(REFEREED RESEARCH)

A RESEARCH ON YARN LIVELINESS TENDENCY OF STAPLE YARNS

ŞTAPEL İPLİKLERİN İPLİK CANLILIĞI EĞİLİMLERİ ÜZERİNE BİR ARAŞTIRMA

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ABSTRACT

Yarn snarling tendency causes several problems at the various post-spinning processes, such as winding, warping, weaving and knitting. In this study we analyzed the snarling tendency of short and long staple yarns. The yarn samples were produced with different raw material, spinning technique and yarn parameter variations. Long staple yarns from 100% wool and 100% acrylic (PAN) fibers were spun in two different nominal yarn counts with three different yarn twist factors using four different yarn spinning techniques. Short staple yarns from 100% cotton, 100% viscose, 100% polyester, 100% modal and 100% lyocell fibers were spun in two different nominal yarn counts with three different yarn twist factors using three different yarn spinning techniques. After spinning process their twist liveliness values were measured on Keisokki Kringel Factor Meter yarn liveliness test apparatus. The tests results were analyzed and evaluated in order to asses the effects of raw material, spinning technique and yarn parameters on yarn twist liveliness.

Key Words: Yarn liveliness, Staple yarn, Long staple spinning, Short staple spinning, Yarn steaming, Fabric spirality.

ÖZET

İpliğin kendi üzerine kıvrılma eğilimi bobinleme, dokuma ve örme gibi eğirme sonrası işlemlerde bir çok probleme neden olmaktadır. Bu çalışmada uzun ve kısa ştapelli liflerden üretilmiş ipliklerin kendi üzerine kıvrılma eğilimi incelenmiştir. İplik numuneleri farklı hammadde, eğirme tekniği ve değişen iplik parametreleri ile üretilmiştir. Uzun ştapelli iplikler %100 yün ve %100 akrilik (PAN) liflerinden iki farklı iplik numarası ve üç farklı iplik büküm katsayısı ile dört farklı iplik eğirme tekniği kullanılarak üretilmiştir. Kısa ştapelli iplikler %100 pamuk, %100 viskon, %100 polyester, %100 modal ve %100 lyocell liflerinden iki farklı iplik numarası ve üç farklı iplik büküm katsayısı ile üç farklı iplik eğirme tekniği kullanılarak üretilmiştir. İpliklerin iplik canlılığı değerleri Keisokki Kringel Factor Meter test aparatı kullanılarak ölçülmüştür. İplik canlılığına hammaddenin, eğirme tekniğinin ve iplik parametrelerinin etkisini belirlemek için test sonuçları analiz edilmiş ve değerlendirilmiştir.

Anahtar Kelimeler: İplik canlılığı, Ştapel iplik, Uzun ştapel iplik eğirme, Kısa ştapel iplik eğirme, İplik büküm fiksajı, May dönmesi.

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1. INTRODUCTION

Textile fibres and yarns are subjected to torsional strains during various processes of yarn manufacturing. In staple yarns, twist is essential to hold the fibres together and to provide the required strength to the yarn structure. Especially, twisting process induces tension within yarn and its constituent fibres. Twist is one of the most important yarn features influencing the properties of yarn. It is a known fact that the yarn liveliness is related with yarn twist and strain.

Yarn twist liveliness is affected by the twist factor, yarn fineness and retractive forces, which, in turn, are determined by the torsional and bending stresses in the fibres, and torque generated during yarn twisting (1).

Yarns tend to snarl in order to relax themselves and simultaneously are twisted in the opposite twist direction. This property is described as “liveliness”.

In fancy yarn production, cut-piled carpet production and medical bandage manufacture, the effect of yarn liveliness is employed as an advantage (2). On the other hand, yarn twist liveliness causes several problems at various post-spinning processes, such as winding, warping, weaving and knitting; for example, it may generate yarn breakage at winding process. In addition, yarn twist liveliness is the main cause of the spirality in single jersey knitted fabrics (3, 4, 5, 6, 7). If a twist-lively yarn is used for knitting, the resultant loop will no longer be symmetric because of the varying induced torsional strain in the yarn (8).

Generally vacuum steaming process is used for reducing the yarn snarling tendency, but it fails to eliminate the snarling tendency completely. There is still a small amount of retained snarling tendency in the yarn after steaming process.

In terms of reducing yarn liveliness, a moderate steaming is much more effective than prolonged storage in an atmosphere of 65% r.h., 20ºC (9).

The yarn twist liveliness phenomenon caused by a wide variety of factors. However, in order to narrow the scope of this study only the most important factors including raw material, yarn count, yarn twist level, spinning technique and steaming operation were selected for this research.

2. EXPERIMENTAL

Short staple yarns from cotton, polyester, viscose, modal and lyocell were spun in two different nominal yarn counts Ne 16 (36.91 tex) and Ne 24 (24.61 tex) with three different yarn twist coefficient (α_e 3.5, α_e 4.1, α_e 4.7) by using three different spinning techniques, ring spinning (Rieter model G30), OE rotor spinning (Rieter model R40) and compact spinning (Zinser compact spinning machine). The specifications of raw materials are given in Table 1.

Table 1. Raw material specifications

Raw material	Fineness	Fibre length
100% cotton	3,95 mic.	29,11 mm (UHML)
100% polyester	1.2 denier	38 mm
100% viscose	1.2 denier	38 mm
100% modal	1.2 denier	38 mm
100% lyocell	1.2 denier	38 mm

After the spinning process, one half of these yarns (the ring and compact yarns were in cop form and the OE yarns were in cone form) were subjected to steaming operation (90°C, 10 min., two cycles of vacuum steaming). Subsequently, the yarn liveliness values of untreated and steamed yarns were measured at standard humidity and temperature (20±2ºC and 65% Rh) by using the Kringel Factor Meter. 10 individual samples were taken from each party, and five tests were done by each sample.

Long staple yarns out of 100% wool and out of 100% acrylic (PAN) were spun in two different nominal yarn counts (Nm20 (50 tex) and Nm 32 (31.25 tex)). Each yarn count was spun at three different twist coefficient (α_m 80, α_m 90, α_m 100) by using four different spinning techniques, ring spinning (Zinser ring spinning machine), siro-spun spinning (Zinser sirospun system), compact spinning (EliTe compact spinning) and compact siro-spun spinning (EliTwist). After the spinning process, one half of these yarns, whose yarn packages were in cop form, were subjected to steaming operation (85°C, 10 min., two cycles of vacuum steaming). Subsequently, the yarn liveliness of untreated and steamed yarns was measured at standard humidity and temperature (20±2ºC and 65% RH) by using the Kringel Factor Meter. The yarn specifications of all yarn samples were measured.

The specifications of raw materials are given in Table 2.

In this study, Keisokki Kringel Factor Meter twist liveliness test apparatus was used (Figure 1). The measuring principle can be described briefly as following steps;

Table 2. Raw material specifications

Raw material	Fineness	Fibre length
100% wool	21 micron (for Nm32 (20 tex) yarns)	71,7 mm
100% wool	22 micron (for Nm 20 (50 tex) yarns)	70,5 mm
100% PAN	2,5 denier (for Nm32 (20 tex)yarns)	90 mm
100% PAN	3 denier (for Nm 20 (50 tex) yarns)	90 mm

I- Yarn is positioned through the pins to form a triangular path.

II- A specific amount of weight is hanged down at the end of the each coupled yarn pair.

III- The weight hanged yarn couple is let free to rotate axially until it reaches to a stable state.

IV- Thereafter, the length of twisted (axially rotated) part of the coupled yarns are measured from the scale.

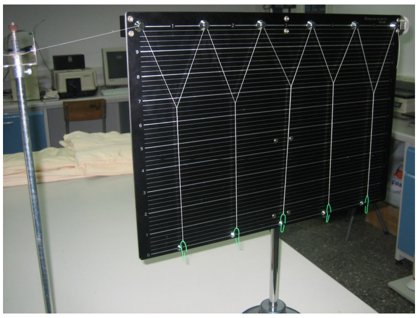

Figure 1. Kringel factor meter yarn liveliness test apparatus

This numeric value which is termed as Kr value (Kringel factor) gives the quantitative measure of the yarn twist liveliness. This apparatus functions with a standard weight for all sorts of yarn counts. However, pre-trials showed that in order to obtain more precise results weight should be varied depending on yarn linear density. A weigh of 10 mg per tex was found to be the most appropriate for our purpose. In addition, the yarn properties of all yarn samples were measured. An individual group of ten cops (cones for OE yarns) were tested for each yarn sample. All of the measurements were carried out under the standard atmospheric conditions.

The tensile properties of the yarns were evaluated by using an Uster Tensorapid 3 tensile testing machine. Unevenness tests were performed by using an Uster Tester 3. The yarn hairiness properties of the yarns were evaluated by using a Zweigle G566 yarn hairiness testing machine.

Furthermore, a party (having the yarn characteristics of 100% PAN, Nm32/1, α_m=90) were selected out of the yarn samples and these selected yarns were knitted on a single system-single jersey hosiery machine. The fabric spirality behavior of the yarns was evaluated over these knitted fabric samples both before and after washing. Statistical analyses were performed by implementing the statistical software. To determine the statistical importance of the variations, ANOVA tests were applied. To deduce whether the parameters were significant or not, p values were examined. Ergün (10) emphasized that if p value of a parameter is greater than 0.05 (p>0.05), the parameter will not be important and should be ignored.

3. RESULTS AND DISCUSSION

Yarn liveliness Kr (Kringel factor) values of untreated and steamed short staple yarn samples were given in Figure 2, Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7.

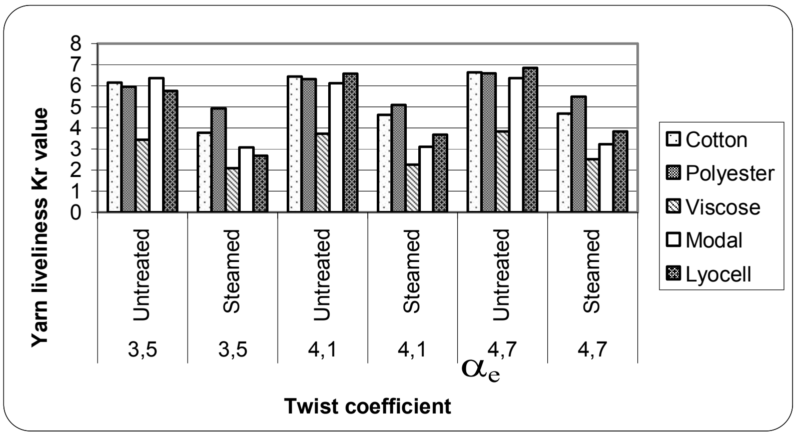

Figure 2. Yarn liveliness values of Ne24 (24,61 tex) short staple ring yarn samples

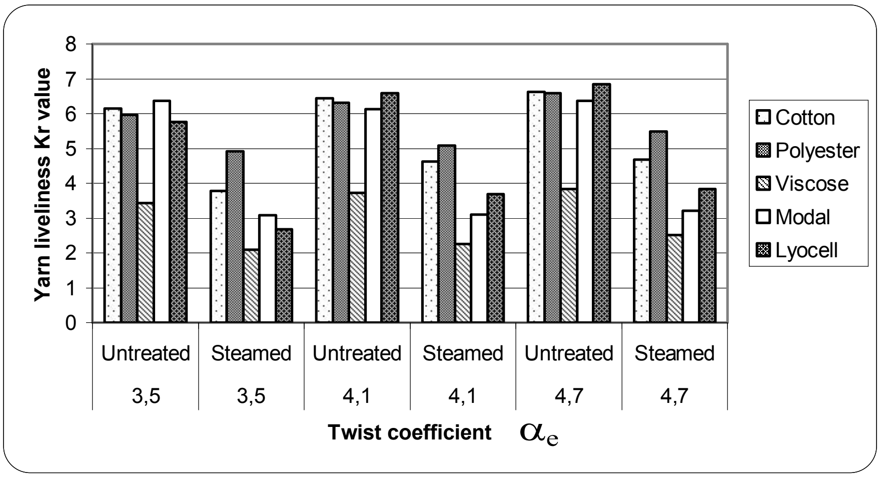

Figure 3. Yarn liveliness values of Ne24 (24,61 tex) short staple OE rotor yarn samples

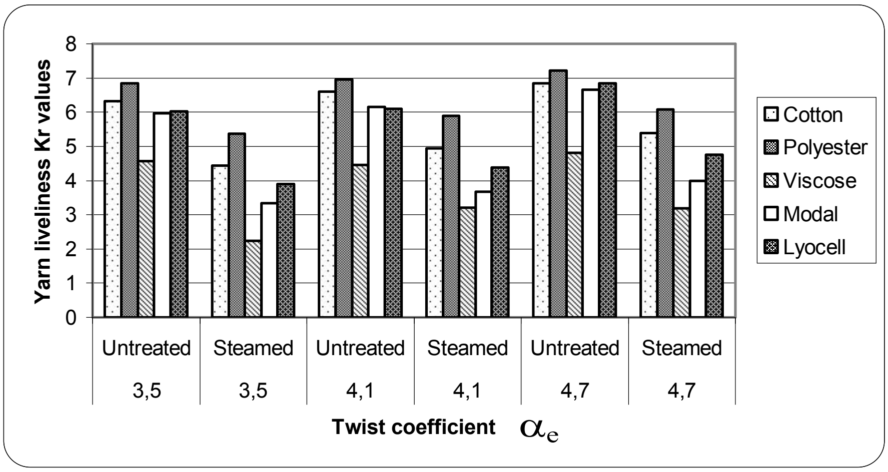

Figure 4. Yarn liveliness values of Ne24 (24,61 tex) short staple compact yarn samples

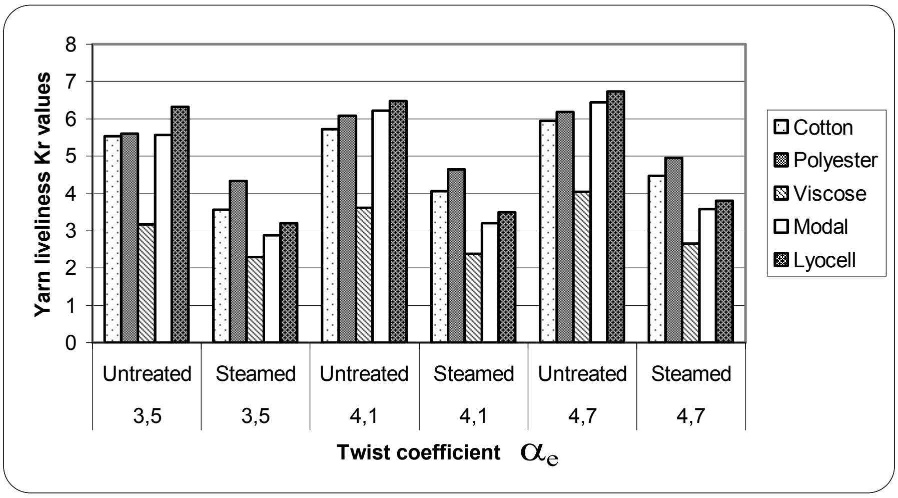

Figure 5. Yarn liveliness values of Ne16 (36 tex) short staple ring yarn samples

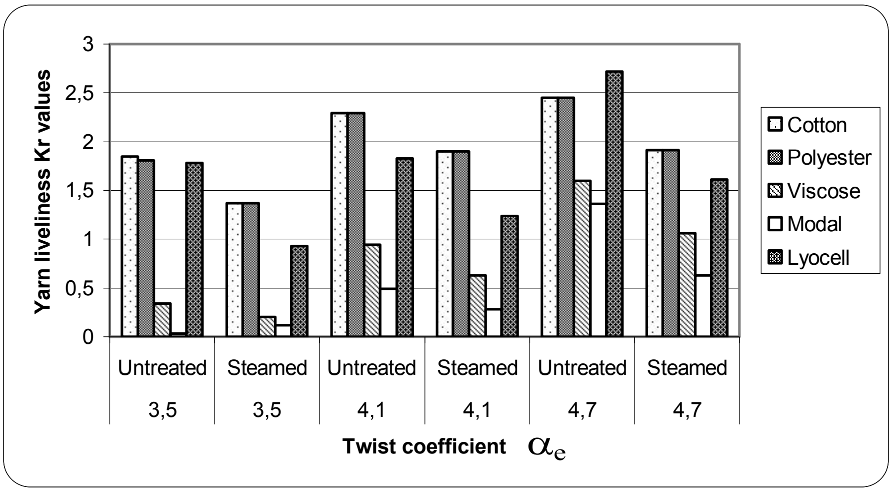

Figure 6. Yarn liveliness values of Ne16 (36 tex) short staple OE rotor yarn samples

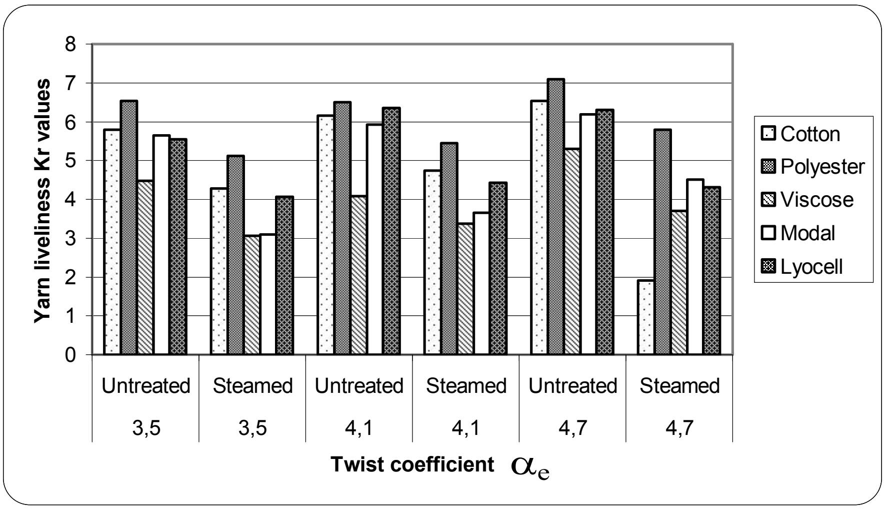

Figure 7. Yarn liveliness values of Ne16 (36 tex) short staple compact yarn samples

Yarn liveliness Kr (Kringel factor) values of untreated and steamed long staple yarn samples were given in Table 3 and Table 4.

The results of the statistical analyses for the parameters influencing the yarn liveliness properties of yarns (including the products of both the short staple spinning methods and the long staple spinning methods) were evaluated as below:

Influence of Raw Material on Yarn Liveliness

The results demonstrated that the influence of the raw material on the yarn liveliness were statistically significant for both spinning methods (the short staple spinning and the long staple spinning (Table 5).

The multiple comparison techniques for the short staple yarns revealed that the difference between cotton and lyocell yarns was statistically insignificant, whereas the differences between cotton and the other raw materials were statistically significant.

The results suggest that the yarns having the viscose raw material tend to display the minimum level of yarn liveliness (Figure 8).

Table 3. Yarn liveliness values of Nm32 (31,25 tex) long staple yarn samples

Raw material	Spinning method	Twist coefficient α_m	Twist liveliness Kr values					
			80	80	90	90	100	100
			untreated	steamed	untreated	steamed	untreated	steamed
Wool	Ring	Kr value	5,37	1,56	5,69	1,35	5,39	1,52
		Kr Cv%	1,77	24,77	2,55	27,10	2,39	19,57
	Siro spun	Kr value	5,05	1,52	5,3	1,47	5,24	1,92
		Kr Cv%	2,51	38,46	1,99	35,14	1,84	12,95
	Compact	Kr value	6,8	1,63	6,93	2	7,11	2,22
		Kr Cv%	1,39	21,65	1,81	13,33	1,40	16,28
	Compact siro	Kr value	7,07	1,5	6,79	1,87	7,36	1,85
		Kr Cv%	1,49	14,74	1,28	14,92	1,45	27,23
PAN	Ring	Kr value	6,44	2,4	6,66	2,92	6,89	2,76
		Kr Cv%	1,50	8,33	1,05	4,21	1,07	5,18
	Siro spun	Kr value	6,4	3,13	6,57	3,09	6,74	3,11
		Kr Cv%	1,47	6,74	1,61	6,90	0,77	4,66
	Compact	Kr value	7,53	3,27	7,53	3	7,68	3,31
		Kr Cv%	1,09	6,46	0,90	6,48	0,82	2,65
	Compact siro	Kr value	7,46	3,35	7,58	3,2	7,75	3,53
		Kr Cv%	0,93	7,34	1,36	6,25	0,91	5,0

Table 4. Yarn liveliness values of Nm20 (50tex) long staple yarn samples

Raw material	Spinning method	Twist coefficient α_m	Twist liveliness Kr values					
			80	80	90	90	100	100
			untreated	steamed	untreated	steamed	untreated	steamed
Wool	Ring	Kr value	5,34	2,19	5,76	2,71	5,76	2,59
		Kr Cv%	2,53	14,51	1,68	14,07	1,21	15,49
	Siro spun	Kr value	5,06	2,27	5,16	2,7	5,55	2,72
		Kr Cv%	1,91	26,35	1,00	14,29	1,27	12,11
	Compact	Kr value	6,59	1,83	6,46	2,03	6,48	2,34
		Kr Cv%	2,72	16,70	2,09	13,94	2,60	13,39
	Compact siro	Kr value	7,07	2,08	7,02	2,72	7,25	2,52
		Kr Cv%	1,64	14,47	1,85	9,13	1,97	6,42
PAN	Ring	Kr value	6,64	2,91	6,7	2,66	6,77	2,94
		Kr Cv%	1,77	5,72	1,00	15,16	1,40	7,21
	Siro spun	Kr value	6,53	3,8	6,61	3,84	6,89	3,84
		Kr Cv%	1,03	10,08	1,12	9,60	0,82	7,18
	Compact	Kr value	7,41	3,73	7,47	3,14	7,63	3,39
		Kr Cv%	1,00	5,06	0,65	12,31	1,24	2,18
	Compact siro	Kr value	7,47	3,81	7,58	3,3	7,73	4,13
		Kr Cv%	0,90	10,53	1,04	5,88	0,62	11,64

Table 5. Influence of raw material on yarn liveliness

Factor	Spinning system	Dependent variable	F values	Significance
Raw material	Short staple spinning	Kr values of untreated yarns	5439,652	0,000*
		Kr values of steamed yarns	3986,940	0,000*
	Long staple spinning	Kr values of untreated yarns	228164,2	0,000*
		Kr values of steamed yarns	512,318	0,000*

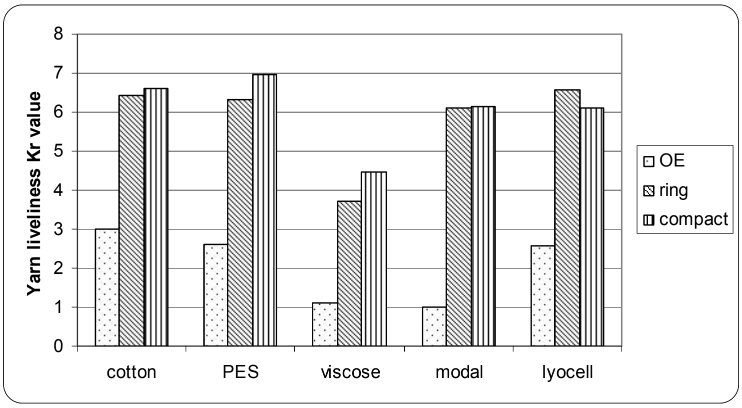

Figure 8. The yarn liveliness Kr values of Ne24 (25 tex) (α_e 4.1) yarns (untreated)

Table 6. Multiple comparison of spinning methods

Dependent variable	(I) method	(J) method	Mean difference (I-J)	significance	%95 confidence interval Lower bound	Upper bound
Yarn liveliness values (untreated yarns)	ring	compact	-0.3330	.000*	-0.3637	-0.3023
		open end	3.8147	.000*	3.7839	3.8454
	compact	ring	0.3330	.000*	0.3023	0.3637
		open end	4.1477	.000*	4.1169	4.1784
	open end	Ring	-3.8147	.000*	-3.8454	-3.7839
		compact	-4.1477	.000*	-4.1784	-4.1169
Yarn liveliness values (steamed yarns)	ring	compact	-0.6940	.000*	-0.7316	-0.6564
		open end	2.2887	.000*	2.2511	2.3263
	compact	ring	0.6940	.000*	0.6564	0.7316
		open end	2.9827	.000*	2.9451	3.0203
	open end	ring	-2.2887	.000*	-2.3263	-2.2511
		compact	-2.9827	.000*	-3.0203	-2.9451

* Differences between means is significant for α = 0,05.

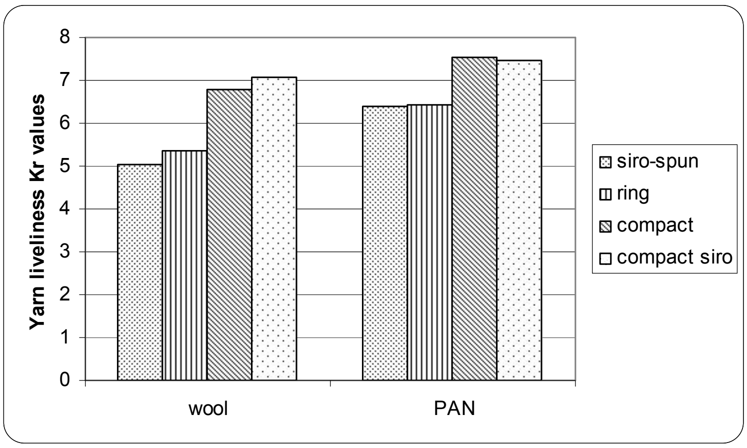

Figure 9. The yarn liveliness Kr values of Nm32 (31.25 tex) (α_m 80) yarns (untreated)

The results of acrylic and wool yarns revealed higher yarn liveliness values for acrylic yarns. The differences of yarn liveliness values between acrylic yarns and wool yarns evolved as statistically significant for both yarn counts.

Numerous researchers mentioned about the influence of fibre's flexural and torsional rigidity properties over yarn snarling (1) (2). Various raw materials have different specific flexural rigidity and torsional rigidity properties, thus the spun yarns out of different raw materials have different yarn liveliness values. For example, Morton and Hearl (14) declared the typical specific flexural rigidity value for cotton fibres as 0,53 mN mm^2/tex^2, and for viscose fibres as 0,35 mN mm^2/tex^2.

Influence of Spinning Method on Yarn Liveliness

The comparison of spinning methods (short staple spinning and long staple spinning) revealed that spinning method had a statistically significant effect on yarn liveliness (Table.6).

The minimum yarn liveliness values were observed in open-end yarns, whereas the maximum yarn liveliness values were observed in compact spun yarns.

The structural properties of the open-end yarns tend to retain lower yarn liveliness values. The fibre straps within the structure of open-end yarns restrain the release of the applied twist through the opposite direction. This is consistent with the results of previous studies of Kadoğlu (11), and Lünenschloss and Farber (12).

Statistical analysis of data showed that there were significant differences in the twist liveliness values of long staple yarns produced by different spinning methods for α= 0.05. The ranking for the twist liveliness values from the lowest value to highest value was siro-spun spinning, ring spinning, compact spinning and compact siro spinning respectively.

The results exposed that the compact spun yarns (both for short staple spinning and for long staple spinning methods) tend to have higher yarn liveliness values. The structure of compact spun yarns is different than the structure of ring spun yarns and compact spun yarns generally have a harder handle. For the yarns that spun with long staple spinning method, the siro-spun yarns displayed the lowest yarn liveliness values, whereas the compact siro-spun yarns displayed the highest values. Siro-spun yarns have stabile yarn construction (13).

Influence of Yarn Count on Yarn Liveliness

The influence of yarn count was recognized as statistically significant (Table 7). A fine yarn count gets more amount of twist than a coarse yarn count for the same spinning coefficient on a unit length of yarn, hence drawing forth a higher yarn liveliness value as

Table 7. Influence of yarn count and twist level on yarn liveliness

Factor	Spinning system	Dependent variable	F values	Significance
Yarn count	Short staple spinning	Kr values of untreated yarns	787,908	,000*
		Kr values of steamed yarns	97,966	,000*
	Long staple spinning	Kr values of untreated yarns	5,920	,000*
		Kr values of steamed yarns	1,896	,111
Twist level	Short staple spinning	Kr values of untreated yarns	1706,951	,000*
		Kr values of steamed yarns	1075,442	,000*
	Long staple spinning	Kr values of untreated yarns	39,023	,000*
		Kr values of steamed yarns	1,630	0,166

* Differences between means is significant for α = 0,05.

Table 8. Comparison of yarn liveliness values of steamed and untreated yarns

Spinning system	Paired samples	Mean	%95 confidence interval of the difference		t	df	Significance (2-tailed)
			Lower	Upper			
Short staple spinning	Yarn liveliness values of untreated yarns - Yarn liveliness values of steamed yarns	1,4463	1,3874	1,5053	48,163	899	,000*
Long staple spinning	Yarn liveliness values of untreated yarns - Yarn liveliness values of steamed yarns	7,2267	6,0012	8,4521	11,598	359	,000*

* Differences between means is significant for α = 0,05.

Table 9. Correlation of yarn liveliness and spirality (100%PAN, Nm32 (20 tex))

		Yarn twist (T/m)	Spirality of knitted fabric (before washing)	Spirality of knitted fabric (after washing)
Yarn liveliness Kr values	Correlation (Pearson)	0,320	0,478	0,243
	significance	,001**	,000**	0,011*

* significant for α = 0,05.
* * significant for α = 0,01.

well. This is consistent with the previous studies of Milosavljevic and Tadic (16) and of Ureyen (15), these studies also similarly emphasis on the significance of the yarn count.

Influence of Yarn Twist Level on Yarn Liveliness

The results in the Table.7 pointed out that the twist level of the yarn over the yarn liveliness was statistically significant. As the twist coefficient rises, the yarn liveliness also rises. This is consistent with the other related studies (1, 8, 11, 15, 16).

Influence of Yarn Steaming on Yarn Liveliness

The results in Table.8 revealed that the heat setting (fixing) operation had a statistically significant influence over the yarn liveliness in consistency with the other previous studies (1, 3, 17).

Influence of the Other Physical Yarn Specifications on Yarn Liveliness

It was not observed any significant relation between the hairiness of, irregularity of and strength of yarns over the yarn liveliness characteristic.

Correlation of yarn liveliness and spirality of knitted fabric

It was detected a strong correlation between yarn liveliness characteristics and knitted fabric spirality as seen in tine results of Table.9. As the yarn liveliness value increases, the degree of knitted fabric spirality tendency also increases. The steaming operation substantially reduced the degree of knitted fabric spirality. As the twist coefficient increases, Kr yarn liveliness value also correspondingly increases, consequently increasing the severity of knitted fabric spirality, which is consistent with the results of previous studies (3, 4, 5, 7, 17).

4. CONCLUSION

Twisting process causes tension in yarn and fibers. Yarn tends to untwist itself due to the internal tension, showing property described as yarn liveliness (16). This phenomenon is regarded as a problem having detrimental effects over workability at textile processes along with quality losses.

In this study, the Kringel Factor Meter test instrument was used for measuring the yarn liveliness. The influences of raw material, spinning method, yarn count, twist coefficient and steaming operation over the yarn liveliness properties were analyzed. For this purpose samples were produced on both short staple spinning system and long staple spinning system.

The results demonstrate that the raw material, the spinning method, the yarn count, the twist coefficient and the steaming operation, each of them individually, have statistically significant influence over the yarn liveliness properties of the yarns for both short staple and also for long staple yarns.

The statistical results of multiple comparison (Bonferroni) test method revealed that the minimum degree of yarn liveliness was attained for viscose yarns among the short staple ones. These results did not show any significant difference between cotton and lyocell yarns for their yarn liveliness properties. We can list that, the yarn liveliness values increases respectively in open-end spinning, ring spinning and compact spinning.

The results demonstrate that the within the long staple yarns, the acrylic fibre yarns have higher yarn liveliness values than wool yarns. The effect of spinning method on yarn twist liveliness was statistically significant. The compact siro yarns had the highest twist liveliness Kr value among the four spinning methods. They were followed by compact yarns, ring yarns and siro-spun yarns. After steaming process the compact siro yarns had the highest Kr values.

An obvious relation detected between the yarn liveliness values and knitted fabric spirality degrees within this study. In conclusion, the results of this study specifically suggest that as the yarn liveliness value Kr increases, the knitted fabric spirality degree increases as well.

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