

COMPARATIVE ANALYSIS OF THE PHYSICAL PROPERTIES OF THE FABRICS KNITTED WITH SIROSPUN AND RING SPUN YARNS PRODUCED BY SHORT AND LONG STAPLE FIBRES

KISA VE UZUN LİF İPLİKÇİLİĞİNDE ÜRETİLEN SIROSPUN VE KLASİK RİNG İPLİKLERİNDEN ÖRÜLMÜŞ KUMAŞLARIN FİZİKSEL ÖZELLİKLERİNİN KARŞILAŞTIRMALI ANALİZİ

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ABSTRACT

The aim of this research is to investigate the effects of spinning method, raw material, twist coefficient and strand spacing on the physical properties of single jersey knitted fabrics. For this purpose, different sirospun and ring spun yarns were produced both in long and short staple spinning systems with different raw materials. Single jerseys knitted fabrics were produced from these yarns. The physical properties of yarns and knitted fabrics were tested and statistically evaluated. Sirospun yarns generally had better yarn properties compared to ring spun yarns. Especially yarn hairiness values of sirospun yarns were considerably lower than ring spun yarns. Generally bursting strength, air permeability, surface friction properties of the fabrics knitted from sirospun yarns were found better than the fabrics knitted from ring spun yarns.

Key Words: Sirospun, Short staple spinning, Long staple spinning, Knitted fabric, Air permeability, Bursting strength, Surface friction property.

ÖZET

Bu çalışmanın amacı, Sirospun iplik üretiminde kullanılan eğirme metodu, hammadde, büküm katsayısı ve fitiller arası mesafenin bu ipliklerden üretilen süprem kumaşların fiziksel özelliklerine etkisinin incelenmesidir. Bu amaçla, uzun ve kısa stapelli eğirme sistemlerinde, çeşitli hammaddeler ile farklı ring ve siro iplikleri üretilmiştir. Bu ipliklerden, süprem kumaşlar elde edilmiştir. İpliklerin ve kumaşların bazı fiziksel özellikleri incelenmiş ve istatistiksel olarak değerlendirilmiştir. Genel olarak, siro ipliklerinin ring ipliklerine göre daha iyi fiziksel özelliklere sahip olduğu görülmüştür. Siro ipliklerin özellikle iplik tüylülüğü değerlerinin, ring ipliklerinden çok daha düşük olduğu görülmüştür. Örne kumaş özellikleri incelendiğinde, siro ipliklerle üretilmiş süprem kumaşların patlama mukavemeti, hava geçirgenliği ve yüzey sürtünme özelliklerinin, ring iplikleriyle üretilmiş kumaşlara göre daha iyi olduğu tespit edilmiştir.

Anahtar Kelimeler: Sirospun, Kısa stapelli eğirme, Uzun stapelli eğirme, Örne kumaş, Hava geçirgenliği, Patlama mukavemeti, Yüzey sürtünme katsayısı

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1. INTRODUCTION

The development of Sirospun technology in the 1970s was an important innovation for the global wool textile industry. The development was commercialized in 1980. Sirospun yarns are fine, even and less hairy

than conventional ring spun yarns. The fabrics produced from these yarns have a smooth feel that gives a cool feeling to the Sirospun fabric. (1)

Sirospun spinning method has been applied successfully in long staple spinning sector for many years. This

method also has found application area in short staple spinning sector in recent years. Sirospun yarns have many advantages for process and fabric quality. Sirospun yarns, which have the same yarn count with conventional double yarns, perform lower yarn imperfection, lower

hairiness, better tenacity and elongation (2). Therefore the fabrics produced from sirospun yarns show better performance on abrasion resistance and pilling formation. There are a lot of studies about sirospun yarns and its properties.

Cheng and Sun (3) investigated effect of strand spacing and twist multiplier on cotton Sirospun yarn. They found that when the strand spacing increased, the tenacity of Sirospun yarn increased slightly because the trapped strand twist increases slightly. It was observed that yarn 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.

Sun and Cheng (4) explained that when compared to single yarn with the same linear density and twist multiplier, cotton Sirospun yarn is superior in tenacity, evenness, hairiness, and abrasion resistance.

Bedez Ute (5) worked on the properties of 100% cotton and 100% viscose Sirospun yarns. She found that spinning stability decreased when the strand spacing increased.

Beceren et al. (6) studied on properties of plain knits from siro-spun viscose/spandex yarns. They stated that the pilling properties of the samples demonstrate 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.

Sun and Cheng (7) worked about the quality of fabric knitted from cotton Sirospun[®] yarn. They stated that the fine gauge plain weft knitted fabrics knitted from cotton Sirospun yarns were more durable and suitable for summer wear. It was found that they have considerable bursting strength, superior abrasion resistance, higher air permeability, cooler hand-feel and greater thermal conductivity than the fabrics knitted from two-fold yarns.

Kireççi et al. (8), investigated the quality parameters of the fabrics knitted from sirospun, single and two-

ply yarns. They have found that physical and mechanical properties of sirospun yarns are similar to or better than those of single and conventional plied yarns. The fabrics test results showed that the bursting strength, abrasion resistance and pilling resistance of the fabrics knitted with sirospun yarns are as good as those of the fabrics knitted with single or conventional plied yarns whereas the spirality values the fabrics produced with plied yarns are slightly lower than those of the fabrics produced with sirospun yarns at finer yarn count values.

In previous works the effects of several parameters on the yarn characteristics had been investigated broadly (5, 9, 10, 11). For further researches the objective of this work was to investigate the effects of raw material, strand spacing and twist level on some physical properties of the fabrics knitted using sirospun yarns spun with long and short staple spinning systems.

2. MATERIAL AND METHOD

In order to determine the effects of raw material, strand spacing and twist level on some physical properties of the fabrics knitted sirospun yarns, sirospun yarns were spun from 100% wool, 100% PAN, 100% cotton and 100% viscose fibers with long and short staple spinning systems in three different twist multipliers. In addition, in order to determine the effect of the spinning method, conventional ring spun yarns were produced using the same raw materials in the same yarn properties.

Long staple yarns from 100% wool (worsted) and 100% acrylic (PAN) (semi worsted) were spun in 31.25 tex nominal yarn count with three different twist coefficient ($\alpha_{\text{tex}}=2528, 2844$ and 3160) by using two different spinning methods, ring spinning (Zinser ring spinning machine) and siro-spun spinning (Zinser sirospun system). Short staple yarns from 100% cotton (combed) and 100% viscose (carded) were 14.8 tex nominal yarn count with three different twist coefficient ($\alpha_{\text{tex}}=3638, 4021$ and 4404) with three different strand spacing (4mm, 8 mm and 12 mm) by using two different spinning methods, ring spinning

(Rieter G30 spinning machine) and siro-spun spinning (Pinter sirospun equipment).

An individual group of ten cops were tested for each yarn and all tests carried out under the standard atmospheric conditions. The tensile properties of the long staple 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 Zweigle G566 yarn hairiness tester. The Zweigle S3 code, which defines the total number of hairs of 3mm length and above, exhibits a hairiness level that causes the pilling problem. So that S3 code values were taken for yarn hairiness evaluation. The tensile properties of short staple yarns were measured by an Uster Tensorapid 4 and unevenness tests of short staple yarns were performed by using an Uster Tester 4. The yarn hairiness properties of the yarns were evaluated by using Uster Tester 4 yarn hairiness testing module. In order to evaluate the effects of spinning method, raw material, twist coefficient and strand spacing on yarn physical properties, test results were evaluated by a statistical program.

Then single jersey structures were knitted using these yarns. The knitting process was completed with constant machine settings in medium tightness value and the samples were kept under the standard atmospheric conditions for 24 hours for the relaxation. The fabric weight (g/m^2), bursting strength (kPa), air permeability ($\text{l/m}^2\text{sn}$) and fabric surface friction properties (μ_{kinetic}) of fabrics were measured according to TS 251, TS 393 EN ISO 13938-2 and TS 391 EN ISO 9237, respectively. The bursting strength properties of the fabrics were measured by using EC37 bursting strength tester (hydraulic) and the air permeability properties of fabrics were measured by using FX 3300 air permeability tester. The surface friction coefficients of fabrics were measured by using FrictorQ. All measurements were performed under the standard atmospheric conditions and they were repeated five times.

Evaluation of the test results was made using 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. 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 [12].

3. RESULTS AND DISCUSSION

The details of yarn characteristics, which were given in previous works, were used for the explanation of their effects on fabrics' physical properties (5, 9, 10, 11). It was found that sirospun yarns generally have better yarn properties compared to ring spun yarns. Sirospun yarns spun from long staple fibers had lower yarn evenness than ring spun yarns and the difference between the values were

found to be statistically significant. For 100% wool yarns, sirospun yarns had higher yarn tenacity and breaking elongation compared to ring spun yarns. Spinning method had no significant effect on tenacity values of 100% PAN yarns. However the difference between the breaking elongation values of sirospun and ring spun yarns were found to be statistically significant. For all yarn types, sirospun yarns had lower yarn hairiness than ring spun yarns (Figure 1). For the yarns produced in short staple spinning system, 100% cotton sirospun yarns had lower yarn evenness, yarn hairiness and higher yarn tenacity and breaking elongation values compared to ring spun yarns. Yarn hairiness values of different yarns are shown in Figure 2. The differences between the values for all properties were found to be statistically

significant. It was observed that 100% viscose sirospun yarns have lower yarn hairiness but higher yarn evenness than viscose ring yarns. The difference between yarn evenness and yarn hairiness value were found statistically significant whereas not significant for tenacity values.

The test results of friction coefficient ($\mu_{kinetic}$) and fabric weight of the fabrics knitted from sirospun and ring spun yarns were given in Table 1 and Table 2. Bursting strength and air permeability results of short and long staple yarns were given in Figure 3, Figure 4, Figure 5 and Figure 6, respectively.

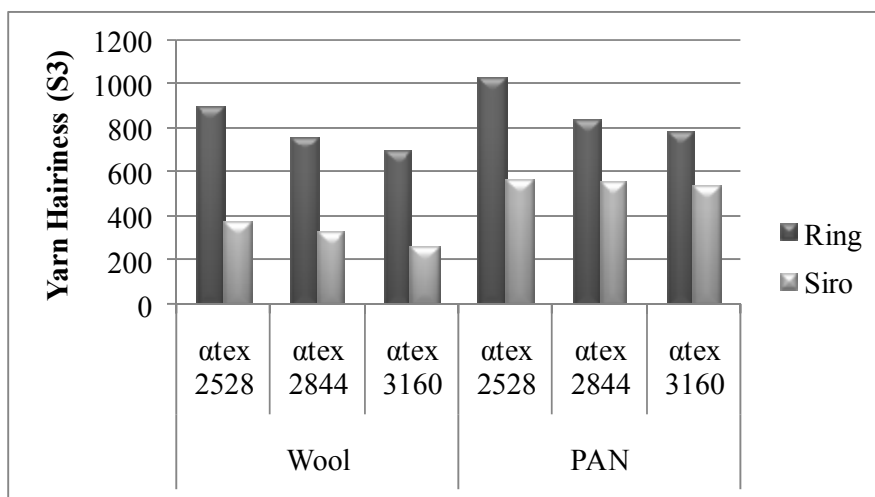


Figure 1. Yarn hairiness values (S3) of long staple yarns

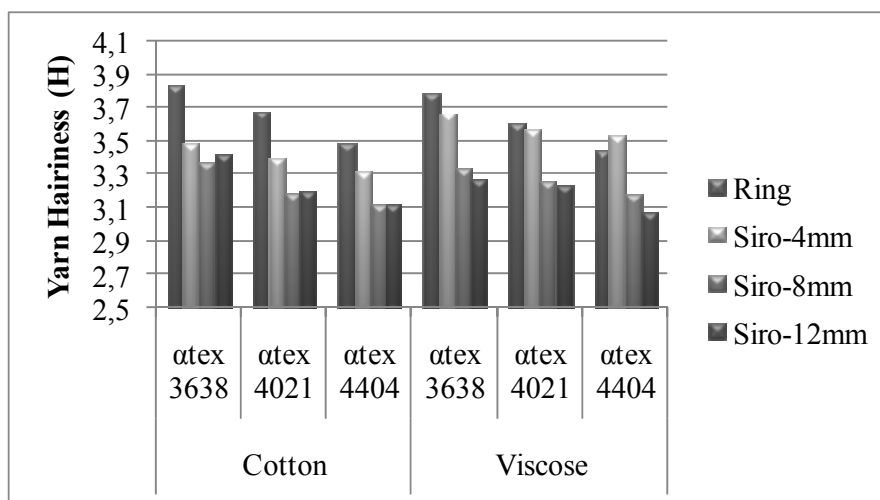


Figure 2. Yarn hairiness values (H) of short staple yarns

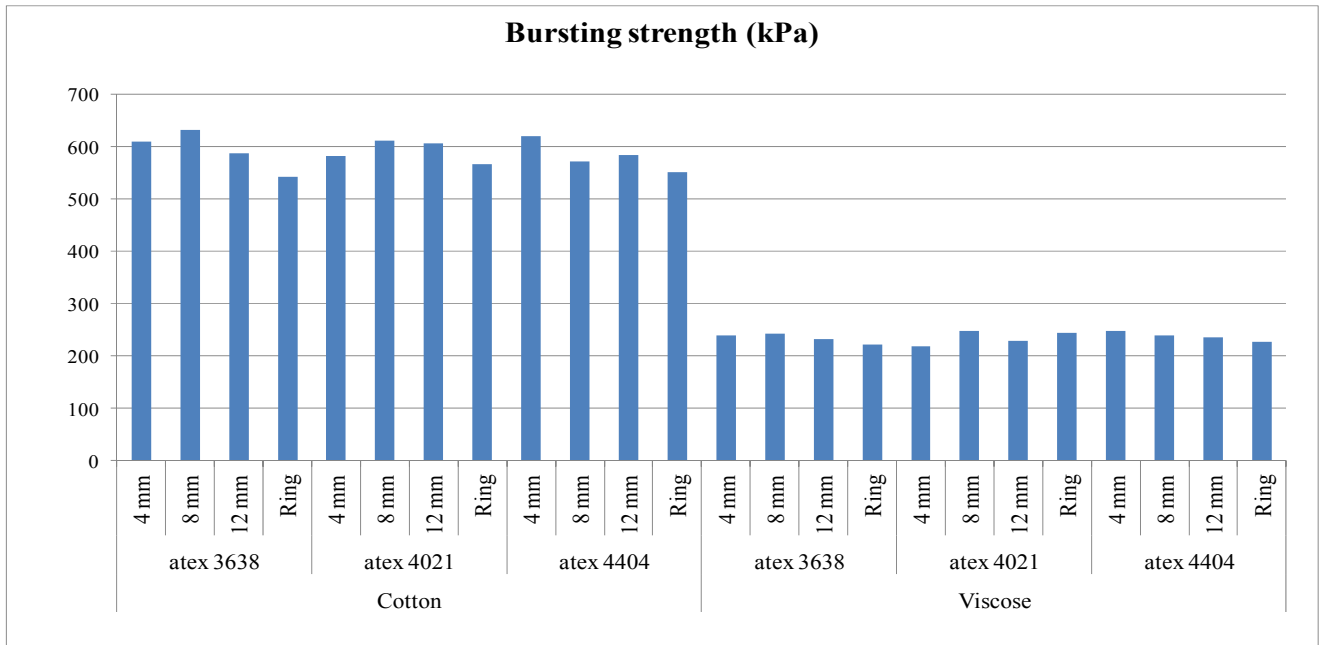


Figure 3. Bursting strength values (kPa) of the fabrics knitted with short staple yarns

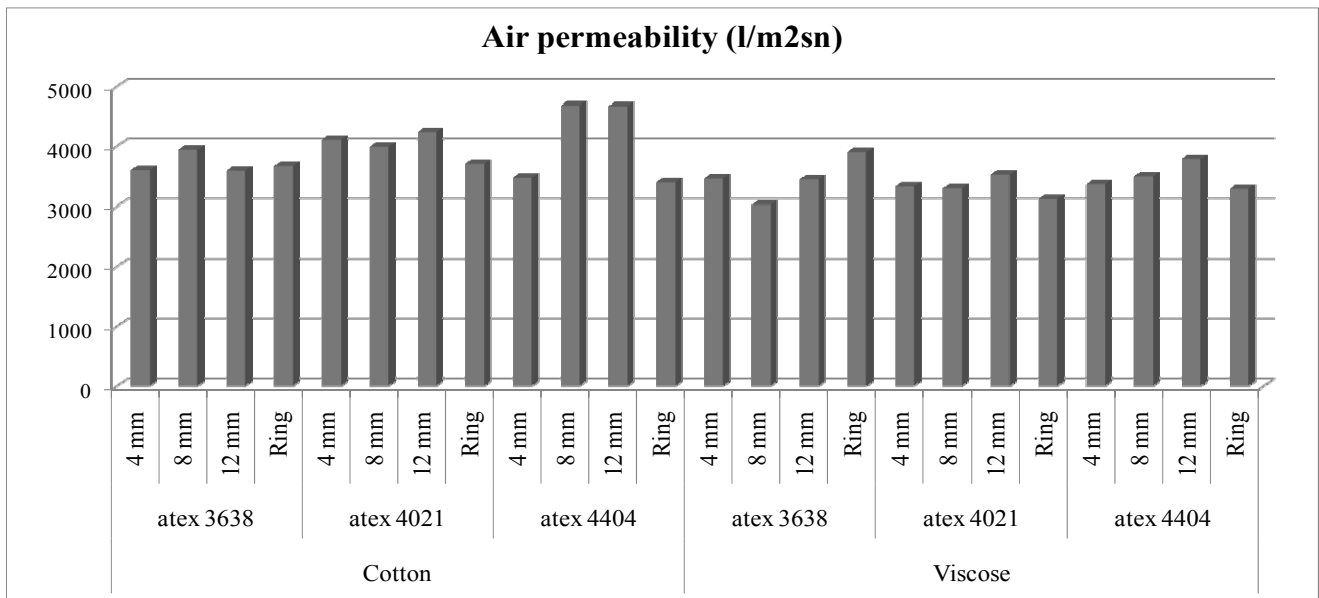


Figure 4. Air permeability (l/m²sn) of the fabrics knitted with short staple yarns

Table.1 Fabric weight and kinetic friction results of the fabrics produced using with short staple yarns

Twist coefficient α_{tex}		α_{tex} 3638				α_{tex} 4021				α_{tex} 4404			
Spinning method		Siro			Ring	Siro			Ring	Siro			Ring
Strand Spacing (mm)		4	8	12	-	4	8	12	-	4	8	12	-
Cotton	$\mu_{kinetic}$	0,320	0,333	0,346	0,334	0,324	0,326	0,320	0,330	0,335	0,323	0,325	0,347
	g/m^{2*}	99,7	112,7	99,5	100,2	99,5	100,7	99,8	99,2	100,2	99,9	99,7	99,7
Viscose	$\mu_{kinetic}$	0,340	0,347	0,347	0,366	0,345	0,339	0,351	0,369	0,366	0,347	0,354	0,365
	g/m^{2*}	90,1	94,5	92,3	90,1	92,6	91,1	94,0	94,5	92,3	91,9	92,1	92,3

*Fabric weight

Table 2. Fabric weight and kinetic friction results of the fabrics produced using with long staple yarns

Raw material	Spinning method	Twist coefficient α_{tex}	$\mu_{kinetic}$	Fabric weight (g/m ²)
Wool	Siro	2528	0,3379	151,1
		2844	0,3457	146,7
		3160	0,3371	148,9
	Ring	2528	0,3402	134,7
		2844	0,3512	132,3
		3160	0,3502	133,5
PAN	Siro	2528	0,3291	161,9
		2844	0,3342	151,8
		3160	0,3361	156,8
	Ring	2528	0,3380	147,5
		2844	0,3412	159,1
		3160	0,3362	153,3

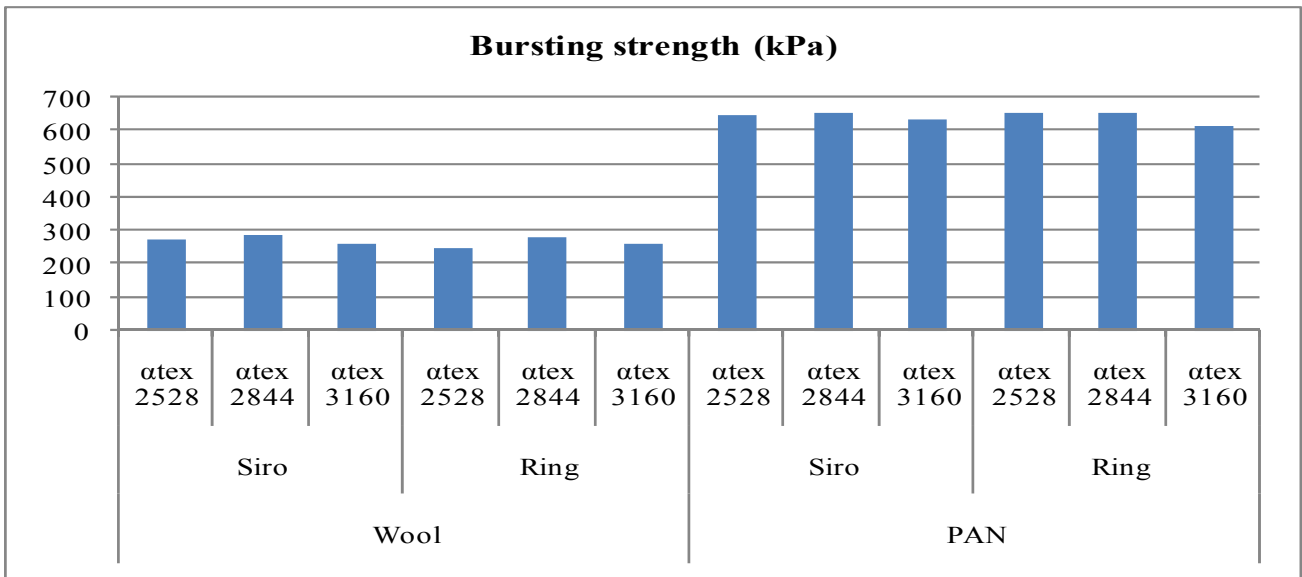


Figure 5. Bursting strength values (kPa) of the fabrics knitted with long staple yarns

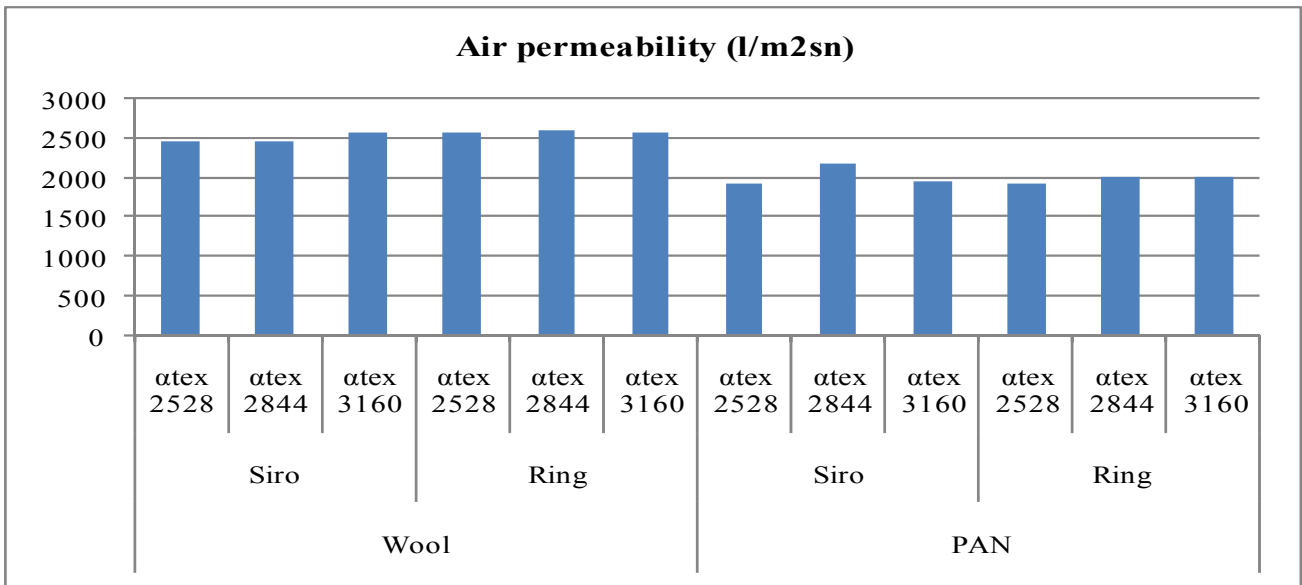


Figure 6. Air permeability (l/m²sn) of the fabrics knitted with long staple yarns

The effects of spinning method, raw material and twist coefficient on the properties of knitted fabrics were investigated and the results of the analysis of the variance were given in Table 3. The effect of spinning method on the fabric properties was investigated only for long staple yarns whereas the effect of strand spacing on the fabric properties was investigated only for short staple yarns.

In long staple spinning, the effects of the spinning method on the fabric weight and friction coefficient were found statistically significant. Fabrics knitted from sirospun yarns had lower friction coefficient than the fabrics knitted from ring spun yarns. Based on the relation between yarn hairiness and friction properties, fabrics knitted from sirospun yarns had lower friction coefficient due to its lower yarn hairiness. Generally, sirospun yarns had higher yarn tenacity compared to ring spun yarns. Knitted fabrics produced from 100% wool sirospun yarns had higher bursting strength than the fabrics produced from ring spun yarns, but the difference was not statistically significant. The similar phenomenon had been found for

100% PAN sirospun and ring spun yarns.

For the fabrics knitted from the yarns produced from short staple fibres, the effects of strand spacing on the bursting strength, air permeability and surface friction coefficient were found statistically significant (Table 3). For detailed evaluation, Student-Newman-Keuls test were performed and bursting strength, air permeability and surface friction coefficient results were given in Table 4, Table 5 and Table 6, respectively.

Generally, fabrics knitted from ring spun yarns had lower bursting strength than the fabrics knitted from sirospun yarns. Besides, the effect of the strand spacing on the bursting strength was not found statistically significant.

The air permeability of the fabrics knitted from ring spun yarns were lower than the fabrics knitted from sirospun yarns for 100% cotton fabrics. Generally the air permeability property increases with the increasing of the strand spacing during the production of sirospun yarns (Table 5). This can be directly related to the yarn hairiness,

because yarn hairiness decreases as long as strand spacing increases. On the other hand, the differences of air permeability values of the fabrics from sirospun yarns produced with 8 mm and 4 mm and the fabrics from ring spun yarns were not found statistically significant for 100% viscose fabrics. Only the air permeability values of the fabrics knitted with sirospun yarns (produced with 12 mm strand spacing) were found higher than others and a statistically significant difference was found. When the sirospun yarns were produced with 12mm strand spacing, yarn hairiness had been reached its lowest values.

Surface friction values of the fabrics knitted from ring spun yarns were found higher than the fabrics knitted from sirospun yarns. Strand spacing had no significant effect on friction properties (Table 6). There were not found general trend within the fabrics knitted with sirospun yarns from 100% cotton and 100% viscose raw materials...

Table 3. The multivariate test results of short and long staple yarns

Factor	Short/Long Spinning System	Bursting strength	Air permeability	μ kinetic	Fabric weight
Material	Short	0,000*	0,000*	0,000*	0,000*
	Long	0,000*	0,000*	0,000*	0,000*
Twist	Short	0,545	0,008*	0,008*	1
	Long	0,030*	0,417	0,011*	1
Method	Long	0,301	0,593	0,000*	0,000*
Strand spacing	Short	0,005*	0,000*	0,000*	0,986

*Statistically significant according to $\alpha = 0.05$

Table 4. The effect of the strand spacing on the bursting strength values of knitting fabrics

	Cotton		Viscose
	Subset		Subset
	1	2	1
Fabrics knitted from Ring spun yarns	557,44		227,87
Fabrics knitted from Sirospun yarns-4mm	589,83	589,83	232,68
Fabrics knitted from Sirospun yarns-12mm	592,01	592,01	232,93
Fabrics knitted from Sirospun yarns-8mm		612,07	242,89
Significance	0,096	0,357	0,366

Table 5. The effect of the strand spacing on the the air permeability values of knitting fabrics

	Cotton			Viscose	
	Subset			Subset	
	1	2		1	2
Fabrics knitted from ring spun yarns	3596,67		Fabrics knitted from Sirospun yarns-8mm	3275,56	
Fabrics knitted from Sirospun yarns-4mm	3730,0		Fabrics knitted from Sirospun yarns-4mm	3387,78	
Fabrics knitted from Sirospun yarns-12mm		4167,78	Fabrics knitted from Ring spun yarns	3434,44	
Fabrics knitted from Sirospun yarns-8mm		4201,11	Fabrics knitted from Sirospun yarns-12mm		3592,22
Significance	0,256	0,774		0,090	1,000

Table 6. The effect of the strand spacing on the surface friction coefficient values of knitting fabrics

	Cotton			Viscose	
	Subset			Subset	
	1	2		1	2
Fabrics knitted from Sirospun yarns-4mm	0,3262		Fabrics knitted from Sirospun yarns-8mm	0,3340	
Fabrics knitted from Sirospun yarns-12mm		0,3353	Fabrics knitted from Sirospun yarns-12mm	0,3463	
Fabrics knitted from Sirospun yarns-8mm		0,3355	Fabrics knitted from Sirospun yarns-4mm	0,3514	
Fabrics knitted from Ring spun yarns		0,3394	Fabrics knitted from Ring spun yarns		0,3682
Significance	1,000	0,173		0,107	1,000

The effects of the raw material on bursting strength, air permeability, friction coefficient and fabric weight were found statistically significant for short and long spinning systems. Fabrics knitted from 100% PAN fibres had higher bursting strength, lower air permeability, lower surface friction coefficient and higher fabric weight than wool fabrics. For short staple spinning system, a general effect of raw material on the fabrics' friction and air permeability properties was not found. However the fabrics knitted from 100% viscose yarns had lower bursting strength and fabric weight compared to the fabrics knitted from 100% cotton yarns.

The effects of the twist coefficient on the surface friction coefficient and bursting strength were found statistically significant for wool and PAN fabrics. Generally, bursting strength of the fabrics, knitted from long staple yarns, decreases with the increasing of twist coefficient due to the decrease in breaking elongation. For short staple yarns, the effect of twist coefficient on air permeability and surface friction coefficient were found statistically significant whereas the

effect of twist coefficient on bursting strength were not found statistically significant. For cotton fabrics, air permeability of the fabrics increase with the increasing of twist coefficient. This can be explained with the relation between twist coefficient and yarn hairiness.

4. CONCLUSION

In this research, the effects of spinning method, raw material, twist coefficient and strand spacing on the physical properties of single jersey knitted fabrics were investigated. For this purpose, different sirospun and ring spun yarns were produced both in long and short staple spinning systems with different raw materials. Single jersey knitted fabrics were produced from these yarns. The physical properties of yarns and knitted fabrics were tested and statistically evaluated.

Sirospun yarns generally had better yarn properties compared to ring spun yarns. Especially yarn hairiness values of sirospun yarns were considerably lower than ring spun yarns.

The effects of the spinning method on the fabric weight and friction coefficient

were found statistically significant, in long staple spinning.

In short staple spinning, the bursting strength values of the fabrics knitted from sirospun yarns were found higher than that of the fabrics knitted from ring spun yarns. The bursting strength values of the fabrics can be improved by using sirospun yarns. Within sirospun yarns, the effect of strand spacing factor on the air permeability and surface friction coefficient properties of the fabrics were found to be statistically significant. It was thought that this phenomenon was related with yarn hairiness, because yarn hairiness decreases with the increasing of strand spacing. The air permeability of the fabrics knitted from ring spun yarns were lower than the fabrics knitted from sirospun yarns.

Surface friction values of the fabrics knitted from ring spun yarns were found higher than the fabrics knitted from sirospun yarns. In the previous research (6), it is found that, fabrics knitted from sirospun yarns had a tendency to be lower abrasion and pilling characteristics than the values of the fabrics knitted from ring spun

yarns. This tendency can be explained with their lower surface friction properties.

Twist coefficient had a statistically significant effect on the surface friction

coefficient and bursting strength of the fabrics knitted with long staple yarns.

These results show that using sirospun yarns for summer wear is more

convenient than using ring spun yarns with their higher air permeability for short staple spinning. Sun and Cheng had found similar results about clothing comfort in their research (7).

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