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INVESTIGATION OF THE USAGE OF ALTERNATIVE NEW GENERATION ECO-FRIENDLY FIBER BLENDS IN SYNTHETIC BASED DENIM FABRICS

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ABSTRACT

Polyester yarn is made from post-consumer waste such as bottles, fabrics, etc., in the composition of polyester ethylene terephthalate (PET). Polyester (mainly polyethylene terephthalate, PET) is the most commonly employed textile fibre with over 50% share in total production of textile fibres. Pla is a biobased and biodegradable polymer produced from renewable resources. PLA is also a thermoplastic aliphatic compostable polyester. In this study, 75% Cotton - 25% PLA, 75% Lyocell - 25% PLA and 75% Cotton - 25% PET blended yarns were produced as rigid, corespun and dualcore in the ring spinning system .The fabrics were weaved with produced yarn. In the finishing processes, some of the fabrics were treated with caustic and some of the fabrics were only washed. Fabrics containing PLA and PET were compared with each other. Fabrics containing PLA and PET fiber were evaluated in terms of strength, elasticity, abrasion and pilling performances. Although the weft tensile and tear properties of Cotton-PLA blended fabrics are lower than Lyocell-PLA and Cotton-PET blends, it has been indicated that PLA blended yarns can be used as an alternative to PET based yarns and fabrics.

KEYWORDS

Pla; Polyester; Lyocell; Blend Yarn and Fabrics; Fabric Performance.

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INTRODUCTION

One of the most common raw materials used in the global textile industry is Polyethylene terephthalate (PET) fiber, cotton fiber and their blends. Cotton and polyester staple fibers constitute 58% and 28% of staple yarns, respectively. [1] Polyester (mainly polyethylene terephthalate, PET). The most widely used textile fiber in total textile fiber production. In general, it has excellent performance properties. In addition to this feature, it is a non-biodegradable fiber that consumes fossil fuels [2]. Polylactic acid (pla) has been recognized as one of the solutions for the disposal of plastics, as it is produced from renewable resources and completely biodegrades at the end of its life [3]. In addition to offering advantages in the use of pet and cotton fiber blends, pet-cotton production has negative effects on the environment. Fabrics made using pla offer good moisture management properties for underwear, sportswear, active wear and fashion wear due to their excellent wicking ability, rapid moisture spreading and drying properties [4]. The dry tensile strength of lyocell fiber is greater than that of other man-made cellulosic staples, not only its physical, mechanical and chemical properties are better than viscose fiber, but also environmentally friendly because the lyocell process uses non-toxic NMMO solvent [5].

The current study aims to comparison of eco-friendly pla fiber to cotton-pes blended fabrics, as well as the physical properties of pla fiber in lyocell-pla and cotton-pla blended fabrics will be compared.

EXPERIMENTAL

Materials

Pla, cotton, polyester and lyocell fibers were used in the production of the yarns used in this study. Polylactic acid (PLA, Palmetto Synthetics LLC), lyocell (TencelRB, Lenzing AG), PET and cotton fibres were sourced. The properties of selected fibres are given in Table 1 and characteristic strength-elongation curves are plotted in Table 1.

Table 1. Fiber details.

Parameters	Pla	Lyocell	Polyester	Cotton
Fineness (dtex)	1,66	1,7	1.53	0.11 (4.7mic)
Fibre length (mm)	38	38	38	29.3
Tenacity (cN.tex–1)	25	33	57.4	29.8
Elongation (%)	52	13	18	7.3

Table 2. Yarn type and compositions.

Yarn Code	Yarn Types	Sheath *fiber* composition	Yarn description
A1	Rigid	25% Pla+75% Lyocell	Ne 18/1 RK
A2	Corespun	Sheath fiber-25% Pla+75% Lyocell	Ne 18/1 RK 78 LYC
A3	Dualcore	Sheath fiber-25% Pla+75% Lyocell	Ne 18/1 55 dtex T400 78 LYC
B1	Rigid	25% Pla+75% Cotton	Ne18/1 RK
B2	Corespun	Sheath fiber-25% Pla+75% Cotton	Ne 18/1 RK 78 LYC
B3	Dualcore	Sheath fiber-25% Pla+75% Cotton	Ne 18/1 55 dtex T400 78 LYC
C1	Rigid	25% Pes+75% Cotton	Ne18/1 RK
C2	Corespun	Sheath fiber-25% Pes+75% Cotton	Ne 18/1 RK 78 LYC
C3	Dualcore	Sheath fiber-25% Pes+75% Cotton	Ne 18/1 55 dtex T400 78 LYC

18 Ne ring-spun rigid, core and dual core-spun yarn has been produced. 78dtex lycra® and 55dtex T400® (PET/PTT) are used in the production of core-spun and dual core-spun yarns.
The details of yarns are given in Table 2.

Methods

Rigid, core-spun and dual-core yarns were produced in the ring-spinning process. The weaving process was completed on Picanol type machines.
Finishing processes of the woven fabrics have been completed. In addition to comparing the use of Pla and the use of Pes, the effect of the pre-treatment step on the fabric performance was also investigated. Fabric weaving details are given in Table 3.

The codes and explanations given to the fabrics according to the pre-processing steps are given in Table 4.

After conditioning the fabrics according to ASTM D 1776 for 24 hours (21ºC±1 temperature, 65±2 % relative humidity), all tests were carried out.
For this study, tensile strength,tear strength,elasticity&growth ,abrasion test results were evaluated.
ASTM D5034, ASTM D1424, ASTM D 3107, TS EN ISO 12947-2 standard methods were used to determine the performance of the fabric, respectively.

Table 3. Fabric details.

	CTPLA B1	CTPLA B2	CTPLA B3	CLYPLA A1	CLYPLAA 2	CLYPLAA 3	CTPES C1	CTPES C2	CTPES C3
Warp Yarn	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub	14/1 RK Slub
Weft Yarn	B1 (Rigid)	B2 (Core-spun)	B3 (Dual core-spun)	A1 (Rigid)	A2 (Core-spun)	A3 (Dual core-spun)	C1 (Rigid)	C2 (Core-spun)	C3 (Dual core-spun)
Comb	70	70	70	70	70	70	70	70	70
Weft Density	21	21	21	21	21	21	21	21	21
Weave Types	3/1Z	3/1Z	3/1Z	3/1Z	3/1Z	3/1Z	3/1Z	3/1Z	3/1Z

Table 4. Pre-processing steps.

Fabric Code	Sheath fiber composition	*Treatment Process*
CTPLA B1-W	%25 Pla +% 75 Cotton	Washed
CTPLA B1-C	%25 Pla +% 75 Cotton	10 Be' Caustic
CTPLA B2-W	%25 Pla +% 75 Cotton	Washed
CTPLA B2-C	%25 Pla +% 75 Cotton	10 Be' Caustic
CTPLA B3-W	%25 Pla +% 75 Cotton	Washed
CTPLA B3-C	%25 Pla +% 75 Cotton	10 Be' Caustic
CLYPLA A1-W	%25 Pla+%75 Lyocell	Washed
CLYPLA A1-C	%25 Pla+%75 Lyocell	10 Be' Caustic
CLYPLA A2-W	%25 Pla+%75 Lyocell	Washed
CLYPLA A2-C	%25 Pla+%75 Lyocell	10 Be' Caustic
CLYPLA A3-W	%25 Pla+%75 Lyocell	Washed
CLYPLA A3-C	%25 Pla+%75 Lyocell	10 Be' Caustic
CTPES C1-W	%25 Pes +% 75 Cotton	Washed
CTPES C1-C	%25 Pes +% 75 Cotton	10 Be' Caustic
CTPES C2-W	%25 Pes +% 75 Cotton	Washed
CTPES C2-C	%25 Pes +% 75 Cotton	10 Be' Caustic
CTPES C3-W	%25 Pes +% 75 Cotton	Washed
CTPES C3-C	%25 Pes +% 75 Cotton	10 Be' Caustic

RESULTS AND DISCUSSION

Tensile properties of fabric

Strength values are important for denim fabrics. Warp tensile values in all Cotton/Pla, Tensile/Pla and Cotton/Pes groups were found to be lower in fabrics made with rigid weft compared to the experiments made with core-spun and dual core-spun weft.

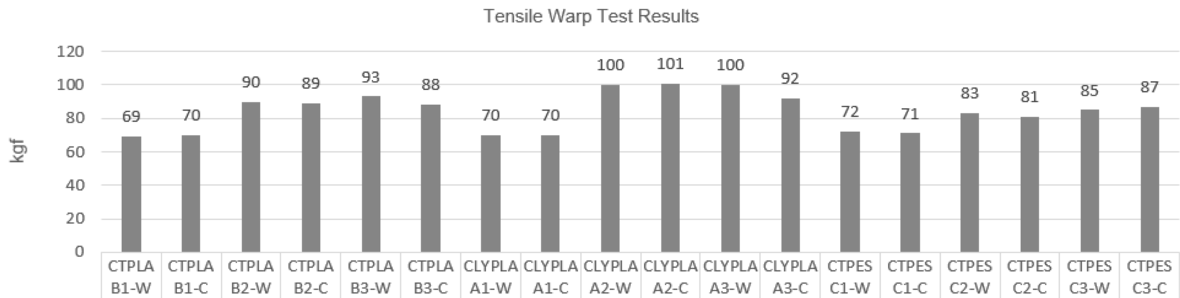
The increase in the warp tensile values of the fabrics using core-spun and dual core-spun weft was due to the increase in the warp yarn density.

The lowest weft tensile values were observed in the Cotton/Pla group. The increase in tensile values of the Tencel/Pla group compared to the Cotton/Pla group is due to the fact that the Tencel fiber is more durable than cotton.

It is possible that the Cotton/Pla group has less strength than the Cotton/Pes group, possibly because the Pla fiber is less durable than the polyester fiber.

Pla fiber is sensitive to alkaline treatments, but it has been determined that it does not significantly affect the tensile values between washing and 10 Be'causticizing processes as a finishing process. Tensile warp and weft test results are given in Figure 1 and Figure 2.

It has been determined that the Warp and Weft Tear test results are in line with the interpretations obtained in the tensile values. Tear warp and weft test results are given in Figure 3 and Figure 4.



	CTPLA B1-W	CTPLA B1-C	CTPLA B2-W	CTPLA B2-C	CTPLA B3-W	CTPLA B3-C	CLYPLA A1-W	CLYPLA A1-C	CLYPLA A2-W	CLYPLA A2-C	CLYPLA A3-W	CLYPLA A3-C	CTPES C1-W	CTPES C1-C	CTPES C2-W	CTPES C2-C	CTPES C3-W	CTPES C3-C
TENSİLE (kgf) WARP	69	70	90	89	93	88	70	70	100	101	100	92	72	71	83	81	85	87

Figure 1. Warp tensile test results

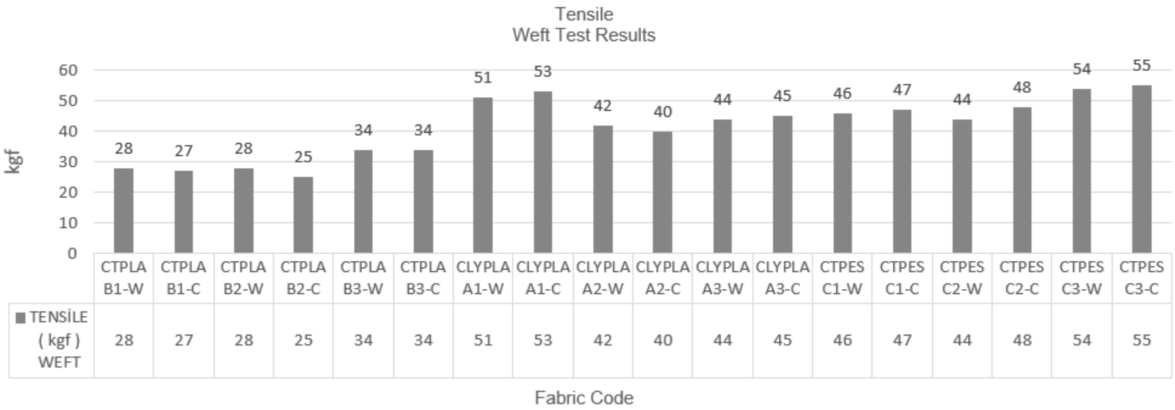


Figure 2. Weft tensile test results.

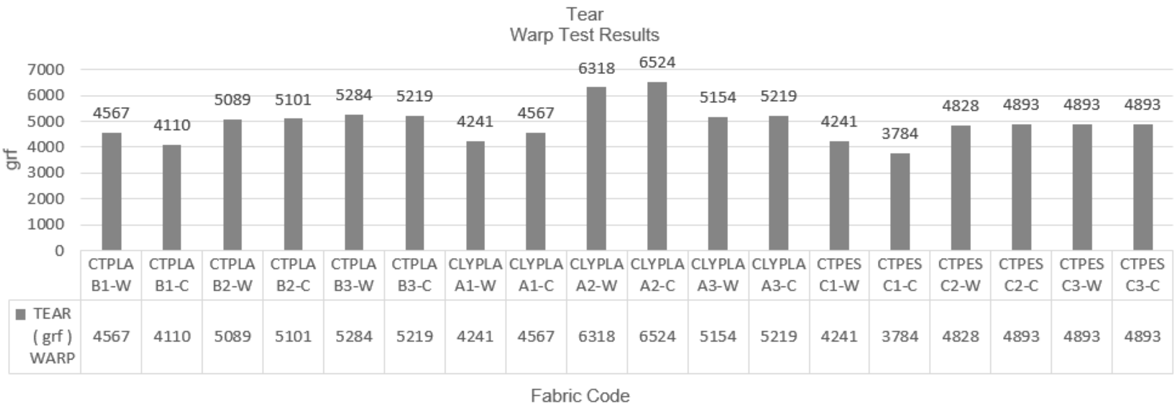


Figure 3. Warp tear test results.

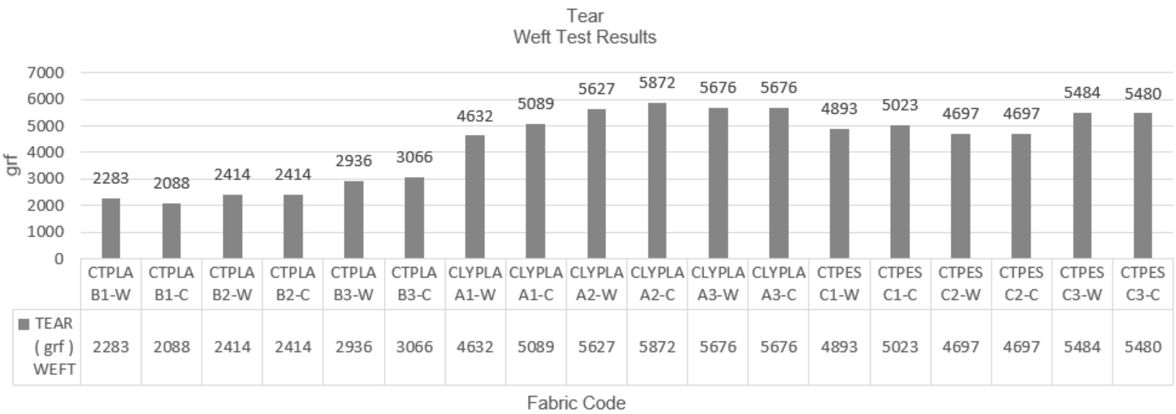


Figure 4. Weft tear test results.

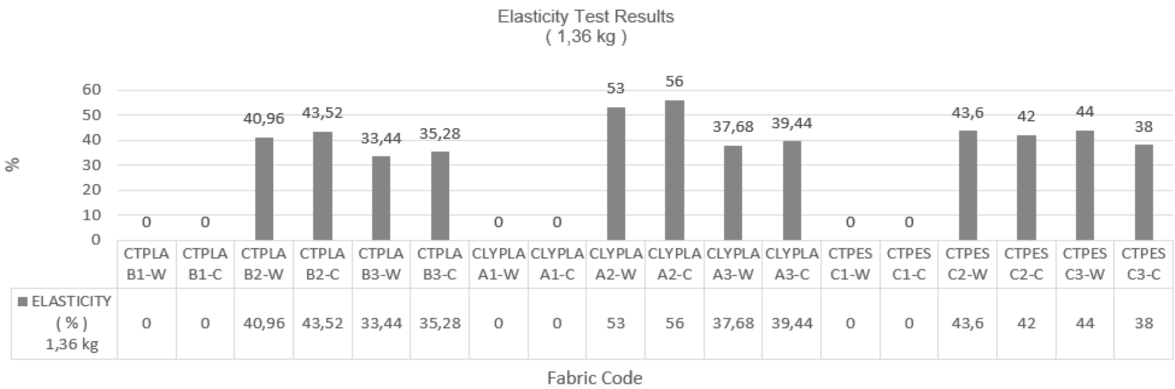


Figure 5. Elasticity test results.

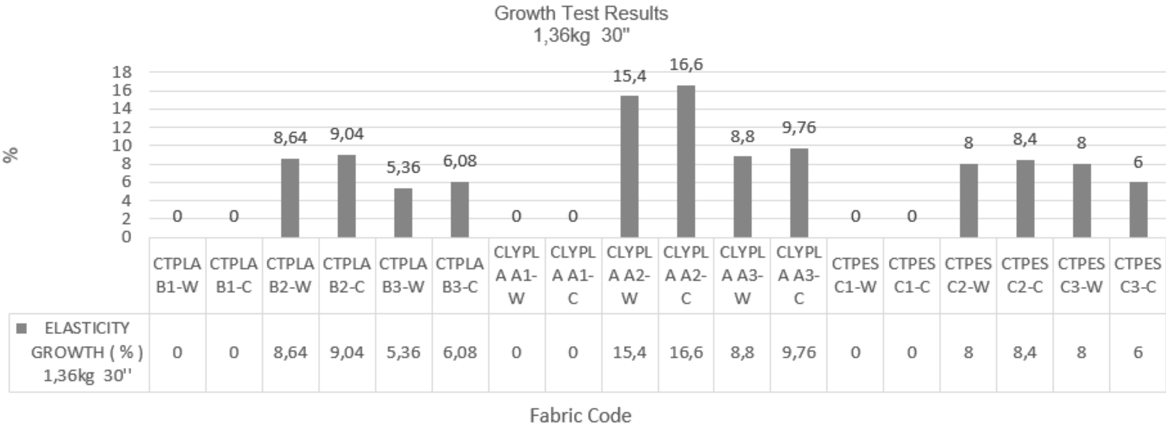


Figure 6. Growth test results.

Elasticity and Growth results of fabrics

The elasticity values of the rigid fabrics are shown as zero. The elasticity value of the core-spun yarns of the cotton/Pla group and the Tencel/Pla group were higher than the elasticity value of the dualcore-spun yarns.In the Cotton/Pes group, elasticity the values of core-spun and dualcore-spun yarns were found to be close to each other.

It was seen that the lowest growth value was in the group with Cotton/Pla, the highest in the group containing Tencel/Pla fiber.

Abrasion results of fabrics

The abrasion test was performed on the back side of the fabrics and up to 25000 cycles. No breakage was detected in the yarns until 25000 cycles. There was no difference between 10 Be'causticization and washing processes.

Figure 7 show the abrasion test results of treated 10 Be' denim samples. Washed fabrics also have a similar backside appearance.

Table 5. Abrasion test results

Fabric Code	Sheath fiber composition	Treatment Process	Abrasion	Fabric Face
CTPLA B1-W	%25 Pla +% 75 Cotton	Washed	>25000	Back
CTPLA B1-C	%25 Pla +% 75 Cotton	10 Be' Caustic	>25000	Back
CTPLA B2-W	%25 Pla +% 75 Cotton	Washed	>25000	Back
CTPLA B2-C	%25 Pla +% 75 Cotton	10 Be' Caustic	>25000	Back
CTPLA B3-W	%25 Pla +% 75 Cotton	Washed	>25000	Back
CTPLA B3-C	%25 Pla +% 75 Cotton	10 Be' Caustic	>25000	Back
CLYPLA A1-W	%25 Pla+%75 Lyocell	Washed	>25000	Back
CLYPLA A1-C	%25 Pla+%75 Lyocell	10 Be' Caustic	>25000	Back
CLYPLA A2-W	%25 Pla+%75 Lyocell	Washed	>25000	Back
CLYPLA A2-C	%25 Pla+%75 Lyocell	10 Be' Caustic	>25000	Back
CLYPLA A3-W	%25 Pla+%75 Lyocell	Washed	>25000	Back
CLYPLA A3-C	%25 Pla+%75 Lyocell	10 Be' Caustic	>25000	Back
CTPES C1-W	%25 Pes +% 75 Cotton	Washed	>25000	Back
CTPES C1-C	%25 Pes +% 75 Cotton	10 Be' Caustic	>25000	Back
CTPES C2-W	%25 Pes +% 75 Cotton	Washed	>25000	Back
CTPES C2-C	%25 Pes +% 75 Cotton	10 Be' Caustic	>25000	Back
CTPES C3-W	%25 Pes +% 75 Cotton	Washed	>25000	Back
CTPES C3-C	%25 Pla +% 75 Cotton	10 Be' Caustic	>25000	Back

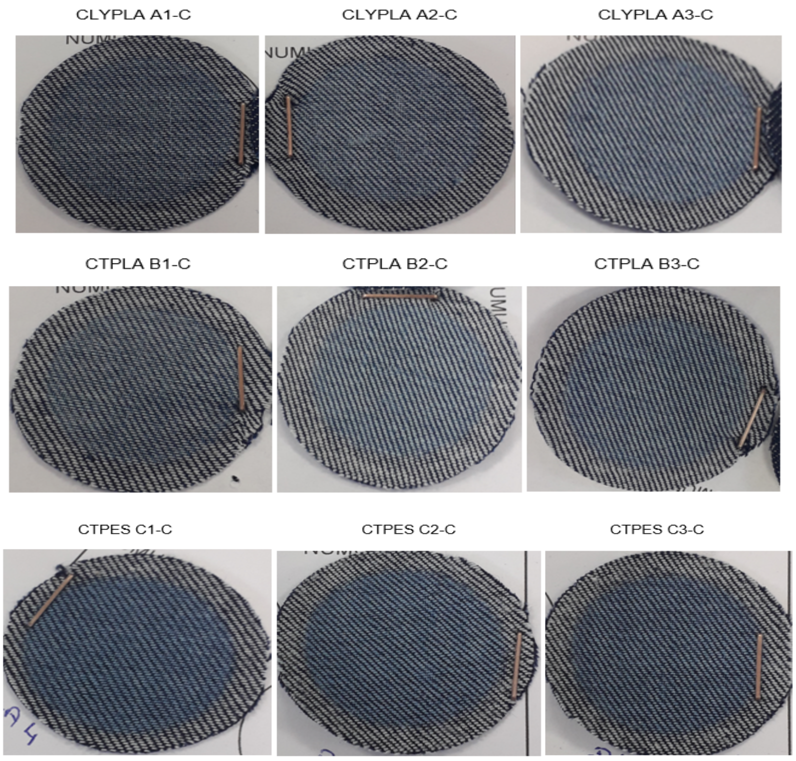


Figure 7. Abrasion test results of treated 10 Be’ denim fabrics.

Table 6. Pilling test results.

Fabric Code	Sheath fiber composition	Treatment Process	Pilling	Fabric Face
CTPLA B1-W	%25 Pla +% 75 Cotton	Washed	4	Back
CTPLA B1-C	%25 Pla +% 75 Cotton	10 Be' Caustic	4	Back
CTPLA B2-W	%25 Pla +% 75 Cotton	Washed	4-5	Back
CTPLA B2-C	%25 Pla +% 75 Cotton	10 Be' Caustic	4-5	Back
CTPLA B3-W	%25 Pla +% 75 Cotton	Washed	4	Back
CTPLA B3-C	%25 Pla +% 75 Cotton	10 Be' Caustic	4	Back
CLYPLA A1-W	%25 Pla+%75 Lyocell	Washed	4-5	Back
CLYPLA A1-C	%25 Pla+%75 Lyocell	10 Be' Caustic	4	Back
CLYPLA A2-W	%25 Pla+%75 Lyocell	Washed	4-5	Back
CLYPLA A2-C	%25 Pla+%75 Lyocell	10 Be' Caustic	4-5	Back
CLYPLA A3-W	%25 Pla+%75 Lyocell	Washed	4-5	Back
CLYPLA A3-C	%25 Pla+%75 Lyocell	10 Be' Caustic	4-5	Back
CTPES C1-W	%25 Pes +% 75 Cotton	Washed	2-3	Back
CTPES C1-C	%25 Pes +% 75 Cotton	10 Be' Caustic	2-3	Back
CTPES C2-W	%25 Pes +% 75 Cotton	Washed	3	Back
CTPES C2-C	%25 Pes +% 75 Cotton	10 Be' Caustic	3	Back
CTPES C3-W	%25 Pes +% 75 Cotton	Washed	3	Back
CTPES C3-C	%25 Pes +% 75 Cotton	10 Be' Caustic	2-3	Back

Pilling Test results of fabrics

When the pilling test results for the Cotton/Pla and Tencel/Pla groups were evaluated over the washing and caustic treatments, results were close to each other. The pilling test results of the Cotton/Pes groups were found to be the lowest. There was no significant difference between 10 Be'Caustic and washing processes.

CONCLUSIONS

The use of Pla fiber instead of Pes fiber was investigated by applying different pretreatment processes. The strength values of Pla fiber blended fabrics and Pes fiber blended fabrics were compared. It has been observed that fabrics containing Pla fiber blend have lower strength than Pes fiber blended fabrics. When the 10 Be'causticizing process is compared with the fabrics that have only been washed, it has been observed that the 10 Be'causticizing process does not have a serious effect on the fabric strength values. When its physical properties are evaluated on the fabric, it has been determined that it can be used as an alternative to pes fiber because it is a biodegradable fiber. When Cotton/Pla blended yarns are evaluated in terms of strength, elasticity, pilling and abrasion test results, it is thought that Pla can be used to reduce the amount of cotton in the yarn. In this respect, it also contributes to sustainability.

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