(REFEREED RESEARCH)

%100 POLYESTER VE POLYESTER / PAMUK KARIŞIMI SİROSPUN İPLİKLERİN EĞRİLEBİLİRLİĞİNİN İNCELENMESİ

A RESEARCH ON SPINNABILITY OF 100% POLYESTER AND POLYESTER – COTTON BLEND SIROSPUN YARNS

Emrah TEMEL
Ege University,
Textile Engineering Department

Pınar ÇELİK
Ege University,
Textile Engineering Department
e-mail: pinar.celik@ege.edu.tr

ÖZET

Sirospun iplik eğirme sistemi, konvansiyonel ring eğirme sistemi üzerinde yapılan bir takım değişikliklerle geliştirilmiş, tek adımda çift katlı iplik eğirme sistemidir. Geçmişten günümüze Sirospun iplik üretimi ile ilgili çeşitli araştırmalar bulunmaktadır. İplik özelliklerini etkileyen çeşitli parametreler incelenmiştir. Bu çalışmada ise Sirospun iplik eğirme sistemi ile eğrilen karışım ipliklerin iplik özellikleri incelenmiştir. Çalışmanın amacı %100 polyester ve polyester / pamuk karışımı Sirospun ipliklerde, karışım oranının, iplik numarasının, büküm katsayısının ve fitiller arası mesafenin iplik özelliklerine etkisinin incelenmesidir. Bu amaçla %100 pamuk, %67 pamuk / %33 polyester, %33 pamuk / %67 polyester ve %100 polyester Sirospun iplikler üretilmiştir. Ayrıca karşılaştırma amacıyla da aynı hammaddeler kullanılarak ring iplikleri üretilmiştir. Üretilen ipliklerin iplik fiziksel özellikleri ölçülmüştür. Varyans analizi uygulanarak sonuçlar değerlendirilmiştir ve karışımın, iplik numarasının, büküm sayısının ve fitiller arası mesafenin iplik özelliklerine etkisi analiz edilmiştir. Analiz sonucunda karışımın, iplik numarasının, iplik büküm katsayısının ve fitiller arası mesafenin iplik özelliklerine etkisi istatistiksel olarak önemli bulunmuştur.

Anahtar Kelimeler: Siro eğirme, İki fitilli eğirme, Karışım iplikler, Fitiller arası mesafe, Büküm katsayısı, İplik özellikleri.

ABSTRACT

Sirospun spinning system, which holds two-folded yarn at one process, was promoted by some changes on ring spinning machines. From past to present various researches on Sirospun yarn production are existed and various parameters which affected yarn properties were analyzed. On this study, yarn properties of Sirospun blended yarns were investigated. The purpose of this work is to examine the influence of raw material, yarn count, twist multiplier and strand spacing on the yarn properties of %100 polyester and polyester/cotton blend yarns. To this end, 100% cotton, 67% cotton / 33% polyester, 33% cotton / 67% polyester and 100% polyester Sirospun yarns were produced and physical properties of the yarns were measured. Furthermore, ring spun yarns were produced for comparison with same raw materials. With the analyses of variance implement, results were evaluated and the influences of raw material, yarn count, twist multiplier and strand spacing on the yarn properties were analyzed. After the analyses, effect of the raw material, yarn count, twist multiplier and strand spacing on the yarn properties was found statistically significant ($p<0,05$).

Key Words: Sirospun, Two-strand spinning, Blended yarns, Strand spacing, Twist multiplier, Yarn properties.

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1. INTRODUCTION

Two-strand spun yarns have now been widely used in the worsted industry (1). Sirospun spinning process was developed for the worsted yarn industry between 1975 and 1976 in CSIRO laboratories. In 1977 CSIRO cooperated with an Australian engineering company named as Repco Ltd. to manufacture the system components. And collaborated with IWS (International Wool Secretariat) to market and familiarize the system all over the world. In 1980, Sirospun spinning process was advertised to the market as a new production method and started to be used for the worsted industry (2).

Since the increasing machinery expenses and labor costs, weavers had to work with high weft insertion speeds and high efficiencies. That's why they tended not to weave with finer woolen yarns. But on the other hand, the finer and the cooler fabrics are necessity of today's fashions and lifestyles and often depend on the unique properties of Sirospun yarns (3).

Hairiness and incapability of strength of single yarns are important problems for the weaving factories. Abrasion resistance and the strength of a single yarn cannot fulfill the stress and tension on the weaving machines. Therefore, two-plied conventional yarns are favored for warp yarn usage. However, Sirospun yarns, which have the same yarn count with conventional double yarns, perform lower yarn imperfection, lower hairiness, better tenacity and elongation. Thus, weaving characteristic of Sirospun yarns attracted the weavers more than double yarns. It's indicated that yarns and fabrics manufactured with Sirospun spinning process show better abrasion resistance and pilling formation.

Another reason Sirospun yarns are to be in demand so much is the economic use of Sirospun spinning process. By the Sirospun spinning process two operational steps (fixing, folding) are skipped and Sirospun yarn can be obtained from the ring spinning machine with no additional processes. It's also enough to place some additional units on the ring spinning frame to produce Sirospun yarns. This production method is still in use for the worsted industry and provides economic advantages.

There have been a lot of studies about spinning Sirospun yarns on short staple system. Johnson and Young (4) studied about twist distribution along Sirospun yarn. They produced Sirospun and single ring spun yarns from wool fibres. They reported that Uster evenness testing of the yarns showed a slight difference in CV% and Sirospun yarn was probably more even.

Salhotra (5) found that the use of finer roving or lower spinning drafts were quite advantageous when spinning Sirospun yarns, and yarn tenacity was greater when finer yarns were spun on this system in his study.

Cheng and Sun (2) investigated effect of strand spacing and twist multiplier on cotton Sirospun yarn. They found that when the strand spacing increased from 3 to 11 mm, the tenacity of Sirospun yarn increased slightly because the trapped strand twist increases slightly. It was observed that yam hairiness decreased gradually as the strand spacing increased. Yarn abrasion resistance also increased gradually as the strand spacing increased, and trapped strand twist increased with increased strand spacing. When the twist multiplier increased, yarn tenacity increased to a maximum and then decreased. Yarn hairiness decreased gradually as the twist multiplier increased. Yarn abrasion resistance improves dramatically, and trapped strand twist increased with increased twist multiplier. They said that spinning performance of cotton Sirospun yarns could be improved by higher twists or longer fibers or a reduction in strand spacing, or by more even strands or lower yarn tension.

Sun and Cheng (6) explained that when compared to single yam with the same linear density and twist multiplier, cotton Sirospun yarn is superior in tenacity, evenness, hairiness, and abrasion resistance. The coarser the yarn, the better the yarn evenness values.

Zhang and He (1) established a dynamical model for Sirospun procedure. They obtained an approximate stability condition for Sirospun spinning equation. This was a necessary condition for stability of the spinning procedure. If this equation could not be satisfied, the spinning procedure could not be stable, so this simple equation is very useful for practical use.

Bedez Ute (7) worked on the properties of 100% cotton and 100% viscose Sirospun yarns. She found that spinning stability decreased when the strand spacing increased. It was reported that the strand spacing increased, yarn evenness values of cotton Sirospun yarns increased. In addition, cotton Sirospun yarns were more even then cotton ring spun yarns, but finer viscose Sirospun yarns had higher Uster CV% values then viscose ring spun yarns. Sirospun yarns had lower yarn hairiness values and yarn liveliness values then ring spun yarns.

There haven't been found any investigation about blended Sirospun yarns, so in this study, the yarn properties of blended Sirospun yarns were investigated. Objective of this work was to investigate the effects of raw material, strand spacing and twist level on the physical properties of Sirospun yarns.

2. MATERIAL AND METHOD

In order to determine the effects of blending ratio and some yarn parameters, Sirospun yarns with two different yarn counts were spun from 100% cotton, 67% cotton / 33% PES, 33% cotton / 67% PES and 100% PES fibers at two different twist multipliers. In addition, in order to determine the effect of the spinning method, Ne30/1 Conventional ring spun yarns were produced from the same raw materials. The specifications of raw materials are given in Table 1.

Table 1. Raw material specifications

Raw material	Fineness	Fibre length
100% Cotton (Co)	5.1 (micronaire)	29.43 (mm) (UHML)
100% Polyester (PES)	1.2 (denye)	38 (mm)

Sirospun and conventional ring spun yarns were spun on Rieter G30 ring spinning machine. In order to produce Sirospun yarns, Pinter Sirospun equipments were assembled on G30 ring spinning machine. By this way it was possible to compare both two systems under identical machine conditions. The details of experimental

Table 2. Experimental Plan

	100% cotton		67%Co/ 33%PES		33%Co/ 67%PES		100%PES	
	Ring spun yarn	Sirospun yarn	Ring spun yarn	Sirospun yarn	Ring spun yarn	Sirospun yarn	Ring spun yarn	Sirospun yarn
Yarn count (Ne)	30/1	40/2, 60/2	30/1	40/2, 60/2	30/1	40/2, 60/2	30/1	40/2, 60/2
Twist multiplier (α_e)	3.6, 4.2	3.6, 4.2	3.6, 4.2	3.6, 4.2	3.6, 4.2	3.6, 4.2	3.6, 4.2	3.6, 4.2
Roving count (Ne)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Strand spacing (mm)	-	5 mm, 10 mm	-	5 mm, 10 mm	-	5 mm, 10 mm	-	5 mm, 10 mm
Spindle speed (rpm)	12.000	12.000	12.000	12.000	12.000	12.000	12.000	12.000

plan are shown in Table 2.

After spinning trials, physical properties of each yarn samples were measured. Priority for testing the yarn samples were conditioned for 24 hours under standard conditions (65% R.H. and 22 °C). Yarn evenness (CV %), the number of thin places, thick places, neps and the hairiness were measured with Uster Tester 5. Yarn tenacity (cN/Tex) and yarn elongation (%) were measured with Zwick Roell Z010. The yarn liveliness values were measured by using Keisokki Kringel Factor Meter. In order to evaluate the effects of raw material, yarn count, twist multiplier and strand spacing on yarn physical properties, test results were evaluated by a statistical program. In addition, measurement results of ring spun yarns and Sirospun yarns were compared with each other. 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. Ergun 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 (8).

Table 3. The general statistical evaluation of all yarn properties

		Raw material	Yarn count	Twist multiplier	Strand spacing
Irregularity, %CV	**F**	186,563	177,504	0,336	1,226
	significance	0,000*	0,000*	0,563	0,269
Thin places/1000m	**F**	13,563	27,702	0,733	0,286
	significance	0,000*	0,000*	0,393	0,593
Thick places/1000m	**F**	24,819	5,244	0,264	0,101
	significance	0,000*	0,023*	0,608	0,751
Neps/1000m	**F**	76,959	49,942	11,397	7,248
	significance	0,000*	0,000*	0,811	0,184
Uster Hairiness	**F**	76,959	1008,172	204,432	41,669
	significance	0,000*	0,000*	0,000*	0,000*
Tenacity cN/tex	**F**	1952,534	16,797	9,962	7,337
	significance	0,000*	0,000*	0,002*	0,007*
Elongation %	**F**	1527,192	85,112	10,758	0,635
	significance	0,000*	0,000*	0,001*	0,426
Yarn liveliness Kr factor	**F**	841,578	200,000	475,174	4,192
	significance	0,000*	0,000*	0,000*	0,042*

* Statistically significant for αm= 0.05

Table 4. The detailed statistical tests results of Ne40/2 and Ne60/2 Sirospun yarns and their significances

		Ne40/2 Sirospun yarns			Ne60/2 Sirospun yarns		
		Raw material	Twist multiplier	Strand spacing	Raw material	Twist multiplier	Strand spacing
Irregularity, %CV	**F**	92,306	1,273	0,135	105,903	4,534	1,562
	significance	0,000*	0,261	0,714	0,000*	0,035*	0,213
Thin places/1000m	**F**	1,490	0,005	0,492	44,595	4,115	9,159
	significance	0,220	0,944	0,484	0,000*	0,044*	0,003*
Thick places/1000m	**F**	39,732	0,275	0,105	7,762	0,101	0,039
	significance	0,000*	0,601	0,747	0,000*	0,751	0,844
Neps/1000m	**F**	38,497	0,963	0,097	43,900	19,198	10,481
	significance	0,000*	0,328	0,755	0,000*	0,426	0,091
Uster Hairiness	**F**	7,333	96,279	21,990	2,887	119,105	20,765
	significance	0,000*	0,000*	0,000*	0,038*	0,000*	0,000*
Tenacity cN/tex	**F**	906,865	6,149	3,234	1058,007	3,898	4,153
	significance	0,000*	0,014*	0,074	0,000*	0,050	0,043*
Elongation %	**F**	786,109	9,312	5,022	747,319	2,745	0,928
	significance	0,000*	0,003*	0,027*	0,000*	0,100	0,337
Yarn liveliness Kr factor	**F**	234,674	277,554	5,481	768,334	198,242	0,111
	significance	0,000*	0,000*	0,021*	0,000*	0,000*	0,739

* Statistically significant for αm= 0.05

3. RESULTS AND DISCUSSION

The outcomes demonstrated that the effects of raw material and yarn count were found statistically significant for all yarn properties. On the other hand, the influences of twist multiplier and strand spacing were found statistically significant for only yarn tenacity, yarn hairiness and yarn liveliness values (Table 3).

It was observed that Ne60/2 Sirospun yarns were more evenness than Ne40/2 Sirospun yarns for all material types. However Ne60/2 Sirospun yarns had less yarn hairiness values than Ne40/2 Sirospun yarns. We couldn't mention a general tendency about yarn liveliness values according to yarn count.

Furthermore in order to eliminate the effect of yarn count, the test results of Ne40/2 and Ne60/2 Sirospun yarns were evaluated separately (Table 4).

The outcomes of the statistical analyses for the parameters influencing the yarn properties of Sirospun yarns were evaluated as below:

Influence of Raw Material

The outcomes demonstrated that the influences of the raw material on the yarn properties were statistically significant (Table 3 and Table 4). In order to see the differences of raw materials clearly, Student- Newman-Keuls (SNK) tests were applied on test results.

When the ratio of polyester increased in yarn (both two yarn counts), yarn

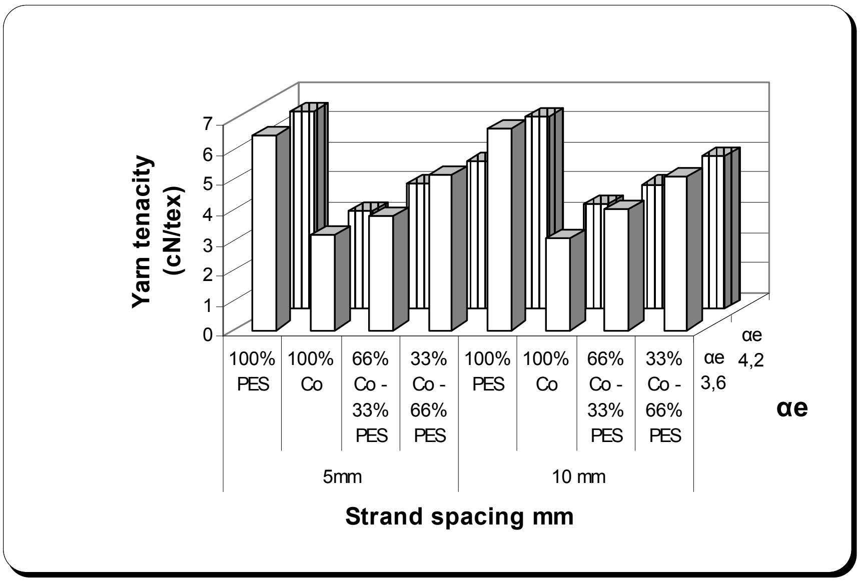

Figure 1. Yarn tenacity values of Ne60/2 Sirospun yarns

Table 5. Comparison of yarn tenacity values of Sirospun yarns (Student-Newman-Keuls)

Raw material	N	Subset			
	1	1	2	3	4
Cotton	80	16,5441			
67 Cotton/33 PES	80		19,5839		
33 Cotton/67 PES	80			25,0835	
PES	80				33,1085
Significance		1,000	1,000	1,000	1,000

Table 6. Comparison of yarn elongation (%) values of Sirospun yarns (Student-Newman-Keuls)

Raw material	N	Subset			
	1	1	2	3	4
Cotton	80	6,8387			
67 Cotton/33 PES	80		8,8397		
33 Cotton/67 PES	80			10,6930	
PES	80				12,3962
Significance		1,000	1,000	1,000	1,000

Table 7. Comparison of yarn evenness values of Sirospun yarns (Student-Newman-Keuls)

Raw material	N	Subset		
	1	1	2	3
PES	80	10,0584		
Cotton	80		13,4369	
67 Cotton/33 PES	80		13,5125	
33 Cotton/67 PES	80			15,8512
Significance		1,000	0,760	1,000

tenacity and yarn elongation increased (Table 5 and Table 6). Yarn tenacity values of Ne60/2 Sirospun yarns were given in Figure 1.

The evenness of 100% polyester Sirospun yarns was better than 100% cotton Sirospun yarns, but that situation was different in blends. In both yarn counts when the polyester ratio increased, yarn evenness values increased (Table 7). Canoglu and Tanir (2009) explained that this situation is related to the non-existence of the thickness variation of polyester fibers. On the other hand, with the addition of cotton fibres in the blend, due to fibre length and fineness variation in the yarn, yarn evenness became worse.

Owing to their different characteristics, the fibres take up different positions in the body of yarn. The fibre migration is dependent upon degree of length, elasticity, stiffness, fineness, crimp, etc. Short, coarse, stiff fibres move out of the core towards the sheath, while long, fine, flexible fibres move towards the core (10).

Thus, polyester fibres tend to move towards the core of the yarn, while cotton fibres want to migrate towards the sheath. Yarn hairiness and yarn evenness values of blended yarns can be explained by fibre migration.

According to "Student – Newman – Keuls" tests results, when the cotton ratio increased in yarn, the yarn hairiness values also increased (Table 8). Most probably this is the result of the higher length variation and short fibre content of cotton fibres compared to polyester. On the other hand, as the cotton ratio increased in yarn, the yarn liveliness values decreased (Table 9). Higher liveliness values of polyester sirospun yarns can be attributed to the higher bending and torsional rigidity associated with polyester fibers.

Table 8. Comparison of yarn hairiness values of Sirospun yarns (Student-Newman-Keuls)

Raw material	N	Subset	
	1	2	1
PES	80	4,4536	
67 Cotton/33 PES	80		4,5630
33 Cotton/67 PES	80		4,6000
Cotton	80		4,6323
Significance		1,000	0,121

Table 9. Comparison of yarn liveliness values (Kr factor) of Sirospun yarns (Student-Newman-Keuls)

Raw material	N	Subset		
	1	2	3	1
Cotton	80	4,7989		
67 Cotton/33 PES	80		5,2229	
33 Cotton/67 PES	80			5,7714
PES	80			5,7845
Significance		1,000	1,000	0,572

Table 10. Statistical comparison of ring spun yarns and Sirospun yarns.

		Strand spacing and spinning method	Raw material	Twist multiplier
Irregularity, %CV	F	2,068	173,498	3,915
	significance	0,129	0,000*	0,003*
Thin places/1000m	F	9,986	65,319	2,992
	significance	0,000*	0,000*	0,085
Thick places/1000m	F	0,571	15,078	0,024
	significance	0,566	0,000*	0,878
Neps/1000m	F	5,426	78,261	2,369
	significance	0,005*	0,000*	0,125
Uster Hairiness	F	288,296	7,218	151,115
	significance	0,000*	0,000*	0,000*
Tenacity cN/tex	F	10,808	1314,355	19,360
	significance	0,000*	0,000*	0,000*
Elongation %	F	14,172	993,977	9,236
	significance	0,000*	0,000*	0,003*
Yarn liveliness Kr factor	F	537,297	1354,965	434,529
	significance	0,000*	0,000*	0,000*

* Statistically significant for αm= 0.05

Table 11. Comparison of yarn tenacity values (Student-Newman-Keuls)

Strand spacing (mm) and spinning method	N	Subset	
	1	2	1
Ring spun yarns	80	23,0495	
Sirospun yarns (5 mm strand spacing)	80		23,6850
Sirospun yarns (10 mm strand spacing)	80		24,1492
Significance		1,000	0,052

Comparison of ring spun yarns and Sirospun yarns

After Sirospun yarns' physical properties were evaluated statistically, Ne30/1 ring spun yarns and Ne60/2 Sirospun yarns were also compared. The effects of spinning method, raw material, twist multiplier and strand spacing on the yarn properties were evaluated (Table 10). "Student Newman-Keuls tests" were applied in order to see the differences between ring spun yarns and Sirospun yarns clearly.

When we analyzed the effect of raw material on yarn physical properties, ring spun yarns and Sirospun yarns showed same tendency as mentioned above.

In order to see the differences between ring spun yarns and Sirospun yarns, Student- Newman-Keuls (SNK) test were applied on test results. Sirospun yarns had better yarn tenacity and yarn elongation (%) values than ring spun yarns and there was no significant difference according to strand spacing (Table 11). When the yarn evenness values were examined, there were no significant differences between ring spun yarns and Sirospun yarns.

When the yarn hairiness values were examined, the yarn hairiness values of ring spun yarns were higher than Sirospun yarns' values. The strand spacing values increases, the yarn hairiness values decreases. When 10 mm strand spacing was used, better hairiness values were obtained (Table 12).

The yarn liveliness values of ring spun yarns were higher than Sirospun yarns' values. There was no significant difference between Sirospun yarns in terms of yarn liveliness (Table 13). It might be related that the Sirospun yarn was more stable than ring spun single yarns.

Table 12. Comparison of yarn hairiness values (Student-Newman-Keuls)

Strand spacing (mm) and spinning method	N	Subset		
	1	2	3	1
Sirospun yarns (10 mm strand spacing)	80	4,1034		
Sirospun yarns (5 mm strand spacing)	80		4,2331	
Ring spun yarns	80			4,8719
Significance		1,000	1,000	1,000

Table 13. Comparison of yarn liveliness values (Kr Factor) (Student-Newman-Keuls)

Strand spacing (mm) and spinning method	N	Subset	
	1	2	1
Sirospun yarns (5 mm strand spacing)	80	5,2751	
Sirospun yarns (10 mm strand spacing)	80	5,2819	
Ring spun yarns	80		5,8150
Significance		0,721	1,000

4. CONCLUSION

In this study, effects of the raw material, yarn count, strand spacing and twist multiplier on the Sirospun yarn properties were examined. In addition, Ne30/1 ring spun yarns were produced for comparison.

The influences of raw materials on the yarn physical properties were found statistically significant ($p<0,05$). When the polyester ratio in the raw material was increased, yarn tenacity, yarn elongation and yarn liveliness were also increased but on the other hand yarn hairiness values were decreased for both Sirospun and ring spinning methods. The other researchers obtained similar results in their studies (2, 7, 11). In terms of yarn evenness 100% PES yarns had the best evenness values. But polyester/cotton blended yarns had higher evenness values than the yarn evenness values of 100% polyester and 100% cotton yarns. It was observed that coarse yarn counts were more even than fine yarn counts.

In addition, the increase of strand spacing and twist multiplier provided better yarn evenness. However, the increase of strand spacing didn't cause a significant change on the yarn liveliness. By the increase of twist multiplier, yarn liveliness was also increased. The influence of strand spacing wasn't found significant on the yarn evenness. On the other hand other researchers indicated that the increase of strand spacing causes worse yarn evenness (7, 12, 13). Cheng and Sun (1998) reported that strand spacing and twist level were significant factors that affected the properties of Sirospun yarns because they controlled the spinning geometry of the yarn at the delivery section of the front roller. Bedez Ute and Kadoglu (2009) showed that due to distortion of the spinning geometry and unstable yarn structure owing to the increase of strand spacing, Uster CV% and the number of thin places, thick places and neps increased, and accordingly, in larger strand spacing, yarn strength and breaking elongation generally decreased.

When the Sirospun and ring spun yarns were compared, Sirospun yarns had better yarn tenacity, yarn elongation, yarn hairiness and yarn liveliness properties. In terms of yarn evenness, the influence of raw material was similar for both yarns.

As the strand spacing increased, the yarn hairiness decreased. This is consisted with previous studies (2, 7, 12, 14, 15, 16, and 17). Bedez Ute (2007) found similar results with this study in terms of yarn hairiness, and reported that yarn hairiness decreased significantly with the increasing strand spacing.

The results showed that Sirospun yarns had lower yarn liveliness tendency than ring spun yarns and some researchers found similar results about yarn liveliness values (7, 11).

In addition, during the study we also noticed some effects of the raw material, yarn count, strand spacing and twist multiplier on the spinnability of the Sirospun yarns. Especially while working with 100% cotton, which has the lowest tenacity, it was little problematic working at high tensions, large strand spacing, finer yarn counts and minor twist multiplier. All these multipliers caused a tension increment on the stand arms and on the spun yarn. If this tension exceeded the strand or spun yarn resistance, Sirospun yarn would certainly break off. And while working with 100% cotton yarns, strand and yarn resistances were always defeated to the spinning tension. On the other hand, it was observed a few yarn breaks when 100% polyester Sirospun yarns were being worked.

In sequel of this study, woven and knitted fabrics can be produced from Sirospun yarns and the effects of the parameters, which influence the Sirospun yarn properties, can be also observed on the last product.

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