EVALUATING THE CLOTHING COMFORT OF POLYESTER FABRICS ENGINEERED WITH CORE-SPUN ELASTANE YARNS

Original scientific paper
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ABSTRACT: *In this study, the performance, comfort, and stretch properties of polyester knitted fabrics containing core-spun elastane yarns with varying linear densities were investigated. Ne 16 core-spun yarns were produced using elastane filaments of 20, 40, 70, and 140 denier as the core material, and polyester staple fibers (38 mm, 1.2 dtex) as the sheath material. Single jersey fabrics were knitted by these yarns. The targeted properties of these fabrics were compared with, the sample in which elastane was incorporated during the knitting process rather than via core-spun yarn production. As a result, core-spun fabrics produced with 20 dtex elastane were found to exhibit better performance regarding thermal comfort in sportswear. Moreover, a regression equation was derived to estimate the elastane ratio in knitted fabrics based on yarn production parameters, offering practical utility for industrial applications.*

Keywords: *core-spun yarn, elastane, knitted fabric, performance properties, regression model.*

PROCENA UDOBNOSTI ODEĆE OD POLIESTERSKIH TKANINA IZRAĐENIH SA ELASTANSKIM JEZGRO-PREĐENIM PREDIVIMA

APSTRAKT: *U ovoj studiji ispitivane su performanse, udobnost i rastegljive osobine poliesterskih pletenih tkanina koje sadrže jezgro-pređena prediva sa elastanom različitih linearnih gustina. Jezgro-pređena prediva Ne 16 proizvedena su korišćenjem elastanskih filamenata od 20, 40, 70 i 140 dtex kao jezgra, i poliesterskih rezanih vlakana (38 mm, 1.2 dtex) kao omotača. Od ovih prediva pletene su jednolične (single jersey) tkanine. Ciljane osobine ovih tkanina upoređene su sa uzorkom u kojem je elastan dodat tokom procesa pletenja, a ne putem proizvodnje jezgro-pređenih prediva. Kao rezultat, utvrđeno je da tkanine sa jezgrom od 20 dtex elastana pokazuju bolje performanse u pogledu termalne udobnosti za sportsku odeću. Pored toga, izvedena je regresiona jednačina za procenu procenta elastana u pletenim tkaninama na osnovu parametara proizvodnje prediva, što nudi praktičnu vrednost za industrijsku primenu.*

Ključne reči: *jezgro-pređeno predivo, elastan, pletena tkanina, performansne osobine, regresioni model.*

1. INTRODUCTION

The increasing demand for high-performance textile products has driven extensive research into the functional properties of knitted fabrics. In recent years, the use of elastane in knitted fabrics has become increasingly widespread, driven by the growing need for garments that offer both comfort and functionality. Elastane is widely appreciated for its elastic properties, which allow fabrics to recover their shape after stretching and provide a better fit to the human body. Depending on how it is incorporated into the yarn—either as a core-spun component or through bare feeding—elastane can significantly influence the fabric's physical behavior.

Key fabric characteristics such as bursting strength, thickness, air permeability, and thermal properties are closely linked to the structural configuration of the yarn, particularly the core-to-sheath ratio and the denier of the elastane used. Although previous studies have examined the general effects of elastane on fabric properties, the combined influence of yarn structure and elastane thickness on both mechanical performance and thermal regulation remains less explored. Several studies have examined the impact of elastane on the structural and comfort-related properties of knitted fabrics [1-5]. Marmaralı et al., Hes et al. and Özdil found that increasing elastane content in knitted and denim fabrics enhances thermal resistance and elastic recovery, while reducing thermal conductivity, water vapour permeability, and dimensional deformation. Herath et al. [6] and Sadek et al. [7] reported that elastane improves dimensional stability and elongation, particularly in single jersey fabrics. Azim et al. [8] and Eryuruk & Kalaoğlu [9] highlighted its influence on air permeability, fabric weight, bursting strength, and spirality. Ertekin et al. [10] observed that higher elastane ratios increase thickness, strength, and thermal conductivity but cause limit breathability. Uyanık [11] and Cingü [12] further emphasized the role of elastane type, denier, and feeding method on thermal comfort, elongation behavior, and surface properties.

This study aims to investigate the effect of elastane configuration on the overall performance of knitted fabrics. For this aim the fabric properties such as thermal resistance, water vapour permeability, air permeability, fabric weight, and elastane content were determined. The obtained results will provide significant data for material selection and design studies in application fields where comfort, breathability and durability are important.

2. EXPERIMENTAL STUDY

In this study, the performance, comfort, and elasticity properties of polyester fabrics containing elastane in different lineer densities were analyzed and compared with the method of feeding elastane into the fabric during knitting production. Additionally, the aim was to develop an equation that identifies the relationship between the the relationship between the core/sheath ratio of the yarn and elastane ratio by weight (%), which could be practically applied in the industry.

As the core material; elastane filaments of different lineer densities (22, 44, 78, and 156 dtex) were used, while staple PES fibers were employed as the sheath material. The PES fibers used in the experiments had a fineness of 1.2 dtex and a staple length of 38 mm and were used in the form of slivers in 295 tex.

According to experimental plan (Table 1), 5 different types of core-spun yarns with a lineer density of 37 tex (final yarn count) were produced using the core-spinning technique on Pinter Merlin ring spinning machine. Draw ratios were 3.5 for feeding elastane filament. Core-spun polyester yarns containing elastane were used to produce single jersey knitted fabrics. To observe the effects of elastane in knitted fabrics, PES yarns without elastane were also produced.

Table 1: Experimental plan for yarn production.

	2	5	8	11	
Elastane (denier)	20	40	70	140	-
Elastane (dtex)	22	44	78	156	-
Sheath (tex)	36	35	34	32	37
Sliver draft ratio	12.1	12.5	12.5	13.7	11.9

To observe the effects of variable parameters, all spinning parameters were kept constant (Yarn twist was 600 T/m, spindle speed to 10,000 rpm, and traveler number to 4). The yarns produced on the ring spinning machine were used to manufacture single jersey tubular fabrics using the Mesdan Labknitter machine with 220 needles under constant machine settings. Additionally, fabrics were produced by incorporating naked elastane (40 denier) commonly used in knitted fabrics, into elastane-free PES yarns for comparison with core-spun yarns. Furhermore, to observe the effect of elastane, a fabric was also produced under the same conditions without any elastane. Production machines are given in Fig 1.

(a) (b)

Figure 1: (a) Pinter Merlin ring spinning machine (b) Mesdan Labknitter

The yarn and fabric tests were done after conditioned for 24 hours at standard atmospheric conditions. Yarn properties such as irregularity, tensile strength, and elongation at break were evaluated, while fabric tests included thickness, weight, air permeability, water vapor permeability, thermal resistance, bursting strength, pilling, stretch (permanent elongation and elasticity), and pressure tests. Additionally, the elastane content in the fabric structure was measured using chemical methods (DMF dissolution method).

3. RESULTS AND DISCUSSION

According to test results in Table 2, an increase in elastane thickness resulted in a decrease in tensile strength while an increase in yarn hairiness and breaking elongation. The decrease in tensile strength with the increase of elastane thickness is thought to be due to the reduced amount of PES fibers in the sheath part of the core-spun yarn. On the other hand, no significant difference was found among the yarn unveness values.

Table 2: Yarn uneveness, hairiness, tenacity and breaking elongation test results.

Elastan no	Yarn unevenness	Yarn hairiness		Yarn tenacity		Breaking	
	CVm %	H	sh	µ	CV %	µ	CV %
20 den	8,39	4,92	0,97	39,99	5,18	15,37	3,22
40 den	8,09	6,38	1,13	37,86	4,85	15,5	3,15
70 den	8,67	8,01	1,58	36,01	6,07	16,08	5,21
140 den	8,67	8,01	1,58	30,51	4,38	17,53	3,45

The fabric labeled with the code "NoEL" represents the elastane-free control sample, while the fabric labeled with the code "NakedEL" refers to the sample produced by incorporating naked elastane into the structure during the knitting process.

Table 3: Fabric weight, thickness, elasticity and pilling test results.

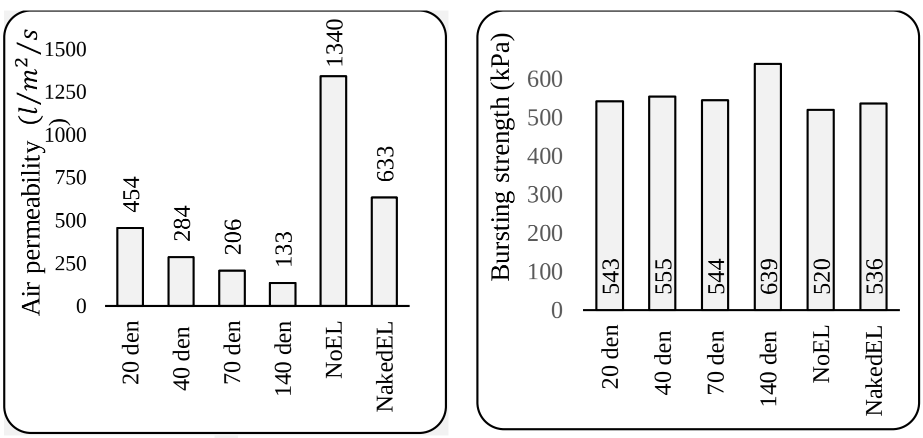
	Soft core-spun yarns				**No-elastane**	**Naked elastane**
Elastane lineer density (denier)	**20**	**40**	**70**	**140**	**-**	**-**
Fabric weight (g/m²)	234.5	253.4	288	367.7	210.1	228.9
Fabric thickness (mm)	1.05	1.26	1.28	1.43	1.01	1.00
Fabric elasticity S (%)	60.7	71.47	79.03	70.22	58.50	63.70
Pilling degree	3/4	2/3	3/4	3/4	4	2/3

In Table 3, S (%) stands for strain percentage, representing the relative elongation of the specimen. Fabrics elongation and elasticity values are the mean values obtained from the tests performed in wale and course direction. As expected from the stretchability tests of knitted fabrics, the elasticity values in the course wise direction were found to be higher than along wales. On the other hand, no significant effect of the elastane denier was observed. Core-spun yarns outperform naked elastane and no-elastane fabrics in elasticity. 70 denier core-spun elastane offers the highest elasticity and controlled deformation.

In general, an increase in elastane thickness resulted in a higher fabric weight in knitted fabrics (According to ISO 12127). As the thickness of elastane increases, the thickness of the knitted fabric also increases (According to ASTM D 1777). When the same elastane count is used, a difference in fabric thickness is observed between the knitted fabric containing core-spun elastane yarn and the fabric produced with naked elastane feeding. This difference indicates that the fabric containing core-spun yarn is thicker.

The pilling test results of the fabrics generally ranged between grades 3 and 4, regardless of the elastane thickness (According to ISO 12945-1).

The air permeability results of the knitted fabrics, as shown in the figure, demonstrate a clear decreasing trend with increasing elastane thickness (According to ISO 9237). Fabrics containing 140 denier elastane exhibited the lowest air permeability value at 133 l/m²/s, while those with 20 den showed a higher permeability at 454 l/m²/s. This trend suggests that thicker elastane content leads to a denser fabric structure, thereby restricting airflow more significantly. The fabric without elastane (NoEL) displayed the highest air permeability (1340 l/m²/s), confirming that the absence of elastane contributes to a looser fabric structure with higher porosity. The naked elastane containing sample (NakedEL) showed a permeability of 633 l/m²/s, which is significantly higher than any of the core-spun elastane-fed fabrics but still lower than the NoEL fabric. This result indicates that core-spun elastane integration not only affects elasticity but also leads to notable compactness, which significantly reduces air permeability compared to naked elastane feeding.



(a) (b)

Figure 2: (a)Air permeability (b) Bursting strength values of the fabrics.

The bursting strength of knitted fabrics varies slightly depending on the elastane thickness and feeding method. The highest bursting strength was recorded for the fabric produced with 140 denier elastane, reaching 639 kPa, indicating a clear reinforcement effect at higher denier levels (According to ISO 13938-2). Other elastane-containing samples (20, 40, and 70 den) exhibited relatively close values, ranging between 543 and 555 kPa, suggesting that changes in denier within this range have a limited impact on bursting strength. Fabrics produced without elastane (NoEL) and those with naked elastane (NakedEL) showed lower bursting strengths, measured at 520 kPa and 536 kPa, respectively. This indicates that core-spun elastane, particularly with higher deniers, provides a compact structure and high resistance more effectively than naked elastane feeding.

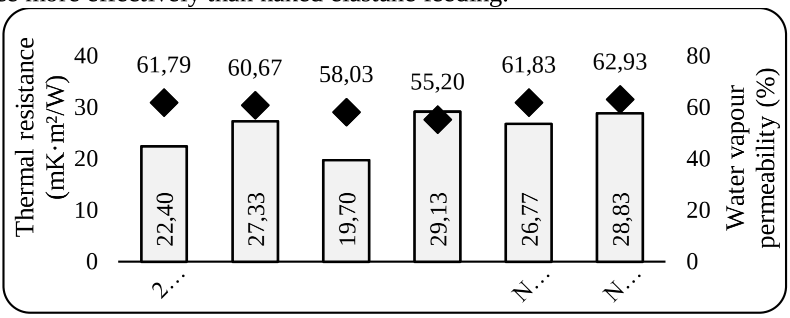


Figure 3: Thermal resistance and water vapour permeability (%) values of the fabrics.

This figure illustrates the thermal resistance (expressed in mK m²/W) and water vapour permeability (%) of various knitted fabric samples containing different elastane thicknesses and feeding methods (According to ISO 11092). The fabric produced with 140 denier elastane exhibited the highest thermal resistance at 29.13 mK m²/W, indicating improved insulation properties. The general trend suggests that as elastane thickness increases, thermal resistance also increases due to a denser fabric structure.
Water vapor permeability values range from 55.20% to 62.93%. NakedEL sample, similar to the fabric knitted by 40 den core-spun elastane, exhibits the highest vapor permeability while also providing higher thermal resistance, meaning a fabric that has adequate insulation but also has sufficient breathability.

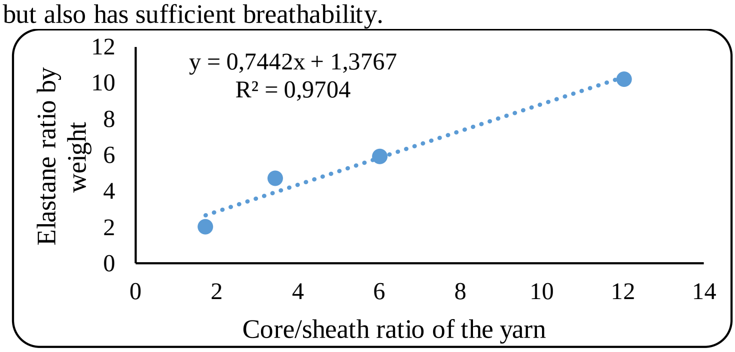


Figure 4: The relationship between fabrics' elastane ratio by weight and core/sheat ratio of the yarn.

In Figure 4, the scatter plot displays the relationship between the core/sheath ratio of the yarn and the elastane ratio by weight (%). The fitted linear regression model is represented by the equation:

$$y = 0.7442x + 1.3767, \qquad (1)$$

with a coefficient of determination $R^2 = 0.9704$. A strong linear correlation is observed between the core/sheath ratio and elastane ratio by weight, as evidenced by the high R^2 value (0.9704), indicating that over 97% of the variation in elastane content can be explained by the core/sheath ratio. As the core proportion increases relative to the sheath, the elastane content in the yarn increases proportionally. This is expected, since elastane is generally located in the core region of the yarn. The regression line indicates that for each unit increase in the core/sheath ratio, the elastane content increases by approximately 0.74% by weight.

4. CONCLUSION

In this study, the effect of various elastane configurations on the performance characteristics of knitted fabrics was investigated in detail. Key focus areas included bursting strength, air permeability, thermal resistance, water vapor permeability, and elastane content in relation to yarn structure.

- The results revealed that increasing the elastane thickness, particularly in core-spun yarns, contributed significantly to the mechanical strength of the fabric. The sample containing 140 denier elastane exhibited the highest bursting strength, while fabrics produced without elastane or with naked elastane showed comparatively lower performance in this regard.
- A clear trend was also observed in terms of air permeability. As the elastane denier increased, fabrics became progressively less breathable, which is attributed to the denser structure formed by higher elastane content. Fabrics produced by naked elastane showed moderate permeability, between core-spun and elastane-free fabrics.
- The analysis of thermal comfort properties showed that samples with greater elastane thickness offered better thermal insulation. However, this also resulted in a reduction in water vapour permeability, suggesting a balance between insulation and breathability. Among all samples, the 40 denier core-spun or naked elastance feeding provided the most balanced thermal comfort characteristics.
- Furthermore, the relationship between core/sheath ratio and elastane ratio by weight was found to be strongly linear, as indicated by a high coefficient of determination ($R^2 = 0.9704$). This finding underscores the predictability of eelastane distribution in yarn based on structural parameters.

Ovrall, the study shows that core-spun yarns with thicker elastane content enhance strength and insulation, though they may limit breathability. These insights can guide the development of knitted fabrics tailored for specific functional requirements, depending on whether durability, insulation, or comfort is prioritized.

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REFERENCES

[1] Marmaralı, A., Özdil, N., & Kretzschmar, D. S. (2007). Elastik iplikli düz örme kumaşların ısıl konfor özellikleri. *Tekstil ve Konfeksiyon*, 17(3), 178-181.
[2] Hes, L., Marmarali, A., Oezdil, N., Oglakcioglu, N., & Mario, L. I. M. A. (2008). The effect of moisture on friction coefficient of elastic knitted fabrics. *Tekstil ve Konfeksiyon*, 18(3), 206-210.
[3] Özdil, N. (2008). Stretch and bagging properties of denim fabrics containing different rates of elastane. *Fibres & Textiles in Eastern Europe*, 16(1), 66.
[4] Ute, T. B., & Kadoglu, H. (2018). The effects of core material parameters on the mechanical properties of double core and single core spun yarns. *In IOP Conference Series: Materials Science and Engineering* (Vol. 459, No. 1, p. 012032). IOP Publishing.
[5] Çelik, P., Bedez Üte, T., Özden, D., Çömlekçi, H., & Akkale, E. C. (2009). The Effect Of Core/Sheath Ratio And Twist Amount On Yarn Charachteristics Of Filament Core Yarns.. Tekstil Teknolojileri Elektronik Dergisi, 3(2), 29-37.
[6] Herath,, C.N., Kang, B.C. (2008). Dimensional Stability of Core Spun Cotton / Spandex Single Jersey Fabrics Under Relaxation. *Textile Research Journal*, Sayı 78, 209-216.
[7] Sadek, R., El-Hossini, A. M., Eldeeb, A. S., & Yassen, A. A. (2012). Effect of lycra extension percent on single jersey knitted fabric properties. *Journal of Engineered Fibers and Fabrics*, 7(2), 155892501200700203.
[8] Azim, A. Y. M. A., Sowrov, K., Ahmed, M., Hasan, H. R. U., & Al Faruque, M. A. 2014. Effect of Elastane on Single Jersey Knit Fabric Properties-Physical & Dimensional Properties. *International Journal of Textile Science*, 3(1), 12-16.
[9] Eryuruk, S. H., & Kalaoglu, F. (2016). Analysis of the Performance Properties of Knitted Fabrics Containing Elastane. *International Journal of Clothing Science and Technology*, 28(4), 463-479.
[10] Ertekin, G., Oğlakcıoğlu, N., & Marmaralı, A. (2018). Strength And Comfort Characteristics of Cotton/Elastane Knitted Fabrics. *Tekstil ve Mühendis*, 25(110), 146-153.
[11] Uyanık, S. (2021) Researching of the Effects of Elastane Ratio on the Thermal Effusivity and Conductivity Properties in Plain Knit Fabrics with Elastane . *Adıyaman Üniversitesi Mühendislik Bilimleri Dergisi*, 8(15), 369-377.
[12] Cingü, N. (2022). Investigation of permanent elongation and comfort characteristics of knitted fabrics containing elastane, *Bursa Uludağ Üniversi*