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Effect of Chenille Yarns Produced with Selected Comfort Fibres on the Abrasion and Bending Properties of Knitted Fabrics

Abstract
In this study, the effects of pile and core yarn material types on the abrasion and bending behaviour of chenille knitted fabrics were studied. For this purpose different chenille yarns were produced from seven types of pile yarn material and two types of core yarn material at the same yarn counts. The different pile yarn fibre types used for the production of chenille yarns were comfort fibres like tencel, bamboo, modal, soybean, 50/50% soybean-tencel and conventional fibres like viscose and cotton; the different core yarn types were polyester and viscose. The abrasion resistance of knitted fabrics made from these yarns was measured with a Martindale Abrasion tester. According to the results of statistical analyses performed using the experimental values, physical properties like mass and thickness loss due to abrasion were affected by the pile and core yarn types. Course way, wale way and fabric bending rigidity properties were not affected by the core yarn fibre types. The course way bending rigidity property was affected by the pile yarn fibre types, while the wale way and fabric bending rigidity properties were affected by the pile yarn fibre types for undyed yarns.

Key words: *chenille yarn, comfort fibres, bamboo, tencel, abrasion resistance, bending rigidity.*

Introduction

There are many different types of fancy yarns throughout the textile industry. Their uses range from upholstery to apparel, from transportation to home furnishings. Fancy yarns are regarded as any yarn which has deliberate inconsistencies applied during processing.

Chenille is the name given to all upholstery; outerwear or decorative fabrics are also produced using a fancy yarn called chenille yarn. These almost exclusively flat fabrics acquire a fuzzy, soft, bulky, bright and velvety surface through the chenille yarn, reminiscent of velour. Use of this yarn usually increases the durability of a flat fabric.

Chenille yarn consists of pile yarn and two core yarn components which are twisted together on a twisting machine, after which the pile yarn is inserted at right angles and cut to within 1 or 2 mm of the core yarn surface to produce the pile. The pile length, count and number of pile yarns as well as how many of them are fed onto the core determine the chenille yarn count [1, 2]. Figure 1 shows the basic structure of chenille yarn. The core yarns grip the pile yarns, which protrude transversely, held stable by means of twisting. The factor preventing the pile fibres being removed is mechanical friction forces between the core and pile yarns [3].

Furthermore, in the manufacturing process of chenille, the pile is inclined in a certain direction, and thus can be given an orientation; but if given a strong orientation, the chenille yarn may protrude. Furthermore, if the yarn hardens due to the attachment of the pile, there will also be a tendency to protrude [4].

Chenille is a difficult yarn to manufacture, requiring great care in production. Chenille yarns have some disadvantages, such as being sensitive to machine washing and tumble drying; it also has low abrasion resistance. When the yarns are in use, it is clear that the abrasion resistance of chenille yarn is of crucial importance, in particular because the effect sought is always a velvety feel of the pile, as the bald look of worn velvet or chenille is not appealing. Any removal of the effect yarn forming the beard, either during further processing or the eventual end-use, will expose the ground yarns, which in turn will result in a bare appearance [5].

Despite the fact that chenille yarns are used to produce special fabrics with a high added value, literature surveys have shown that there has been limited research on the physical properties of such yarns and fabrics. Recently, several researchers have attempted to determine the effect of yarn structure (pile length, twist level, pile fibre type) on abrasion characteristics [6 - 11]. They used conventional fibre types for abrasion assessments.

There has been a growing demand for absorbent fibres which are comfortable and fashionable [12]. Some of the fibres which have comfort properties are tencel, modal, bamboo and soybean. The starting material for tencel, modal and viscose is the same, i.e. wood pulp of the beech tree; however, the manufacturing processes are different [13 - 16].

Figure 1. *Chenille yarn.*

Bamboo fibre is a type of regenerated cellulose made using pulp from bamboo plants. Soybean protein fibre is a kind of regenerative plant fibre that is produced by extracting proteins from the residual oils of soybean cake [17].

Tencel, modal, bamboo and soybean fibres are eco-friendly fibres which are breathable and absorbent [14 - 18]. Bamboo is also characterised by softness and anti-bacterial properties. Soybean has a gentle drape, a soft and smooth structure, luster appearance, as well as anti-bacterial and anti-ultraviolet properties [18, 19]. Nevertheless, there has been no research on investigating and comparing the abrasion and bending behaviour of chenille yarns with respect to comfort properties. In this study, pile yarns which have comfort properties were chosen for the production of chenille yarns. Fabric stiffness is one of the most important factors in determining the handle and comfort of apparel. The stiffness is calculated with the bending rigidity measurements.

Thus, the study involved research into chenille yarns to investigate the influence of chenille yarn parameters like pile and core fibre type on fabric abrasion and bending behaviour.

Experimental

The experiments included chenille yarn samples produced from seven different types of pile yarn material and two different types of core yarn material at the same yarn count.

The different types of pile yarn material used for the production of chenille yarns were tencel, bamboo, viscose, modal, soybean, 50/50% soybean-tencel and cotton, and the different types of core yarn material were polyester and viscose. Fourteen different chenille yarns were produced with a final linear density of 150 tex (6.5 Nm), incorporating pile and core yarns with a linear density of 20 tex (50/1 Nm), as mentioned above, on a Yu-Shin YS 13 CN gilette type chenille yarn machine with a pile length of 1.0 mm and yarn twist of 800 turns/ m- in the S direction.

Yarn bobbins were dyed in a Loris Bellini USR 95 bobbin dyeing machine. All the yarn samples were dyed with reactive dyes at 60 °C, and then aftertreatments (washings) for reactive dyeing were performed. Finally, the bobbins were dried on a radio frequency drier.

Table 1. *Properties of chenille yarns.*

Core yarn fibre type	Pile yarn fibre type	Twist (Turn/m)		Yarn Count (Nm)	
		undyed	dyed	undyed	dyed
Polyester	tencel	766	788	6.87	6.99
	bamboo	794	854	6.44	6.25
	viscose	771	802	6.47	6.04
	modal	772	807	7.00	6.74
	soybean	725	846	7.45	6.89
	50/50% soya-tencel	726	833	7.08	6.60
	cotton	730	808	7.07	6.57
Viscose	tencel	790	916	6.55	6.21
	bamboo	749	831	7.11	6.09
	viscose	769	836	6.93	6.39
	modal	788	809	6.44	6.00
	soybean	803	830	7.34	6.84
	50/50% soya-tencel	820	840	6.13	5.94
	cotton	754	828	6.59	6.47

Table 2. *Properties of chenille fabrics.*

Core yarn fibre type	Pile yarn fibre type	Weight, g/m²		Thickness, mm		Courses/cm		Wales/cm	
		undyed	dyed	undyed	dyed	undyed	dyed	undyed	dyed
Polyester	tencel	256.50	325.20	2.07	2.08	6.89	8.33	3.25	3.83
	bamboo	312.15	330.05	2.11	2.19	7.50	8.67	3.39	3.83
	viscose	281.35	349.20	2.18	2.07	7.00	8.30	3.47	3.83
	modal	265.00	309.35	2.33	2.31	6.67	8.67	3.73	4.00
	soybean	252.85	320.60	2.14	2.33	6.78	9.00	3.77	3.67
	50/50% soya-tencel	255.70	337.70	2.39	2.08	7.00	8.17	3.50	3.89
	cotton	230.40	301.45	2.20	2.06	6.50	7.72	3.60	3.55
Viscose	tencel	298.30	347.00	2.47	2.19	7.33	8.17	3.33	3.83
	bamboo	263.60	341.40	2.26	2.22	7.33	8.00	3.30	3.76
	viscose	265.95	339.65	2.20	2.04	6.67	8.17	3.38	3.83
	modal	282.95	341.35	2.22	2.42	6.50	8.00	3.40	3.89
	soybean	287.25	305.70	2.48	2.39	7.50	8.00	3.30	3.83
	50/50% soya-tencel	310.80	335.20	1.99	2.11	7.33	8.00	4.00	4.00
	cotton	291.55	303.45	2.17	2.18	6.50	8.00	3.72	3.72

Afterwards plain jersey fabrics from undyed and dyed chenille yarns were knitted on an E7 gauge SES 234-F model Shima Seiki flat knitting machine. All the fabric types were knitted at the same cam setting in order to see the effect of yarn structure on the fabric properties. The properties of the chenille yarns and fabrics are shown in ***Tables 1*** and ***2***, respectively.

The dry relaxation process was applied to the chenille fabric samples. After the samples were taken off the machine, they were laid on a smooth and flat surface in standard atmospheric conditions for one week.

The following properties of the fabrics were measured when they were in a dry relaxation state in accordance with relevant standards: course and wale per cm, ISO 7211-2; fabric weight (g/m^2), ISO 3801; fabric thickness (mm), ISO 5084; bending rigidity, BS 3356.

Abrasion resistance tests of the knitted chenille fabric samples were carried out with the help of a Martindale abrasion tester in accordance with ISO 12947 [20]. Abrasion cycles were limited to 5000 testing cycles, and mass losses in milligrams and thickness losses in mm were determined for three abrasion levels at 1000, 2000 and 5000 cycles. Average values of the mass loss in % and thickness loss ratios were obtained from the proportion of the mass loss and thickness loss of the samples after the test levels divided by the initial mass and thickness of the samples.

An SPSS 13.0 statistical package was used for all statistical procedures. Statistical analyses were carried out using a

Table 3. ANOVA results for bending rigidity and abrasion resistance.

Source	Bending Rigidity-Wale Way				Bending Rigidity-Course Way			
	undyed		dyed		undyed		dyed	
	F Ratio	Probability (F-ratio)	F Ratio	Probability (F-ratio).	F Ratio	Probability (F-ratio)	F Ratio	Probability F-ratio)
Pile Type	3.04	.007	0.99	.436	4.05	.001	4.53	.000
Core Type	0.49	.481	1.29	.257	0.08	.784	0.37	.544
PileType*CoreType	2.17	.047	0.12	.994	3.46	.003	1.34	.241
Source	**Bending Rigidity-FabricWale Way**				**Thickness Loss-1000 cycles**			
	undyed		**dyed**		**undyed**		**dyed**	
	F Ratio	**Probability (F-ratio)**	**F Ratio**	**Probability (F-ratio).**	**F Ratio**	**Probability (F-ratio)**	**F Ratio**	**Probability (F-ratio)**
Pile Type	3.88	.001	2.17	.047	11.63	.000	15.06	.000
Core Type	0.43	.514	0.03	.872	17.13	.000	3.73	.064
PileType*CoreType	3.15	.006	0.35	.907	9.38	.000	25.04	.000
Source	**Thickness Loss-2000 cycles**				**Thickness Loss-5000 cycles**			
	undyed		**dyed**		**undyed**		**dyed**	
	F Ratio	**Probability (F-ratio)**	**F Ratio**	**Probability (F-ratio).**	**F Ratio**	**Probability (F-ratio)**	**F Ratio**	**Probability (F-ratio)**
Pile Type	20.06	.000	13.68	.000	16.84	.000	17.37	.000
Core Type	5.03	.033	18.06	.000	67.23	.000	27.73	.000
PileType*CoreType	20.11	.000	3.21	.016	14.66	.000	8.93	.000
Source	***Mass Loss-1000 cycles***				***Mass Loss-2000 cycles***			
	undyed		***dyed***		***undyed***		***dyed***	
	F Ratio	***Probability (F-ratio)***	***F Ratio***	***Probability (F-ratio).***	***F Ratio***	***Probability (F-ratio)***	***F Ratio***	***Probability (F-ratio)***
Pile Type	21.98	.000	5.299	.001	22.19	.000	18.73	.000
Core Type	0.009	.924	31.00	.000	4.28	.048	48.44	.000
PileType*CoreType	19.25	.000	17.76	.000	14.16	.000	7.403	.000
Source	**Mass Loss-5000 cycles**							
	undyed		**dyed**					
	F Ratio	**Probability (F-ratio)**	**F Ratio**	**Probability (F-ratio).**				
Pile Type	19.47	.000	37.98	.000				
Core Type	13.70	.001	87.01	.000				
PileType*CoreType	2.79	.030	9.26	.000				

***Table 4.** Effects of pile and core yarn fibre types on the abrasion resistance of chenille fabric (mass loss ratio and thickness loss ratio at 1000, 2000 and 5000 abrasion cycles), Student-Newman-Keuls (SNK) Test; 1)The different letters (a, b, etc.) next to the counts indicate that they are significantly different from each other at a 5 percent significance level.*

Parameter1)		Mass loss,%						Thickness loss,%					
		1000 cycles		2000 cycles		5000 cycles		1000 cycles		2000 cycles		5000 cycles	
		undyed	dyed	undyed	dyed	undyed	dyed	undyed	dyed	undyed	dyed	undyed	dyed
Pile yarn fibre type	tencel	8.92 a	13.81 a	20.87 b	21.23 a	36.28 b	29.43 a	16.08 a	21.86 b	25.82 a	28.00 a	48.85 b	36.89 a
	cotton	8.42 a	14.44 a	15.57 a	23.46 b	28.65 a	31.59 b	19.24 b	21.56 b	29.72 b	29.25 ab	45.31 a	36.62 a
	bamboo	8.75 a	13.54 a	22.47 b	25.27 b	43.52 e	33.73 c	19.14 b	17.59 a	33.38 c	27.35 a	57.14 e	38.41 a
	soybean	9.28 a	14.94 a	22.54 b	24.91 b	39.36 bcd	35.10 cd	22.64 c	23.09 b	37.33 d	38.60 c	53.08 cd	44.99 b
	50/50% soya-tencel	9.12 a	17.20 b	21.15 b	25.58 b	38.54 bc	36.28 d	16.99 ab	25.76 c	29.68 b	37.44 c	50.46 bc	46.64 b
	modal	15.34 b	14.44 a	29.78 c	28.19 c	42.42 cd	40.43 e	19.09 b	17.93 a	29.22 b	29.03 ab	54.87 de	44.86 b
	viscose	8.20 a	15.89 ab	21.88 b	31.37 d	40.86 cd	40.47 e	18.05 ab	21.69 b	28.86 b	33.20 b	56.36 de	45.79 b
Core yarn fibre type	polyester	9.74 a	13.73 a	21.34 a	23.73 a	36.94 a	32.90 a	17.79 a	20.82 a	29.87 a	29.83 a	49.04 a	39.88 a
	viscose	9.70 a	16.06 b	22.73 b	27.70 b	40.10 b	37.68 b	19.71 b	21.89 a	31.27 b	33.85 b	55.55 b	44.17 b

completely randomised two-factor analysis of variance (RM ANOVA) as a fixed model in order to determine the significance of the factors for the fabric mass loss ratio, fabric thickness loss ratio as well as for course and wale way bending rigidity values (***Table 3***). The means were compared by Student-Newman-Keuls (SNK) tests. All test results were assessed at a confidence level of at least 95% (mostly at a 5% significance level). Treatment levels were set in accordance with the mean values, and any levels denoted by the same letter showed that they were not significantly different.

Results and discussion

Figure 2 illustrates average mass loss values of knitted fabrics produced with dyed and undyed chenille yarns versus seven types of pile yarn material for two different core yarn material types after 5000 abrasion cycles. ***Figure 3*** illustrates average thickness loss values of chenille knitted fabrics produced with dyed and undyed chenille yarns versus seven types of pile yarn material for two different core yarn material types after 5000 abrasion cycles.

SNK test results of fabrics knitted with dyed and undyed chenille yarns for mass loss and thickness loss are given in ***Table 4***.

According to the variance analysis results for chenille fabrics, the type of pile yarn fibre was a significant factor affecting mass loss at all levels of abrasion cycle (1000, 2000, 5000 cycles). However, the effect of the core yarn type on the abrasion resistance was significant except for in case. At 1000 abrasion cycles the type of core yarn fibre was an insignificant factor for the mass loss of fabrics produced with undyed chenille yarns.

The results of the variance analysis revealed statistically significant differences between the thickness loss values of chenille fabrics for different pile yarn fibre types. However, the effect of core yarn type on the thickness loss was significant except for one case. Core yarn fibre type was an insignificant factor for the thickness loss of chenille fabrics produced with dyed chenille yarns at 1000 abrasion cycles.

In terms of the core yarn fibre type, for mass loss and thickness loss values, there was a tendency towards decreased mass loss and thickness loss with the use of polyester fibre as the core yarn material. The mass losses of fabrics produced using chenille yarns with viscose core yarn were greater than those produced using chenille yarns with polyester core yarn at 2000 and 5000 abrasion cycles. This situation was the same for fabrics produced with both dyed and undyed chenille yarns. At 1000 abrasion cycles the mass loss of fabrics produced using undyed chenille yarns with polyester core yarn was greater than that with viscose core yarn.

In addition to this, the thickness losses of fabrics produced using chenille yarns with viscose core yarn were greater than those produced using chenille yarns with polyester core yarn at all the levels of abrasion cycles. This situation was same for fabrics produced with both dyed and undyed chenille yarns.

There was a decrease in mass loss and thickness loss values with the use of polyester core yarn in chenille yarns when the yarn parameters were constant. It is generally stated that the ability of a fibre to withstand repeated distortion is the key to its abrasion resistance. In a general assessment of fibre abrasion resistance, polyamide is the most outstanding followed by polyester; wool and cotton have a moderate abrasion resistance. Viscose and acetates are found to have the lowest degree of resistance to abrasion [21].

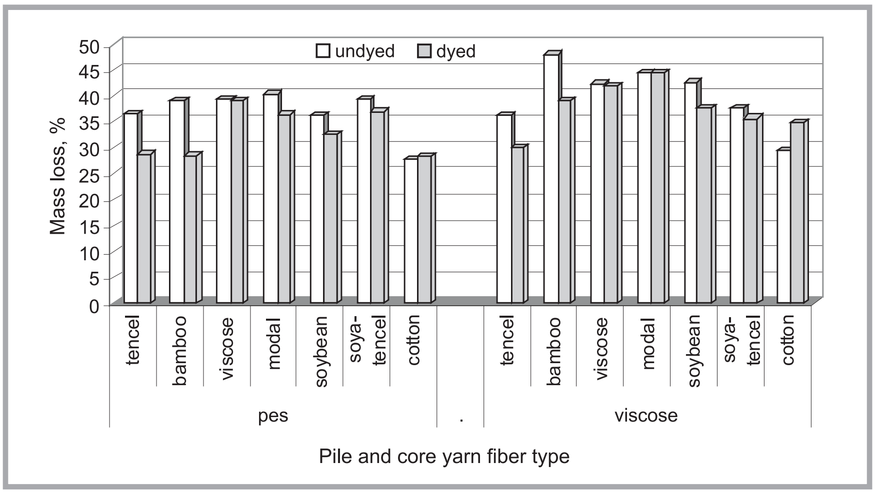

__Figure 2.__ Mass loss values versus pile and core yarn fibre types for fabrics produced with dyed and undyed chenille yarns after 5000 abrasion cycles.

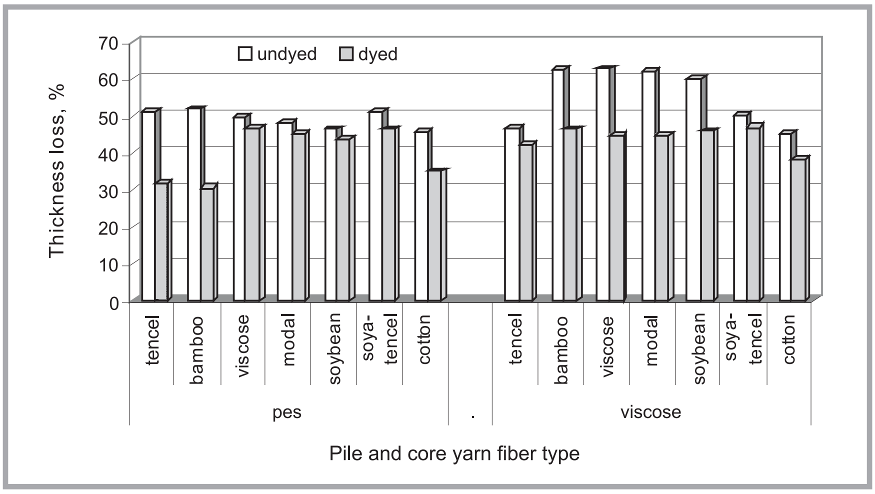

__Figure 3.__ Thickness loss values versus pile and core yarn fibre types for fabrics produced with dyed and undyed chenille yarns after 5000 abrasion cycles.

In terms of the pile yarn fibre type, except for the mass loss values of fabrics produced with undyed chenille yarns at 5000 abrasion cycles, there was a tendency towards decreased mass loss when tencel, cotton and bamboo were used as pile yarn for the production of chenille yarns. At all the abrasion levels viscose and modal pile yarn fibre types displayed poor abrasion resistance, with higher values of mass loss than the other fibre types.

Fabrics produced using undyed chenille yarns with modal pile fibre gave higher mass loss results than those using chenille yarns with viscose pile fibre. When the mass loss results of the dyed fabrics were compared according to pile fibre type, the abrasion resistance of the fabrics produced using chenille yarns with modal pile fibre increased after the dyeing process. Due to this increment, the mass loss values of the modal fabrics became lower than those of the viscose fabrics at all the abrasion cycles. From the starting level to an abrasion level of 2000 cycles, the difference between the mass loss results of viscose and modal fabrics are statistically significant. Despite the values obtained from the starting level, at anabrasion level of 5000 cycles, differences between the mass loss results of viscose and modal fabrics are of no importance at a 5% significance level. Fabrics produced using chenille yarns with soybean and 50/50% soybean-tencel blend pile fibres showed moderate abrasion resistance compared with the other types.

When the thickness loss results of chenille fabrics were compared with regard to pile yarn type, it was seen that chenille fabrics with soybean pile yarn experienced greater thickness loss than those with other pile types. Except for the thickness loss values of fabrics produced

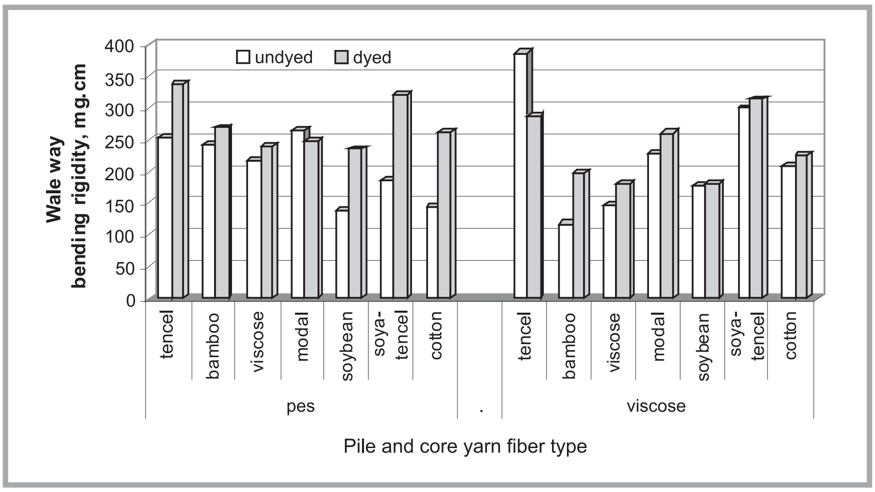

Figure 4. *Wale way bending rigidity values versus the pile and core yarn fibre types for fabrics produced with dyed and undyed chenille yarns.*

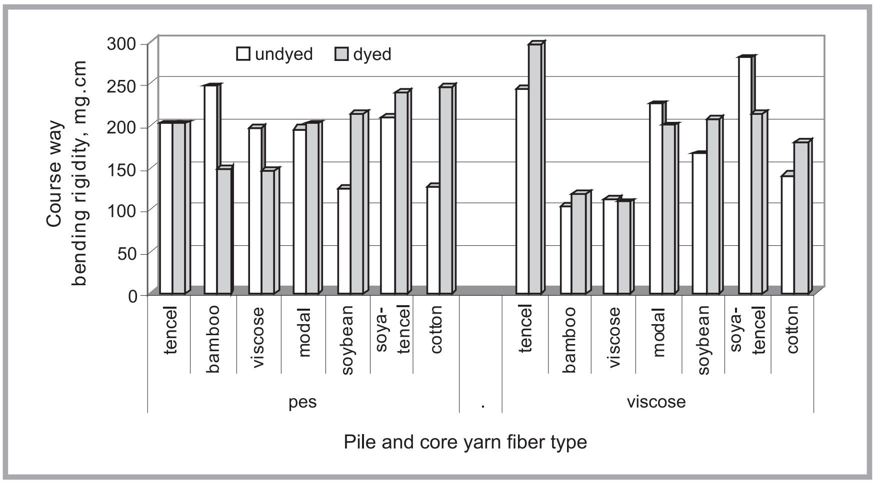

Figure 5. *Course way bending rigidity values versus the pile and core yarn fibre types for fabrics produced with dyed and undyed chenille yarns.*

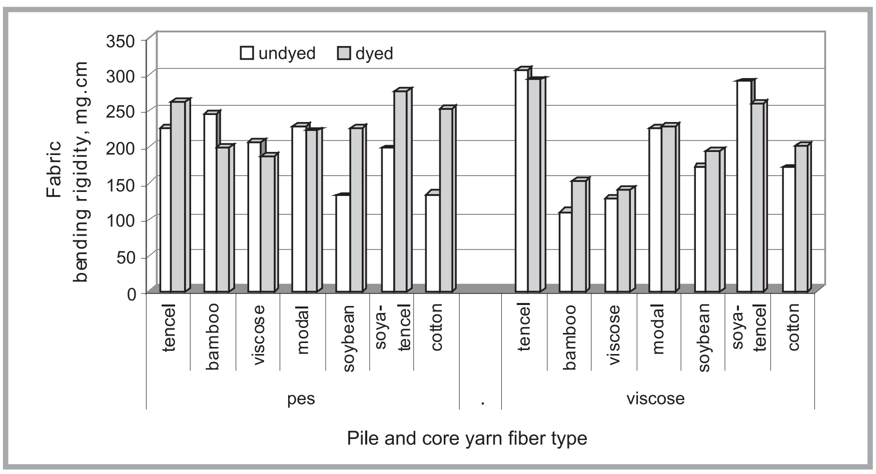

Figure 6. *Fabric bending rigidity values versus the pile and core yarn fibre types for fabrics produced with dyed and undyed chenille yarns.*

with undyed chenille yarns at 5000 abrasion cycles, there was a tendency towards decreased thickness loss with the use of tencel as pile yarn for the production of chenille yarns.

The comparison of the results of chenille fabrics with increasing abrasion cycles shows an interesting situation. While the thickness loss values of modal and viscose fabrics were moderate at 1000 and 2000 abrasion cycles, at 5000 abrasion cycles these fabrics showed a higher thickness loss than the other fibre types; the thickness loss values of viscose and modal fibre types were statistically same. ***Figures 4 - 6*** illustrate the average wale way, course way and fabric bending rigidity values of chenille knitted fabrics produced with undyed and dyed chenille yarns versus seven pile yarn material types for two different types of core yarn material, respectively.

SNK test results of fabrics knitted with dyed and undyed chenille yarns for wale way, course way and fabric bending rigidity are given in ***Table 5***.

The results of variance analysis for fabric bending rigidity, wale and course way bending rigidity revealed that the effect of core yarn fibre type was insignificant in fabrics knitted with dyed and undyed chenille yarns.

According to the variance analysis results, except in one case (wale way bending measurements of fabrics with dyed chenille yarns), pile yarn fibre type was a significant factor affecting the wale and course way bending rigidity of chenille fabrics produced with dyed and undyed chenille yarns.

Fabrics produced using chenille yarn with tencel pile fibre was the most rigid in wale way bending compared to the other types. Soybean, cotton, bamboo and viscose fabrics produced with undyed chenille yarns have a lower wale way bending rigidity. Tencel and 50/50% soybean-tencel fabrics produced with dyed and undyed chenille yarns were the most rigid in course way bending compared to the others. Cotton fabrics produced with undyed chenille yarns have the lowest course way bending rigidity. In addition to this, viscose and bamboo fabrics produced with dyed chenille yarns have the lowest course way bending rigidities.

The results of variance analysis for fabric bending rigidity revealed that the effect of pile yarn fibre type was insignificant in fabrics knitted with dyed chenille yarns. Cotton fabrics produced with undyed chenille yarns have the lowest fabric bending rigidity, while tencel and 50/50% soybean-tencel fabrics have the highest.

***Table 5.** Effects of pile and core yarn fibre types on the bending rigidity of chenille fabric (wale way, course way and fabric bending rigidities), Student-Newman-Keuls (SNK) Test;[1)] The different letters (a, b, etc.) next to the counts indicate that they are significantly different from each other at a 5 percent significance level.*

Parameter[1)]		Bending rigidity, mg.cm%					
		Wale way		Course way		Fabric	
		Undyed	dyed	undyed	dyed	undyed	dyed
Pile yarn fibre type	tencel	320.03 b	312.54 a	222.23 bc	249.35 b	219.07 c	224.34 a
	cotton	177.16 a	243.97 a	133.33 a	212.35 ab	120.89 a	178.40 a
	bamboo	180.40 a	233.53 a	175.28 abc	132.51 a	153.06 abc	128.00 a
	soybean	158.97 a	208.40 a	144.95 ab	210.98 ab	130.93 ab	155.69 a
	50/50% soya-tencel	242.26 ab	316.91 a	244.85 c	226.88 b	200.64 bc	216.61 a
	modal	246.52 ab	253.59 a	210.32 abc	201.09 ab	193.83 abc	174.96 a
	viscose	181.44 a	210.70 a	154.09 ab	127.36 a	139.37 ab	129.38 a
Core yarn fibre type	polyester	206.49 a	273.46 a	181.77 a	199.39 a	160.56 a	174.07 a
	viscose	224.02 a	235.01 a	181.38 a	189.33 a	170.24 a	170.89 a

Conclusions

The objective of this study was to investigate the specific influences of pile yarn fibres of the comfort type and core yarn fibre types on the abrasion and bending properties (mass loss, thickness loss, wale way bending rigidity, course way bending rigidity, and fabric bending rigidity) of knitted fabrics produced with chenille yarns.

When the results are examined, the following conclusions can be drawn.

- Pile and core yarn fibre types have significant influences on the abrasion resistance of chenille fabrics. Pile loss is encouraged by inadequate fibre adherence. The careful choice of pile and core yarns to increase inter-fibre friction may assist in reducing the rate of pile loss. Our results imply that using polyester as core yarn fibre, and tencel and cotton as pile yarn fibre in the production of chenille yarns will help to produce knitted chenille fabrics with high abrasion resistance.
- For undyed chenille yarns, pile yarn fibre type is statistically significant for the change in course way, wale way and fabric bending rigidity. The results for fabric bending rigidity and the wale and course way bending rigidity reveal that the effect of core yarn fibre type is insignificant for fabrics knitted with dyed and undyed chenille yarns.
- Bamboo chenille fabrics have a moderate abrasion resistance with mass loss values between those of viscose and cotton chenille fabrics, while modal chenille fabrics have less resistance to abrasion with mass loss values close to those of viscose. In addition to this, bamboo chenille fabrics have a soft handle. Tencel and 50/50% soybean-tencel chenille fabrics are the stiffest fabrics from among the types.
- Furthermore, it will be useful to carry out studies about the influence of dyeing processes on the change in the physical properties of chenille yarns.

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