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# COMPARATIVE STUDY OF STRUCTURAL CHANGES IN SINGLE JERSEY AND 1X1 RIB CORE SPUN COTTON-SPANDEX KNITTED FABRICS DURING RELAXATION

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## INTRODUCTION

There are various structural distortions taking place at the machine off state and during usage of knitted fabrics, resulting in changes in linear and area dimensions, changes in fabric thickness and area density (GSM) and changes in various physical properties (Marmarali, 2003 and Herath, 2009). These kinds of distortions are of equal concern to the fabric manufacturer, retailer, garment manufacturer and consumer. These distortions are based on yarn type and its parameters, knitted specifications, knitted structure and structural parameters, tightness factor of knitted structures, relaxation treatments, washing conditions etc. (Mikucioniene, 2004).

During relaxation treatments such as dry-, wet-, full-relaxation and washing treatments, knitted stitches gradually reach a minimum energy condition, which changes the stitch configuration. Meanwhile, various structural changes happen and cause fabric distortions, which are higher with water agitation, tumbler drying and repeated washing treatments (Ananad, 2002). Thus, unbalanced knitted structures such as single jersey are quite easy to distort and reported higher changes in dimensions and physical properties during relaxation, compared to double jersey structures. It was also highlighted that these changes significantly depend on the material type and fabric structure (Mikucioniene, 2004 and Herath, 2008). Today, knitted fabric manufacturers and garment manufacturers use spandex mixed with cotton extensively, especially for intimate apparels, sportswear, leisure wear, lingerie etc. Because, spandex mix with cotton shows greater extensibility and recovery, shape retention, soft and smooth handle, improved comfortability than pure spandex.

This paper focuses on the structural changes that take place on core spun cotton-spandex single jersey and 1x1 rib structures knitted with three tightness factors using a circular knitting machines, during dry-, wet-, full-relaxation and repeated washing treatments (till 10$^{th}$ washing cycle).

## METHODOLOGY

### Materials

Cotton-spandex (CO-SP) with 93% cotton and 7% spandex yarns were used to knit single jersey and 1x1 rib structures in a circular knitting machine. Ring spun 100% cotton and 40decitex spandex filaments (HSSX-40D) were used for CO-SP spinning. In order to obtain three tightness factors (TF), stitch lengths such as low, medium and high were selected. Table 1 shows the knitting specifications. Table 2 gives the machine set stitch lengths and machine off stitch lengths, which are measured under 95% significant level, are given in parenthesis in Table 2.

**Table 1. Knitting specifications for CO-SP sample preparation**

| Structure | Machine diameter [inches] | Gauge | Machine RPM | No. of positive feeders | No. of needles |
|---|---|---|---|---|---|
| Single jersey | 30 | 28 | 22 | 72 | 2640 |
| 1x1 Rib | 30 | 18 | 20 | 60 | 1680 |

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Machine off stitch lengths given in Table 2 are calculated according to the SCSL (Structural knit Cell Stitch Length - i.e. length of yarn required to knit one structural knit cell [SKC] ).Yarn count has been determined following normal procedure and TF was calculated using the formula given under Table 2.

**Table 2. Machine set and machine off stitch lengths in cm.**

| Structure | Material | Low fabric tightness [L-TF] stitch length(cm) | Medium fabric tightness [M-TF] stitch length(cm) | High fabric tightness [H-TF] stitch length(cm) |
|---|---|---|---|---|
| Plain | CO/SP | 0.29 (0.268±0.020) | 0.27 (0.255±0.012) | 0.25 (0.240±0.010) |
| 1x1 Rib | CO/SP | 0.29 (0.266±0.053) | 0.27 (0.244±0.054 | 0.25 (0.231±0.066) |

Note: TF(TF)=√tex/stitch length or SCSL ($tex^{1/2}$ $cm^{-1}$)

**Procedure**

Six samples in size of 30x30 $cm^2$ were cut from each TF of each knitted samples. Samples were first subjected to dry- and wet- relaxation and then subjected to full relaxation (according to ASTM D 1284-76) followed by machine washing treatments (according to the ISO6330) up to 10 cycles. For course and wale density measurements, there were 5 places selected in each tested fabric sample, after subjected to the standard atmospheric conditions. In 1x1 rib fabrics, wale spacing calculations are based on the SCSL concept. Thus, for linear dimensional measurements, five lines were marked in each of length and width directions and measurements were taken under the standard atmospheric conditions.

## RESULTS AND DISCUSSION

Figure 1 shows the course and wale spacing variations of CO-SP single jersey fabrics during relaxation and washing treatments. Figure 2 gives the similar variations for CO-SP 1x1 rib fabrics. They show that all the spacing reduced with progressing of treatments.

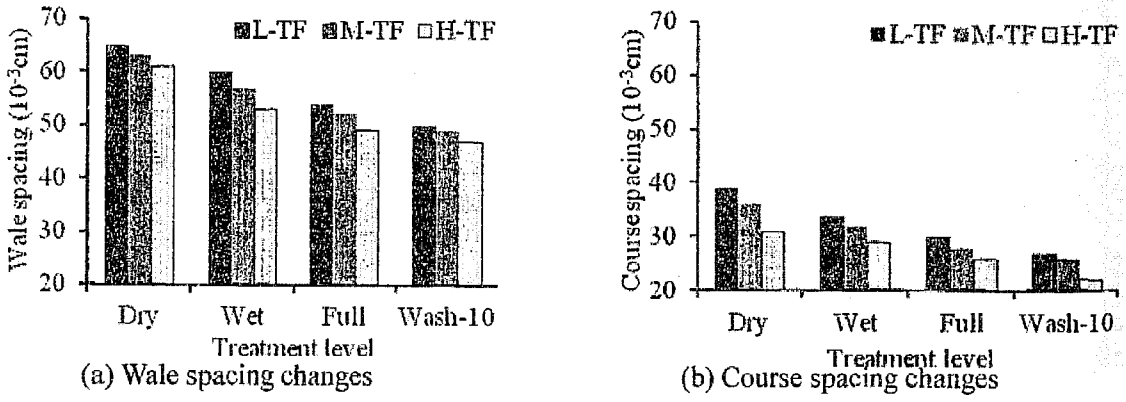
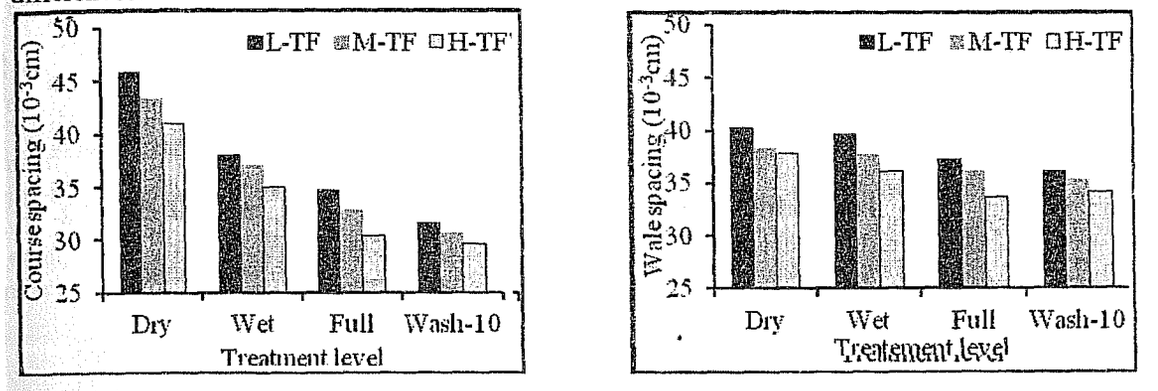



**Figure 1. Course and wale spacing variations of CO-SP single jersey fabrics during treatments**

According to figures 1 and 2, course and wale spacing gradually decreased with progression of treatments. Because, water agitation during wet relaxation, heat and mechanical energy provide by tumble drying in full relaxation and water treatments during washing allow the knitted stitches for further relaxation. This will result in structural changes, increasing the fabric weight density (GSM) and fabric thickness (Herath, 2009). Thus, structural spacing in course and wale directions negatively correlates with fabric TF for single jersey and 1x1 rib structures. The reason would be that the higher course and wale densities given by higher TF fabrics may give greater restriction forces against changing the stitch configuration during relaxation. Due to a similar reason, it was noticed that spacing reduction in wale and course directions was also proportionate to $TF^{-1}$.

Thus, course spacing is higher in rib fabrics than single jersey fabrics, but, wale spacing is higher in single jersey fabrics compared to rib fabrics. Further, it was determined that higher course spacing reductions (27-30% for single jersey and 27-31% for rib fabrics) than wale spacing reductions (22-23% for single jersey and 8-10% for rib fabrics) for these two knitted structures during dry relaxation to the end of $10^{th}$ washing cycle. It can be noticed that course spacing reductions are almost in the same range compared to wale spacing changes. Because, course densities of both single jersey and rib structures under three TFs are approximately in the same range and therefore changing the stitch configuration may happen with minimum differences.




(a) Wale spacing changes (b) Course spacing changes

Figure 2. Course and wale spacing variations of CO-SP 1x1 rib fabrics during treatments

However, wale spacing reduction is more than double for single jersey fabrics compared to rib fabrics. Due to the two planar construction, wale densities of rib structures get higher values than course densities and therefore, higher compressional and frictional forces may act on each stitch in wale direction, which results lower wale spacing reductions in rib fabrics. But, single jersey structures are single planar and therefore, they have lesser restrictions for stitch configurations and spacing reductions. Figure 3 shows the stitch density changes of cotton-spandex single jersey and 1x1 rib fabrics under relaxation and washing treatments.

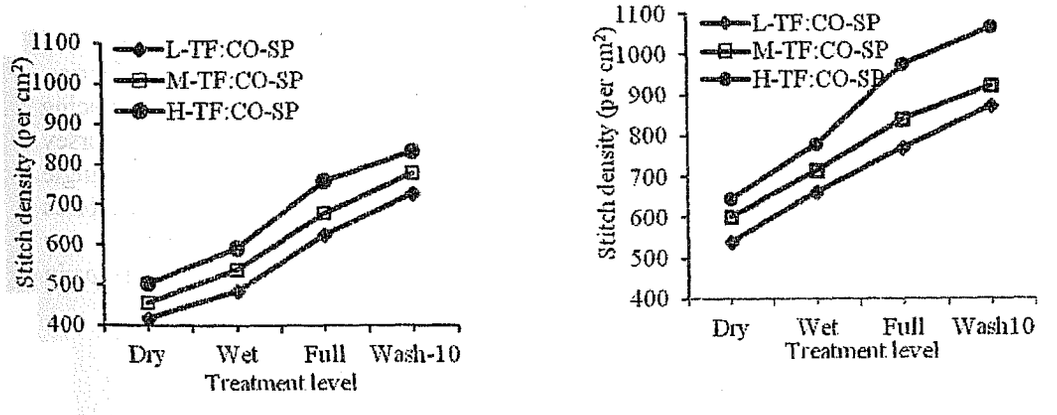



**Figure 3. Stitch density variations of CO-SP fabrics: (a) Single jersey fabrics (b) 1x1 rib fabrics**

Stitch density variations positively correlates with fabric TF in both fabric structures and densities have been significantly increased with the progression of treatments. Even though both structures knitted with same machine set stitch lengths and under same knitting conditions, 1x1 rib structures have given comparatively higher stitch densities than single jersey structures at each treatment level. The reason is that two planar construction of rib structures can accommodate higher number of stitches in a unit area than single jersey single planar construction and it is also possible to get higher fabric thicknesses due to bending knitted stitches into 3rd dimension easily, which allows the structures to accommodate more stitches (Anand 2002 and Herath, 2008). Figure 4 shows the linear dimensional changes of knitted fabrics during treatments. As a result of structural spacing reductions, fabric dimensions will change and results in shrinkages. According figure 4, fabric shrinkage has been gradually increased with the progression of treatments. Thus, in both structures, lengthwise shrinkages are higher than widthwise at each treatment level, due to higher course spacing reductions than wale spacing reduction (course spacing reductions: 27-30% for single jersey and 27-31% for rib fabrics; wale spacing reductions: 22-23% for single jersey an d 8-10% for rib fabrics) changes of CO-SP single jersey and 1x1 rib fabrics.

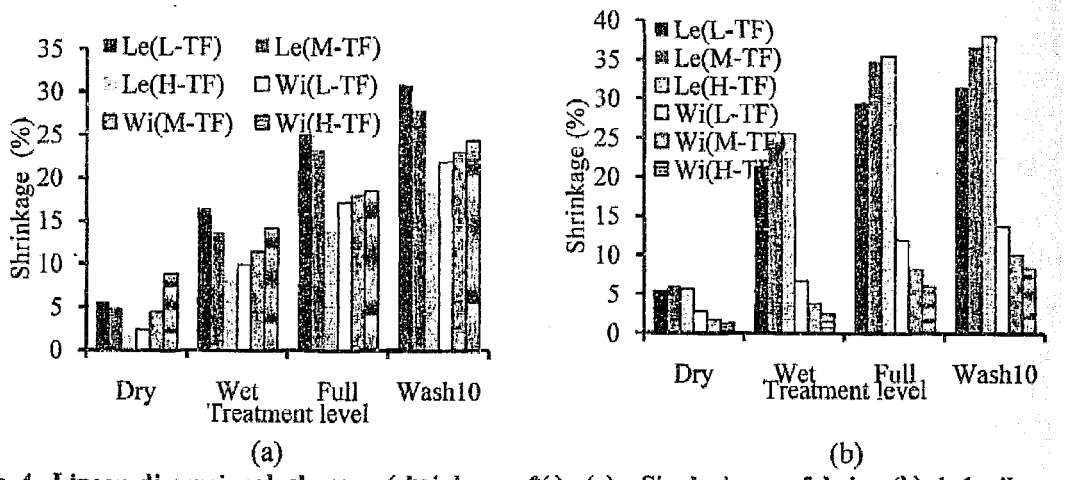



**Figure 4. Linear dimensional changes (shrinkages %): (a) Single jersey fabrics (b) 1x1 rib fabrics**

Meanwhile, width shrinkages are higher in single jersey fabrics compared to rib fabrics. Because, according to figures 1 and 2, higher wale spacing and greater wale spacing reductions (22-23% for single jersey and 8-10% for rib fabrics) reported by single jersey fabrics. Thus, it was noted that length shrinkages are higher in rib fabrics compared to single jersey fabrics. The reason would be the higher course spacing reported by single jersey fabrics than rib fabrics. In single jersey fabrics, length shrinkages and width shrinkages are proportionate to $TF^{-1}$ and TF respectively. However, rib fabrics showed these relationships in the opposite way.

## CONCLUSIONS

Higher course spacing was given by rib fabrics, while single jersey fabrics gave higher wale spacing. Structural spacing of the knitted fabrics correlates positively with TF. Structural spacing and linear dimensions reduced with progression of treatments. Higher course spacing reductions have been shown by both structures compared to wale spacing reductions, which resulted in higher length shrinkages. Length shrinkages and width shrinkages are proportionate to $TF^{-1}$ and TF respectively for single jersey fabrics, but rib fabrics showed an opposite behavior. Rib fabrics gave much lower width shrinkages than their length shrinkages and were also much lower than single jersey fabrics. Thus, 1x1 rib structures have given higher stitch density values at each treatment level than the single jersey fabrics. Even though

both structures were knitted with same stitch lengths and same CO-SP yarns, their structural behaviors are different under relaxation.

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