Properties of the fabrics knitted from yarns with different slub parameters

DOI: 10.35530/IT.076.01.202452

NİLGÜN ÖZDİL
ZEHRA EVRİM KANAT
BEHİYE ELİF TOPUZ
GONCA ÖZÇELİK
GAMZE SÜPÜREN MENGÜÇ

ABSTRACT – REZUMAT

Properties of the fabrics knitted from yarns with different slub parameters

Slub yarns, whose characteristic feature is planned thick regions in the yarn diameter, have an important place among the fancy yarns that have an increasing usage in clothing and home textile products. These yarns, used in woven and knitted fabrics, create unique visual and textural effects compared to conventional yarns, giving yarn manufacturers a competitive advantage. In this study, the performance properties of knitted fabrics produced from slub yarns were examined depending on slub parameters such as slub thickness, slub frequency, slub length, yarn twist coefficient and slub population. The results showed that slub frequency, slub thickness, and twist coefficient significantly affect the air permeability of the fabrics Additionally, the study found that slub frequency and slub thickness are important parameters for abrasion resistance, while yarn twist coefficient is crucial for bursting strength. In terms of fabric pilling property, increasing slub thickness, length, and frequency were found to increase fabric pilling tendency.

Keywords: *slub thickness, slub length, slub frequency, slub population, knitted fabric*

Proprietățile tricoturilor din fire cu diferiți parametri ai nopeului

Firele de efect cu nopeuri, a căror trăsătură caracteristică sunt regiunile groase planificate în diametrul firului, ocupă un loc important printre firele fantezie care sunt din ce în ce mai utilizate în artiocle textile pentru casă. Aceste fire, utilizate în țesături și tricoturi, creează efecte vizuale și texturale unice în comparație cu firele convenționale, oferind producătorilor de fire un avantaj competitiv. În cadrul acestui studiu, au fost examinate proprietățile de performanță ale tricoturilor din fire de efect cu nopeuri, în funcție de parametrii nopeului, cum ar fi grosimea nopeului, frecvența nopeurilor, lungimea nopeului, coeficientul de torsiune a firului și populația de nopeuri. Rezultatele au arătat că frecvența nopeurilor, grosimea nopeului și coeficientul de torsiune influențează semnificativ permeabilitatea la aer a tricoturilor. În plus, studiul a constatat că frecvența nopeurilor și grosimea nopeului sunt parametri importanți pentru rezistența la abraziune, în timp ce coeficientul de torsiune a firului este crucial pentru rezistența la rupere. În ceea ce privește proprietatea de piling a tricotului, s-a constatat că creșterea grosimii, a lungimii și a frecvenței nopeurilor duce la creșterea tendinței de piling a tricotului.

Cuvinte-cheie*: grosimea nopeului, lungimea nopeului, frecvența nopeurilor, populația de nopeuri, tricot*

INTRODUCTION

The main aim of technical research and innovation in the field of textiles has been to obtain yarns with perfect uniformity in terms of colour and structure for centuries. However, after it was seen that yarn faults could create a pleasant effect, yarn production methods that included planned faults emerged. Fancy yarns, which are produced in this way, express decorative unevenness in terms of colour form or both [1–3]. Fancy yarns are yarns that have a very diverse and complex structure are not uniform in structure and have at least one different material, colour and twist variations.

Today, fancy yarns have an important position in yarn and fabric technology in terms of their different appearance and usage properties. Fancy yarn production technologies enable the production of textile products with high added value. Slub yarns are one of the most common fancy yarns.

Slub yarns are a type of fancy yarn that achieves a slub appearance by changing the linear density of the yarn during the spinning process and is widely used in various garments due to its special appearance. Producing slub yarn instead of standard products provides a competitive advantage and economic benefit to yarn manufacturers, and also offers a better decorative effect for customers. The defining feature of slub yarns is the planned formation of irregularities of varying sizes in the yarn structure at certain intervals along their length. The different effects caused by changing length, thickness and slub spacing are used in woven and knitted fabrics, especially denim, for clothing purposes, as well as in home textiles such as curtains and upholstery [4].

Simple slub yarns; are achieved by changing the draft while producing a single-ply yarn in spinning systems. In the yarn obtained by this method, the slub and the basic yarn are integrated and the slub material is the same as the basic yarn [1]. While the

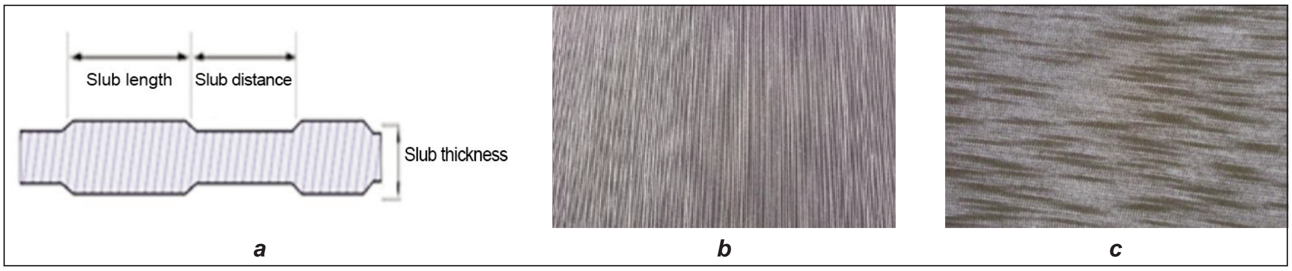

Fig. 1. Structure of: *a* – slub yarn; *b* – slub yarns; *c* – knitted fabric made from slub yarns

soft, more voluminous and thicker part of the yarn in the slub yarn structure, which has less twist, forms the slub, the other parts, which have more twist and appear thin, form the basic yarn [5]. To define simple slub yarns; the number of slubs per unit length (number/m), slub thickness ratio, slub length (cm), slub distance (cm) and slub effect structure are specified (figure 1).

Most of the previous studies on slub yarns were focused on the production technologies of slub yarns, characterisation of slub yarns, measurement of quality properties (especially evenness, hairiness and size measurements), geometric parameters and analysis methods [6–12].

There are also some studies in the literature on the properties of fabrics produced from slub yarns. Fouda 's study showed that, when the slub yarn ratio increased, the fabric weight, thickness and thermal resistance of single jersey knitted fabrics increased, the air permeability decreased, and in addition, the fabric spirality, shrinkage and abrasion resistance improved [13]. Ray et al. examined the effect of slub parameters on abrasion damage in woven fabrics using fabric mass loss and appearance change. As a result of the research, it was seen that the fabric could have less damage to its surface appearance despite higher mass loss due to abrasion [14]. Altaş and Özgen showed that the effect of slub length and slub thickness on the abrasion resistance properties of the fabric is not linear, the slub distance has a small effect on abrasion, and they found that the linear density of the yarn is the most important factor affecting the abrasion properties [15]. In another study, researchers showed that slub thickness is the most important parameter for air permeability [16]. Mukhopadhyay et al. concluded that with the increase in slub length and slub thickness, the mass loss due to abrasion in the fabric initially decreased and then increased [17]. As a result of another study, researchers suggested that the abrasion resistance of knitted fabrics produced from slub yarn is improved by lesser slub thickness whereas in the case of woven fabric, the abrasion resistance is improved by higher slub thickness [18]. Atef et al. stated that with increasing slub frequency, fabric friction, and bursting performance increased, but fabric flexibility, pilling performance, air flow rate and water vapour transmission decreased [19]. Thanabal et al. stated that as the slub thickness and slub length increase, fabric weight and bursting strength increase, while air permeability decreases. However, as the club length increased further, there was a sudden decrease in bursting strength. Researchers suggested that the reason for this is the decrease in yarn elongation due to the decrease in twists in the slub yarn section [20]. Ertekin et al. examined fabric thermal properties from elastane core slub yarns and found that the parameters of slub thickness and slub length have a significant effect on fabric spirality, relative water vapour permeability, thermal conductivity and thermal absorptivity however slub length has not significant effect on friction coefficient and air permeability characteristics [21].

Unlike other studies, this paper aimed to investigate the effects of yarn twist coefficient and different population usage on fabric properties, in addition to basic parameters such as slub length, slub thickness, and slub frequency. Moreover, while most of the previous studies focused on abrasion resistance and air permeability properties of fabrics, this study also studied bursting strength and pilling properties which have been studied in a limited number of research. A systematic and comprehensive test plan was prepared for this purpose, and all slub yarns were produced under mill conditions.

MATERIAL AND METHODS

In the study, slub yarns with different parameters were produced on the Merlin Spa spinning machine using polyester and cotton fibres, and ring-spun yarns were also produced for comparison purposes [5]. All the yarn linear density was tex 29.5 (Ne 20). The fibre length was 28.87 mm for cotton and 40 mm for polyester fibre. Slub thickness ratio (1.2, 1.4, 1.6 and 1.8), slub length (1–3, 5–7 and 10–12 cm), slub frequency (0.5, 3 and 6 number/m.) and slub population (2 different populations) were selected as slub parameters. To determine the population effect, yarns with a single type of slub length, that is, single population (basic slub – 1–3 and 10–12 cm slub length), and yarns with two different lengths of slub, that is, two populations (1–3, 10–12 (P2P3)) were produced. To examine the effect of twist, α_e=3.8, α_e = 4.2 and α_e = 4.6 were used as twist coefficients (table 1). All types of yarns were knitted in single jersey structures with the same tightness using a laboratory-type LAB KNITTER 294E MESDAN knitting machine.

Before measurements, all samples were conditioned under standard atmospheric conditions (temperature 20±2°C, 65±4% Rh) and all the measurements were performed under standard atmospheric conditions. The abrasion properties of fabrics were measured with the Martindale Pilling and Abrasion Tester according to the TS EN ISO 12947-2 standard using fine sandpaper. Bursting strength values of the fabrics were tested according to TS EN ISO 13938-1 standard using with hydraulic type TMI EC 37 testing device. TS EN 12127 and TS 7128 ISO 5084 standards were used for fabric weight and thickness respectively. Air permeability tests were done according to TS 391 EN ISO 9237 standard. The pilling test was performed on the Nu-Martindale test device according to TS EN ISO 12945-2 standard.

Evaluation of test results was carried out using SPSS statistical software. ANOVA test was conducted to decide whether the effects of slub thickness, slub length, slub frequency, yarn twist, and population were statistically significant at the 95% confidence level ($p < 0.05$) for bursting strength and air permeability. Also, Post-Hoc and multiple comparison tests were done.

Since the result of the abrasion resistance test is a discrete variable, the Kruskal Wallis one-way variance test, one of the non-parametric analysis methods, was performed to evaluate the data. The Kruskal-Wallis test is the most commonly used in testing the null hypothesis that "more than two independent samples were drawn from the same population". The alternative hypothesis is "The median of at least one main population is different from that of other populations". If $p < 0.0.5$, it is concluded that the median of at least one main population among the independent groups examined is important compared to the other populations with 95% confidence.

RESULTS AND DISCUSSION

Effect of slub thickness

In terms of the strength properties of the fabrics, as the slub thickness ratio increases, both abrasion resistance and bursting strength increase, but beyond a certain point, both values decrease (figure 2). These results are consistent with the results of Mukhopadhyay et al.'s study. As the slub yarn ratio increases, the probability of the existence of apparent thick areas resulting in higher strength in fabric increases. However, as the slub thickness ratio increases further, the twist slips into the thinner areas of the yarn, causing the fibres to move away more easily during the abrasion resistance test and slide

Table 1

YARN AND FABRIC PARAMETERS USED IN THE STUDY

Parameter	Material	Twist coefficient (α_e)	Slub type	Slub frequency (number/m)	Slub thickness (ratio)	Slub length (cm)	Fabric weight (g/m²)	Fabric thickness (mm)	Fabric density (wales/cm)
Slub thickness	PES	3.8	Without Slub	-	-	-	164	0.687	12.5
	PES	3.8	Basic Slub	3	1.2	5–7	176	0.726	12
	PES	3.8	Basic Slub	3	1.4	5–7	163	0.741	11.5
	PES	3.8	Basic Slub	3	1.6	5–7	160	0.742	11.3
	PES	3.8	Basic Slub	3	1.8	5–7	155	0.771	11
Slub length	PES	3.8	Without Slub	-	-	-	164	0.687	12.5
	PES	3.8	Basic Slub	3	1.6	1–3	156	0.760	11.5
	PES	3.8	Basic Slub	3	1.6	5–7	160	0.742	11.3
	PES	3.8	Basic Slub	3	1.6	10–12	163	0.780	11
Slub frequency	PES	3.8	Without Slub	-	-	-	164	0.687	12.5
	PES	3.8	Basic Slub	0.5	1.6	5–7	166	0.741	11.5
	PES	3.8	Basic Slub	*3*	1.6	5–7	160	0.742	11.3
	PES	3.8	Basic Slub	*6*	1.6	5–7	155	0.705	10.5
Twist coefficient	Cotton	3.8	Without Slub	-	-	-	187	0.696	11.5
	Cotton	3.8	Basic Slub	3	1.6	5–7	189	0.717	11.5
	Cotton	4.2	Basic Slub	3	1.6	5–7	196	0.788	10.5
	Cotton	4.6	Basic Slub	3	1.6	5–7	198	0.750	11
Slub population	PES	3.8	P2, P3	3	1,6	1–3, 10–12	158	0.734	11
	PES	3.8	Basic Slub	3	1.6	1–3	155	0.760	11.3
	PES	3.8	Basic Slub	3	1.6	10–12	165	0.780	11

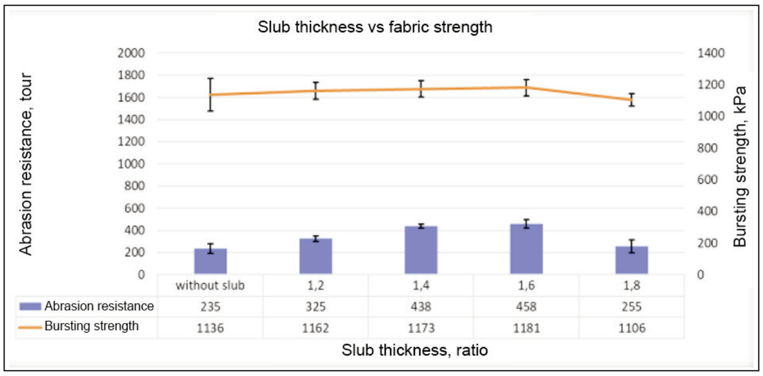

Fig. 2. Effect of slub thickness on fabric strength

over each other more easily during the bursting strength test. Moreover, at the highest slub thickness ratio, the fabrics become looser structures resulting in lower fabric strength.

At low slub thickness due to the higher fabric weight and thickness, the fabrics' air permeability values are lower than the fabrics produced yarns without slub (table 2). When the air permeability values of fabrics with slub yarns are compared it was revealed that as the slub thickness ratio increases, the air permeability value increases. Lower fabric density values, resulting from the increased thickness due to higher slub thickness ratios cause an increase in air permeability values._Here, it can be mentioned that the reduction in yarn twist caused by the thicker areas of the higher thickness ratios, enables more air to pass between the yarns.

The effect of slub thickness on the pilling properties of fabrics is also given in table 2. It is observed that fabrics produced from yarns without slub exhibit the lowest pilling tendency. As the slub thickness increases, the degree of pilling decreases, that is, the tendency to pilling increases. It is attributed to the decrease in fabric density value at high slub thickness which makes the fibre migration to the fabric surface easier causing a reduction in the pilling resistance and a decrease in twist in increased slub thickness regions causes more pilling as well.

Table 2

EFFECT OF SLUB THICKNESS ON THE AIR PERMEABILITY AND PILLING OF THE FABRIC

Parameter	Slub thickness				
	Without slub	1.2	1.4	1.6	1.8
Air permeability (l/dm^2/min)	1783	1592	1633	1927	1998
Pilling (grade)	3	2.5	2.5	2	2

Variance analysis test results showed that air permeability values were significant statistically (table 3). Multiple comparison test results of air permeability for slub thickness are given in table 4. According to the Kruskal Walllis test about slub thickness, the difference in mean values of abrasion resistance was significant (p = 0.017).

Table 3

P VALUE OF ANALYSIS OF VARIANCE REGARDING SLUB THICKNESS

Parameter	p-value
Bursting strength	0.301
Air permeability	0.000*

Note: *Statistically significant according to α = 0.05.

Effect of slub length

The fabric strength values are given in figure 3. As the test results were examined, similar to the results for slub thickness ratio, an increase in slub length caused an increase in abrasion resistance and bursting strength values of the fabrics. The abrasion resistance of the fabric increases as the slub length increases in case of longer slub length causing a higher number of fibers in the slub parts of the yarn. Furthermore, the decrease in a twist due to the longer slub regions of the yarn increases the bursting strength values by increasing the yarn elasticity. However, beyond the optimum point (5–7 cm slub length) caused the fibres to slide over each other more easily, causing a decrease in strength, as discussed in Thanabal's study in 2021 [26].

Table 4

95% CONFIDENCE INTERVAL BOUNDS ACCORDING TO TUKEY MULTIPLE COMPARISONS OF THE AIR PERMEABILITY RESULTS BASED ON THE SLUB THICKNESS

Slub thickness	Without slub	1.2	1.4	1.6	1.8
	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound
Without slub	-	–304.12/–77.22*	–262.78/–35.88*	31.21/258.12*	101.88/328.78*
1.2	77.22/304.12*	-	–72.12/154.78	221.88/448.78*	292.55/519.45*
1.4	35.88/262.78*	–154.78/72.11	-	180.55/407.45*	251.22/478.12*
1.6	–258.12/–31.22*	–448.78/–221.88*	–407.45/–180.55*	-	–42.78/184.12*
1.8	–328.78/–101.88*	–519.45/–292.55*	–478.12/–251.22*	–184.12/42.78*	-

Note: *Statistically significant according to α = 0.05.

In this study, a constant slub thickness ratio of 1.6 was used for different slub lengths, it can be said that the increase in air permeability depending on the slub length is a result of the increase in fabric porosity, similar to the effect of slub thickness. It is possible to explain the decrease in the porosity value beyond the limit value. Since the slub frequency is consistent for all yarns in different slub lengths, it is expected that the increase in slub length after a certain limit value will reduce the fabric porosity. Higher slub length results in a more uniform, thicker and heavier fabric structure in a unit area. Consequently, a decrease in fabric air permeability occurs for slub lengths of 10–12.

When the effect of slub length on the pilling properties of the fabrics was examined, it was found that fabrics produced from unslub yarns had a lower tendency to pilling than fabrics with slub yarns (table 5). As the slub length increases, the tendency to pilling increases. This can be attributed that at higher slub lengths, the decreasing twist value causes the fibres to surface more easily, thereby, reducing the fabric's pilling resistance.

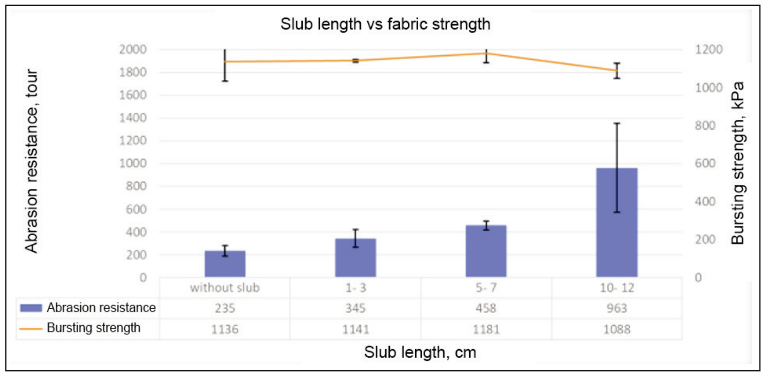

Fig. 3. Effect of slub length on fabric strength

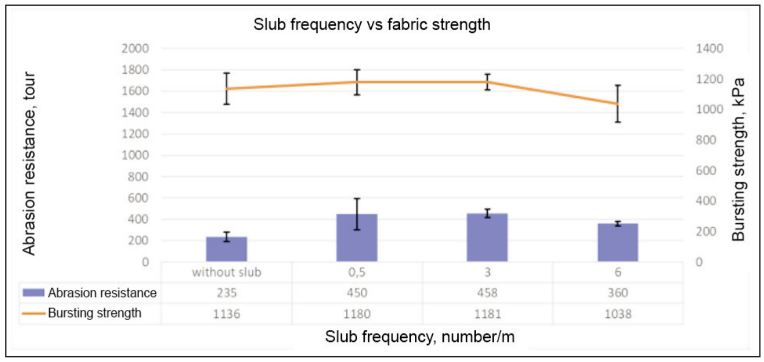

Fig. 4. Effect of slub frequency on fabric strength

According to the variance analysis, the differences were insignificant for bursting strength and air permeability (table 6). However, the Kruskal Walllis test results show that there was a significant difference between the abrasion resistance values regarding slub length ($p = 0.041$).

Table 5

EFFECT OF SLUB LENGTH ON THE AIR PERMEABILITY AND PILLING OF THE FABRIC

Parameter	Slub length (cm)			
	Without slub	**1–4**	**5–7**	**10–12**
Air permeability (l/dm^2/min)	1783	1818	1927	1753
Pilling (grade)	3	2.5	2.5	2

Table 6

P VALUE OF ANALYSIS OF VARIANCE REGARDING SLUB LENGTH

Parameter	p-value*
Bursting strength	0.075
Air permeability	0.157

Note: *Statistically significant according to α = 0.05.

Effect of slub frequency

The abrasion resistance and bursting strength of the fabric increase as the slub frequency increases, as shown in figure 4. However, beyond a certain slub frequency limit, these values decrease. It can be interpreted that when slubs are closer with increasing frequency they behave similarly to an increase in slub length. As the higher than the optimum frequency value (3 number/m), significant decreases were detected in the abrasion resistance and bursting strength values due to the decreasing fabric density and weight, especially at a slub frequency of 6.

An increase in air permeability values is an expected result as the number of pores per unit area increases as the slub frequency increases. In terms of pilling property, more pilling was observed in slub fabrics (table 7). Especially beyond the optimum frequency value, the pilling tendency is higher for fabrics with high slub frequency (6 number/m).

Table 7

EFFECT OF SLUB FREQUENCY ON THE AIR PERMEABILITY AND PILLING OF THE FABRIC

Parameter	Slub frequency (number/m)			
	Without slub	**0.5**	**3**	**6**
Air permeability (l/dm^2/min)	1783	1788	1927	1938
Pilling (grade)	3	2.5	2.5	2

Variance analysis shows that the difference between air permeability values is significant (table 8) and according to the Kruskal Wallis test results, there was a significant difference between the abrasion resistance values ($p = 0.041$). Table 9 shows the 95% confidence interval bounds of the air permeability

Table 8

P VALUE OF ANALYSIS OF VARIANCE REGARDING SLUB FREQUENCY	
Parameter	**p-value**
Bursting strength	0.088
Air permeability	0.000*

Note: *Statistically significant according to α = 0.05.

results. In cases where the slub frequency is 3 and 6, the air permeability values of the fabrics are higher than the fabrics without slub and with a slub frequency of 0.5

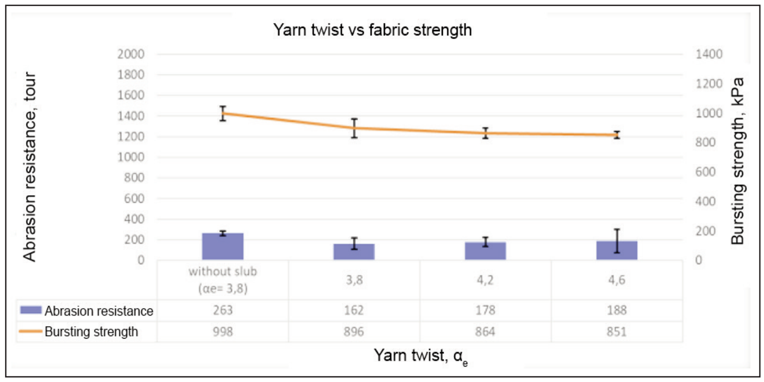

Fig. 5. Effect of twist coefficient on fabric strength

Table 9

95% CONFIDENCE INTERVAL BOUNDS ACCORDING TO TUKEY MULTIPLE COMPARISONS OF THE AIR PERMEABILITY RESULTS BASED ON THE SLUB FREQUENCY				
Slub frequency	**Without slub**	**0.5**	**3**	**6**
	Lower bound/ Upper bound	**Lower bound/ Upper bound**	**Lower bound/ Upper bound**	**Lower bound/ Upper bound**
Without slub	-	–230.43/21.10	18.90/270.43*	29.57/281.10*
0.5	–21.10/230.43	-	123.57/375.10*	134.23/385.76*
3	–270.43/–18.90*	–375.10/–123.57*	-	–115.10/136.43
6	–281.10/–29.57*	–385.76/–134.24*	–136.43/115.10	

Note: *Statistically significant according to α = 0.05.

Effect of yarn twist coefficient

The fabrics produced from cotton fibre were used to determine the effect of the twist coefficient. Because of the shorter fibre length unlike the polyester fabrics results, the strength of the fabrics in slub yarns was found to be lower than those produced with unslub yarn. The presence of slub areas leads to lower strength due to these fibre characteristics. When the effect of yarn twist coefficient on slub fabric properties is examined, as the yarn twist increases, the fibres are packed more tightly, making it difficult to separate the fibre from the yarn due to friction, thus an increase in the abrasion resistance was determined. However, the increase in twist also causes a decrease in yarn elasticity and fabric bursting strength values.

With the increase in yarn twist coefficient, a decrease in yarn diameter and an increase in air permeability were observed. When the relationship between yarn twist coefficient and fabric pilling is examined, it is seen that increasing the twist coefficient reduces the pilling tendency. The increase in the twist coefficient ensures that the fibres are wrapped more tightly into the yarn structure, which reduces the tendency to pilling (table 10).

Table 10

EFFECT OF TWIST COEFFICIENT ON THE AIR PERMEABILITY AND PILLING OF THE FABRIC				
Parameter	**Twist coefficient (α_e)**			
	Without slub (α_e = 3.8)	**3.8**	**4.2**	**4.6**
Air permeability (l/dm^2/min)	1021	1034	1176	1189
Pilling (grade)	2.5	2.5	2.8	3

The effect of yarn twist on bursting strength and air permeability values is statistically significant (table 11). While the twist increase in slub yarns did not make a significant difference for fabrics in slub yarn, it was observed that their bursting strength was significantly lower than that of yarns without slub (table 12). In cases where α_e values are 4.2 and 4.6, the air permeability value of fabrics is higher than other fabrics (table 13) The difference in mean values of abrasion resistance was insignificant according to the Kruskal Wallis test (p = 0.270).

Table 11

P VALUE OF ANALYSIS OF VARIANCE REGARDING TWIST COEFFICIENT	
Parameter	**p-value**
Bursting strength	0.000*
Air permeability	0.000*

Note: *Statistically significant according to α = 0.05.

Effect of slub population

The yarn which has two different slub lengths (1–3 and 10–12) was used to determine the effect of slub population. The comparison was made between fabrics produced from single slub yarn in 1–3 slub length and 10–12 slub length. Statistical analysis indicated

Table 12

95% CONFIDENCE INTERVAL BOUNDS ACCORDING TO TUKEY MULTIPLE COMPARISONS OF THE BURSTING STRENGTH RESULTS BASED ON THE TWIST COEFFICIENT				
Twist coefficient	Without slub (α_e = 3.8)	3.8	4.2	4.6
	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound
Without slub (α_e = 3.8)	-	–181.75/–20.85*	–214.19/–53.29*	–227.37/–66.47*
3.8	20.85/181.75*	-	–112.89/48.01	–126.07/34.83
4.2	53.29/214.20*	–48.01/112.89	-	–93.63/67.27
4.6	66.47/227.37*	–34.83/126.07	–67.27/93.63	-

Note: *Statistically significant according to α = 0.05.

Table 13

95% CONFIDENCE INTERVAL BOUNDS ACCORDING TO TUKEY MULTIPLE COMPARISONS OF THE AIR PERMEABILITY RESULTS BASED ON THE TWIST COEFFICIENT				
Twist coefficient	Without slub (α_e = 3.8)	3.8	4.2	4.6
	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound	Lower bound/ Upper bound
Without slub (α_e = 3.8)	-	–63.90/90.24	78.32/232.47*	91.66/245.81*
3.8	–90.24/63.90	-	65.16/219.30*	78.50/232.64*
4.2	–232.47/–78.33*	–219.30/–65.16*	-	–63.74/90.41
4.6	–245.80/–91.66*	–232.64/–78.50*	–90.41/63.74	-

Note: *Statistically significant according to α = 0.05.

that the slub population had no significant effect on the strength and air permeability of the fabric (table 14). Bursting and abrasion resistance values of two-population fabrics were between the results of single-population fabrics. Since there are slubs in two different lengths along the yarn, it was an expected result (figure 6).

In terms of air permeability values, the fabrics in two populations showed the highest result. This could be stated that the reason for the higher air permeability values is due to the presence of different populations in the yarn, more porous structure of the fabric.

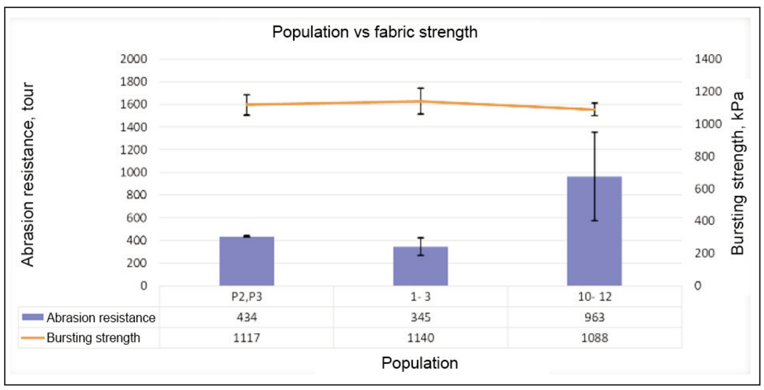

Fig. 6. Effect of slub population on fabric strength

When evaluating the pilling properties of fabrics with different populations, it was seen that fabrics produced from yarns with two different populations had a lower tendency to pilling than fabrics with a single population. It is thought that this situation is due to the lowest thickness of the P2, P3 fabric. The thickness of slub fabrics is determined by the regional slub thickness, and therefore, the slub areas are damaged first when performing the pilling test. For this reason, it can be said that the slubs are distributed homogeneously in the P2, P3 fabric and are less pilled (table 15).

Table 14

P VALUE OF ANALYSIS OF VARIANCE REGARDING SLUB POPULATION	
Parameter	p-value*
Bursting strength	0.194
Air permeability	0.120

Note: *Statistically significant according to α = 0.05.

Table 15

EFFECT OF SLUB POPULATION ON THE AIR PERMEABILITY AND PILLING OF THE FABRIC			
Parameter	Slub population		
	P2, P3	1–3	10–12
Air permeability (l/dm^2/min)	1911	1818	1753
Pilling (grade)	3	2.5	2

CONCLUSION

The increasing use of slub yarns in recent years has required examining of the properties of fabrics produced from these yarns. In this study, the effects of slub thickness, slub length, slub frequency, yarn twist and population parameters on the bursting strength, permeability and pilling properties of knitted fabrics produced from slub yarns were examined.

According to the study results it was observed that slub length and population characteristics did not have a significant effect on bursting strength and air permeability values. However, slub thickness ratio, slub frequency, and twist coefficient value are the parameters affecting air permeability significantly, and it can be said that the effect of slub parameters on fabric density and porosity is quite important.

In terms of strength properties of the fabrics, increasing the slub thickness and frequency provides increments in the fabric abrasion and bursting resistance due to the thick areas there, but using 1.6 slub thickness and slub frequency higher than 3 number/m causes these values to decrease due to easier removal of fibres in the slub areas and decreasing fabric density. Additionally, the twist value of the yarn has been found to have a significant impact on fabric bursting strength.

When the effect of slub parameters on fabric pilling properties is examined, increasing slub thickness, length, frequency and population number give rise to tendency of the fabric pilling-formation.

Considering the strength behaviours of fabrics produced from slub yarns, it was observed that the values increased up to a certain limit value and after reaching this value, the tendencies changed and began to decrease. Therefore, it is important to determine these values to obtain the optimum physical properties expected from fabrics.

In researching slub yarns and the resulting fabrics, it is advisable to carry out studies that examine the effects of slub properties on different types of fabric and fabric parameters.

ACKNOWLEDGEMENT

This study was funded by Ege University BAP project number 16-MÜH-086.

REFERENCES

[1] Gong, R.H., Wright, R.M., *Fancy Yarns*, In: Woodhead Publishing Limited Cambridge England, 2002

[2] Turay, A., *Çeşitli Fantezi İpliklerden Örülen Kumaşların Isıl Özelliklerinin İncelenmesi*, Master Thesis, E.Ü. Fen Bilimleri Enstitüsü-Bornova-İzmir, 2008

[3] Süpüren, G., Özçelik, G., Turay, A., Özdil, N., *Yaygın Olarak Kullanılan Fantazi İplikler ve Özellikleri*, In: Niğde Tekstil Sempozyumu, Niğde Üniversitesi, 2008

[4] Özdil, N., Özçelik Kayseri, G., Süpüren Mengüç, G., *Şantuklu İplik Özellikleri*, In: Nevşehir Bilim ve Teknoloji Dergisi, 2019, 8, 1, 33–41, https://doi.org/10.17100/nevbiltek.453740.

[5] Şamlı, E., *Şantuklu İpliklerde Düzgünsüzlük Ölçümü ve İplik Özelliklerinin İncelenmesi*, Master Thesis, Ege Üniversitesi Fen Bilimleri Enstitüsü, Bornova-İzmir, 2010

[6] Wang, J., Huang, X., *Parameters of Rotor Spun Slub Yarn*, In: Textile Research Journal, 2002, 72, 12–16, https://doi.org/10.1177/004051750207200102

[7] Grabowska, K.E., *Characteristics of Slub Fancy Yarn*, In: Fibres and Textiles in Eastern Europe, 2001, 9, 1, 28-30

[8] Rudnik, J., Jackowski, T., *Influence of Twist of Slub Yarn on its Physic-mechanical Indications,* In: Proceedings of Conference ArchTex'2001. Innovation in Textile Technology, Lodz, Poland, 2001, 27–32

[9] Souid, H., Babay, A., Sahnoun, M., Cheikrouhou M., *A Comparative Quality Optimisation Between Ring Spun and Slub Yarns by Using Desirability Function*, In: AUTEX Research Journal, 2008, 8, 3, 72–76

[10] Liu, J., Li, Z., Lu, Y., Jiang, H., *Visualisation and Determination of the Geometrical Parameters of Slub Yarn*, In: Fibres and Textiles in Eastern Europe, 2010, 18, 1, 78, 31–35

[11] Liu, J., Xie, Z., Gao, W., Jiang, H., *Automatic Determination of Slub Yarn Geometrical Parameters Based on an Amended Similarity-based Clustering Method*, In: Textile Research Journal, 2010, 80, 11, 1075–1082, https://doi.org/10.1177/004051750935252

[12] Lu, Y.Z., Gao, W.D., Zhang, X.Y., *Assessing Texture of Slub-Yarn Fabric Using Image Analysis*, In: Journal of Donghua University (English Edition), 2007, 24, 2, 219–221

[13] Fouda, A., *Effect of Slub Yarn Ratio on Single Jersey Knitted Fabric Properties*, In: Journal of Textile Science & Engineering, 2016, 6, 5, 1–7, https://doi.org/10.4172/2165-8064.1000273

[14] Ray, N.C., Mukhopadhyay A., Midha V.K., *Impact of Abrasion on Mass Loss and Surface Appearance of Woven Fabrics Made with Injected Slub Yarn in Weft*, In: Journal of The Institution of Engineers (India): Series E, 2016, 97, 2, 99–106, https://doi.org/10.1007/s40034-016-0085-5

[15] Altaş, S., Ozgen, B., *The effect of slub yarn descriptive parameters and yarn linear density on upholstery fabric abrasion resistance*, In: The Journal of the Textile Institute, 2016, 107, 10, 1232–1239, https://doi.org/10.1080/00405000.2015.1100414

[16] Ozgen, B., Altaş, S., *Evaluation of Air Permeability of Fabrics Woven with Slub Yarns*, In: Tekstil ve Konfeksiyon, 2017, 27, 2, 126–130

[17] Mukhopadhyaya, A., Midha, V.K., Ray, N.C., *Impact of abrasion on mass loss and appearance of injected slub yarn fabrics,* In: Indian Journal of Fibre & Textile Research, 2017, 42, December, 413–419, https://doi.org/10.56042/ijftr.v42i4.12973.

[18] Mukhopadhyay, A., Midha, V.K., Ray, N.C., *Multi-objective optimization of parametric combination of injected slub yarn for producing knitted and woven fabrics with least abrasive damage*, In: Research Journal of Textile and Apparel, 2017, 21, 2, 111–133, https://doi.org/10.1108/RJTA-10-2016-0024

[19] Atef, R., Elbealy, R., Badr, A.A., Elkhalek, R.A., *Performance of Knitted Fabrics Produced from Fancy Yarns with Different Slub/Meter and Blend Ratio*, In: Journal of Textile Science & Engineering, 2018, 8, 378, 1–7, https://doi.org/10.4172/2165-8064.1000378

[20] Thanabal, V., Gopalakrishnan, M., Vijayasekar, R., *Study on the Quality Characteristics of Slub Yarn Knitted Fabrics*, In: Indian Journal of Fibre and Textile Engineering, 2021, 1, 1, 10–14

[21] Ertekin, G., Ertekin, M., Marmaralı, A., *Visual Perception and Performance Properties of Fabrics Knitted with Elastic Core Cotton Slub Yarns*, In: Journal of Natural Fibers, 2022, 19, 3, 810–822, https://doi.org/10.1080/15440478.2021.1944428

Authors:

NİLGÜN ÖZDİL[1], ZEHRA EVRİM KANAT[2], BEHİYE ELİF TOPUZ[1], GONCA ÖZÇELİK[3], GAMZE SÜPÜREN MENGÜÇ[3]

[1]Textile Engineering Department, Faculty of Engineering, Ege University, 35100, İzmir, Türkiye
e-mail: nilgun.ozdil@ege.edu.tr, behiye.elif.samli@ege.edu.tr

[2]Textile and Fashion Design Department, Faculty of Fine Arts, Canakkale Onsekiz Mart University, 17100, Canakkale, Türkiye

[3]Emel Akın Vocational Training School, Ege University, İzmir, 35100, Türkiye
e-mail: gonca.ozcelik@ege.edu.tr, gamze.supuren.menguc@ege.edu.tr

Corresponding author:

ZEHRA EVRİM KANAT
e-mail: zehraevrim.kanat@comu.edu.tr