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Properties of Plain Knits from Siro-Spun Viscose/Spandex Yarns

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Abstract
This paper focuses on the dimensional and selected physical properties of a series of plain jersey fabrics made from viscose siro-spun and carded ring yarns of 2/10 tex and 20 tex, respectively. Elastane yarn was incorporated into the fabric using the plaiting technique. In general, for both greige and dyed knitted fabrics, the stitch density decreased, whereas the weight increased as the stitch length increased. Moreover, for greige and dyed dry-relaxed fabrics from siro yarn, the twist had an influence on fabric properties, the effect being relatively more prominent for slack samples. Moreover, both slack and tight dry relaxed dyed samples from high twist siro yarns featured lower resistance to abrasion. As far, as dyed and laundered samples from siro yarns are concerned, the results revealed that irrespective of the loop length, the samples from average twist siro yarns tended to give a higher stitch density and weight values. When abrasion resistance values of samples from both average and high twist siro yarns were studied, it could be suggested that in addition to yarn properties, the effect of fabric properties on the abrasion behaviour of the samples became more prominent after laundering. As far as the abrasion resistance and pilling properties of the samples are concerned, the fabrics from siro-spun yarns tended to perform better. Finally, the pilling test method employed affected not only the size and shape of the pill entanglements on the surface of the samples but also the degree of fibre damage within the fuzz entanglements.

Key words: *plain knitted fabrics, siro-spun yarn, viscose/elastane yarn, pilling, laundering.*

Introduction

Knitted goods of all kinds are generally popular because of their flexibility, their ability to adapt as well as stretch themselves to a particular shape when worn, and because of their general comfortable wear. However, such fabrics are easily distorted and develop dimensions which are not very stable, as a result of which they suffer from shrinkage of varying amounts when they are subjected to any kind of washing process. The dimensional stability of knitted structures from mostly conventional yarns (i.e. ring, open end, etc.), together with other physical properties, has been one of the most extensively discussed subjects in both industry and research [1 - 22]. Although the problem of knitted fabric shrinkage can be solved, to some extent, by replacing 100% cotton with a cotton/synthetic fibre blend yarn, the severity and longevity of the pilling has, in turn, greatly increased; pilling having become a much more serious problem for the knitted apparel industry than ever before. In addition to its unsightly appearance, the development of pills on a fabric surface, initiates the attrition of the garment and causes premature wear. Because of the importance of this very subject, the mechanism of pill formation, as well as factors affecting it, has been investigated by many researchers since the mid-1950s [23 - 34].

In spite of rapidly changing fashion trends and customer demands, literature surprisingly shows that knitted fabrics made from unconventional yarns, such as siro spun yarns, have been given very little attention [35 - 38]. It is also interesting to note that there has been very limited research on the properties of fabrics knitted with elastane despite the fact that elastane is an almost must for the knitting industry [8, 39]. Therefore, the authors conducted the work discussed in this paper in an attempt to comparatively investigate the performance of siro and ring spun viscose/spandex yarns. In addition, the extent of fibre damage and pill entanglement developed on the fabrics pilled were also of interest in this work. For this purpose, SEM (scanning electron microscope) photos were utilised.

Experimental study

Material and method

For this work plain jersey fabrics of 30” diameter were knitted on a 28-cut Mayer&Cie. circular knitting machine. Elastane yarn was fed into the machine using the plaiting technique in a way that the fabrics had 92% viscose yarn and 8% elastane. Information regarding some of the fibre and yarn properties employed for the production of the fabric samples are presented in ***Table 1***.

Each fabric sample from both siro-spun and carded ring yarns was produced at two different stitch lengths: l = 2.8 and 3.1 mm, respectively. Following the knitting, the fabric samples were subjected to a heat setting and then to dyeing processes under the same conditions. At the end of each process, including knitting, a certain amount of the fabric sample was set aside, which was then dry relaxed in a standard atmosphere (20 °C, 65% relative humidity) for two weeks for the tests. The dry relaxed samples were then laundered at 30 °C and flat dried. Finally, the areal density, dimensional stability to washing, pilling (both ICI and Martindale), abrasion resistance, and thickness were measured in turn in accordance with the following standards: ISO 3801, ISO 6330 (flat dried), BS 5811, BS 5690, and BS 2544. The wale and course densities were measured in the way explained in previous works of the author [4 - 7], and then the product of these was employed to determine the stitch density of each sample. The results obtained for the samples were then statistically assessed using

Table 1. *Yarn characteristics; Fibre type - Viscose, 38 mm long and 1.3 dtex.*

Yarn type	Ring, carded (R)	Sirospun - average twist (SR AT)	Sirospun - high twist (SR HT)
Tex	20	2/10	2/10
αe	3.30	3.30	3.60
Hairness (H)	5.60	4.18	3.97

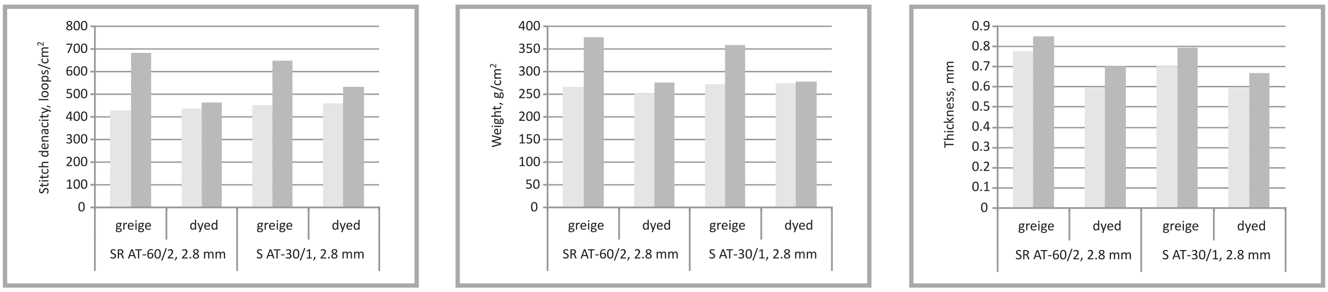


***Figure 1**. Dimensional properties of SR AT 2.8 and R AT 2.8 fabrics before (■) and after laundering (■).*

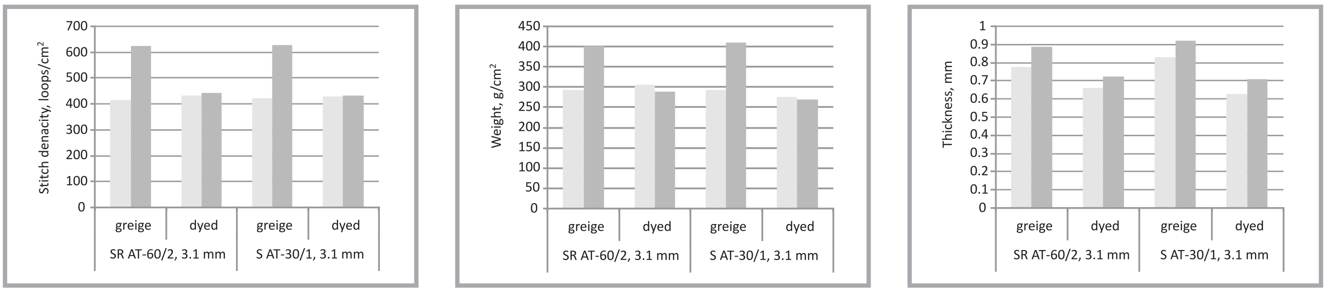


***Figure 2.** Dimensional Properties of SR AT 3.1and R AT 3.1 fabrics before (■) and after laundering (■).*

***Table 2.** Dimensional properties of the dry-relaxed and laundered viscose sample.*

Yarn kind / fabric type		Dry-relaxed			Laundered			Dimensional change in direction, %	
		Stitch density, loops/cm2	Weight, g/m2	Weight loss, %	L_stitch density, loops/cm2	L_weight, g/m2	L_weight loss, %	widthwise	lengthwise
SR HT-60/2 viscose sirospun, high twist,2.8 mm	greige	419.00	268.50	3.19	648.00	371.50	1.44	-7.75	-13.75
	dyed	440.00	275.33	4.75	458.67	272.43	2.84	-5.25	5.50
SR HT-60/2 viscose sirospun, high twist, 3.1 mm	greige	397.80	290.43	4.45	612.33	407.27	1.24	-9.25	-13.25
	dyed	405.50	284.57	4.01	425.00	280.07	4.13	1.75	1.50
SR AT-60/2 viscose sirospun, average twist, 2.8 mm	greige	430.73	267.43	3.28	684.33	376.80	1.83	-8.25	-15.5
	dyed	435.18	252.00	2.66	462.67	277.23	3.37	-4.75	4.00
SR AT-60/2 viscose sirospun, average twist, 3.1 mm	greige	416.67	294.50	3.85	624.17	401.80	1.33	-10.25	-16.5
	dyed	431.77	306.30	1.42	442.67	288.30	3.83	1.00	3.50
R AT-30/1 viscose, carded ring, average twist, 2.8 mm	greige	453.33	271.87	2.60	648.00	360.37	1.65	-8.00	-13.50
	dyed	459.60	273.90	2.44	533.33	278.87	3.47	-4.25	3.50
R AT-30/1 viscose, carded ring, average twist, 3.1mm	greige	423.93	294.17	1.25	629.00	411.33	1.74	-9.25	-15.25
	dyed	429.77	275.57	5.37	433.33	269.63	4.18	3.25	1.25

one-way ANOVA (for 95% confidence interval).

In order to evaluate the resistance to abrasion of the samples, the fabrics were subjected to 20 000 rubs, and for comparison the percentage of the weight loss of the samples was calculated at the end of each test cycle. Moreover, in order to evaluate the extent of fibre damage and pill entanglement developed on the fabrics after theyhad been subjected to the pilling tests, some of the fabric samples were examined under a scanning electron microscope (SEM) at a magnification of 400, 500, 1000, and 4000×. Samples were taken from the fabrics that were pilled, which were then mounted on SEM stubs of 1 cm diameter andfinally gold coated prior to examination. SEM photos of the fabrics are presented in ***Figure 6***. Both the abrasion and pilling tests were repeated for the samples laundered in order to observe the effect of washing on the properties discussed.

For simplicity, the knitted fabrics were classified according to the following general form: R AT 2.8 (or 3.1), SR AT 2.8 (or 3.1), and SR HT 2.8 (or 3.1), where R (ring) and SR (siro) stand for yarn type, AT (average) and HT (high) for twist level, and 2.8 and 3.1 are used for the two different stitch lengths.

Results and discussion

Properties of the dry-relaxed fabrics

Siro versus Ring

Irrespective of loop length, the stitch density of the SR AT greige fabrics was lower than that of the R AT greige fabrics. However, the difference between the fabric groups (siro & ring) were statistically significant only for the samples knitted at a stitch length of 2.8 mm. The thickness values of the SR AT 2.8 samples were higher than those of the R AT 2.8 samples; however, it was the R samples which gave the greatest thickness values from amongst the slack fabrics (i.e. knitted at a stitch length of 3.1 mm)

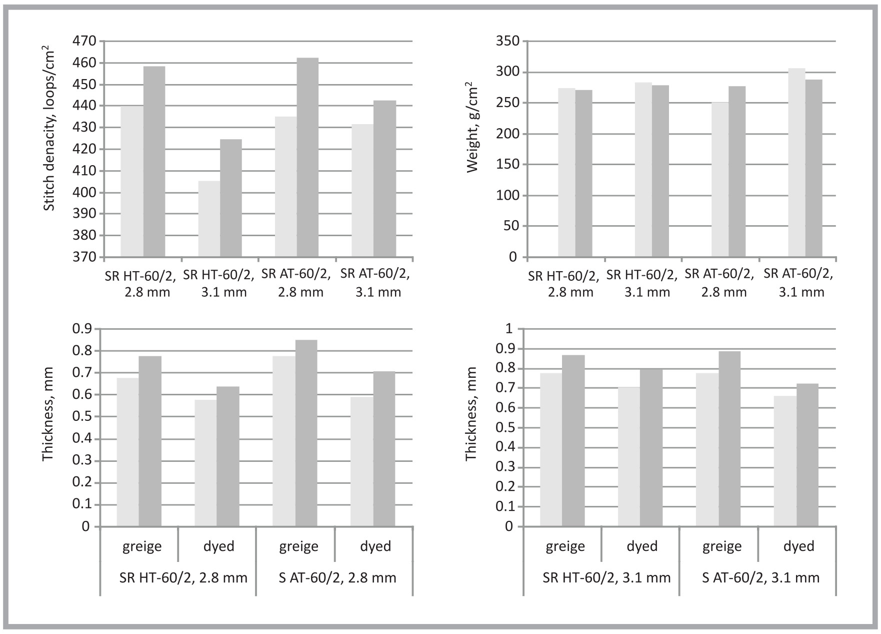


***Figure 3.** Dimensional properties of SR HT and SR AT fabrics before (■) and after laundering (■).*

(see ***Figures 1** & **2,*** and ***Table 2***), and the difference in each case was found to be statistically significant. Finally, from both the slack and tight fabrics (3.1 mm & 2.8 mm), the SR AT samples showed relatively lower resistance to abrading when compared to the R AT samples.

As far as the dyed fabrics are concerned, the SR AT 2.8 fabrics had a lower stitch density and weight values than the R AT 2.8 fabrics, the differences between the groups (i.e. ring and siro) being statistically significant. In the case of slack fabrics, however, the stitch density and weight values of the SR AT 3.1 samples were higher than those of the R AT 3.1 mm samples (see ***Figures 1** & **2,*** and ***Table 2***). For each loop length under discussion, there was no statistically significant difference between the thickness values of siro and ring fabrics. A comparative study of the abrading behaviour of the siro and ring samples showed that, as expected, the R AT samples (i.e. fabrics knitted from ring yarn) had lower resistance to abrading than the SR AT samples (i.e. fabrics knitted from siro yarn).

In brief, as the loop length increased, the stitch density decreased and the weight increased for both the griege and dyed samples (see ***Table 2***), which was in agreement with the findings in literature [2, 5 - 7]. Also, in light of the findings outlined above, it may be concluded that when compared to the SR AT samples, the effect of the stitch length on the dimensional properties of the R AT samples was more obvious.

High Twist Siro versus Average Twist Siro

For the same stitch length, the SR AT greige fabrics had greater stitch density values than the SR HT samples; however,, based on ANOVA results, the difference between these two groups of data was not statistically significant. Moreover, the SR HT 2.8 greige fabrics showed higher weight values; however, it was the SR AT 3.1 greige samples which gave relatively greater areal densities (see ***Figure 3** & **Table 2***). A comparative study of the thicknesses of the siro samples revealed that for a stitch length of only 2.8 mm, there was a statistically significant difference between the SR AT and SR HT samples: the SR AT greige samples were much thicker than the SR HT ones. From the slack fabrics the thickness values of the samples were almost the same. As regards the abrasion behaviour of the griege samples from high and average twist siro yarns, the SR AT 2.8 samples abraded more than the SR HT 2.8 ones, while the SR HT 3.1 samples showed less resistance to abrasion when compared to the SR HT 2.8 ones (see ***Table 2***).

As for the dyed siro samples, from the tight samples (i.e. loop length of 2.8 mm) the SR HT fabrics gave higher stitch densities than the SR AT ones, whereas from the relatively slack samples (i.e stitch length of 3.1 mm) the SR AT samples had higher stitch densities than the SR HT ones. Furthermore, for these fabrics the difference was also found to be statistically significant. The SR HT 2.8 samples gave greater weight values than the SR AT 2.8 ones. From the slack fabrics it was the SR AT 3.1 samples which had relatively higher areal densities. In each case, the statistical analyses showed the differences to be significant. Furthermore, the results revealed that from the group of slack fabrics, the SR HT samples were thicker than the SR AT samples. Irrespective of the loop length, it was the SR HT samples which gave lower abrasion resistance. Moreover, the statistical analysis suggested that "twist" had a significant effect on the abrasion behaviour of the fabrics from siro spun yarns (see ***Figure 3*** and ***Table 2***).

Consequently, as in the findings of previous works [1, 2, 3 - 7], for both the greige and dyed knitted fabrics, the stitch density decreased, whereas the weight increased as the stitch length increased (see ***Table 2***). Moreover, for the greige and dyed dry-relaxed SR fabrics, the twist had an influence on fabric properties, the effect being relatively more prominent for slack samples. However, it should be noted that in terms of stitch density and weight, the SR HT samples gave lower values than was expected, which may have resulted from the heat setting applied to the yarns before knitting. Also, as a result of high twist, which will in turn increase yarn-yarn friction, the relaxation of the HT samples may have been realised more slowly when compared to that of the AT samples [36]. From both the slack and tight dry relaxed dyed SR fabrics, the SR HT samples featured lower resistance to abrasion. With reference to ***Tables 1*** and ***2***, it may be concluded that due to the abrasion behaviour of the samples, yarn properties were more dominant than fabric properties, which may have resulted from the fact that high twist may have caused greater tension on fibres and, thus, may have facilitated infibre fibres breaking away from the fabric surface when the samples were abraded.

Properties of the laundered fabrics

Siro versus ring

From the tight greige fabrics, the SR samples gave a higher stitch density and weight values. From the slack fabrics, however, the R samples featured greater stitch density and weight values. Furthermore, it was shown that for tight samples only there was a statistically significant

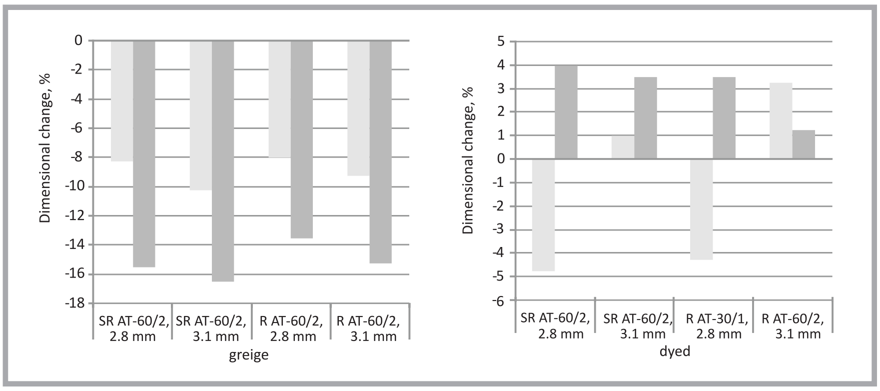


Figure 4. *Dimensional changes in SR AT and R AT fabrics for ( ) widthwise and ( ) lengthwise direction.*

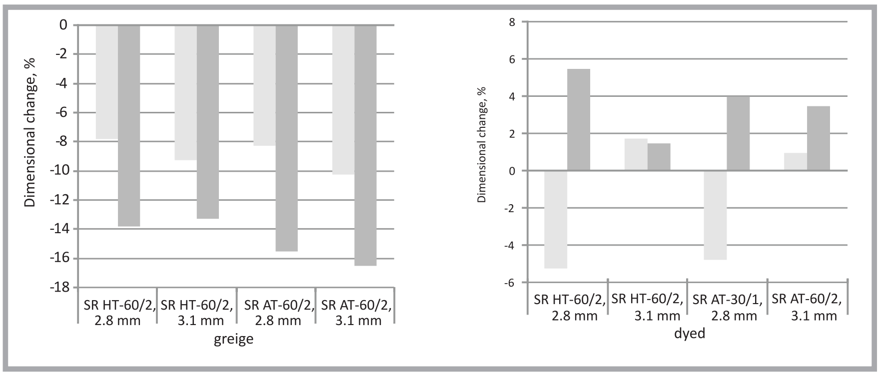


Figure 5. *Dimensional changes in SR HT and SR AT fabrics for ( ) widthwise and ( ) lengthwise direction.*

relation between the loop length and stitch density. As far as the thickness and abrasion resistance properties of the samples are concerned, the SR AT 2.8 and R AT 3.1 fabrics were thicker than their corresponding samples (i.e. R AT 2.8 and SR AT 3.1). Furthermore, from the tight fabrics, the SR samples presented lower resistance to abrasion, whereas from the slack fabrics, the R samples gave lower abrasion resistance values. In terms of dimensional stability, both the slack and tight R samples showed a better performance than the SR AT samples, and, irrespective of stitch length, both the SR and R fabrics showed shrinkage widthwise as well as lengthwise. For tight samples only it was found that there was a statistically significant relation between yarn type (siro or ring) and widthwise dimensional stability (see ***Table 2 and Figure 4***).

From the dyed samples, the SR AT 2.8 gave lower stitch density values than the R AT 2.8, while from the slack fabrics it was the R AT sample which had a lower stitch density. With reference to ***Table 2***, from the tight fabrics the SR AT was found to be thicker, whereas from the slack fabrics the R AT became thicker. The ANOVA results suggest that the effect of yarn type on stitch density as well as on thickness is more potent for tight fabrics. For each loop length studied, there was no marked difference between the weight values of the samples. A comparative study of the abrasion resistance behaviour of the samples revealed that from both the slack and tight samples, the R AT ones performed worse than the SR AT samples. Widthwise dimensional stability results showed that the R AT 2.8 and SR AT 3.1 performed much better than the corresponding samples (i.e. SR AT 2.8 and R AT 3.1, respectively). As regards lengthwise dimensional stability results, however, both the slack and tight R AT samples gave lower values than the SR AT ones. The ANOVA results concluded that the effect of yarn type on dimensional stability is only significant for slack fabrics (see ***Table 2*** and ***Figure 4***).

As was expected, the stitch density increased after the laundering process, irrespective of stitch length, yarn type, etc. Similarly, weight values of the samples tended to increase. Unlike the findings of previous studies [35], the SR AT samples, irrespective of loop length, gave lower stitch density values than the R AT samples, which may partially be due to the fact that elastane yarn is a more dominant factor in determining the dimensional behaviour of knitted fabrics. This may have also resulted from the fact that the heat setting of the fabrics before dyeing may have affected the extension recovery values of the yarns. With the help of the heat setting and dyeing processes, the dyed fabrics featured better dimensional stability than the greige fabrics. Moreover, it appeared that for the same loop length, the laundering process caused the SR AT ve R AT dyed samples to behave differently, which may have been due to changes in the loop shape; as in laundered fabrics, the loop shape is effected by factors such as the twist liveliness of yarns, yarn bulkiness, and fibre-fibre and yarn-yarn friction [22]. Finally, the ANOVA results showed that for both the greige and dyed SR AT and R AT samples, there was a statistically significant relation between the loop length and stitch density as well as between the loop length and thickness.

High Twist Siro versus Average Twist Siro

From both slack and tight fabrics, the greige SR AT samples gave higher stitch density and thickness values than the SR HT ones. In the case of tight fabrics, the greige SR AT samples had greater weight values than the greige SR HT ones, but the SR AT fabrics showed lower resistance to abrasion when compared to the SR HT samples. However, ANOVA results showed that the differences in these properties were significant only for tight fabrics. A comparative study revealed that both the SR HT 2.8 and SR AT 2.8 samples did shrink widthwise as well as in a lengthwise direction, and that from the slack fabrics the SR AT samples were found to have lower dimensional stability than the SR HT ones in both directions. Furthermore, the statistical analysis suggested that for slack fabrics twist had a significant effect on dimensional stability in the lengthwise direction (see ***Table 2*** and ***Figure 5***).

For both loop lengths studied, the dyed SR AT samples gave a higher stitch density and weight values than the SR HT ones. In terms of thickness, however, the SR AT 2.8 was bulkier than the SR HT 2.8, and the SR HT 3.1 was thicker than SR AT 3.1. Also, from the tight fabrics, the SR AT was less resistant to abrasion than the SR HT. From the slack fabrics, on the other hand, the SR HT performed better than the SR AT. The differences between the thickness and abrasion resistance values of the fabric groups (i.e. SR AT and SR HT) were found to be statistically significant. Irrespective of loop length, the SR AT showed better dimensional stability than the SR HT in the widthwise direction. For the tight fabrics, the dimensional change was in the form of shrinkage, while for slack fabrics it was in the form of an extension. A study of dimensional changes in the lengthwise direction showed that the SR HT 2.8 performed worse than the SR AT 2.8, and the SR AT 3.1 featured lower dimensional stability than the SR HT 3.1. Both the SR HT and AT samples extended in the lengthwise direction, and ANOVA results revealed that the differences were statistically significant only for slack fabrics (see ***Table 2*** and ***Figure 5***).

With the help of the heat setting and dyeing processes, the dyed SR fabrics were more dimensionally stable than the greige SR fabrics. As far as the dyed and laundered SR samples are concerned, the SR HT samples were expected to have higher shrinkage potential than the SR AT samples. However, the results revealed that for both the slack and tight fabrics, the SR AT samples tended to have a higher stitch density and weight values. This may have been because of the laundering process, which was not conducted for fully relaxed samples. When abrasion resistance values of the SR AT and HT samples were studied, it could be suggested that in addition to yarn properties, the effect of fabric properties on the abrasion behaviour of the samples became more prominent after laundering.

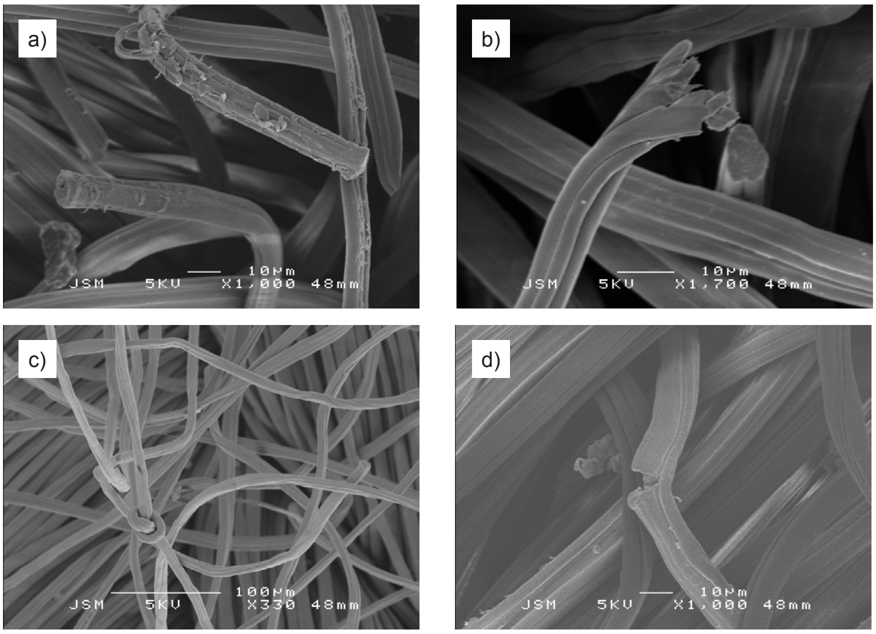
A comparative study of the pilling properties of the samples reveals that plain jersey fabrics from siro-spun yarns have a slightly higher resistance to pilling than fabrics from ring yarns (see ***Table 3***). Furthermore, knits from high twist siro-spun yarn perform relatively better than those from normal twist siro-spun yarn. The pilling grades also suggest that the laundering process may improve the pilling resistance of the samples. This may result from the areal and stitch densities, which have increased by the end of washing process (see ***Table 3***).

Finally, the samples from ring yarns (the R AT 2.8 and R AT 3.1 groups) have the lowest resistance to pilling, irrespective of the test method used. These are followed by samples of the SR AT 2.8 and SR AT 3.1 groups. With reference to ***Tables 1*** and ***3***, it may be suggested that yarn hairiness tended to effect the pilling behaviour of the samples. In an attempt to investigate the effect of the test method on the pilling behaviour of the fabrics, SEM photos were also taken, as mentioned before.

In light of these photos and the pilling of the samples, it may be concluded that pill entanglements on the surface of samples abraded using a Martindale abrasion tester are much tighter and have a more ball-like structure. In addition, the degree of fibre damage observed in fibres within the fuzz entanglements, which are mostly in the form of flakes and cracks, is more severe than that observed on the surfaces of samples pilled on an ICI pilling tester. In some fuzz entanglements fibres knotted onto themselves were also observed (see ***Figre 6***).

Table 3. *Pilling properties of the dry relaxed and laundered samples.*

Yarn kind / fabric type		Dry relaxed			Laundered	
		Martindale pilling	ICI 9000 revs	ICI 11 000 revs	L_Martindale Pilling	L_ICI 11 000 revs
SR HT-60/2, 2.8 mm	greige	4	4	3	4/5	3
	dyed	3/4	4	2	3/4	3
SR HT-60/2, 3.1 mm	greige	3	3	½	2/3	1/2
	dyed	2	¾	2/3	2	2
SR AT-60/2, 2.8 mm	greige	2/3	3	2/3	3	3
	dyed	3	2/3	2/3	2/3	2/3
SR AT-60/2, 3.1 mm	greige	3	3	½	3/4	3
	dyed	3	3	3	3	2/3
R AT-30/1, 2.8 mm	greige	3/4	2	½	4/5	3/4
	dyed	3	3	2/3	3	3
R AT-30/1, 3.1mm	greige	2	1/2	1	3	2/3
	dyed	3	3	3	2	3



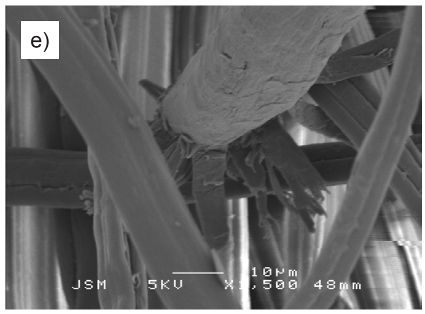


Figure 6. *SEM photo of fabric sample:*
a) SR HT 2,8-dyed$_{ICI}$*,*
b) SR HT 3,1-greige$_{ICI}$*,*
c) SR AT 3,1-greige$_{ICI}$*,*
d) SR AT 2,8-greige$_{ICI}$ *fabric sample,*
e) R AT 2,8-dyed$_{Martindale}$*.*

Conclusion

This paper focused on the dimensional and selected physical properties of a series of plain jersey fabrics made from viscose siro-spun and carded ring yarns of Ne 60/2 and Ne 30, respectively. Elastane yarn was incorporated into the fabric using the plaiting technique. In general, for both the greige and dyed knitted fabrics, the stitch density decreased, and the weight increased as the stitch length increased. Moreover, for greige and dyed dry-relaxed fabrics from siro yarn, the twist had an influence on fabric properties, the effect being relatively more prominent for slack samples. Both slack and tight dry relaxed dyed samples from high twist siro yarns featured lower resistance to abrasion.

As far as the dyed and laundered samples from siro yarns are concerned, the results revealed that irrespective of loop length, the samples from average twist siro yarns tended to give higher stitch density and weight values. When abrasion resistance values of the samples from both average and high twist siro yarns were studied, it could be suggested that in addition to yarn properties, the effect of fabric properties on the abrasion behaviour of the samples became more prominent after laundering.

A comparative study of the pilling properties of the samples demonstrates that plain jersey fabrics from siro spun yarns have a slightly higher resistance to pilling than those from ring yarns. Furthermore, knits from high twist siro-spun yarn perform relatively better than those from normal twist siro-spun yarn. The pilling grades also suggest that the laundering process may improve the pilling resistance of samples. Finally, with reference to SEM photos taken for the work, the test method employed affects the size and shape of pill entanglements on the surface of samples.

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Kaunas University of Technology (KTU)

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KAUNO TECHNOLOGIJOS UNIVERSITETAS

The roorts of the university go back to 1920 when the first centre of university-type higher courses was established. In 1922 the Government of Lithuania accepted a resolution establishing Kaunas University, which was then given the name of Vytautas the Magnus in 1930. In 1950 Kaunas University was reorganized into Kaunas Polytechnic Institute (KPI) and Kaunas Medical Institute. In 1990 KPI changed its name to the present name of Kaunas University of Technology (KTU). Now KTU is the largest technological University not only in Lithuania, but also in all the Baltic States. Many Prime Ministers, Ministers, Members of the Lithuanian Parliament and even the President of the Republic of Lithuania have graduated from KTU.

The University is the only one in Lithuania engaged in textile engineering. The Department of Textile Technology dates back to 1929, when the decision to begin education in textile engineering at the University was accepted, and in 1932 the first lectures started. The Department of Textile Technologies, as an organisational unit, was established in 1940, due to the founding of a Laboratory of Fibre Technology in 1936. The creator and first Head of the Department was Professor J. Indriunas. Up to now more than 2500 students have graduated in textile technology (including more than 200 from Latvia and Estonia) and more than 80 postgraduate students have been awarded a Ph. D. degree. The majority of textile engineers of the Lithuanian textile industry graduated from this department. Senior Professors of the Department, such as A. Matukonis, V. Milašius, and A. Vitkauskas are well known not only in Lithuania, but also in Poland and the whole of Europe.

Today the Department's staff includes 7 professors, 4 associate professors, 7 lecturers and 12 doctoral students. Up to now more than 2000 scientific articles have been published in Lithuanian and international journals as well as in conference proceedings. The main fields of research activity carried out by the Department of Textile Technology are as follows:

- *the rheological properties of textiles,*
- *the flammability and heat transfer of textiles,*
- *the wettability of textiles,*
- *computerised structural design,*
- *the development of textile manufacturing technologies, and*
- *the manufacturing of nanofibres, among others.*

The department is a member of the international Association of Universities for Textiles (AUTEX). The Professors of the Department have given lectures at various European universities regarding the activities of AUTEX and the European Masters Studies Programme in Textile Engineering (E-TEAM).

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