilling (5)while the bio pretreated, bio polished and dyed samples after wear, exhibited no pilling(5). This proves that the bio polishing treatment is effective in making the fabric surface smooth and free of pills.

✶ **Air Permeability - 100% Cotton**

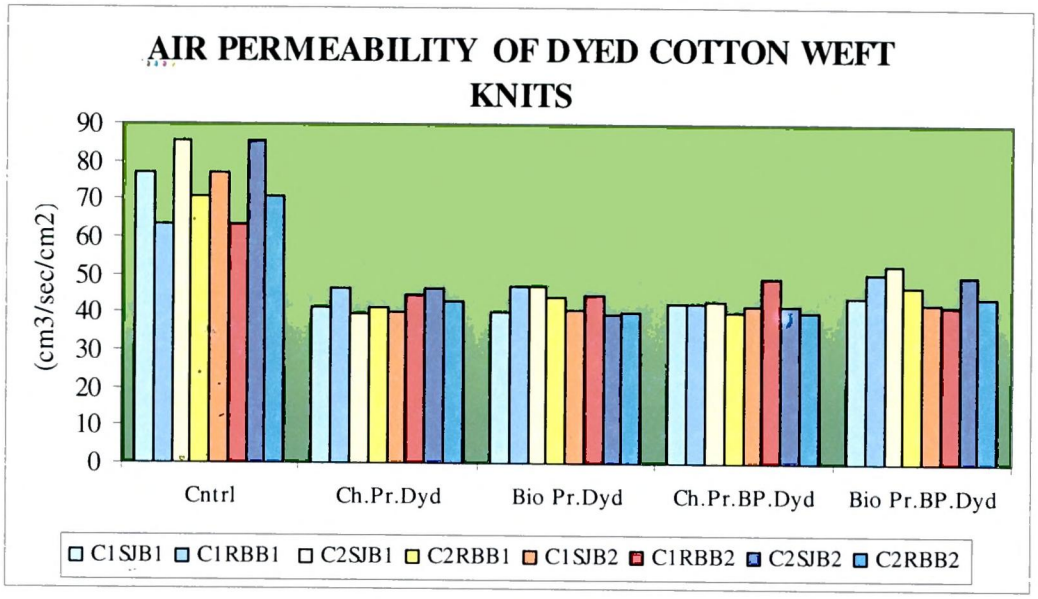
Table LIX and Figure 40 present the air permeability readings and the F values of cotton weft knits after dyeing and wear.

**TABLE LIX**
**AIR PERMEABILITY OF COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in ($cm^3/sec/cm^2$) | Sample | Control | Chemical Pretreated &Dyed | % Gain/ Loss over Control | Bio Pretreated & Dyed | % Gain/ Loss over Control | Chemical Pretreated, Bio polished & Dyed | % Gain/ Loss over Control | Bio Pretreated, Bio polished &Dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | C1SJB1 | 77.21 | 41.58 | -46.15 | 40.02 | -48.17 | 42.47 | -44.99 | 44.12 | -42.86 |
| | C1RBB1 | 63.65 | 46.15 | -27.49 | 46.89 | **-26.33** | 42.67 | -32.96 | 50.37 | **-20.86** |
| | C2SJB1 | 85.28 | 39.63 | -53.53 | 47.13 | -44.73 | 43.15 | -49.4 | 52.46 | -38.48 |
| | C2RBB1 | 70.6 | 41.37 | -41.4 | 44.35 | -37.18 | 40.13 | -43.16 | 46.78 | -33.74 |
| | C1SJB2 | 77.21 | 40.17 | -47.97 | 40.48 | -47.57 | 41.92 | -45.71 | 42.73 | -44.66 |
| | C1RBB2 | 63.65 | 44.54 | -30.02 | 44.76 | -29.68 | 49.38 | -22.42 | 41.64 | -34.58 |
| | C2SJB2 | 85.28 | 46.26 | -45.76 | 39.68 | -53.47 | 41.69 | -51.11 | 50.05 | -41.31 |
| | C2RBB2 | 70.6 | 42.75 | -39.45 | 40.38 | -42.8 | 39.97 | -43.39 | 44.35 | -37.18 |
| After Wear | C1SJB1 | 77.21 | 37.15 | -51.88 | 40.37 | -47.71 | 39.25 | -49.16 | 41.17 | -46.68 |
| | C1RBB1 | 63.65 | 40.61 | -36.2 | 41.49 | **-34.82** | 40.45 | -36.45 | 47.33 | **-25.64** |
| | C2SJB1 | 85.28 | 40.12 | -52.95 | 42.46 | -50.21 | 48.65 | -42.95 | 40.54 | -52.46 |
| | C2RBB1 | 70.6 | 38.45 | -45.54 | 38.69 | -45.2 | 38.45 | -45.54 | 38.18 | -45.92 |
| | C1SJB2 | 77.21 | 37.18 | -51.85 | 38.96 | -49.54 | 39.11 | -49.35 | 40.97 | -46.94 |
| | C1RBB2 | 63.65 | 39.43 | -38.05 | 40.13 | -36.95 | 40.23 | -36.79 | 46.12 | -27.54 |
| | C2SJB2 | 85.28 | 37.02 | -56.59 | 42.01 | -50.74 | 39.66 | -53.49 | 45.89 | -46.19 |
| | C2RBB2 | 70.6 | 37.14 | -47.39 | 38.23 | -45.85 | 37.32 | -47.14 | 37.68 | -46.63 |
| F values | C1SJ | | 3.227* | | 2.411 | | 3.131* | | 3.706* | |
| | C1RB | | 14.601** | | 4.011* | | 8.937** | | 6.077** | |
| | C2SJ | | 10.217** | | 0.562 | | 12.832** | | 2.547 | |
| | C2RB | | 4.597** | | 1.605 | | 8.68** | | 2.546 | |

** Significant at 1% level * Significant at 5% level

# AIR PERMEABILITY OF COTTON WEFT KNITS AFTER DYEING AND WEAR



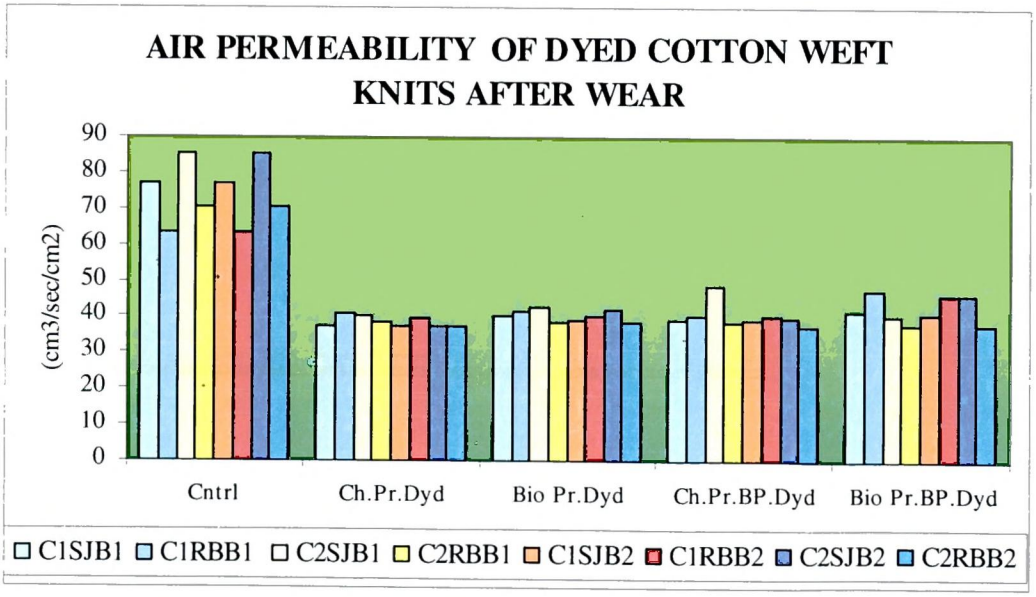




**FIGURE 40**

The Table LIX reveals a reduction in air permeability in all samples after dyeing and wear when compared to their controls. This may be attributed to consolidation after dyeing and wear. The lower the loss percentage from the control, the higher is the air permeability of the fabric. A minimum loss of 26.33% was observed in the bio pretreated and dyed sample C1RBB1 and in the same sample after bio polishing and dyeing, with 20.86 %.

After wear the same trend followed showing a loss of 34.82% in the bio pretreated and dyed sample C1RBB1 and 25.64% loss in the same sample which had been bio pretreated, bio polished and dyed. The percentage loss has increased after wear which may be attributed to repeated washes.

The statistical analysis reveals significant differences at 5% level in C1SJ after chemical pretreatment and dyeing and chemical pretreatment, bio polishing and dyeing, while all the other samples in the same category exhibited significant differences at 1% level. In the bio pretreated and dyed category, sample C1RB showed significant effect at 5% level and in the bio pretreated, bio polished and dyed category, C1SJ and C1RB showed significant effect at 5% and 1% level, respectively.

**✶ Air Permeability - Lycra Cotton**

The air permeability of lycra cotton weft knits, after dyeing and wear, are presented, along with the one way ANOVA values, in Table LX and Figure 41.

From Table LX, it is clear that a substantial decrease in air permeability readings was noticed in all the samples after dyeing indicating that the air permeability has decreased when compared to their controls. The minimum loss was observed in bio pretreated and dyed sample LC2SJB2 with 37.35% and in the bio pretreated, bio polished and dyed sample LC2SJB1 with 30.99%. The loss percentage was high in majority of the samples which were bio polished and dyed due to closeness of structure after bio polishing.

Table LX reveals that after wear few of the pretreated and dyed samples showed an increase in values when compared to their controls. About 50 to 60% of the bio polished and dyed samples after wear showed an increase in air permeability. Oinuma (1988) has stated that the void spaces between yarns of the fabric is one of the constituents for porosity which has an effect on air permeability. The air permeability increases linearly with the increase of porosity. The reason for the increase in values may be due to the removal of short fibres after bio polishing leading to increase in pores between the yarns of the fabric. The maximum

gain is seen in bio pretreated and dyed sample LC1SJB1 with 36.77% and in the bio pretreated, bio polished and dyed sample LC2SJB2 with 46.12%.

**TABLE LX**

**AIR PERMEABILITY OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in ($cm^3/sec/cm^2$) | Sample | Control | Chemical Pretreated &Dyed | % Gain/ Loss over Control | Bio Pretreated & Dyed | % Gain/ Loss over Control | Chemical Pretreated, Bio polished & Dyed | % Gain/ Loss over Control | Bio Pretreated, Bio polished &Dyed | % Gain/ Loss over Control |
|---|---|---|---|---|---|---|---|---|---|---|
| After Dyeing | LC1SJB1 | 35.95 | 16.16 | -55.05 | 16.71 | -53.52 | 21.85 | -39.21 | 17.62 | -51 |
| | LC1RBB1 | 74.08 | 32.83 | -55.69 | 23.1 | -68.81 | 29.01 | -60.84 | 19.63 | -73.5 |
| | LC2SJB1 | 35.88 | 18.45 | -48.58 | 15.39 | -57.09 | 18.45 | -48.58 | 24.76 | **-30.99** |
| | LC2RBB1 | 98.38 | 39.14 | -60.21 | 39.08 | -60.28 | 53.31 | -45.81 | 42.69 | -56.61 |
| | LC1SJB2 | 35.95 | 22.13 | -38.44 | 16.85 | -53.12 | 22.06 | -38.63 | 15.74 | -56.21 |
| | LC1RBB2 | 74.08 | 25.6 | -65.44 | 22.41 | -69.75 | 28.8 | -61.12 | 20.39 | -72.47 |
| | LC2SJB2 | 35.88 | 18.87 | -47.42 | 22.48 | **-37.35** | 24.46 | -31.82 | 21.02 | -41.42 |
| | LC2RBB2 | 98.38 | 46.44 | -52.8 | 39.21 | -60.14 | 49.35 | -49.83 | 46.37 | -52.87 |
| After Wear | LC1SJB1 | 35.95 | 35.07 | -2.448 | 49.17 | **36.77** | 47.74 | 32.80 | 35.8 | -0.421 |
| | LC1RBB1 | 74.08 | 41.6 | -43.84 | 41.49 | -43.99 | 31.32 | -57.72 | 43.96 | -40.66 |
| | LC2SJB1 | 35.88 | 39.93 | 11.28 | 45.42 | 26.576 | 40.49 | 12.835 | 45.97 | 28.125 |
| | LC2RBB1 | 98.38 | 49.51 | -49.67 | 69.58 | -29.27 | 57.15 | -41.91 | 64.79 | -34.14 |
| | LC1SJB2 | 35.95 | 39.17 | 8.9476 | 29.93 | -16.74 | 35.42 | -1.484 | 39.58 | 10.107 |
| | LC1RBB2 | 74.08 | 30.42 | -58.94 | 43.13 | -41.78 | 59.38 | -19.85 | 41.94 | -43.38 |
| | LC2SJB2 | 35.88 | 33.51 | -6.616 | 31.01 | -13.58 | 40.73 | 13.512 | 52.43 | **46.12** |
| | LC2RBB2 | 98.38 | 54.65 | -44.45 | 74.72 | -24.05 | 101 | 2.6693 | 90.9 | -7.601 |
| F values | LC1SJ | | 43.013** | | 53.706** | | 42.090** | | 69.614** | |
| | LC1RB | | 20.860** | | 40.812** | | 106.256** | | 56.043** | |
| | LC2SJ | | 44.398** | | 48.254** | | 49.355** | | 56.43** | |
| | LC2RB | | 13.468** | | 103.478** | | 193.389** | | 47.21** | |

** Significant at 1% level * Significant at 5% level

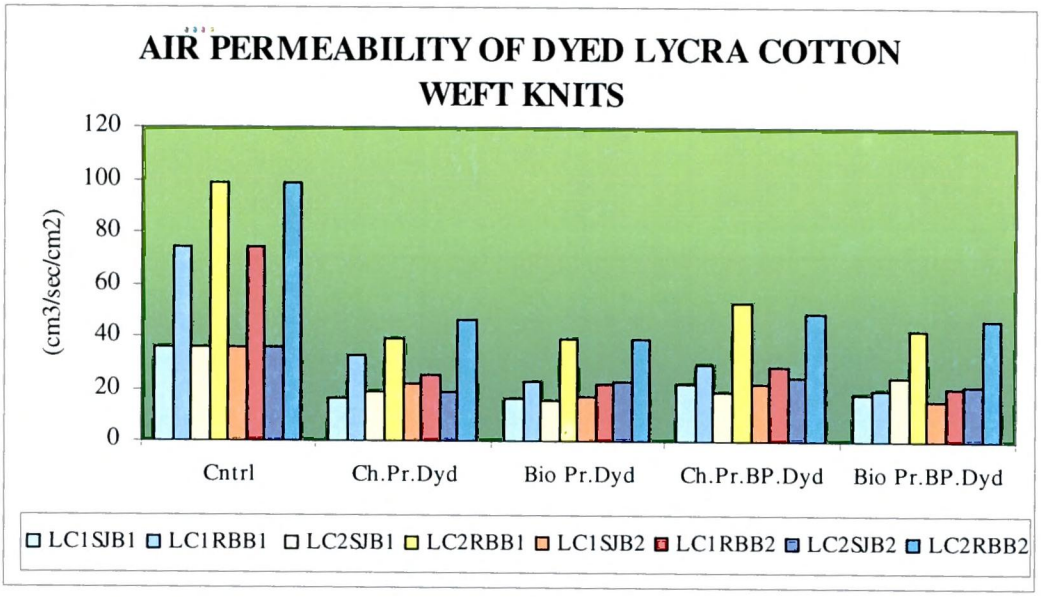
All the samples, statistically analyzed with one-way ANOVA, showed significant differences after the dyeing and wear with respect to air permeability at 1% level.

### ✶ Wicking - 100% Cotton

***Wicking Results of Dyed Cotton Weft Knits***

Table LXI and Figure 42 gives the correlation coefficients, constant and slope values obtained by linear regression analysis by plotting log of height verses log of time in seconds. The log value of height and the log value of time in seconds of cotton weft knits after dyeing are given in Appendix 8.

# AIR PERMEABILITY OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



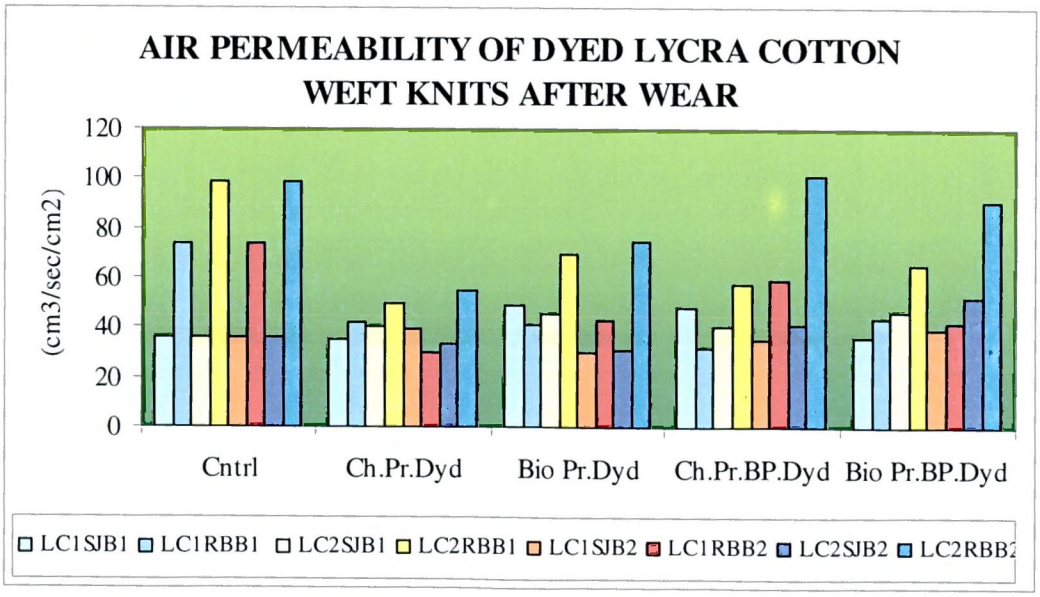




**FIGURE 41**

## TABLE LXI

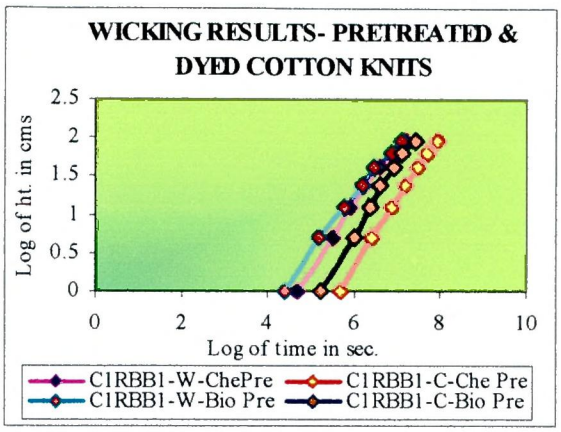
## REGRESSION ANALYSIS FOR WICKING OF DYED COTTON WEFT KNITS

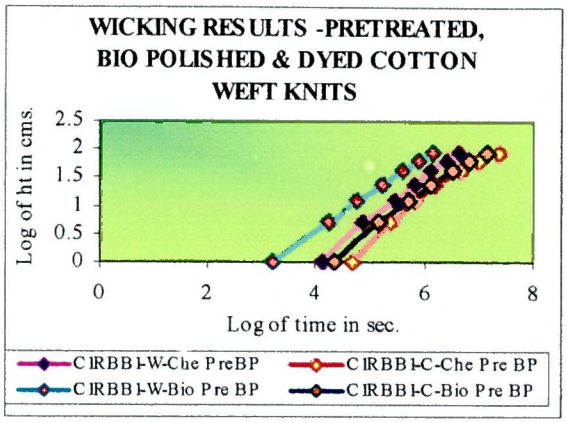
**Model : log (ht) = constant + b. log (time)**

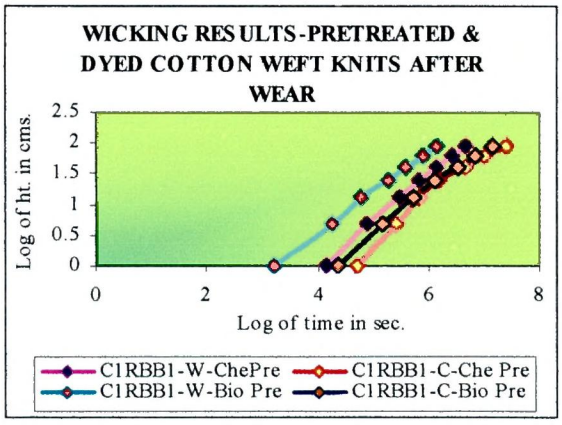
| | Chemical Pretreated & Dyed | | | Bio Pretreated & Dyed | | |
|---|---|---|---|---|---|---|
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope(b) |
| C1SJB1-W | 0.995 | -3.3168 | 0.7543 | 0.999 | -3.7476 | 0.8201 |
| C | 0.998 | -3.0659 | 0.6447 | 0.995 | -4.2645 | 0.8491 |
| C1RBB1-W | 0.995 | -3.0468 | 0.711 | 0.996 | -3.5791 | 0.7771 |
| C | 0.999 | -4.9597 | 0.8766 | 0.992 | -4.7997 | 0.92 |
| C2SJB1-W | 0.997 | -4.0882 | 0.7992 | 0.997 | -2.9213 | 0.6869 |
| C | 0.998 | -2.648 | 0.5656 | 0.994 | -3.4394 | 0.7824 |
| C2RBB1- W | 0.987 | -3.9923 | 0.7545 | 0.991 | -6.0932 | **1.0663** |
| C | 0.997 | -3.335 | 0.6527 | 0.985 | -3.2198 | 0.6692 |
| C1SJB2-W | 0.996 | -3.3912 | 0.7563 | 0.998 | -4.0418 | 0.8517 |
| C | 0.998 | -3.155 | 0.6544 | 0.995 | -4.4565 | 0.872 |
| C1RBB2-W | 0.994 | -3.8155 | 0.8069 | 0.996 | -3.4389 | 0.7626 |
| C | 0.999 | -5.09 | **0.8898** | 0.995 | -4.6579 | 0.9002 |
| C2SJB2-W | 0.995 | -4.4253 | 0.8442 | 0.994 | -2.6757 | 0.6638 |
| C | 0.997 | -2.6504 | 0.5627 | 0.999 | -3.6523 | 0.788 |
| C2RBB2- W | 0.998 | -4.0248 | 0.74 | 0.992 | -6.1716 | 1.0778 |
| C | 0.993 | -3.4073 | 0.6912 | 0.988 | -3.7993 | 0.7117 |
| | Chemical Pretreated & Bio Polished & Dyed | | | Bio Pretreated & Bio Polished & Dyed | | |
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope (b) |
| C1SJB1-W | 0.998 | -3.242 | 0.6825 | 0.995 | -2.7889 | 0.7429 |
| C | 0.999 | -2.7953 | 0.6015 | 0.995 | -2.9325 | 0.7502 |
| C1RBB1-W | 0.998 | -3.1058 | 0.765 | 0.999 | -2.1206 | 0.6642 |
| C | 0.983 | -2.9636 | 0.6978 | 0.995 | -3.1811 | 0.713 |
| C2SJB1-W | 0.998 | -2.5717 | 0.7043 | 0.998 | -3.8844 | 0.7517 |
| C | 0.997 | -3.0498 | 0.6065 | 0.998 | -3.5359 | 0.8005 |
| C2RBB1- W | 0.991 | -2.5374 | 0.6153 | 0.997 | -1.9548 | 0.6265 |
| C | 0.996 | -2.1638 | 0.6326 | 0.996 | -3.2713 | 0.6556 |
| C1SJB2-W | 0.994 | -4.3055 | **0.8301** | 0.997 | -3.0506 | 0.7787 |
| C | 0.998 | -2.8978 | 0.6142 | 0.996 | -3.3763 | 0.8139 |
| C1RBB2-W | 0.997 | -3.3398 | 0.7946 | 1.000 | -3.1057 | 0.8105 |
| C | 0.983 | -3.1522 | 0.7239 | 0.994 | -3.8289 | 0.788 |
| C2SJB2-W | 0.998 | -2.7145 | 0.7238 | 0.998 | -3.8459 | 0.7446 |
| C | 0.975 | -3.7251 | 0.8181 | 0.999 | -5.6391 | **0.942** |
| C2RBB2- W | 0.991 | -2.7376 | 0.6385 | 0.997 | -2.4327 | 0.6955 |
| C | 0.994 | -3.5155 | 0.6847 | 0.996 | -2.7614 | 0.7192 |

From the Regression Analysis Table LXI the highest slope values was observed in bio pretreated and dyed sample C2RBB1 (1.0663) in the wale direction and in bio pretreated, bio polished and dyed samples C2SJB2 (0.942) in the course direction. A majority of the bio pretreated and dyed samples (81.25%) and bio pretreated, bio polished and dyed samples (about 87.5%) had higher slope values than their chemical counter parts, indicating better wickability. Sheth and Musale (2005), narrate that the bulk trial results of bio scouring and bleaching result in better absorbency and whiteness as compared with alkali scouring and bleaching. The correlation coefficient values in all samples was positive ranged from 0.983 to 1.000 indicating good correlation between the log of height verses log of time.

# WICKING RESULTS OF COTTON WEFT KNITS AFTER DYEING AND WEAR



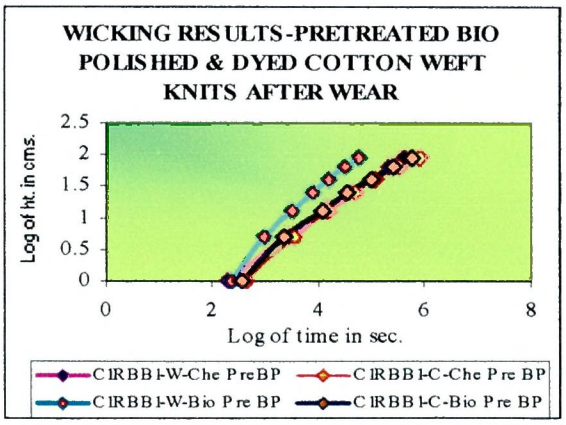




**FIGURE 42**

*Wicking Results of Dyed Cotton Weft Knits After Wear*

Table LXII and Figure 42 gives the correlation coefficients, constant and slope values, of dyed cotton weft knits after wear, obtained by linear regression analysis. The log value of height and the log value of time in seconds, of the dyed cotton weft knits after wear are given in Appendix 8.

**TABLE LXII**

**REGRESSION ANALYSIS OF DYED COTTON WEFT KNITS AFTER WEAR**
**Model : log (ht) = constant + b. log (time)**

| | Chemical Pretreated & Dyed | | | Bio Pretreated & Dyed | | |
|---|---|---|---|---|---|---|
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope(b) |
| C1SJB1-W | 0.998 | -0.8395 | 0.539 | 0.998 | -0.8917 | 0.57 |
| C | 0.995 | -1.4119 | 0.5851 | 0.994 | -1.5111 | 0.6489 |
| C1RBB1-W | 0.997 | -1.5459 | 0.5969 | 1.000 | -2.1614 | 0.7102 |
| C | 0.994 | -2.7841 | **0.8082** | 0.983 | -1.7186 | 0.6437 |
| C2SJB1-W | 0.991 | -1.747 | 0.7105 | 0.998 | -1.9386 | 0.7565 |
| C | 0.997 | -2.7274 | 0.7981 | 0.999 | -1.4845 | 0.631 |
| C2RBB1- W | 0.999 | -1.2517 | 0.5289 | 0.997 | -1.4774 | 0.5861 |
| C | 0.994 | -1.4247 | 0.5568 | 0.995 | -1.8015 | 0.6138 |
| C1SJB2-W | 0.992 | -0.7458 | 0.5353 | 0.994 | -1.9866 | 0.7514 |
| C | 0.997 | -1.4573 | 0.6158 | 0.997 | -2.616 | 0.7808 |
| C1RBB2-W | 0.997 | -1.207 | 0.55 | 0.995 | -2.8503 | 0.8181 |
| C | 0.999 | -0.7581 | 0.4629 | 0.999 | -1.2328 | 0.5321 |
| C2SJB2-W | 0.998 | -1.7371 | 0.6688 | 0.998 | -1.9386 | 0.7565 |
| C | 0.999 | -1.4845 | 0.631 | 0.996 | -2.0244 | 0.7126 |
| C2RBB2- W | 0.994 | -1.5093 | 0.5974 | 0.999 | -2.8191 | 0.7882 |
| C | 0.996 | -0.8532 | 0.4458 | 0.994 | -2.7841 | **0.8082** |
| | Chemical Pretreated & Dyed After Wear | | | Bio Pretreated & Dyed after Wear | | |
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope (b) |
| C1SJB1-W | 0.998 | -0.8701 | 0.5582 | 0.992 | -1.0464 | 0.6461 |
| C | 0.999 | -1.3533 | 0.5798 | 0.989 | -1.3074 | 0.6347 |
| C1RBB1-W | 1.000 | -1.333 | 0.5855 | 0.995 | -1.5977 | 0.6825 |
| C | 0.992 | -1.3963 | 0.5951 | 0.994 | -1.4747 | 0.5964 |
| C2SJB1-W | 0.997 | -0.8385 | 0.5658 | 0.999 | -1.6374 | 0.6962 |
| C | 0.992 | -0.9882 | 0.5126 | 0.999 | -0.6392 | 0.4775 |
| C2RBB1- W | 0.994 | -1.5239 | 0.6182 | 0.993 | -1.8676 | 0.7311 |
| C | 0.997 | -1.3644 | 0.5669 | 0.998 | -2.4327 | 0.7414 |
| C1SJB2-W | 0.996 | -0.6701 | 0.5515 | 0.999 | -2.0339 | 0.7645 |
| C | 0.998 | -1.1658 | 0.5362 | 0.998 | -1.6303 | 0.6779 |
| C1RBB2-W | 0.994 | -1.4023 | **0.6485** | 0.997 | -2.2375 | 0.7479 |
| C | 0.984 | -1.1235 | 0.5102 | 0.997 | -1.6771 | 0.6203 |
| C2SJB2-W | 0.999 | -1.4388 | 0.613 | 0.999 | -1.667 | 0.6776 |
| C | 0.998 | -1.1754 | 0.5363 | 0.998 | -1.5559 | 0.6268 |
| C2RBB2- W | 0.999 | -0.66 | 0.4774 | 0.997 | -2.616 | **0.7808** |
| C | 0.999 | -1.2325 | 0.5313 | 0.998 | -1.2319 | 0.5489 |

From the Regression Analysis Table LXII, it is seen that the highest slope values were similar in both chemical pretreated and dyed sample C1RBB1 (0.8082), in the course direction, and bio pretreated and dyed sample C2RBB2 (0.8082), in the course direction,

after wear. A majority (about 87.5%) of the bio pretreated and dyed samples after wear, had higher slope values when compared to the chemical pretreated and dyed samples after wear.

Bio pretreated, bio polished and dyed samples after wear, showed highest slope values in sample C2RBB2 (0.7808), in the wale direction and among the chemical pretreated, bio polished and dyed samples after wear, highest slope values were noticed in sample C1RBB2 (0.6485), in the wale direction. A majority (about 93.75%) of the bio pretreated, bio polished and dyed samples after wear had higher slope values when compared to the chemical pretreated, bio polished and dyed samples after wear. As the slope value increases, the regression analysis indicates that the fabric has better wicking ability.

The correlation coefficient values in all samples was positive and ranged from 0.983 to 1.000 indicating good correlation between the log of height verses log of time.

✶ **Wicking - Lycra Cotton**

***Wicking Results of Dyed Lycra Cotton Weft Knits***

Table LXIII and Figure 43 gives the correlation coefficients, constant and slope values of dyed lycra cotton weft knits, obtained by linear regression analysis. The log value of height and the log value of time in seconds, of the dyed lycra cotton weft knits are given in Appendix 8.

From the regression analysis Table LXIII the highest slope value of 0.899 was observed in bio pretreated and dyed samples, LC1RBB2 in the wale direction, while among the chemical pretreated and dyed samples, highest slope value of 0.884 was noted in chemical pretreated and dyed sample LC2RBB1. In the case of bio pretreated, bio polished and dyed samples, LC2RBB2 (2.845) had the highest slope value in the course direction. Among the chemical pretreated, bio polished and dyed samples, LC2RBB1(2.253) recorded the highest slope value in the course direction. A majority of the samples (about 81.25%) of the bio pretreated and dyed samples and (about 75%) of the bio pretreated, bio polished and dyed samples exhibited higher slope values than their chemical counterparts.

The correlation coefficient values in all samples was positive ranged from 0.902 to 1.000 indicating good correlation between the log of height verses log of time.

## TABLE LXIII

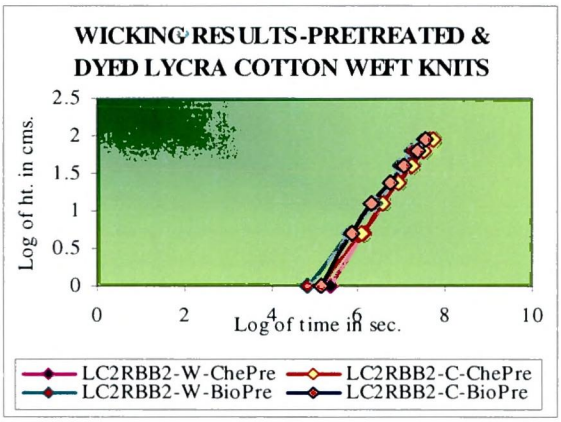
## REGRESSION ANALYSIS FOR WICKING OF DYED LYCRA COTTON WEFT KNITS
**Model : log (ht) = constant + b. log (time)**

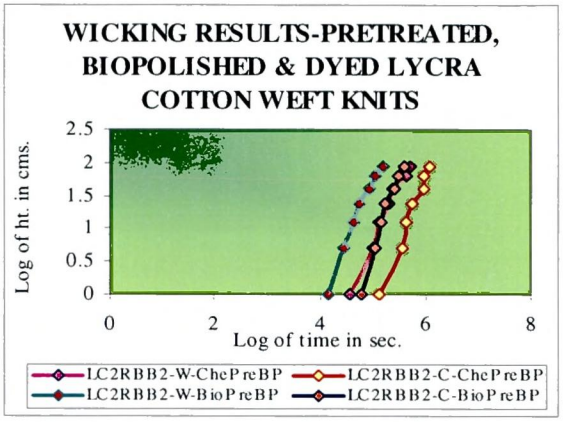
| | Chemical Pretreated & Dyed | | | Bio Pretreated & Dyed | | |
|---|---|---|---|---|---|---|
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope(b) |
| LC1SJB1-W | 0.998 | -2.060 | 0.621 | 0.997 | -2.994 | 0.709 |
| C | 0.999 | -3.895 | 0.800 | 0.999 | -4.048 | 0.855 |
| LC1RBB1-W | 0.999 | -3.286 | 0.697 | 0.997 | -4.412 | 0.863 |
| C | 0.996 | -4.159 | 0.827 | 0.999 | -4.342 | 0.829 |
| LC2SJB1-W | 0.998 | -3.064 | 0.668 | 0.997 | -4.025 | 0.847 |
| C | 1.000 | -3.905 | 0.789 | 0.999 | -3.567 | 0.759 |
| LC2RBB1- W | 0.998 | -4.588 | **0.884** | 0.990 | -2.821 | 0.648 |
| C | 1.000 | -3.714 | 0.738 | 0.999 | -4.153 | 0.815 |
| LC1SJB2-W | 0.993 | -2.431 | 0.638 | 0.996 | -2.887 | 0.742 |
| C | 0.999 | -3.829 | 0.775 | 0.999 | -3.860 | 0.819 |
| LC1RBB2-W | 0.999 | -3.477 | 0.718 | 0.999 | -4.846 | **0.899** |
| C | 1.000 | -4.407 | 0.836 | 0.996 | -4.401 | 0.854 |
| LC2SJB2-W | 0.999 | -4.695 | 0.894 | 0.997 | -2.469 | 0.626 |
| C | 0.999 | -3.103 | 0.678 | 1.000 | -3.094 | 0.682 |
| LC2RBB2- W | 0.999 | -3.625 | 0.746 | 0.999 | -4.496 | 0.847 |
| C | 1.000 | -3.855 | 0.754 | 0.995 | -3.987 | 0.791 |
| | **Chemical Pretreated, Bio Polished & Dyed** | | | **Bio Pretreated, Bio Polished & Dyed** | | |
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope(b) |
| LC1SJB1-W | 0.977 | -5.817 | 1.505 | 0.960 | -8.429 | 2.158 |
| C | 0.988 | -1.630 | 0.661 | 0.907 | -5.243 | 1.334 |
| LC1RBB1-W | 0.877 | -4.529 | 1.228 | 0.902 | -5.135 | 1.241 |
| C | 0.981 | -5.828 | 1.395 | 0.959 | -10.524 | 2.248 |
| LC2SJB1-W | 0.976 | -3.421 | 0.936 | 0.875 | -6.897 | 1.790 |
| C | 0.959 | -7.146 | 1.619 | 0.977 | -4.744 | 1.258 |
| LC2RBB1- W | 0.987 | -7.932 | 1.757 | 0.853 | -6.729 | 1.660 |
| C | 0.918 | -11.462 | **2.253** | 0.864 | -8.495 | 1.884 |
| LC1SJB2-W | 0.956 | -4.826 | 1.280 | 0.940 | -9.633 | 2.382 |
| C | 0.979 | -3.636 | 1.059 | 0.958 | -6.819 | 1.644 |
| LC1RBB2-W | 0.977 | -4.744 | 1.258 | 0.951 | -5.561 | 1.320 |
| C | 0.985 | -7.241 | 1.615 | 0.913 | -12.895 | 2.725 |
| LC2SJB2-W | 0.944 | -5.990 | 1.406 | 0.927 | -9.842 | 2.384 |
| C | 0.973 | -5.270 | 1.248 | 0.936 | -9.053 | 2.121 |
| LC2RBB2- W | 0.985 | -7.898 | 1.739 | 0.944 | -5.821 | 1.471 |
| C | 0.989 | -10.605 | 2.066 | 0.959 | -13.879 | **2.845** |

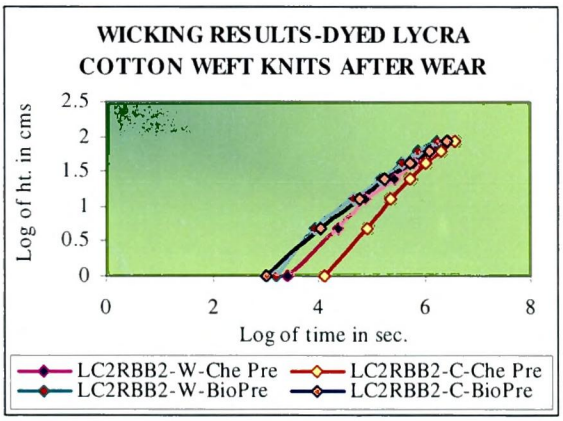
### *Wicking Results of Dyed Lycra Cotton Weft Knits After Wear*

Table LXIV and Figure 43 gives the correlation coefficients, constant and slope values of dyed lycra cotton weft knits after wear, obtained by linear regression analysis. The log value of height and the log value of time in seconds, of the dyed lycra cotton weft knits after wear are given in Appendix 8.

# WICKING RESULTS OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



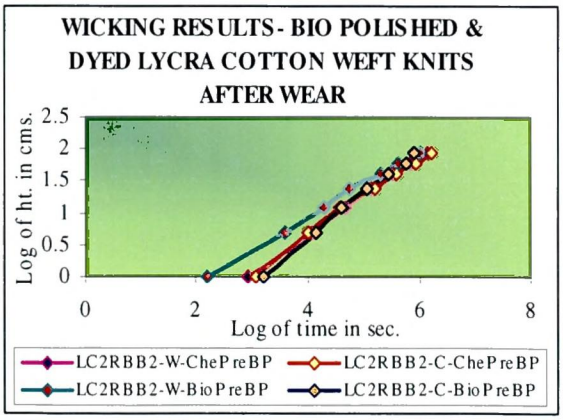




**FIGURE 43**

## TABLE LXIV

## REGRESSION ANALYSIS FOR WICKING OF DYED LYCRA COTTON WEFT KNITS AFTER WEAR

**Model : log (ht) = constant + b. log (time)**

| | Chemical Pretreated & Dyed | | | Bio Pretreated & Dyed | | |
|---|---|---|---|---|---|---|
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope(b) |
| LC1SJB1-W | 0.992 | -2.710 | 0.750 | 0.994 | -1.872 | 0.622* |
| C | 0.996 | -2.334 | 0.679 | 0.984 | -1.744 | 0.607* |
| LC1RBB1-W | 0.999 | -2.105 | 0.634 | 0.990 | -2.206 | 0.670 |
| C | 0.998 | -2.938 | **0.759** | 0.998 | -1.846 | 0.594* |
| LC2SJB1-W | 0.997 | -2.318 | 0.673 | 0.989 | -1.763 | 0.605* |
| C | 0.998 | -1.911 | 0.607 | 0.998 | -1.357 | 0.517* |
| LC2RBB1- W | 0.996 | -2.315 | 0.671* | 0.999 | -3.432 | **0.820** |
| C | 0.998 | -2.693 | 0.698 | 0.997 | -2.699 | 0.707 |
| LC1SJB2-W | 0.998 | -1.147 | 0.522* | 0.999 | -2.121 | 0.664 |
| C | 0.998 | -1.845 | 0.624* | 0.997 | -1.955 | 0.627 |
| LC1RBB2-W | 0.989 | -1.249 | 0.529* | 0.997 | -2.365 | 0.681 |
| C | 0.998 | -1.413 | 0.526* | 0.997 | -3.008 | 0.772 |
| LC2SJB2-W | 0.995 | -1.736 | 0.618* | 0.997 | -1.955 | 0.627 |
| C | 0.995 | -1.837 | 0.615* | 0.997 | -1.955 | 0.627 |
| LC2RBB2- W | 0.993 | -1.842 | 0.619* | 0.997 | -2.105 | 0.637 |
| C | 0.995 | -1.538 | 0.548* | 0.998 | -3.217 | 0.797 |
| | **Chemical Pretreated, Bio Polished & Dyed** | | | **Bio Pretreated, Bio Polished & Dyed** | | |
| | Correlation | Constant (a) | Slope (b) | Correlation | Constant (a) | Slope (b) |
| LC1SJB1-W | 0.998 | -1.393 | 0.582 | 0.999 | -1.495 | 0.605 |
| C | 0.995 | -1.802 | 0.628 | 0.998 | -1.590 | 0.599* |
| LC1RBB1-W | 0.999 | -1.758 | 0.626 | 0.992 | -1.645 | 0.639 |
| C | 0.996 | -1.685 | 0.591* | 0.995 | -1.785 | 0.608 |
| LC2SJB1-W | 0.997 | -1.195 | 0.550* | 0.997 | -1.709 | 0.623 |
| C | 0.991 | -1.759 | 0.577 | 0.998 | -1.565 | 0.592 |
| LC2RBB1- W | 0.998 | -1.564 | 0.591 | 0.997 | -1.826 | 0.642 |
| C | 0.999 | -1.872 | 0.575 | 0.995 | -1.962 | 0.635 |
| LC1SJB2-W | 0.991 | -0.801 | 0.488 | 0.997 | -1.072 | 0.543 |
| C | 0.995 | -1.330 | 0.542 | 0.994 | -1.945 | 0.682 |
| LC1RBB2-W | 0.999 | -1.005 | 0.495 | 0.997 | -1.679 | 0.631 |
| C | 0.999 | -1.798 | 0.615 | 0.996 | -1.238 | 0.549* |
| LC2SJB2-W | 0.997 | -1.869 | **0.659** | 0.999 | -1.495 | 0.605* |
| C | 0.995 | -1.318 | 0.518 | 0.992 | -1.251 | 0.555 |
| LC2RBB2- W | 0.999 | -1.803 | 0.616 | 0.999 | -1.157 | 0.523* |
| C | 0.995 | -1.785 | 0.608 | 0.996 | -2.133 | **0.683** |

The Regression Analysis Table LXIV reveals that after wear, highest slope values in bio pretreated and dyed sample LC2RBB1 (0.820) in the wale direction and in bio pretreated, bio polished and dyed sample LC2RBB2 (0.683) in the course direction. Among the chemical pretreated and dyed samples after wear, sample LC1RBB1 showed a high slope value of 0.759 in the course direction while sample LC2SJB2 in the wale direction, showed a high slope value of 0.659 among the chemical pretreated, bio polished and dyed samples after wear.

The regression analysis indicates that a majority of the samples which had undergone enzymatic treatment had higher slope values, before and after wear, thereby emphasizing the fact that enzymatic treatment attributes good wicking qualities to the fabric. Shabarbaty *et al.* (2008), express that wear comfort of clothing concerns with the heat and moisture transport properties and the way it helps to maintain the heat balance of the body during various levels of activity. Hence good wickability of the fabric helps in fulfilling the thermo-physiological comfort.

The correlation coefficient values in all samples was positive ranged from 0.989 to 0.999 indicating good correlation between the log of height verses log of time.

✶ **Dimensional Change - 100% Cotton**

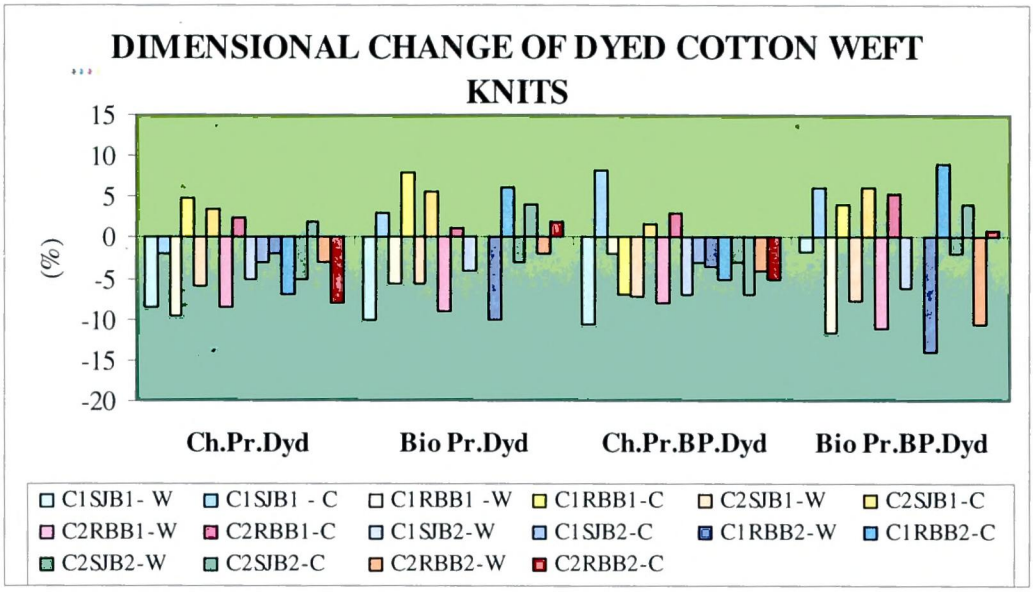
The dimensional changes in the fabric, after dyeing and wear, are given along with the F values, in Table LXV and Figure 44.

**TABLE LXV**
**DIMENSIONAL CHANGE OF COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Dimensional Change (%) | Sample | Chemical Pretreated & Dyed | Chemical Pretreated & Dyed after wear | Bio pretreated & Dyed | Bio pretreated & Dyed after wear | Chemical Pretreated & Bio polished & Dyed | Chemical Pretreated Bio polished& Dyed After wear | Bio Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed After wear |
|---|---|---|---|---|---|---|---|---|---|
| After dyeing and wear | C1SJB1- W | -8.6 | -10 | -10 | -11 | -10.6 | -10 | -1.6 | -8 |
| | C1SJB1 - C | -2 | 5.2 | 3 | 10 | 8.2 | 13 | 6 | 11 |
| | C1RBB1 -W | -9.6 | -14 | -5.6 | -9 | -2 | -10 | -11.6 | -14 |
| | C1RBB1-C | 4.8 | 21 | 8 | 19 | -7 | 28.8 | 4 | 23.6 |
| | C2SJB1-W | -6 | -7 | -5.6 | -7.7 | -7.2 | -6.7 | -7.6 | -5.6 |
| | C2SJB1-C | 3.4 | 9 | 5.7 | 8 | 1.6 | 2.5 | 6 | 7.7 |
| | C2RBB1-W | -8.6 | -12.5 | -9 | -8 | -8 | -15 | -11 | -12.4 |
| | C2RBB1-C | 2.4 | 10.5 | 1.2 | 9.5 | 3 | 12.3 | 5.4 | 10.2 |
| | C1SJB2-W | -5 | -3.6 | -4 | **0** | -7 | -2 | -6.2 | -4 |
| | C1SJB2-C | -3 | 13.8 | **0** | 7.5 | -3 | 1.62 | **0** | 3.2 |
| | C1RBB2-W | -2 | -3.2 | -10 | -2.6 | -3.52 | -4 | -14 | -5.1 |
| | C1RBB2-C | -7 | 9.6 | 6 | 7.8 | -5 | 20 | 9 | 10 |
| | C2SJB2-W | -5 | -3.6 | -3 | **0** | -3 | **0** | -2 | -2 |
| | C2SJB2-C | 2 | 9.2 | 4 | 5 | -7 | 3.8 | 4 | 4.5 |
| | C2RBB2-W | -3 | -4.8 | -2 | -4 | -4 | -5 | -10.5 | -6.4 |
| | C2RBB2-C | -8 | 11 | 2 | 14 | -5 | 20 | 1 | 12 |
| F values | C1SJ-W | 180.634** | | 803.509** | | 15.754** | | 183.373** | |
| | C1RB-W | 941.853** | | 408.587** | | 347.033** | | 323.527** | |
| | C2SJ-W | 216.174** | | 969.634** | | 723.950** | | 367.776** | |
| | C2RB-W | 541.579** | | 376.297** | | 977.497** | | 228.919** | |
| | C1SJ-C | 1125.978** | | 601.291** | | 28.758** | | 610.227** | |
| | C1RB-C | 4782.049** | | 657.996** | | 11100.250** | | 1689.012** | |
| | C2SJ-C | 256.250** | | 219.126** | | 646.372** | | 110.132** | |
| | C2RB-C | 1892.706** | | 2689.881** | | 3967.453** | | 899.708** | |

[ W – wales, C –Courses] [** Significant at 1% level * Significant at 5% level]

# DIMENSIONAL CHANGE OF COTTON WEFT KNITS AFTER DYEING AND WEAR



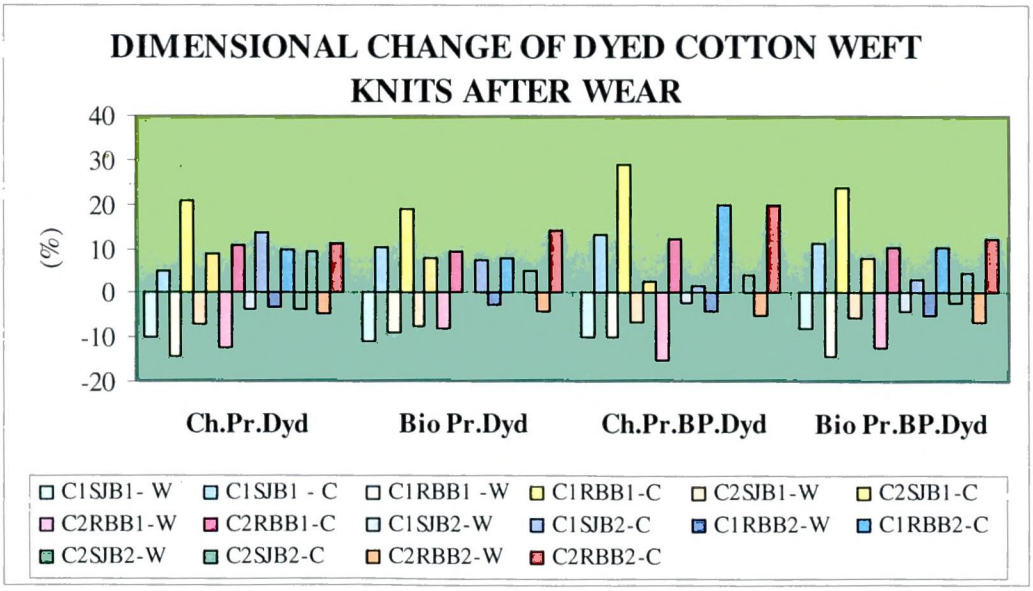




**FIGURE 44**

The Table LXV shows that all samples exhibited negative values in both fabric structures, the wale direction, indicating shrinkage and the course direction recorded positive values indicating growth. The value near zero indicates better dimensional stability. In the course direction, sample C1SJB2, bio pretreated with and without bio polishing and dyeing exhibited zero indicating good dimensional stability. A majority of the samples after bio polishing showed lower values in both wale and course directions, showing that the fabric has become more stable.

A mixed response was noticed in the samples after wear. However zero values were noticed in bio pretreated and dyed samples C1SJB2 and C2SJB2 in the wale direction and in chemical pretreated, bio polished and dyed sample C2SJB2 in the wale direction.

The F values showed significant differences with regard to dimensional stability in all samples, after dyeing and wear, at 1% level in both wale and course directions.

✶ **Dimensional Change - Lycra Cotton**

The dimensional changes in the fabric after dyeing and wear are presented, with the F test values, in Table LXVI and Figure 45.

From Table LXVI, bio pretreated and dyed sample LC1RBB2 shows zero value in the course direction, indicating good dimensional stability. Zero value was also noted in bio pretreated, bio polished and dyed samples LC2RBB1 and LC1RBB2, in the course direction, proving that these fabrics were dimensionally stable.

After wear, higher values were noted in a majority of the samples which may be due to the impact of agitation in the tumble washing machine. After wear, the lowest value of -1% was noted in bio pretreated and dyed sample LC1SJB2 in the wale direction and in bio pretreated, bio polished and dyed sample LC2RBB2 with -3.25% in the wale direction.

The one way ANOVA values revealed significant differences in all samples, after dyeing and wear, with respect to dimensional stability at 1% level in both the wale and course directions.

**TABLE LXVI**
**DIMENSIONAL CHANGE OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR**

| Units in (%) | Sample | Chemical Pretreated & Dyed | Chemical Pretreated & Dyed after wear | Bio pretreated & Dyed | Bio pretreated & Dyed after wear | Chemical Pretreated & Bio polished & Dyed | Chemical Pretreated Bio polished& Dyed after wear | Bio pretreated & Bio Polished & Dyed | Bio pretreated, Bio Polished & Dyed after wear |
|---|---|---|---|---|---|---|---|---|---|
| After dyeing and wear | LC1SJB1- W | -10 | -16 | -10 | -12 | -8.6 | -12.5 | -10 | -11 |
| | LC1SJB1 - C | 7 | 13.5 | 9 | 13 | 2.6 | 5.2 | 4.8 | 9 |
| | LC1RBB1 -W | -9 | -11.5 | -10 | -13 | -3.6 | -6 | -8 | -13 |
| | LC1RBB1-C | 2.4 | 10 | 2 | 11.6 | 0.4 | 9 | 0 | 13 |
| | LC2SJB1-W | -9 | -15 | -12 | -10 | -9 | -13 | -7 | -8 |
| | LC2SJB1-C | 4.6 | 11.2 | 6.4 | 10.4 | 4.4 | 10.4 | 2 | 7 |
| | LC2RBB1-W | -13 | -15.6 | -9.2 | -12 | -10.6 | -12 | -6 | -11 |
| | LC2RBB1-C | 7 | 14 | 0.8 | 10.4 | 6 | 17 | **0** | 13.48 |
| | LC1SJB2-W | -6 | -6 | -6 | **-1** | -7.8 | -6 | -8 | -4.8 |
| | LC1SJB2-C | 4 | 12 | 1 | 5 | 4 | 11 | 4 | 11.4 |
| | LC1RBB2-W | -10 | -11.2 | -4 | -4 | -8 | -10 | -8 | -4 |
| | LC1RBB2-C | 1.2 | 8 | **0** | 8 | -3 | 14 | **0** | 7 |
| | LC2SJB2-W | -5.4 | -5.4 | -6.4 | -1.4 | -6.52 | -4.72 | -8.6 | -5.2 |
| | LC2SJB2-C | -1 | 9 | 3.8 | 7.8 | -1 | 8 | 8 | 18 |
| | LC2RBB2-W | -11.2 | -12.2 | -9.6 | -9.6 | -6 | -8 | -7.12 | **-3.25** |
| | LC2RBB2-C | 2 | 9.8 | 1.2 | 9.2 | 7 | 10 | 3 | 10 |
| F values | LC1SJ-W | 572.595** | | 498.204** | | 9.684** | | 167.950** | |
| | LC1RB-W | 84.391** | | 606.178** | | 481.673** | | 1720.920** | |
| | LC2SJ-W | 548.894** | | 1139.550** | | 298.022** | | 68.672** | |
| | LC2RB-W | 142.865** | | 251.113** | | 229.351** | | 330.191** | |
| | LC1SJ-C | 546.475** | | 615.562** | | 34.698** | | 149.173** | |
| | LC1RB-C | 848.447** | | 1160.706** | | 1981.779** | | 370.560** | |
| | LC2SJ-C | 2061.041** | | 282.189** | | 440.615** | | 1257.026** | |
| | LC2RB-C | 1703.240** | | 2498.516** | | 865.694** | | 1200.846** | |

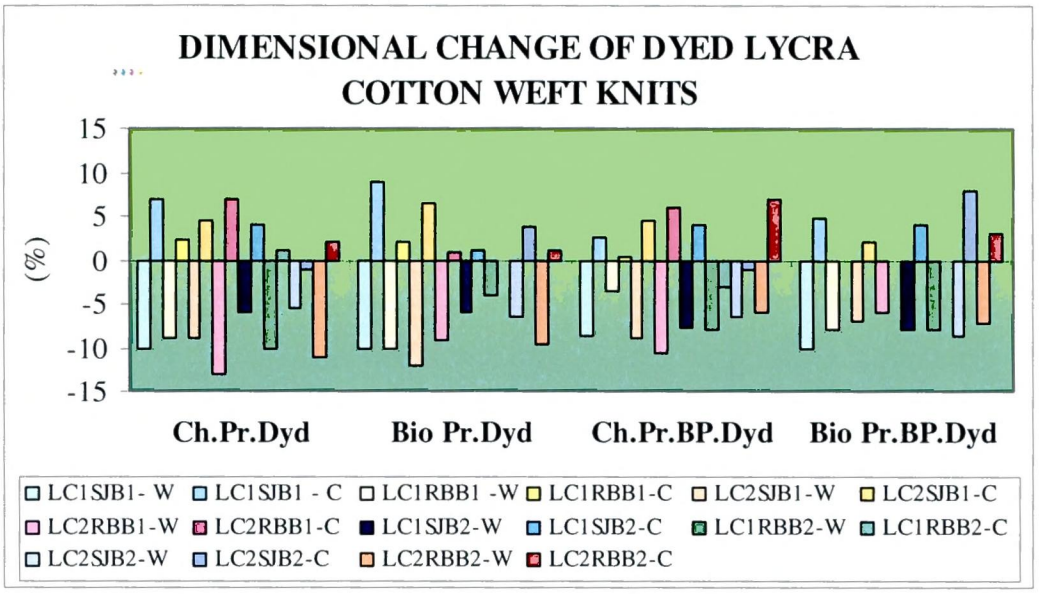
[ W – wales, C –Courses] [** Significant at 1% level * Significant at 5% level]

✶ **Colour Fastness - 100% Cotton**

The colour fastness test results of the cotton weft knits after dyeing and wear are presented in Table LXVII.

From the Table LXVII, it is evident that the overall colour fastness results of both chemical processed and bio processed samples were good. The colour fastness results to washing shows that a majority of the bio pretreated dyed (4/5 to 5) and the bio pretreated, bio polished and dyed samples (4/5 to 5) were better than the chemical processed samples (4).

# DIMENSIONAL CHANGE OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



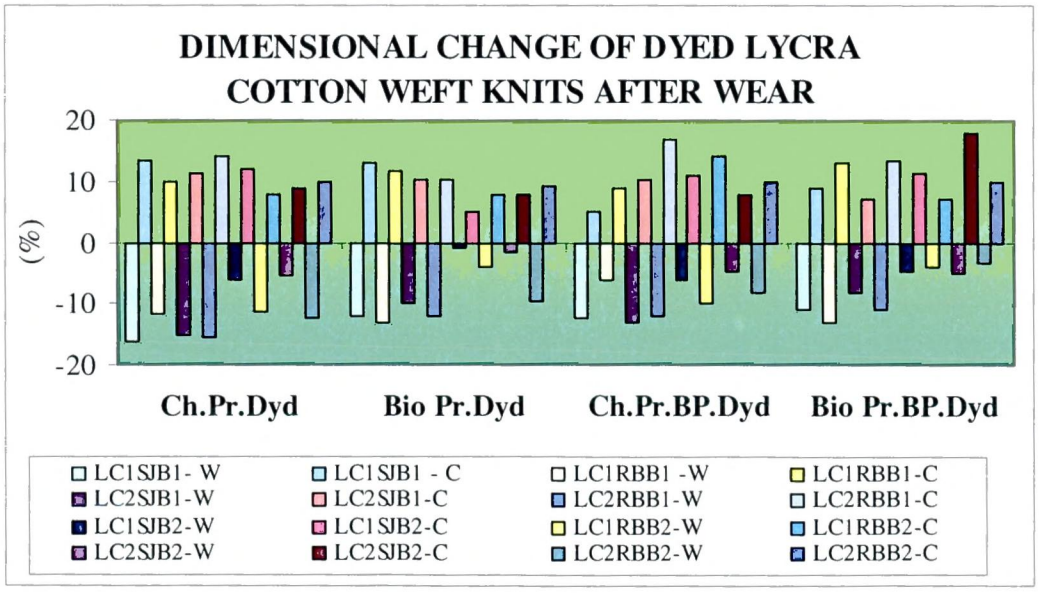




**FIGURE 45**

## TABLE LXVII

## COLOUR FASTNESS OF COTTON WEFT KNITS AFTER DYEING AND WEAR

| Sample | Chemical Pretreated & Dyed | | Chemical Pretreated & Dyed after wear | | Bio pretreated & Dyed | | Bio pretreated & Dyed after wear | | Chemical Pretreated Bio polished& Dyed | | Chemical Pretreated Bio polished& Dyed after wear | | Bio pretreated, Bio Polished & Dyed | | Bio pretreated, Bio Polished & Dyed after wear | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wash Fastness** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** |
| C1SJB1 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 |
| C1RBB1 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 |
| C2SJB1 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 |
| C2RBB1 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 |
| C1SJB2 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 |
| C1RBB2 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 |
| C2SJB2 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 |
| C2RBB2 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 |
| **Light Fastness** | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | |
| C1SJB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3-4 | |
| C1RBB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| C2SJB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| C2RBB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| C1SJB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3-4 | |
| C1RBB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| C2SJB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| C2RBB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| **Fastness To Perspiration** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** |
| C1SJB1- Cc | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| C1SJB1-St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C1RBB1 -Cc | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| C1RBB1 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C2SJB1-Cc | 3/4 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 3 | 3 | 4 | 5 | 4 | 4 |
| C2SJB1- St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C2RBB1 -Cc | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| C2RBB1 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C1SJB2 -Cc | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 |
| C1SJB2 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C1RBB2 -Cc | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| C1RBB2 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C2SJB2 -Cc | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| C2SJB2- St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| C2RBB2 -Cc | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 |
| C2RBB2 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| **Fastness To Crocking** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** |
| C1SJB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| C1RBB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| C2SJB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| C2RBB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| C1SJB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| C1RBB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| C2SJB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| C2RBB2- St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |

B1 –Light Blue Colour; Ac -Acid Perspiration; W- Wet Crocking; Cc - Colour Change

B2 –Dark Blue Colour Al -Alkaline Perspiration; D- Dry Crocking; St - Staining

**Grey Scale Ratings :**

For Colour Change : 1- Very Poor, 2 – Poor, 3- Moderate, 3/4- Fair, 4- Good, 4/5 – Very Good, 5 – Excellent.

For Staining: 1- Very Poor, 1/2 - Poor, 2/3 – 3- Moderately Poor, 3/4 –Fair, 4 –Good, 4/5 – Very Good, 5-Excellent.

It may be observed that after wear there is a reduction in the grey scale readings which may be attributed to the loss of colour due to the rigours of repeated washing. The grey scale ratings for staining are similar for both cases.

The grey scale ratings for light fastness are similar in both the bio pretreated dyed and the bio pretreated, bio polished and dyed samples and their chemical counterparts before and after wear.

The colour fastness to perspiration results indicate that in all cases the ratings for colour change in acid perspiration was lower than alkaline perspiration. A subsequent reduction was also noted after wear. In the case of staining to cotton all the samples were rated from good (4) to excellent (5). In both cases, colour change ratings and the staining ratings, the bio processed samples (4-5) had better results than the chemical processed samples (3/4-4).

The colour fastness to crocking results revealed that the fastness to dry crocking (5) was better than the fastness to wet crocking (4/5). The grey scale ratings for colour change and staining had similar results in both bio processed and chemical processed and dyed samples before and after wear.

On the whole the colour fastness results revealed that the bio pretreated and dyed and the bio pretreated plus bio polished and dyed samples were almost equal to or slightly better than the chemical pretreated and dyed and the chemical pretreated plus bio polished and dyed samples, before and after wear. Losonczi (2004) affirms that there was no differences in the colour fastness properties between the conventionally scoured and bio pretreated and dyed cotton fabrics.

**✶ Colour Fastness - Lycra Cotton**

The colour fastness test results of the lycra cotton weft knits after dyeing and wear are presented in Table LXVIII.

From the Table LXVIII, it is clear that the colour fastness was good in both chemical and bio pretreated samples. The wash fastness results revealed that the bio pretreated, dyed (good to excellent) and the bio pretreated, bio polished dyed samples (very good to excellent) showed higher ratings than the chemical pretreated and chemical pretreated, bio polished dyed samples. After wear the ratings were almost same in all cases except for a few samples. The grey scale ratings for staining were similar for most of the cases and exhibited good results irrespective of the processing done and fabric composition and structure.

## TABLE LXVIII
## COLOUR FASTNESS OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR

| Sample | Chemical Pretreated & Dyed | | Chemical Pretreated & Dyed after wear | | Bio pretreated & Dyed | | Bio pretreated & Dyed after wear | | Chemical Pretreated Bio polished& Dyed | | Chemical Pretreated Bio polished& Dyed after wear | | Bio pretreated, Bio Polished & Dyed | | Bio pretreated, Bio Polished & Dyed after wear | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wash Fastness** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** | **Cc** | **St** |
| LC1SJB1 | 4 | 4/5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 |
| LC1INB1 | 4 | 4/5 | 3 | 5 | 4/5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 |
| LC2SJB1 | 4 | 4/5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 |
| LC2INB1 | 4 | 4/5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 |
| LC1SJB2 | 4 | 4/5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 |
| LC1INB2 | 4 | 4/5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 3 | 5 |
| LC2SJB2 | 4 | 4/5 | 3 | 5 | 4/5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3/4 | 5 |
| LC2INB2 | 4 | 4/5 | 3 | 5 | 4/5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 4/5 | 5 | 3 | 5 |
| **Light Fastness** | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | | **Cc** | |
| LC1SJB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3-4 | |
| LC1INB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| LC2SJB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| LC2INB1 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| LC1SJB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3-4 | |
| LC1INB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| LC2SJB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| LC2INB2 | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | | 4 | | 3 | |
| **Fastness To Perspiration** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** | **Ac** | **Al** |
| LC1SJB1- Cc | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| LC1SJB1-St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC1INB1 - Cc | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| LC1INB1 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC2SJB1- Cc | 3/4 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 3 | 3 | 4 | 5 | 4 | 4 |
| LC2SJB1- St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC2INB1 - Cc | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3/4 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| LC2INB1 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC1SJB2 - Cc | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 |
| LC1SJB2 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC1INB2 - Cc | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| LC1INB2 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC2SJB2 - Cc | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 2/3 | 3 | 4 | 5 | 4 | 4 |
| LC2SJB2- St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| LC2INB2 - Cc | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 5 | 4 | 4 |
| LC2INB2 - St | 4 | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4 | 4/5 | 4/5 | 5 | 4/5 | 5 |
| **Fastness To Crocking** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** | **W** | **D** |
| LC1SJB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| LC1INB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| LC2SJB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| LC2INB1 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| LC1SJB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| LC1INB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 |
| LC2SJB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| LC2INB2 - St | 4/5 | 5 | 4 | 4 | 4/5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |

B1 –light blue colour; Ac -Acid Perspiration; W- Wet Crocking; Cc - Colour Change
B2 –dark blue colour Al -Alkaline Perspiration; D- Dry Crocking; St - Staining

**Grey Scale ratings :**

For Colour Change : 1- very poor, 2 – poor, 3- moderate, 3/4- Fair, 4- good, 4/5 – very good, 5 – excellent.
For Staining: 1- very poor, 1/2 - poor, 2/3 – 3- moderately poor, 3/4 –Fair, 4 –good, 4/5 – very good, 5-exccellent.

The light fastness results gave similar results for both the chemical and bio pretreated and dyed and the pretreated, bio polished and dyed samples. After wear the same ratings were seen in all cases. No difference was noticed between knit structures, type of yarn and depth of shade.

The colour fastness results to perspiration highlighted that the bio pretreated, bio polished and dyed samples exhibited very good to excellent ratings whereas their chemical counter parts were rated as (3/4) fair to good (4). It was noted that the colour fastness to acid perspiration was (3) moderate to fair (3/4). The same trend was noticed in all samples after wear. The grey scale ratings for staining were recorded as (4/5) very good to excellent (5) in all cases.

The colour fastness to crocking showed better results to dry cocking when compared to wet crocking in all cases. Here again the bio pretreated samples exhibited same results as their chemical counter parts.

On the whole it was found that the bio pretreated and bio polished samples dyed in both light and dark shades presented better ratings; after wear, colour fastness ratings also showed the same trend highlighting the fact that bio pretreatment and bio polishing lead from good to excellent dye sustainability before and after the laundering processes. Vigneswaran (2004) states that the wash fastness, rubbing fastness and fastness to perspiration ratings of the bio processed lycra cotton fabrics were better with reference to both colour change and staining.

✶ **Instrumental Colour Measurements - 100% Cotton**

The spectro photometric results, which include Colour Difference, Relative Colour Strength and K/S values, of the cotton weft knits after dyeing and wear are presented in Table LXIX and Figure 46.

From the Table LXIX, it is seen that there is a range in values from low to high between the samples from 0.35 as lowest to 1.97 as highest. The chemical pretreated and dyed samples were taken as standard and the colour difference $\Delta E$ was tabulated. $\Delta E$ values are assessed by referencing a limit of $\Delta E \leq 1$. $\Delta E$ value 0.9 to 1 is considered to be marginally acceptable, beyond which the difference is too high for acceptance between samples and standard. About 35% of the bio pretreated bio polished and dyed samples showed higher values when compared to the chemical pretreated and dyed samples since the dye uptake was greater.

## TABLE LXIX

## COLOUR DIFFERENCE, RELATIVE COLOUR STRENGTH AND K/S VALUES OF DYED COTTON WEFT KNITS

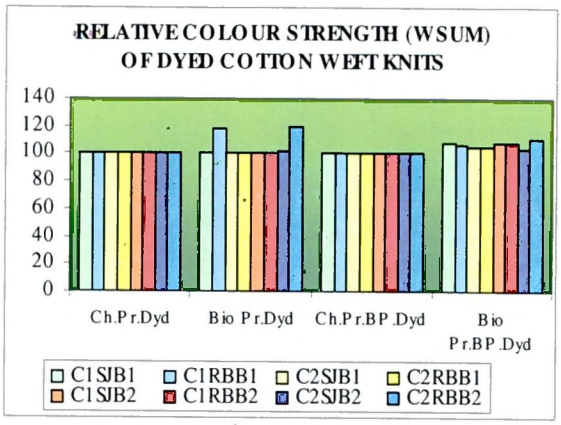
| Sample | COLOUR DIFFERENCE (ΔE) | | | | RELATIVE COLOUR STRENGTH (WSUM) | | | | K/S | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chemical Pretreated & Dyed | Bio pretreated & Dyed | Chemical Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed | Chemical Pretreated & Dyed | Bio pretreated & Dyed | Chemical Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed | Chemical Pretreated & Dyed | Bio pretreated & Dyed | Chemical Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed |
| **After Dyeing** | | | | | | | | | | | | |
| C1SJB1 | std | 0.35 | std | 0.61 | 100 | 100.83 | 100 | 107.58 | 1.25 | 1.28 | 1.14 | 1.23 |
| C1RBB1 | std | 1.06 | std | 0.62 | 100 | 118.08 | 100 | 106.59 | 1.29 | 1.45 | 1.03 | 1.28 |
| C2SJB1 | std | 0.84 | std | 0.5 | 100 | 100.74 | 100 | 104.32 | 1.33 | 1.52 | 1.14 | 1.42 |
| C2RBB1 | std | 0.83 | std | 0.56 | 100 | 100.41 | 100 | 104.98 | 1.30 | 1.38 | 1.14 | 1.23 |
| C1SJB2 | std | 1.61 | std | 0.32 | 100 | 101.06 | 100 | 107.85 | 10.21 | 22.38 | 20.56 | 21.53 |
| C1RBB2 | std | 0.7 | std | 0.76 | 100 | 100.42 | 100 | 108.46 | 21.74 | 22.38 | 19.17 | 21.33 |
| C2SJB2 | std | 0.5 | std | 0.12 | 100 | 101.42 | 100 | 104.01 | 23.64 | 24.92 | 22.48 | 23.16 |
| C2RBB2 | std | 1.97 | std | 0.46 | 100 | 120.23 | 100 | 110.26 | 21.33 | 23.40 | 21.74 | 22.16 |
| **After Wear** | | | | | | | | | | | | |
| C1SJB1 | std | 0.30 | std | 0.52 | 100 | 104.85 | 100 | 109.17 | 1.22 | 1.31 | 1.16 | 1.26 |
| C1RBB1 | std | 0.46 | std | 0.58 | 100 | 102.62 | 100 | 109.23 | 1.39 | 1.41 | 1.30 | 1.39 |
| C2SJB1 | std | 0.43 | std | 0.53 | 100 | 104.82 | 100 | 107.83 | 1.25 | 1.55 | 1.18 | 1.55 |
| C2RBB1 | std | 0.45 | std | 0.54 | 100 | 103.76 | 100 | 109.16 | 1.27 | 1.51 | 1.21 | 1.42 |
| C1SJB2 | std | 0.54 | std | 0.83 | 100 | 102.55 | 100 | 105.83 | 20.53 | 23.08 | 21.34 | 22.53 |
| C1RBB2 | std | 0.43 | std | 0.55 | 100 | 105.67 | 100 | 110.54 | 23.60 | 24.29 | 20.98 | 23.19 |
| C2SJB2 | std | 0.06 | std | 0.72 | 100 | 102.65 | 100 | 104.64 | 24.39 | 25.61 | 22.16 | 22.93 |
| C2RBB2 | std | 0.76 | std | 1 | 100 | 105.22 | 100 | 111.76 | 23.16 | 24.14 | 20.94 | 23.64 |

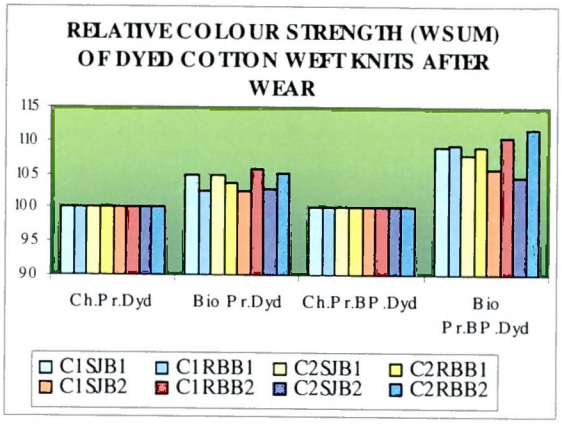
[B1 – dyed with light blue colour; B2 – dyed with dark blue colour]

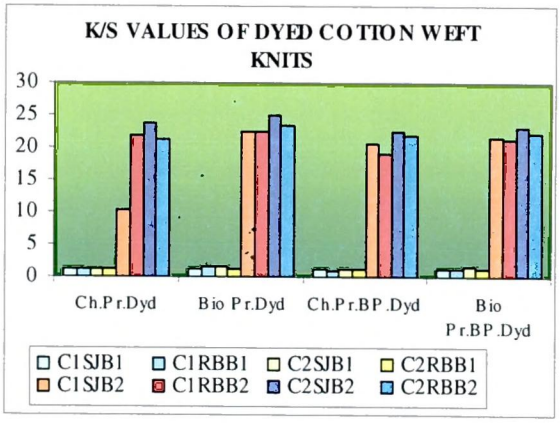
Singh and Goel (2004) explain that the enzymatic treatment enhances the surface tension of the fabric, which improves the moisture holding capacity and absorption of dyes. After bio polishing and dyeing the variation was lower highlighting the fact that bio polishing renders even and consistent dyeing resulting in lower colour differences. After wear, the ΔE values showed that the colour differences were within the reference standards indicating that both the chemical and bio pretreated samples with and without bio polishing have attained the same colour deviations which are within acceptable limits.

The Table LXIX reveals that the relative colour strength was marginally higher in the bio pretreated dyed samples when compared to the chemical standard whereas the bio pretreated, bio polished samples have recorded substantially higher values when compared to the chemical pretreated, bio polished, dyed standard. The chemical standard was 100 and the readings greater than 100 indicate better colour strength. After wear, the relative colour strength values are high in the bio pretreated and dyed samples. This trend was also seen in

# INSTRUMENTAL COLOUR MEASUREMENTS OF COTTON WEFT KNITS AFTER DYEING AND WEAR



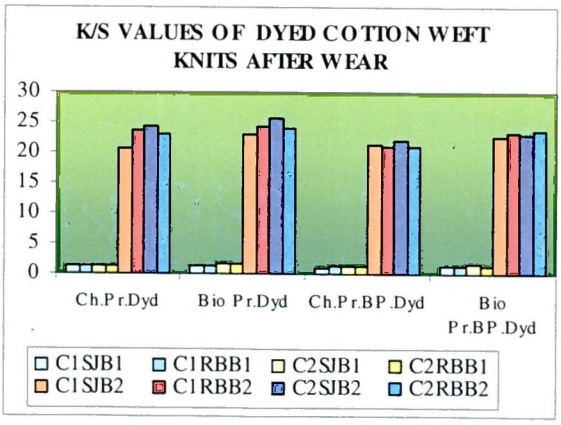




**FIGURE 46**

the bio polished samples. The readings highlight the fact that the same trend was maintained before and after wear.

In all cases the K/S values of the bio pretreated samples showed higher values than the chemical pretreated samples. Ismal *et al.* (2007) comment that K/S values of the alkali pretreated fabrics can be easily reached by the enzymatically pretreated fabrics. Even higher colour depths could be obtained. The cellulase enzyme removes the protruding fibres which in turn decreases the scattering coefficient, thus increasing the K/S values of cellulase treated materials, explain Tyagi and Gupta (2009). After wear a marginal reduction in values are seen in few cases but in all other cases the same trend was maintained.

✶ **Instrumental Colour Measurements - Lycra Cotton**

The spectro photometric results namely Colour Difference, Relative Colour Strength and K/S values, of lycra cotton weft knits after dyeing and wear are presented in Table LXX and Figure 47.

The colour difference and relative colour strength was computed with the chemical pretreated and dyed samples as the standard. The Table LXX reveals that about 75 per cent of the samples that were bio pretreated and dyed had colour difference values which were more than the acceptable standard which is $\Delta E \leq 1$. This indicates that the dye uptake was very good in the case of the bio pretreated and dyed samples when compared to the chemical standard. Wasif and Laga (2004) state that enzyme treatment before dyeing improves the dye uptake, colour strength and the K/S values due to enzymatic catalysis.

In the case of the bio pretreated, bio polished and dyed samples, the colour difference values were within the acceptable limits as both the chemical and bio pretreated samples have been treated with the bio polishing enzyme. This indicates that bio polishing treatment gave consistent even results in both the chemical and bio pretreated samples. Diller *et al.*(1999) report that if cellulase treatment was performed prior to dyeing, higher K/S values were observed and the increase was from 19 to 32 per cent greater than the K/S values of untreated fabrics. After wear, except for one or two samples, the colour differences were within the limit indicating that after repeated laundering the dyed samples exihibited marginal difference in colour.

## TABLE LXX

## COLOUR DIFFERENCE, RELATIVE COLOUR STRENGTH AND K/S VALUES OF DYED LYCRA COTTON WEFT KNITS

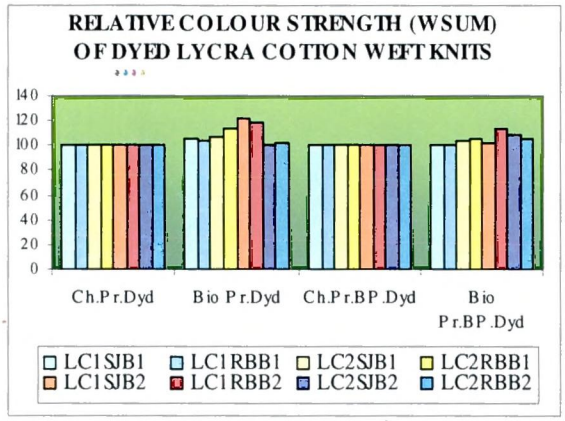
| Sample | Colour Difference (ΔE) | | | | Relative Colour Strength (WSUM) | | | | K/S | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chemical Pretreated & Dyed | Bio pretreated & Dyed | Chemical Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed | Chemical Pretreated & Dyed | Bio pretreated & Dyed | Chemical Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed | Chemical Pretreated & Dyed | Bio pretreated & Dyed | Chemical Pretreated Bio polished& Dyed | Bio pretreated, Bio Polished & Dyed |
| **After Dyeing** | | | | | | | | | | | | |
| LC1SJB1 | std | 1.43 | std | 0.61 | 100 | 105.07 | 100 | 101.17 | 0.94 | 1.01 | 0.90 | 1.27 |
| LC1RBB1 | std | 1.01 | std | 0.39 | 100 | 102.95 | 100 | 100.10 | 0.88 | 0.96 | 0.85 | 1.45 |
| LC2SJB1 | std | 1.59 | std | 0.33 | 100 | 106.33 | 100 | 104.37 | 0.98 | 1.03 | 1.01 | 1.95 |
| LC2RBB1 | std | 1.11 | std | 0.38 | 100 | 113.14 | 100 | 106.17 | 0.99 | 1.10 | 0.96 | 1.28 |
| LC1SJB2 | std | 1.88 | std | 0.21 | 100 | 122.44 | 100 | 101.40 | 12.36 | 15.52 | 13.64 | 16.56 |
| LC1RBB2 | std | 1.55 | std | 1.06 | 100 | 118.15 | 100 | 114.15 | 13.11 | 14.99 | 13.47 | 17.23 |
| LC2SJB2 | std | 0.18 | std | 0.75 | 100 | 100.46 | 100 | 109.21 | 12.13 | 15.52 | 13.68 | 18.83 |
| LC2RBB2 | std | 0.28 | std | 0.51 | 100 | 101.42 | 100 | 104.66 | 14.51 | 17.81 | 14.94 | 19.12 |
| **After Wear** | | | | | | | | | | | | |
| LC1SJB1 | std | 0.40 | std | 0.34 | 100 | 103.65 | 100 | 101.32 | 0.95 | 0.97 | 1.02 | 1.41 |
| LC1RBB1 | std | 0.28 | std | 0.30 | 100 | 102.29 | 100 | 103.31 | 1.22 | 1.30 | 1.24 | 1.32 |
| LC2SJB1 | std | 0.46 | std | 0.54 | 100 | 104.76 | 100 | 108.15 | 1.03 | 1.15 | 1.14 | 1.45 |
| LC2RBB1 | std | 0.43 | std | 0.52 | 100 | 103.28 | 100 | 103.83 | 1.27 | 1.34 | 1.23 | 1.49 |
| LC1SJB2 | std | 0.49 | std | 0.13 | 100 | 103.66 | 100 | 101.41 | 15.20 | 15.96 | 15.38 | 17.09 |
| LC1RBB2 | std | 1.73 | std | 0.81 | 100 | 118.14 | 100 | 107.73 | 14.35 | 19.50 | 14.50 | 19.57 |
| LC2SJB2 | std | 0.55 | std | 0.22 | 100 | 106.23 | 100 | 107.58 | 15.23 | 18.63 | 16.01 | 18.85 |
| LC2RBB2 | std | 1.01 | std | 0.87 | 100 | 110.18 | 100 | 108.95 | 16.18 | 19.15 | 16.45 | 19.16 |

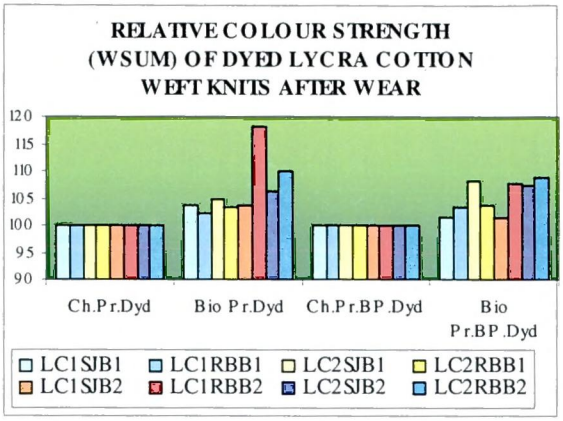
[B1 – dyed with light blue colour; B2 – dyed with dark blue colour]

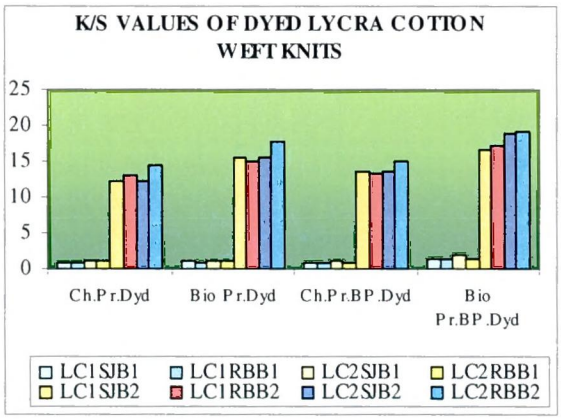
From the above data, it may be observed that the relative colour strength values were higher in all the bio pretreated, dyed samples and bio pretreated, bio polished, dyed samples, when compared to their respective chemical standards. Presa and Tavcer (2009) explain that the difference in colour strength may also be attributed to the initial whiteness index which is lower in the case of bio pretreated samples. This results in the darker shades which are richer and brilliant. After wear, all the bio pretreated samples exhibited better values when compared to the chemical standards.

The results clearly show that the K/S values are higher in the case of the bio pretreated, dyed and bio pretreated, bio polished and dyed samples when compared with the chemical pretreated counterparts. This trend was also observed after wear.

# INSTRUMENTAL COLOUR MEASUREMENTS OF LYCRA COTTON WEFT KNITS AFTER DYEING AND WEAR



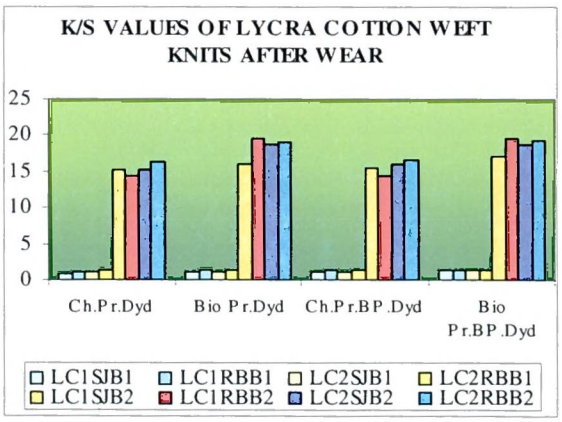




**FIGURE 47**

## 4.4. TECHNO ECONOMIC STUDY

The Table LXXI and Figure 48 show the cost particulars of Bio and Chemical Pretreatment for 100% cotton and lycra cotton weft knits. The cost sheet showing the consumption and cost of chemicals/enzymes/auxillaries and the estimate of overhead costs for bio and chemical pretreatments are given in Appendix 10.

**100% Cotton**

From Table LXXI, it is clear that the total cost for bio pretreatment of 100% cotton weft knits (Rs.14.67 per kg.) is lower than chemical pretreatment (Rs. 18.34 per kg.) by 25%.

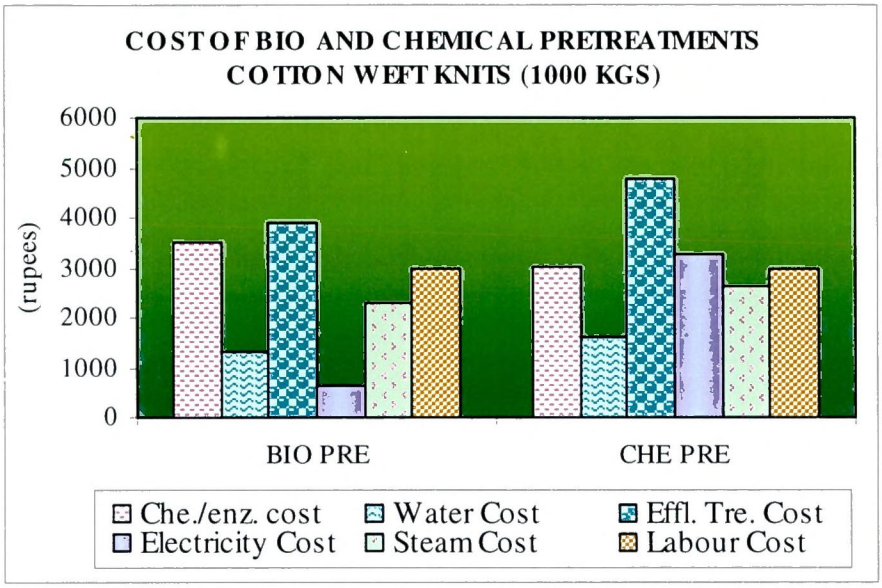
**TABLE LXXI**

**TOTAL COST FOR BIO AND CHEMICAL PRETREATMENTS OF 100% COTTON AND LYCRA COTTON WEFT KNITS**

| S. No. | Cost for 1000 kgs of fabric | 100% Cotton | | Lycra Cotton | |
|---|---|---|---|---|---|
| | | Bio Pretreatment | Chemical Pretreatment | Bio Pretreatment | Chemical Pretreatment |
| 1. | Cost of chemicals / enzymes / auxiliaries | 3,536.00 | 3,040.00 | 3,776.00 | 3,621.00 |
| 2. | Water Cost | 1,300.00 | 1,600.00 | 1,700.00 | 2,000.00 |
| 3. | Effluent Treatment Cost | 3,900.00 | 4,800.00 | 5,100.00 | 6,000.00 |
| 4. | Electricity Cost | **624.00** | 3,245.00 | **831.00** | 3,638.00 |
| 5. | Steam Cost | 2,313.00 | 2,650.00 | 2,375.00 | 2,713.00 |
| 6. | Labour Cost | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 |
| | Total | 14,673.00 | 18,335.00 | 16,782.00 | 20,972.00 |
| | **Cost / kg** | **Rs.14.67/-** | **Rs.18.34 /-** | **Rs.16.78 /-** | **Rs.20.97/-** |

From the estimate of overhead costs, the process cycle for bio pretreatment (1 hour 30 minutes) is lower than chemical pretreatment (2 hours 48 minutes) by 87% leading to lower electricity cost and increase in the number of production cycles per day. Savings (420%) in electricity cost is the major criteria leading to lower production cost per kilogram of bio pretreated material. The lower water consumption for bio pretreatment leads to lower cost, by 23% each, for water and effluent treatment, when compared to chemical pretreatment. Hence savings are evident in a majority of the parameters included for the techno economic study.

# TECHNO ECONOMIC STUDY RESULTS - BIO AND CHEMICAL PRETREATMENTS OF COTTON AND LYCRA COTTON WEFT KNITS



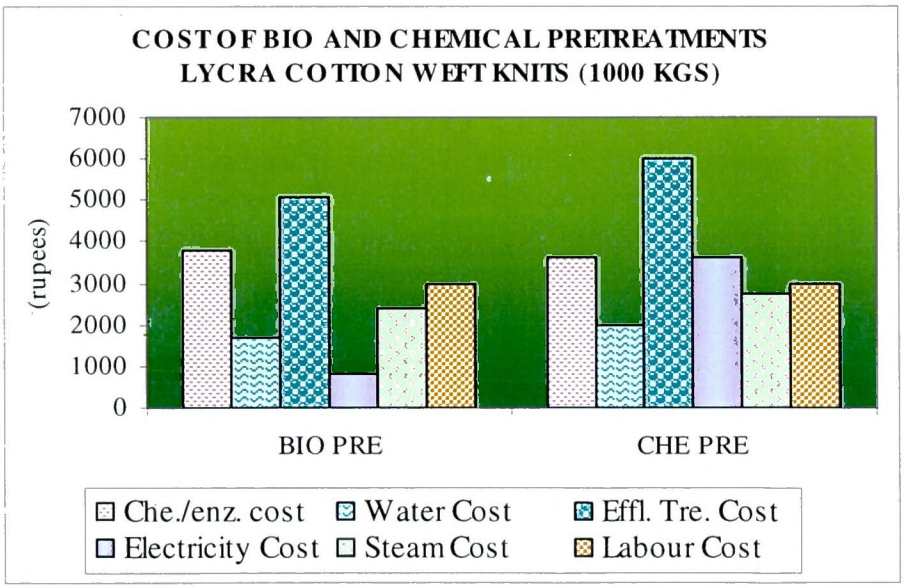




**FIGURE 48**

**Lycra Cotton**

It is evident from Table LXXI that the total cost for bio pretreatment of lycra cotton weft knits (Rs.16.78 per kg.) is lower than chemical pretreatment (Rs. 20.97 per kg.) by 25%. From the estimate of overhead costs, the process cycle for bio pretreatment (2 hours) is lower than chemical pretreatment (3 hours 33 minutes) by 77.5% leading to lower electricity cost and increase in the number of production cycles per day. Savings (337%) in electricity cost is the main factor contributing to lower production cost per kilogram of bio processed material. The lower water consumption for bio pretreatment leads to lower cost, by 17.6% each, for water and effluent treatment, when compared to chemical pretreatment. Hence a majority of the parameters analysed for the techno economic study, show greater savings in bio pretreatment when compared to chemical pretreatment.

Ramasamy and Kandasamy (2004), state that the time for scouring can be reduced by more than 50% leading to increased productivity and substantial reduction in over head costs to a great extent as the bath temperature is maintained at $60^{\circ}$ to $70^{\circ}$ C for 45 minutes as against $100^{\circ}$ C for more than 2 hours in alkali scouring, steam consumption is reduced. Effluent load in bio scouring is 30-60% lower than alkali scouring and hence water treatment cost is reduced by 50% of alkali scouring.

The cost for bio polishing is Rs.15/- per kg of fabric and cost of reactive dyeing hot brand is Rs.95/- per kg for dark colour (3.033% shade depth) and Rs.70/- per kg for light colour(0.222% shade depth).

Hence it can be highlighted that bio pretreatment is a cost effective process that can be recommended for industrial purposes. This process also helps in reducing environmental pollution and saves natural resources like water and energy, which are in great demand at present times.