AUTEX Research Journal, DOI 10.2478/aut-2022-0015

INVESTIGATION OF THE PERFORMANCE OF COTTON/POLYESTER BLEND IN DIFFERENT YARN STRUCTURES

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Abstract:

The demand for polyester fiber is increasing gradually day by day. Because of its good strength, low manufacturing cost, and ease of modification, polyester fiber has distinct characteristics, whereas cotton is well known for its comfort. Blending these fibers improves the performance of yarns. In this study, cotton/polyester was blended in different ratios to evaluate yarn performance. Three groups of yarn: rigid, core, and dual-core-spun, have been produced to examine the yarn's performance. From the study, it has been found that increasing the polyester blend ratio increases the yarn strength and elongation but decreases the yarn unevenness and imperfections. Among the group, having more core components decreases yarn strength, unevenness, and imperfection but increases elongation. From the statistical analysis, except strength, all other properties have good interaction on yarn type and blending ratio. Pearson correlation also indicated that elongation and hairiness have a good correlation with yarn type where, except for hairiness, all other properties have shown a strong positive correlation on blending ratio.

Keywords:

Cotton, polyester, blending, core-spun yarn, dual-core-spun yarn, yarn performance

1. Introduction

According to their source of origin, fibers are classified into two groups: natural fiber and manmade fiber or synthetic fiber. Among the natural fibers, cotton is the most widely used fiber, with a variety of applications, due to its supreme and unique characteristics. With outstanding moisture absorption and thermal qualities associated with comfort, cotton is by far the most important natural fiber on the market. Compared to natural fiber, manmade fiber has many advantages in terms of quality and properties over natural fiber, which has driven the growth of demand for manmade fibers in the global textile market in the last few decades. From the manmade fiber group, polyethylene terephthalate (PET) is the most widely used synthetic polyester textile material for both home and industrial purposes, as the uses of polyester fiber can range from traditional textiles to technical textiles [1,2]. PET takes the top spot as the polyester for fiber manufacturing, not only because of its good end-use qualities and low cost of manufacture, but also because of its ease of physical and chemical modification, which can suppress undesirable properties while improving positive ones. Molecular structure and the presence of aliphatic and aromatic components in macromolecular chains give these fibers their distinct characteristics [3].

In 2016, the total amount of polyester fiber, or PET fiber produced exceeded 50 million tons, and in 2020 it exceeded 56 million with a growth rate significantly greater than any other natural or synthetic fiber. It is also estimated that in 2030, the production of polyester fiber will be almost 70 million tons, thus continuing its dominance over other fibers [4–6]. The following are some reasons why PET fiber is so popular: low cost, easy processing, wash-and-wear qualities, high modulus coupled with outstanding modulus retention, recycling, reuse, adaptable performance, and blendability with cotton and other natural fibers [6].

Polyester fibers are easy to texture, and modifying their elastic, pilling, coloring, and shrinking qualities is achievable. In addition to dimensional stability and low moisture absorption, polyester fibers provide great wear resistance, weather and light resistance, abrasion resistance, and the ability to blend well with cotton fibers, among other qualities [3]. Cotton fiber is well known for its comfort features, whereas polyester fiber is well known for its strength, whiteness, anti-mildew, and anti-wrinkle properties [7]. The thermal conductivity of polyester fibers is around three times lower than that of cotton fibers [8]. The tenacity and elongation of polyester fiber are higher than cotton fiber [9]. Though polyester fibers have a hydrophobic nature, which limits their wide range of applications, blending with other fibers, especially with cotton, helps overcome these limitations [10,11].

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Blending is the process of combining different batches of fibers to create a homogenous material [12]. In order to achieve or improve particular qualities of a yarn's shape or processing performance, multiple fibers with various properties are frequently blended together [9]. However, the improvements in certain desired characteristics are almost invariably accompanied by a loss or drop in other desirable characteristics [13]. There are many advantages to using mixed yarns instead of traditional yarns. In this way, they can be used for apparel, underwear, socks, and hygienic textile items, in addition to composite materials [9].

In the spinning industry, different fiber blends are frequently used to improve the performance as well as the aesthetic features of textile fabric. It is possible that a fabric made from a blend of yarns has superior properties over one made from a single strand [14]. Fabricators blend raw materials in an effort to improve their finished product's characteristics while reducing costs. The composition and compatibility of components are key factors in the qualities of blended yarn. Aside from that, the ratio of fibers in the blend is also important [9]. For example, tensile properties and thermal comfort properties depend on the blending ratio of the constituent fibers [15–17]. When it comes to blending or mixing materials, the complex interaction between components is the most essential aspect that impacts quality [18]. Material type, percentage, machine type, and machine parameters all influence the quality of blended yarn [19]. When spinning a blend of fibers with different qualities, the ratio of constituent fibers in the blend is extremely critical, even more so than the machine settings [14]. The stress-strain response of the blended yarn was significantly altered by the interaction between the different constituents [13].

The goal of blending yarns is to bring out the best qualities of the constituent fibers [13]. There are several advantages to cotton/polyester blends, including improved evenness, reduced pilling, less static charge, and better spinnability [20]. The durability of polyester/cotton blends is better than that of 100% cotton [9]. For blending yarn, interfiber friction of the fiber is important for the yarn properties, and during yarn formation, the twist creates frictional forces between contacting fiber elements. There are three important frictional forces in cotton/polyester yarn blends: cotton-to-cotton, polyester-to-polyester, and cotton-to-polyester, where attention has been given to cotton and polyester [13,21]. Since cotton fibers slide more easily over polyester fibers than over one other, the frictional qualities between the two fibers were taken into consideration [22]. Low-cotton-blend yarns may have reduced tenacity and breaking elongation because of low-coefficient-of-friction friction between the cotton and polyester fibers [23].

In the decomposition process, polyester had interaction when it was blended with cotton [2]. Cotton gets strength and easy-care characteristics when combined with polyester, which is why polyester/cotton blends are so extensively used [24]. If the polyester is the main fiber in the blend, the yam strength usually increases [25]. Moreover, studies have demonstrated that changes in frictional behavior between the cotton and staple polyester components of a blend have a meaningful influence on the load elongation qualities of the yams produced [13]. Increasing the percentage of polyester in a blend boosts the yarn's tensile strength, liveliness, and elongation while reducing the yarn's hairiness, as there is a clear correlation between the amount of cotton fiber in a blend and the hairiness of the yarn; in addition, yarn evenness improves as polyester content is increased [26–28].

Along with blending, the different composite structures of the yarn, like core- and dual core-spun yarn, have been developed to achieve better yarn performance. This yarn structure influences the yarn performances significantly [29]. In core-spun yarn structure, staple fiber is used as sheath fiber, while an elastic filament is used as the core component; in dual core-spun yarn, two filaments are used. One is an elastic filament, and another is a semi-elastic filament [30].

Many types of research have been done on cotton/polyester blended yarn, while limited work has been found for cotton/polyester blended core- and dual core-spun yarn. As the use of core- and dual core-spun yarn increases, it is necessary to examine yarn performance. In this study, a comparative analysis has been done on the performance of the cotton/polyester rigid, core, and dual core-spun yarn with different blend ratios to evaluate their properties and to understand yarn performance better.

2. Experimental

2.1. Materials

For this study, cotton(CO) fiber and polyester(PES) fiber were used with different blending ratios. Cotton fiber and polyester fiber (Dacron®) properties are given in Table 1 and Table 2, respectively. Here, blending was done in the yarn spinning drawing process. Obtained drawn sliver and roving properties from the draw frame and simplex machine are given in Table 3. Rigid, core, and dual-core-spun groups of yarns were produced from these blended fibers, where rigid group indicates yarn without any core component. Yarn linear density was 328.06 dtex (Ne 18/1) for all groups. For core-spun yarn, 78 dtex Lycra® (elastane (El)), and for dual-core-spun yarn, 50 dtex polybutylene terephthalate (PBT) filament and 78 dtex Lycra® (elastane) were used as the core components. The yarn composition with the blend ratio is given in Table 4 to display the design of the experiment.

2.2. Methods

For this study, to produce core- and dual core-spun yarns, a modified ring spinning method was operated where the core components used were fed into the center of the feeding system; commercially, it is the most accepted system. Figure 1 shows the schematic view of the core- and dual core-spun yarns' ring spinning process with the feeding system. For yarn production, all the machine settings were kept as standard for all three groups. Drafts of the PBT and elastane were 1.0 and 3.5, respectively. Here, the yarn's strength, elongation, unevenness, hairiness, and imperfections were evaluated to determine the yarn's performance. To determine the yarn's performance, TS

244 EN ISO 2060, TS 2394, TS12863, and TS 245 EN ISO 2062 standard test methods were followed for yarn count, Uster unevenness, yarn hairiness, and yarn-breaking tenacity measurement, respectively. For each measurement, five tests were done, and a calculated mean was used for evaluation. Before testing the samples, yarns were conditioned according to ASTM D 1776 test method. Rather than having numerous criteria, the yarn quality index (YQI) is useful to understand the yarn quality. YQI measures how excellent the quality of the yarn is. In general, having better YQI means a higher quality of yarn. Yarn strength, elongation, and irregularity are all included in the total quality index. YQI is calculated by using the following formula [31]:

$$YQI = \frac{Yarn\ tenacity\ (cN/tex)\ X\ Elongation\ \%}{Unevenness\%}$$

A two-way ANOVA test was done using SPSS 25.0 for the yarn properties. Two-way ANOVA is a statistical test where the effect of two independent variables on a dependent variable is analyzed. ANOVA also determines whether there is any form of interaction between the two variables in addition to examining the main effect of each independent variable. Here in this study, yarn type (rigid, core, dual core) and blending ratio were considered independent variables to evaluate the yarn properties statistically. A correlation analysis was performed among the yarn type, blending ratio, and yarn properties. Pearson correlation measured the statistical relationship between the yarn type and blending ratio on yarn properties, along with giving information about the magnitude and direction of the relationship. For the correlation analysis, the coefficient value can be ranged from -1 to +1, where -1 indicates a perfect negative relationship and +1 denotes a perfect positive relation. A value of zero has no correlation. As long as the coefficient value is between ±0.50 and ±1, the association is regarded to be strong. It is considered a medium correlation if the value is between ±0.30 and ±0.49 and a small correlation if the number is below ±0.29. Furthermore, a regression model was also developed from the regression analysis for the yarn properties where yarn type (A) and blending ratio (B) acted as independent variables or predictors for predicting the yarn properties referred to as dependent variables. For correlation and regression analysis, yarn type was counted as a quantitative variable considering the presence of core component numbers in the yarn.

3. Results and Discussion

In this study, yarn strength, yarn elongation, yarn unevenness, yarn hairiness, and total imperfections have been evaluated, and Figs. 2 to 6 represents them, respectively. Table 5 shows a two-way ANOVA analysis for the yarn properties. Tables 6 and 7 represent the Pearson correlation and regression analysis for the yarn properties. Later on, for better understanding,YQI was also determined.

3.1. Yarn Strength

As seen in Fig. 2, it was found that 100% CO yarn has the lowest strength, while 100% PES yarn has the highest amount

Table 1. Cotton fiber properties used in this study

Fineness (mic)	Length (mm)	Uniformity Index	Strength (gr/tex)	Elongation (%)	Brightness (Rd)	Spinnability Index	Short Fiber Index
4-4.5	28-31	83-85	29-34	5-6.5	69-72	110-140	9-12

Table 2. Polyester fiber properties used in this study

Fineness (dtex)	Length (mm)	Tenacity (cN/tex)	Elongation %	Dry Heat Shrinkage % (196°C, 30 min)	Crimp/cm	Luster
1.33	32	63.6	15	6	4.3	Semi-dull

T**able 3.** Drawn sliver and roving properties

	Drawn Sliver				Roving			
Raw materials	% Um*	% CVm*	% CVm 1m*	% CVm 3m*	% Um*	% CVm*	% CVm 1m*	% CVm 3m*
100% Cotton	3.28	4.14	0.86	0.72	4.53	5.35	1.52	1.04
75% Cotton - 25% PES	2.09	2.64	0.56	0.43	3.59	4.53	1.48	1.14
50% Cotton - 50% PES	1.95	2.45	0.59	0.5	3.46	4.36	1.29	0.93
25% Cotton - 75% PES	1.81	2.28	0.45	0.32	3.45	4.38	1.85	1.42
100% PES	1.83	2.28	0.45	0.28	2.92	3.69	1.31	0.64

*% U = mean linear irregularity; % CVm = coefficient of variation of mass; % CVm (L) = coefficient of variation of mass at the cut length of L.

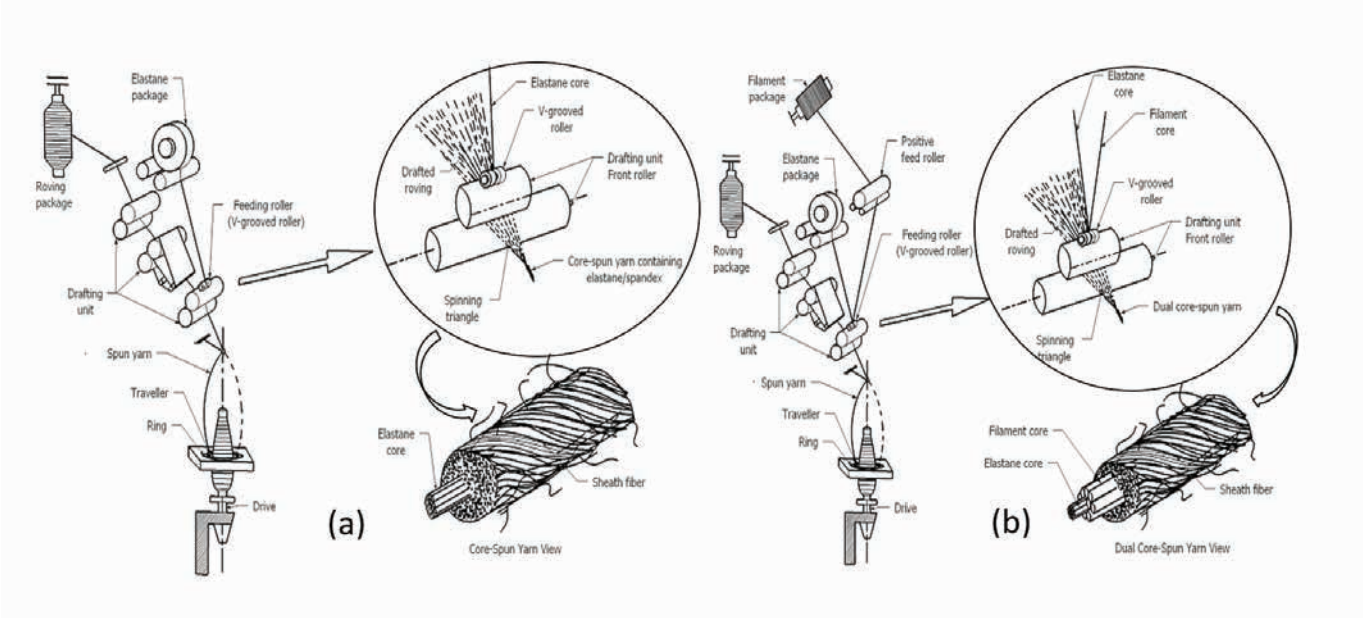


Figure 1. Modified ring spinning method. (a) Core-spun yarn production; (b) dual-core-spun yarn production [32,33].

Table 4. Yarn composition

Sample Code		Sheath	Core	Yarn Composition
R1	Rigid yarn	100% CO	--	100% CO
R2		75/25% (CO/PES)	--	75/25% (CO/PES)
R3		50/50% (CO/PES)	--	50/50% (CO/PES)
R4		25/75% (CO/PES)	--	25/75% (CO/PES)
R5		100% PES	--	100% PES
C1	Core-spun yarn	100% CO	78 dtex El	93.4% CO + 6.6% El
C2		75/25% (CO/PES)	78 dtex El	70% CO + 23.4% PES + 6.6% El
C3		50/50% (CO/PES)	78 dtex El	46.7% CO + 46.7% PES + 6.6% El
C4		25/75% (CO/PES)	78 dtex El	23.4% CO + 70% PES + 6.6% El
C5		100% PES	78 dtex El	93.4% PES + 6.6% El
DC1	Dual-core-spun yarn	100% CO	50 dtex PBT 78 dtex El	76.7% CO + 16.7% PBT + 6.6% El
DC2		75/25% (CO/PES)	50 dtex PBT 78 dtex El	57.5% CO + 19.2% PES + 16.7% PBT + 6.6% El
DC3		50/50% (CO/PES)	50 dtex PBT 78 dtex El	38.3% CO + 38.3% PES + 16.7% PBT + 6.6% El
DC4		25/75% (CO/PES)	50 dtex PBT 78 dtex El	19.2% CO + 57.5% PES + 16.7% PBT + 6.6% El
DC5		100% PES	50 dtex PBT 78 dtex El	76.7% PES + 16.7% PBT + 6.6% El

of strength for the rigid group. Core- and dual core groups also show the same results. From all groups, it can be stated that increasing the polyester amount gradually enhances the yarn strength. Because polyester fiber has more strength than cotton fiber, having a higher amount of polyester fiber in the yarn shows higher strength [14,22,34]. Among the group, for a particular blending ratio, it was found that rigid yarns have higher strength value than core- yarns and dual core yarns, respectively. Due to the presence of core components, the amount of cotton and polyester fiber is reduced in core- and dual core yarn, which has less strength than rigid yarn. Moreover, in the yarn cross section for core- and dual core-spun yarn, there is a high probability of spreading the fiber, which results in decreased packing density and less strength [35].

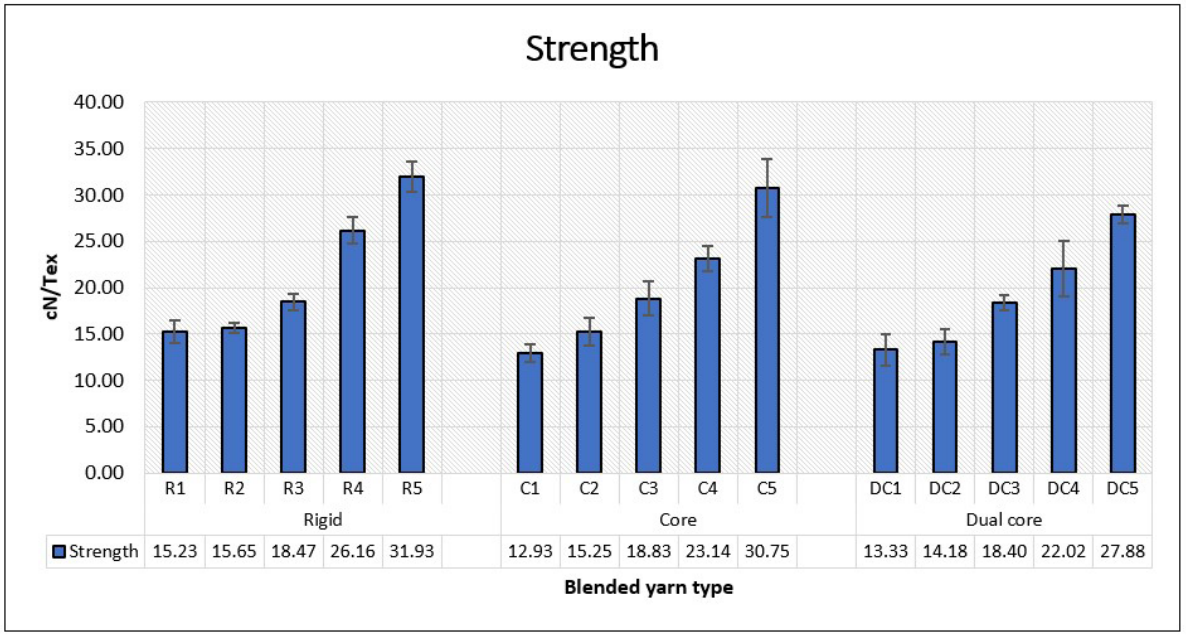


Figure 2. Effect of blending ratio on yarn strength.

A two-way ANOVA test was conducted, and the effect of yarn type and blending ratio on yarn strength was examined. From Table 5, it can be observed that interaction between yarn type and blending ratio could not be demonstrated as $p = 0.067$, though a statistically significant ($p < 0.001$) difference in yarn strength is found by both yarn type and blending ratio. Pearson correlation analysis from Table 6 reveals a strong positive correlation for blending ratio on yarn strength but nothing about yarn type. Equation 1 in Table 7 shows the regression equivalent for the yarn strength, and it is found that independent variables are statistically significant ($p < 0.001$), useful for predicting yarn strength. R-squared was found to be 0.879, which reveals 87.9% of the variance in yarn strength is attributable to yarn type and blending ratio.

3.2. Yarn Elongation and B-Work

Figure 3 shows that increasing the PES ratio in the yarn increases the elongation amount B-work (break to work) for rigid, core, and dual core-spun yarn groups individually. 100% PES rigid, core, and dual core-spun yarns have the highest amount of elongation, while 100% cotton yarns have the lowest

Table 5. Two-way ANOVA table for yarn properties

Dependent Variable	Source	F	Sig.
Strength	Yarn type	12.538	0.000
	Blending ratio	252.487	0.000
	Yarn type*Blending ratio	1.965	0.067
Elongation	Yarn type	306.378	0.000
	Blending ratio	191.811	0.000
	Yarn type*Blending ratio	2.371	0.027
Unevenness	Yarn type	30.359	0.000
	Blending ratio	527.621	0.000
	Yarn type*Blending ratio	3.226	0.004
Hairiness	Yarn type	33.944	0.000
	Blending ratio	22.488	0.000
	Yarn type*Blending ratio	12.402	0.000
IPI	Yarn type	113.053	0.000
	Blending ratio	12075.166	0.000
	Yarn type*Blending ratio	156.161	0.000

Table 6. Pearson correlation coefficient table

	Yarn Type	Blending ratio	Strength	Elongation	Unevenness	Hairiness	IPI
Yarn Type	1	0.000	-0.150	.648**	-0.157	.453**	-0.043
Blending ratio		1	.925**	.716**	-.965**	-.319**	-.980**
Strength			1	.600**	-.881**	-.260*	-.926**
Elongation				1	-.788**	0.077	-.738**
Unevenness					1	0.217	.966**
Hairiness						1	.231*
IPI							1

Note: **Correlation is significant at the 0.01 level (2-tailed); *correlation is significant at the 0.05 level (2-tailed).

Table 7. Regression equation for yarn properties

Yarn Properties	P-value	R-squared	Regression Equation	Equation No.
Strength	0.000	0.879	10.164 – 1.163A + 4.146B	1
Elongation	0.000	0.932	1.316 + 2.767A + 1.764B	2
Unevenness	0.000	0.957	12.668 - 0.282A – 1.001B	3
Hairiness	0.000	0.307	6.851 + 0.226A – 0.092B	4
Imperfections	0.000	0.962	503.327 – 7.090A -94.187B	5

Note: Yarn type (A) and blending ratio (B).

elongation value in the rigid, core, and dual core yarn groups, respectively. It can be said that the PES ratio has a positive relation with yarn elongation. The figure shows that having more core components in the yarn cross section reduces the B-work amount. Furthermore, the Pearson correlation analysis also validates the statement statistically, since Table 6 indicates that yarn type and blending ratio positively correlate with yarn elongation properties. Moreover, polyester fiber has a higher elongation than cotton fiber, so increasing the polyester content in the yarn helps to enhance yarn elongation [22]. For a given blending ratio, the figure reveals that dual core-spun yarns have more elongation than rigid and core-spun yarns, whereas rigid yarns have the lowest elongation value due to having no elastic material in their core.

From the two-way ANOVA analysis in Table 5, it can be observed that there is a statistically significant interaction between the effect of yarn type and blending ratio on yarn elongation ($p < 0.05$). The regression equation for yarn elongation has been shown in Table 7 and it can be observed that independent variables are statistically significant for predicting ($p < 0.001$), and 93.2% variability can be explained by the independent variables for yarn elongation.

3.3. Yarn Unevenness

According to Fig. 4, increasing the amount of PES reduces the unevenness of the yarns for each rigid, core, and dual core group. Here, 100% cotton rigid, core, and dual core yarns have the highest unevenness, and 100% PES rigid, core, and dual core yarns have the lowest unevenness value in their group. So, the amount of cotton or PES has a strong effect in terms of unevenness on these yarns. The Pearson correlation from Table 6 also represents a strong negative relationship between yarn unevenness and blending ratio, but a low degree of negative relationship is found for yarn type. The increased evenness of the yarn in the cross section is attributable to the staple length and consistent fineness of polyester fiber [26–28]. The yarn with PBT filament and elastane in the core has less unevenness than the yarn with only elastane or without any core components, due to the presence of less amount of cotton because cotton fiber has fineness variations.

The p-value from the two-way ANOVA test for the interaction between yarn type and blending ratio on yarn unevenness is $p < 0.005$, which indicates that the interaction is statistically significant on yarn unevenness. Equation 3 in Table 7 represents the regression model for yarn unevenness, which is statistically reliable for independent variables ($p < 0.001$, R-squared = 0.957).

3.4. Yarn Hairiness

Figure 5 illustrates that 100% cotton yarn has the highest amount of hairiness for the rigid group, and 50/50 CO/PES has the lowest amount. In the rigid group, for the presence of

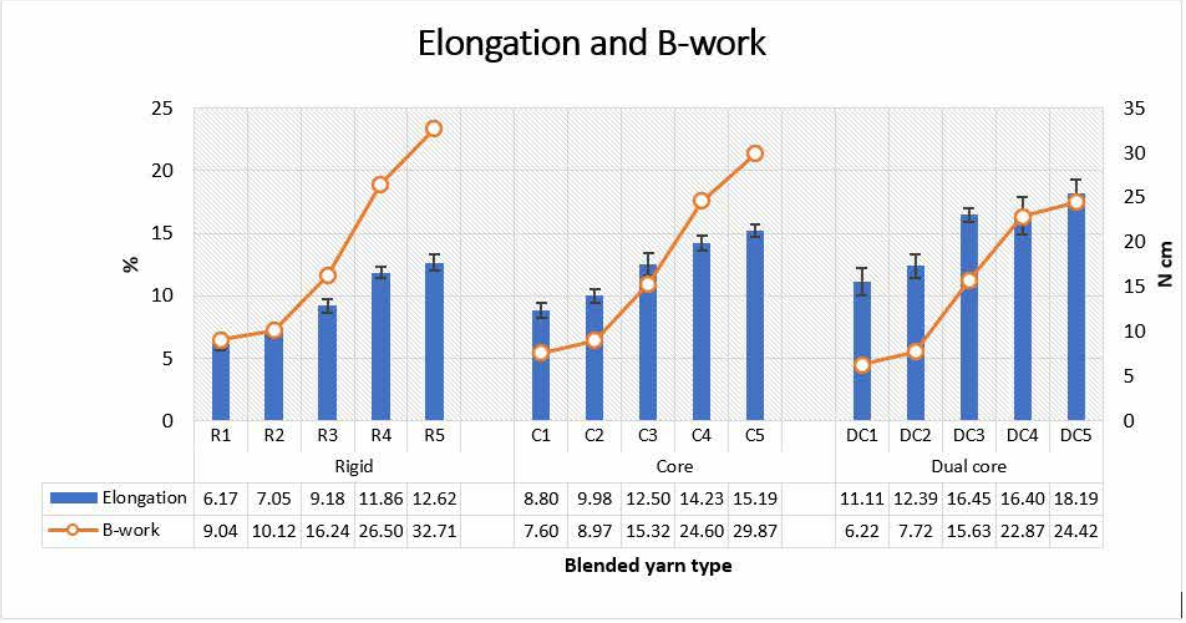


Figure 3. Effect of blending ratio on yarn elongation.

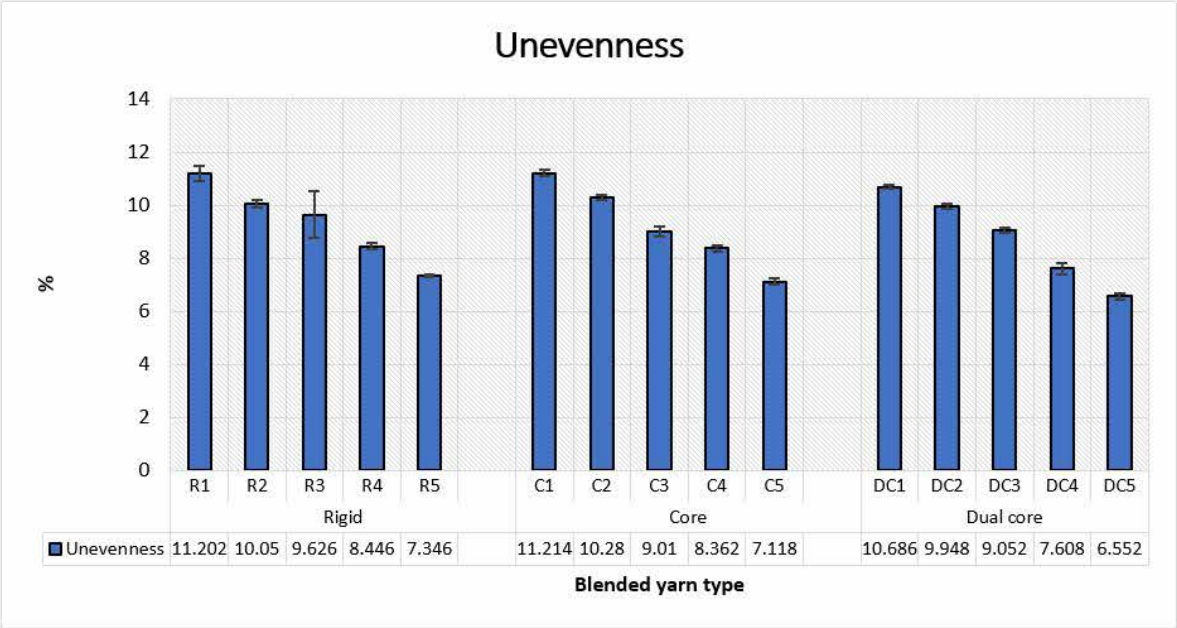


Figure 4. Effect of blending ratio on yarn unevenness.

polyester fiber in blended yarn, hairiness is reduced between 10% and 17% as compared to 100% cotton yarn. However, it can be observed that 100% polyester core-spun yarn has the highest hairiness value for the core group, while 50/50 CO/PES has the lowest. For the core group, it can be noticed that the cotton/polyester ratio influences hairiness, while hairiness is initially reduced with an increase of polyester but increases after the 50/50 ratio. This scenario happens due to the incorporation of cotton fiber with polyester and core components. Short fiber is reduced at first due to the reduction of cotton fiber, resulting in less hairiness until the CO/PES blending ratio reaches 50/50. While the blended yarn has more polyester fiber than cotton fiber, the polyester fiber most likely holds back the cotton fiber on the yarn's surface, resulting in a higher hairiness value. Again, 100% cotton has the highest hairiness in the dual-core group, and 75/25 CO/PES has the lowest value. For the dual-core group, there is no regular change of hairiness for the blending ratio. So, there is a fluctuating observation for the dual-core group. Cotton fiber has the tendency to migrate to the center of the yarn while blended with polyester, which could be attributed to these irregular changes of the yarn hairiness. Fiber movement after spinning and uneven fiber control during spinning are also some of the probable reasons for it [36].

Moreover, the short fiber content of cotton fiber and the uniform length of polyester fiber has influences on yarn hairiness [18]. Figure also depicts that, among the group, for a certain blending ratio, core and dual core yarn have more hairiness than the rigid group in the presence of polyester fiber. Most probably due to incorporation with the core components, cotton could not move inwards of the yarn while increasing polyester.

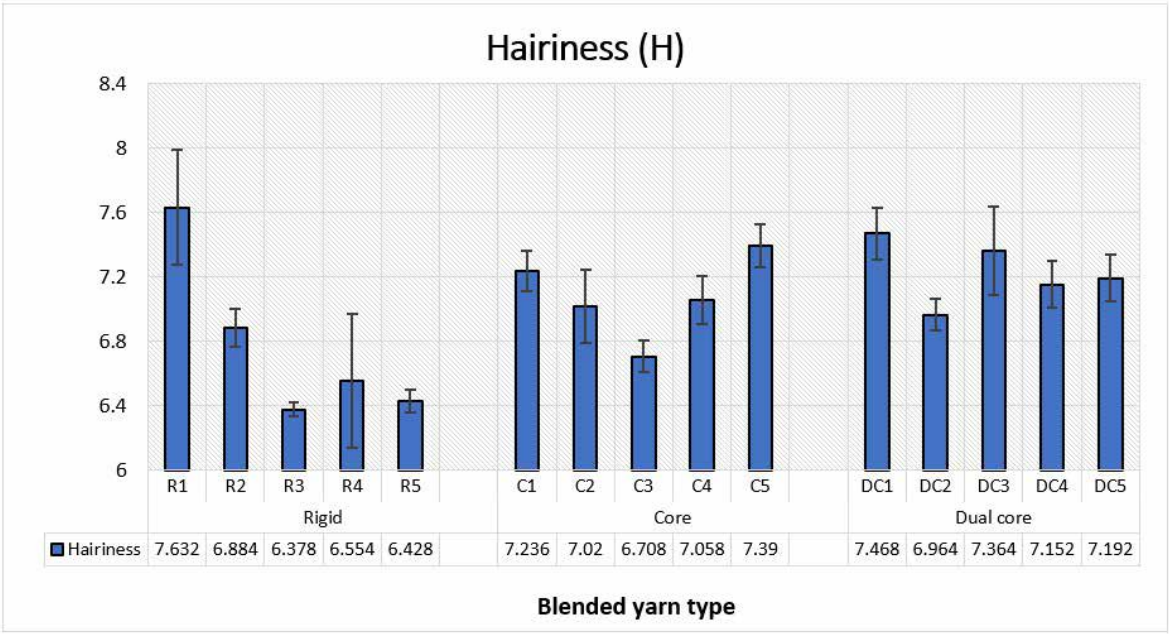


Figure 5. Effect of blending ratio on yarn hairiness.

The two-way ANOVA test examined the effect of yarn type and blending ratio on yarn hairiness, and it was found that there is a statistically significant interaction between the two independent variables, $p < 0.001$. The positive correlation of yarn type and negative correlation of blending ratio came up to a significant level for yarn hairiness in Table 6. Equation 4 in Table 7 represents the regression model for yarn hairiness, which is statistically significant, but can be explained by the 30.7% variability of the yarn hairiness ($p < 0.001$, R-squared = 0.307).

3.5. Yarn Imperfections

The yarn imperfection index (IPI) is the sum of thin places (-50%), thick places (+50%), and neps (+200%) per kilometer. According to Fig. 6, there is an inverse nature of yarn IPI with an increase of polyester content for each group of yarn because of the length and fineness uniformity of the polyester fiber. When it comes to yarn imperfections, fiber properties play a major role. In all groups, 100% polyester yarn has the lowest IPI value (less than 10), while 100% cotton yarn has the highest IPI value (more than 350). There is no regular change for a certain blending ratio among the groups. From the correlation analysis in Table 6, it can be observed that there is a strong negative relationship for the yarn blending ratio, which is statistically significant, but the yarn type does not show a significant association.

The two-way ANOVA test found that the interaction between yarn type and blending ratio on IPI values is statistically significant ($p < 0.001$). The regression model for the IPI of yarns is shown in Table 7 with equation 5, which is a good fit for the data ($p < 0.001$, R-squared = 0.962).

3.6. YQI

The YQI was calculated to better understand the yarn quality; the values are shown in Fig. 7. The figure shows that by having more polyester content in the yarn, the YQI is increased, as polyester fiber has less irregularity and higher tenacity than cotton fiber. 100% cotton yarn has the lowest YQI values, and 100% polyester shows the highest YQI values for all groups. 100% polyester yarn has almost six times the YQI value of 100% cotton for all groups, and 50/50% CO/PES has more than two times the YQI value. Among the rigid, core, and dual core groups, the dual core-spun yarn has better YQI than others following core and rigid yarn. For 100% cotton, YQI is increased about 21% from rigid to core and about 36% from core- to dual core-spun yarn, but for 75/25 % CO/PES, the change is about 35% and 20%, respectively. From rigid to core, about 48% and from core to dual-core about 28% of the YQI value is increased for a 50/50 ratio. However, increasing the polyester amount for 25/75% CO/PES blending ratio, an increase of 7% and 20% YQI value is observed from rigid to core and core to the dual core group, respectively. For 100% polyester, this increase is less than 20%.

4. CONCLUSIONS

Within the scope of this study, cotton/polyester blended: rigid, core, and dual core-spun yarn performance was evaluated. From the study, the following conclusions may be drawn from the results.

By increasing the polyester content in the yarn, strength and elongation are increased, but having core components, the strength value decreases, while elongation increases. Strength is strongly correlated with blending ratio only, but elongation positively correlates with yarn type and blending ratio. There is a statistically significant interaction between yarn type and blending ratio on yarn elongation, but strength does not have a statistically significant interaction.

When the polyester blending ratio increases, yarn unevenness and imperfection diminish, while hairiness has no regular

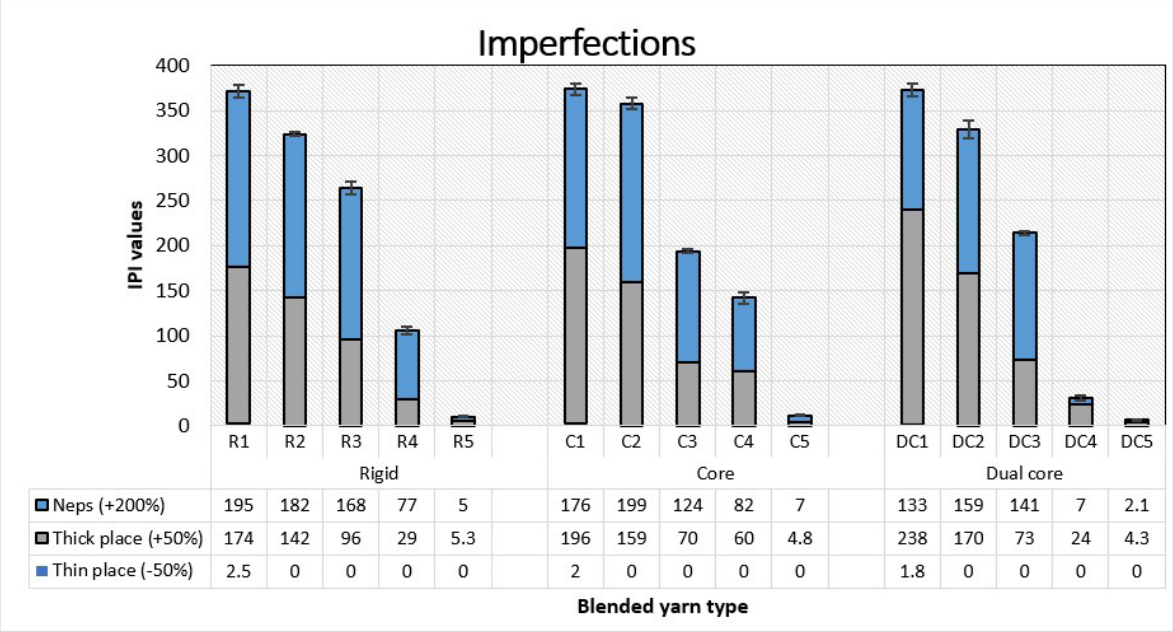


Figure 6. Effect of blending ratio on yarn imperfections.

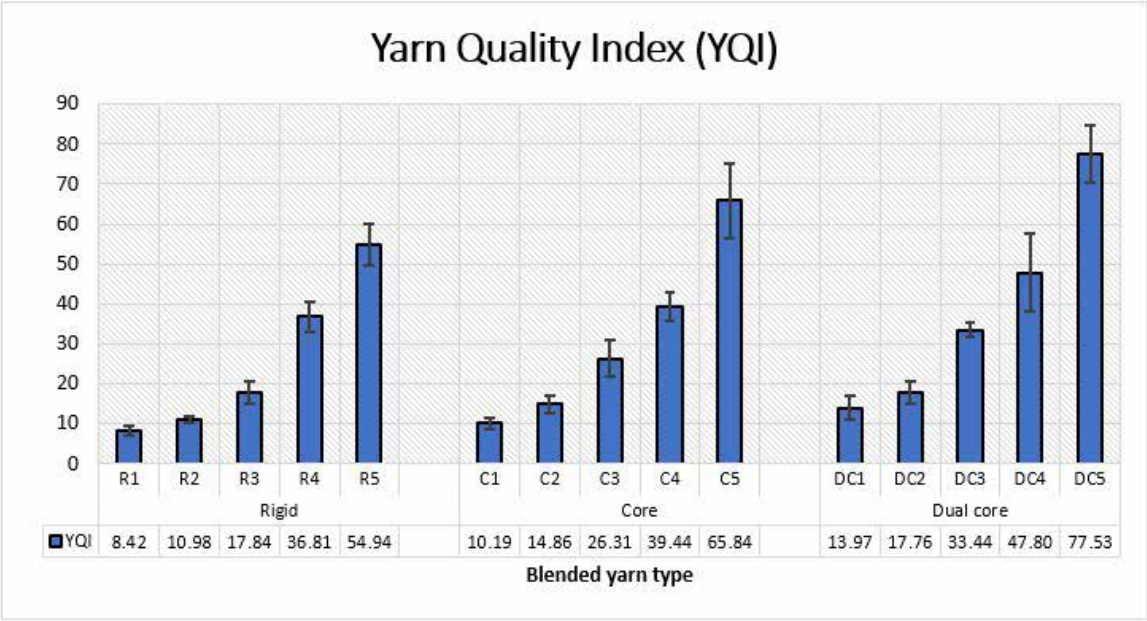


Figure 7. Effect of blending ratio on YQI.

effect. Dual core-spun yarns have shown a smaller amount of unevenness and imperfections. There is a statistically significant interaction between yarn type and blending ratio on yarn unevenness, imperfections, and hairiness. Hairiness has a moderate positive correlation with yarn type, whereas yarn unevenness and imperfections have a strong negative correlation with the blending ratio.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Karacasu Tekstil Ticaret ve Sanayi AŞ, R&D Center and ÇALIK DENİM Tekstil AŞ, R&D Department for their support and contributions.

CONFLICT OF INTEREST

Regarding this paper's research, writing, or publication, the authors declare no potential conflicts of interest.

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