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# Investigation of Elasticity and Growth Properties of Denim Fabrics Woven with Core and Siro Spun Yarn

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**ABSTRACT**

In this study, elasticity and growth parameters which are important for denim fabrics were investigated. Elasticity and growth performances were determined after three home laundering and compared in fabrics produced with different weft yarn counts, elastane draft ratio, elastane lineer density, spinning method and weft density parameters. The elasticity and growth values obtained from the produced fabrics were evaluated by SPSS statistical analysis program and significant conclusions were obtained. As a result of the study, it is observed that all of these variables have a significant effect on elasticity and growth values.

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**KEYWORDS**

Denim, elasticity, growth, core spun, siro spun

## 1. INTRODUCTION

People want to feel comfortable in their clothes and they want their clothes to look good. Designers use flexible yarns in woven and knitted fabrics to increase the comfort of the garments and enhance their aesthetic appearances [1].

Elastic fabrics can stretch under the natural forces that are exposed in the areas where they are used in our daily lives, can be restored to their original size in great dimensions and can provide comfort and ease of movement. These kinds of fabrics do not deform during clothing and can maintain their shape, which are not overly wrinkled during washing and dry cleaning, which can maintain its original size and shape [2, 3]. While elastic fabrics that stretches with the effect of the elastane yarns are subjected to a force, the non-elastic yarn tries to pull the fabric in a narrower area. In this case, an orange peel effect can be observed in the fabric, since the fabric swells and there is not enough space to move. Therefore, when an elongation of 20% is desired in the fabric, the weft density should be 20% lower than the weft density in the non-elastic fabric [3].

Therefore, streching is an important requirement for the comfort and convenience of the user. It is usually necessary to stretch comfortably in accordance with body movements, and also to maintain its original shape without any deformation after stretching. If the clothes do not have a lot of flexibility, deformation occurs, which called fabric is bagging. It causes some problems in aesthetic appearance [4].

Elastane was first used in classical underwear, corset and added new applications in the field of sportswear. The rate of use of elastic fabrics in ladies' and men's top wear continued to rise. Elastic fabrics are required to have elastic properties of 18-25% for classic top garment products, 35-60% for sportswear, and 80-120% for corset type functional garments [3].

Elastane fibers have an important share in the production of elastomeric denim production. Those fibers can be used with many staple fibers thanks to the core yarn production method. In elastic denim production, it is possible to reach elasticity levels (10-100%) which will provide consumer expectations with yarns containing elastane in weft or warp. For this reason, almost all of the world's elastane-containing denim productions are realized with the use of elastane [5].

Elastane fibers are used in combination with various yarns and fiber types in order to ensure that fiber structure does not deteriorate, to meet different requirements and to

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provide ease in post-spinning processes. Combined yarns with elastane content produced for these purposes have characteristics which vary according to the type of yarn forming components and systems used in production. The most widely accepted method is the production of core spun elastane yarn [3].

Core spun yarns have a structure in which one of the constituents, in most cases a synthetic filament either mono or multi is concealed by a different component, a staple fibre sheath. Therefore a core yarn consists of a core part and a sheath. Meanwhile, the spandex remains in the center of the yarn and is covered with the fiber used. Thus, it is ensured that the spandex remains in the center and is covered with the used blend and covered perfectly [6].

The main aim of using core spun yarn is to take advantage of the different properties of its both components. The filament increases the yarn strength and also permits the use of lower twist level, while the sheath provides the staple fibre yarn appearance and surface physical properties. Core-spun yarn is preferred in knitted and woven fabrics [7]. Core yarns are used in awning fabrics for high tenacity property, special industrial fabrics, medical textiles, underwear clothes, swimsuits, socks, sport clothes and sewing threads. There are different methods for production of core yarns. The most common of them are ring and friction spinning systems [8].

Sirospun is a spinning process that allows a two-fold (two strand) worsted yarn to be produced on a conventional ring spinning machine, dispensing with no need for spinning to be followed by separate two-folding and its attendant processes. In this process, two rovings are drawn separately from each other, then combined and twisted on the same spindle. Sirospun yarns are widely used in the worsted industry because of their better wearability. Sirospun method is to produce two plyyarns in a single spinning process [9].

Many studies were managed to optimize and evaluate the physical and mechanical properties of core spun yarns and fabrics. Qadir et al. (2014) investigated the effects of elastane linear density and draft ratio on the physical and mechanical properties of single core-spun yarns According to the statistical evaluations they found that elastane linear density and the draft have statistically significant effect on yarn tenacity, elongation and hairiness but the yarn IPI and CVm are not significantly affected by these parameters [10].

The influence of spinning parameters on sheath slippage of core-spun yarn was studied by Miao et al. (1996). It was observed that the yarn strength increased by increasing filament ratio and increasing filament feeding tension. It has been stated that the pre-twist applied to the filament has an important effect on the abrasion resistance of the yarn [11].

Celik and Kaynak (2017) examined the effects of elastane draw ratio on air permeability of denim woven fabrics [12].

Celik et al. (2009) researched on the effects of core-sheath ratio and twist coefficient on the yarn properties of the ring PET core-spun yarns. According to the experiments and statistical evaluations; it has been determined that the change of core / sheath ratio and twist count affects the tenacity, elongation at break and yarn vitality. When the core ratio is increased, the strength value increases [13].

Cataloglu (2007) investigated the elasticity and growth properties of elastane composed denim fabrics and stated that alternative to elastane, using bi-component polyester fibres and polybutylene terephthalate (PBT) has inspired interest with regarding to higher strength due to better chemical resistance, better recovery, dimensional stability and elasticity properties [5]. Romdhane et al. (2016) has investigated the effect drafting tension of Multifilament "T400" on the dual core spun yarns to enhance the quality of denim stretch fabric [14]. Many researchers attempted to produce short staple yarn with siro spun system. Cheng and Sun (1998) found that spinning performance of sirospun yarns can be improved by decreasing the strand spacing and increasing the twist coefficient. [15]. Su et al. (2003) investigated the optimum drafting conditions for siro spinning by changing the roving spacing using lyocell roving. They concluded that there is a limited break draft beyond which the drafting force decreases, and consequently an increase in the variation of the drafting force causes deterioration in yarn evenness, leading to an increase in yarn faults [16].

Also some studies conducted in denim fabric stretch properties are available in the literature. Bedez Üte, (2019) revealed the effect of the composition of double-core (dual-core) and core-spun weft yarns and weft density on the some mechanical properties of denim fabrics and concluded that weft density is found to be more effective than weft yarn composition for mechanical and dimensional properties of denim yarns [17]. Çeven et al. (2018) investigated the denim fabrics produced at three different weft and warp density with different yarn numbers and elastane ratios in terms of tenacity and stretching properties (elongation, permanent elongation, elastic recovery) considering the different washing cycles of 0, 5 and 15. According to the results, higher values for stretching ratios (%) and permanent stretching ratios (%) of denim samples were obtained as the washing cycle increased whereas there was a fluctuation observed for the elastic recovery ratios (%) regarding to washing cycles [18]. The effects of different aesthetic finishes applied while manufacturing, different elastane content and fabric weight on denim fabric's mechanical and stretch properties were researched by Choudhary and Sheena (2018). It was observed that the tensile strength of denim fabric decreases with increasing elastane percentage, while breaking extension increases.

Elastane content percentage shows significant influence on air permeability of denim [19]. The interactive effect of twist multiplier of weft yarn, denier elastane fibre and fabric areal density on performance of denim fabric was investigated by Choudhary, Sheena and Nikhil (2018) and they show that the tensile strength and breaking elongation properties of denim fabric, for both before and after cyclic loading show the same trend. Higher twist multiplier results in higher fabric tensile strength, but decrease in breaking elongation [20].

Although there are a few studies to compare the properties of fabrics manufactured from two-strand, single and plied yarns, there is still a lack of information in the literature which investigates the properties of elasticity and growth parameters of denim fabrics manufactured with core spun and sirospun yarns.This experimental study investigates and focus on this subject. Weft yarn counts, elastane draft ratio, elastane lineer density, weft density and spinning methods are the variables used in the study. Elasticity and growth values obtained from the produced different fabrics and evaluated with SPSS statistical analysis program and significant inferences were obtained [21].

## 2. MATERIAL AND METHOD

### 2.1 Material

Elasticity is the percent of elongation under tension on the yarn or fabric. Growth is the return to its original length, shape and size when the tension is removed [3]. In the experiments 3/1 Z twill denim fabrics were produced. Ne 13.5 conventional ring spun %100 cotton yarns were used as warp direction and warp density is the same for all fabrics (43 ends/cm). Ne 13, 16, 20 yarns were used in the weft direction. 3, 3,5 and 3,8 draft ratios, 18,5 and 20 weft density, 78 and 135 dtex elastane, cotton-elastane (CO) core-spun, cotton-polyester (CO + PES) sirospun blend yarn experiments were performed. In fact, since there were 5 variables, mentioned above, with different levels, 72 different fabrics, having different specifications, should be produced to cover all of the variations. However, due to the factory restrictions, only 14 fabrics could be produced. Table 1 presents the specifications of the denim fabrics.

### 2.2 Method

All tests were carried out after the specimens were conditioned in standard atmospheric conditions (temperature 20 ± 2 °C, 65 ±2 % relative humidity). Elasticity and growth properties were determined after three home laundering according to ASTM 3107 [22]. A stretch testing instrument, consisting of a frame with separate clamps fixed at the top and at the bottom, was implemented to determine the stretch properties of the fabrics. 3 strips for each sample from weft direction were hung on the apparatus after marking a 250 mm index in the central part of each specimen. A 1360 gram load, which was hung according to the fabric weight in the bottom hanger, was applied to the sample three times and after the fourth application; the marked distance was measured. The samples were hung for 30 minutes, and the distance was measured again for elasticity. The distance between the marked points after 1 hour of relaxation was measured once again for growth. Elasticity and growth values were calculated from these measured outcomes.

For elasticity in percent values, the formulas were used.

$$Elasticity\ (\%) = \frac{B-A}{A} x100 \quad (1)$$

A: The distance marked between the upper and bottom parts of the fabric (250 mm)

B: The distance between the marked points after hanging the sample for 30 minutes with the load (mm).

Elastic recovery was calculated by inducluding a proportion between the difference in the distance of the marked points of the fabric after hanging it for 30 minutes, and the distance to maximum stretching after 1 hour relaxation time.

Growth was calculated as follows:

$$Growth\ (\%) = \frac{C-A}{A} x100 \quad (2)$$

C: The distance between the marked points after 1 hour of relaxation.

A: The distance marked between the upper and bottom parts of the fabric (250 mm).

## 3. RESULTS AND DISCUSSION

Since the elastane is used in the weft yarn, elasticity and growth tests are performed only in the weft direction. Performance characteristics of fabrics weaved using elastic core-spun yarns and siro-spun yarns in different properties were examined. Three tests were carried out for each sample. The mean values and standard deviations (SD) obtained after the tests are given in Table 2.

According to the findings, the effect of yarn and fabric technical parameters on elasticity and growth were statistically analyzed. Statistical analysis program SPSS was applied according to ANOVA method and the parameters formed by the parameters based on the model of the significant relationship was obtained. In order to determine whether the effects of parameters affecting elasticity and growth were significant, statistical analysis revealed that the value of p was less than 0.05 ($\alpha = 0.05$) [21].

### 3.1. Assesment of Dependent Factors

### 3.1.1. Elasticity

As can be seen in Table 3, p-value was less than 0.05 in all variables of weft yarn count, weft density, elastane draft ratio, elastane lineer density and spinning method. Test results showed that all of the parameters have a significant effect on elasticity property.

### 3.1.2. Growth

The expectation from all of the fabrics is that the growth value is as close to zero as possible. Clothing manufacturers want the growth value to be maximum 2% in trousers and clothes, and maximum 3% in daily and sportswear depending on the finishing processes. Bagging behavior is observed when the growth values of the clothes are 3% and above [4, 5]. The elasticity and growth value of the fabric change according to the comfort properties expected by the end user and the usage area of the product. In the denim market, although stretching fabrics are desired, yarn structures and fabric constructions having lower growth value as much as possible during the stretching process are preferred.

According to the results of the analysis in Table 4 below, it has been determined that these parameters have a meaningful effect on growth because all the factors' p-value values are less than 0.05.

**Table 1**. Samples specifications of denim fabrics and their codes

| Sample code | Weft yarn count (Ne) | Weight per unit area | Weft density (picks/cm) | Elastane draft ratio | Elastane lineer density (dtex) | Weft spinning method |
|---|---|---|---|---|---|---|
| CS1 | 13 | 340 | 18,5 | 3 | 78 | CORE SPUN |
| CS2 | 13 | 343 | 18,5 | 3 | 135 | CORE SPUN |
| CS3 | 13 | 340 | 18,5 | 3,5 | 78 | CORE SPUN |
| CS4 | 13 | 339 | 18,5 | 3,8 | 78 | CORE SPUN |
| CS5 | 13 | 347 | 20 | 3,8 | 78 | CORE SPUN |
| CS6 | 16 | 330 | 20 | 3 | 78 | CORE SPUN |
| CS7 | 16 | 329 | 20 | 3,5 | 78 | CORE SPUN |
| CS8 | 16 | 326 | 20 | 3,8 | 78 | CORE SPUN |
| CS9 | 16 | 333 | 20 | 3,8 | 135 | CORE SPUN |
| SS1 | 13 | 341 | 18,5 | 3,8 | 78 | SIRO SPUN |
| SS2 | 16 | 334 | 20 | 3,8 | 78 | SIRO SPUN |
| SS3 | 16 | 332 | 20 | 3,8 | 135 | SIRO SPUN |
| SS4 | 20 | 314 | 20 | 3,8 | 78 | SIRO SPUN |
| SS5 | 20 | 309 | 18,5 | 3,8 | 78 | SIRO SPUN |

**Table 2.** Test results of denim fabrics

| Sample code | Weft yarn count (Ne) | Weft density (picks/cm) | Elastane draft ratio | Elastane lineer density (dtex) | Weft spinning method | Elasticity (%)/(SD) | Growth (%)/(SD) |
|---|---|---|---|---|---|---|---|
| CS1 | 13 | 18,5 | 3 | 78 | CORE SPUN | **62,0** / (4,8) | **7,9** / (0,4) |
| CS2 | 13 | 18,5 | 3 | 135 | CORE SPUN | **57,9** / (7,4) | **5,9** / (0,5) |
| CS3 | 13 | 18,5 | 3,5 | 78 | CORE SPUN | **64,1** / (3,9) | **8,8** / (1,0) |
| CS4 | 13 | 18,5 | 3,8 | 78 | CORE SPUN | **66,9** / (7,0) | **10,4** / (0,4) |
| CS5 | 13 | 20 | 3,8 | 78 | CORE SPUN | **60,5** / (8,6) | **8,9 / (**0,8) |
| CS6 | 16 | 20 | 3 | 78 | CORE SPUN | **63,9** / (6,0) | **6,7** / (0,2) |
| CS7 | 16 | 20 | 3,5 | 78 | CORE SPUN | **68,0** / (4,9) | **6,9** / (0,2) |
| CS8 | 16 | 20 | 3,8 | 78 | CORE SPUN | **70,3** / (3,8) | **7,9** / (0,5) |
| CS9 | 16 | 20 | 3,8 | 135 | CORE SPUN | **67,6** / (5,2) | **5,9** / (0,3) |
| SS1 | 13 | 18,5 | 3,8 | 78 | SIRO SPUN | **68,4** / (1,9) | **6,8** / (0,5) |
| SS2 | 16 | 20 | 3,8 | 78 | SIRO SPUN | **70,1** / (9,9) | **6,4** / (1,1) |
| SS3 | 16 | 20 | 3,8 | 135 | SIRO SPUN | **73,6** / (6,6) | **4,1** / (0,3) |
| SS4 | 20 | 20 | 3,8 | 78 | SIRO SPUN | **78,1** / (4,6) | **5,2** / (0,7) |
| SS5 | 20 | 18,5 | 3,8 | 78 | SIRO SPUN | **84,7** / (7,4) | **6,8** / (0,6) |

**Table 3.** The effect analysis of weft yarn count, draft, elastane lineer density, weft density and spinning method to elasticity

| **Tests of Between-Subjects Effects** | | | | | |
|---|---|---|---|---|---|
| Dependent Variable: | ELASTICITY | | | | |
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
| Weft yarn count | 635,003 | 2 | 317,502 | 370,419 | ,000 |
| Weft density | 125,453 | 1 | 125,453 | 146,362 | ,000 |
| Elastane lineer density | 7,864 | 1 | 7,864 | 9,175 | ,005 |
| Spinning method | 30,091 | 1 | 30,091 | 35,106 | ,000 |
| Draft | 96,693 | 2 | 48,347 | 56,404 | ,000 |

**Table 4.** The effect analysis of weft yarn count, draft, elastane lineer density, weft density and spinning method to growth

| Tests of Between-Subjects Effects | | | | | |
|---|---|---|---|---|---|
| Dependent Variable: | GROWTH | | | | |
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
| Weft yarn count | 1,533 | 2 | ,766 | 8,748 | ,001 |
| Weft density | 7,053 | 1 | 7,053 | 80,500 | ,000 |
| Elastane lineer density | 18,818 | 1 | 18,818 | 214,770 | ,000 |
| Spinning method | 25,662 | 1 | 25,662 | 292,881 | ,000 |
| Draft | 10,898 | 2 | 5,449 | 62,188 | ,000 |

According to Anova results (Table 3-Table 4), yarn count and linear density of elastane have a significant effect on fabric elasticity and growth. When 78 dtex elastane and 135 dtex elastane samples for both core spun and siro spun were analyzed comparatively, it was observed that elasticity levels are similar. But the growth value decreased in the samples using 135 dtex. Rising elastane yarn count results increase of yarn elastane percentage. Because of high elastane percentage occurred in 135 dtex elastane the recovery force are higher than 78 dtex elastane result. Cataloglu indicated in his study that in cases where high elasticity and low permanent elongation values are expected, elastane type change can also be made to provide these values. Especially with the increase in the weight of the fabric, higher elastane yarn count can also be used in order to increase the recovery force [5]. It is clear that through the use of more powerful elastane can be reduced growth value in denim fabrics.

According to effect analysis shown in Table 3 and Table 4, since the p values are lower than 0,05, spinning methods have significant effect on elasticity and growth results. It was found that the elasticity results are higher and growth results of siro spun yarns are lower than core spun yarns. This is due to the fact that the polyester fiber, which has a more even surface, exhibits less friction and facilitates the return of the elastane, on the other hand there is high friction of the elastane with cotton.

### 3.2. Assesment of Independent Factors

Figure 1 and 2 show the elasticity and growth values of the core spun and siro spun samples according to the weft yarn count and elastane draft ratio.

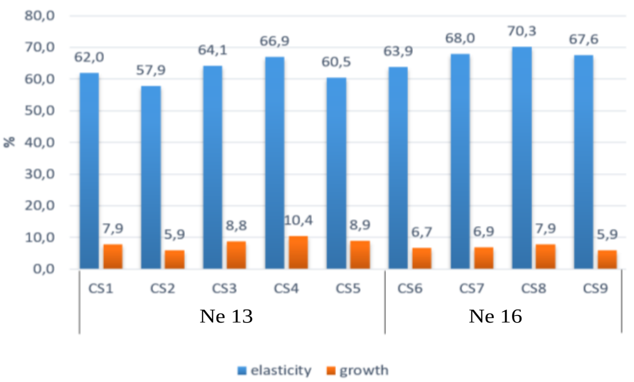


**Figure 1.** Elasticity and growth values for core spun yarns

According to the results shown in Figure 1 and 2, the observed elasticity for the average of CS5, SS1 samples in Ne 13 is 65,4 %, for CS8, SS2 samples in Ne 16 is 70,2 %, and for SS4, SS5 samples in Ne 20 is 81,4 %. The outcomes revealed that elasticity values increase when the counts of yarn increase. In addition that the growth averages for the same samples are observed as in Ne 13 is 8,4 % , in Ne 16 is 6,6 % and in Ne 20 is 6 %. This is due to the increase of yarn count, resulting an increase of elastane percentage and effect of yarn. High elastane percentage resulted with high fabric stretch and because of high recovery force it resulted with lower growth value.

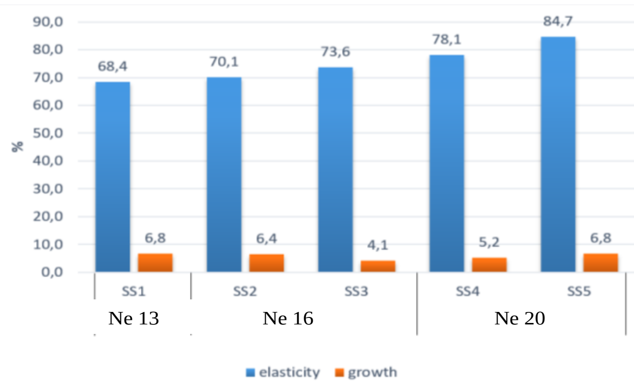


**Figure 2.** Elasticity and growth values for siro spun yarns

In spinning process elastane percentage decreases by increasing the elastane draft. However test results in Figure 1 displays that the increase in elastane draft resulting increase of fabric elasticity. When the test results of CS1, CS3 and CS4 group and CS6, CS7 and CS8 group are compared in the same yarn count, elastane yarn count, weft density and spinning method, the averages of elasticity are observed as for draft (3) 62,9 %, for draft (3,5) 66,0 %, and for draft (3,8) 68,6 %. This can be explained with high retraction force of high draft of elastane yarns. Qadir et al. indicated in their study that when a fabric containing elastane yarns spun with higher draft is taken off the loom then due to higher retraction force, the fabric contracts more in width as compared to a fabric containing elastane yarns spun with lower draft. A fabric that has higher contraction is more stretchable than one which has less contraction [10]. When the growth averages of the same fabric samples are compared, they are observed as for draft (3) 7,3 %, for draft (3,5) 7,8 %, and for draft (3,8) 9,1 %. It is obvious that the fabric growth values are increasing by increasing elastane draft ratio. Since the elastane percentage decrases by increasing elastane draft ratio, it results with high growth values.

It is seen in Figure 1 and 2 that the elasticity values are decreasing with the increase of weft density. This outcome is similar to previous studies (Cataloglu, 2007). Although the amount of elastane in the unit area increases as a result of increasing weft density, elasticity decreases. Cataloglu indicated in his study the reason for this is thought to be the blocking of the weft yarn as a result of the internal tensions [5].

### 3.3. Regression Analysis

The cause-effect relationship between two variables, Y dependent and X independent variables, is determined by regression analysis in stepwise method. The variables elasticity and growth dependent on analysis made to estimate elasticity and growth values of denim fabrics, independent variables weft yarn count, elastane draft ratio, weft density and elastane lineer density were started. Since the spinning method is not numerical, it is not included in the model. In this method the variables with weak effect in t-test were subtracted and regression analysis was repeated. After these processes, it is aimed to explain the relationship between dependent and independent variables by using regression analysis method.

**Elasticity**

Analysis was started with all independent variables predicted to affect the elasticity value, and according to the t-test results elastane factor was removed from the model as significance value was more than 0.05 and the output images given in Table 5 were obtained. The adjusted $R^2$ value of the model is 0.925 which is shown in model summary that means 92.5 % of the elasticity value in denim fabric is explained by the weft yarn count, weft density and draft ratio. Adjusted $R^2$ show that the predictive power of the model is high enough.

In "Anova table", significance value obtained as less than 0,01 and that means model is meaningful. "B" values titled in "Coefficients" table shows the coefficients of each indenpedent variables in this model. Since all significance values are less than 0,05 here, this specifies a significant relation between dependent and independent variables.

According to the coefficients, while weft yarn count and draft ratio has a positive effect on elasticity, weft density has negative. Curve fit plots for elasticity are shown in Figure 3. Finally the equation for elasticity in denim fabrics is shown as below;

$$E= 60,650+2,486xWC-3,132xWD+8,442xD \quad (3)$$

E: elasticity, WC: weft yarn count, WD: weft density, D: draft ratio

**Growth**

According to t-test analysis, as the significance values are more than 0,05, draft and weft density variables were removed from the model. Therefore only weft yarn count and elastane lineer density variables remained in the model. The adjusted $R^2$ value is obtained 0,625 as shown "Table 6a model summary". In Anova Table 6b, significance values are obtained less than 0,01 and this means model is meaningful. Since all significance values are less than 0,05 in t analysis, there is a significant relation between draft, weft density independent variables and growth.

Based on "Coefficients Table 6c", both weft yarn count and elastane lineer density have negative effects on growth results. Curve fit plots for growth are shown in Figure 4. As a result, the obtained formula for growth is shown in the following equation;

$$G= 16,524-0,376xWC-0,041xE \quad (4)$$

G: growth, WC: weft yarn count, E: elastane lineer density

**Table 5.** Regression analysis results for elasticity

**a)** Model Summary[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,965[a] | ,931 | ,925 | 1,89455 |

**b)** Anova Table

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 1832,264 | 3 | 610,755 | 170,158 | ,000[b] |
| | Residual | 136,395 | 38 | 3,589 | | |
| | Total | 1968,659 | 41 | | | |

**c)** Coefficients

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 60,650 | 7,908 | | 7,669 | ,000 |
| | Weft yarn count (WC) | 2,486 | ,139 | ,862 | 17,840 | ,000 |
| | Weft density (WD) | -3,132 | ,437 | -,340 | -7,164 | ,000 |
| | Draft (D) | 8,442 | ,973 | ,398 | 8,672 | ,000 |
| a. Dependent Variable: ELASTICITY | | | | | | |

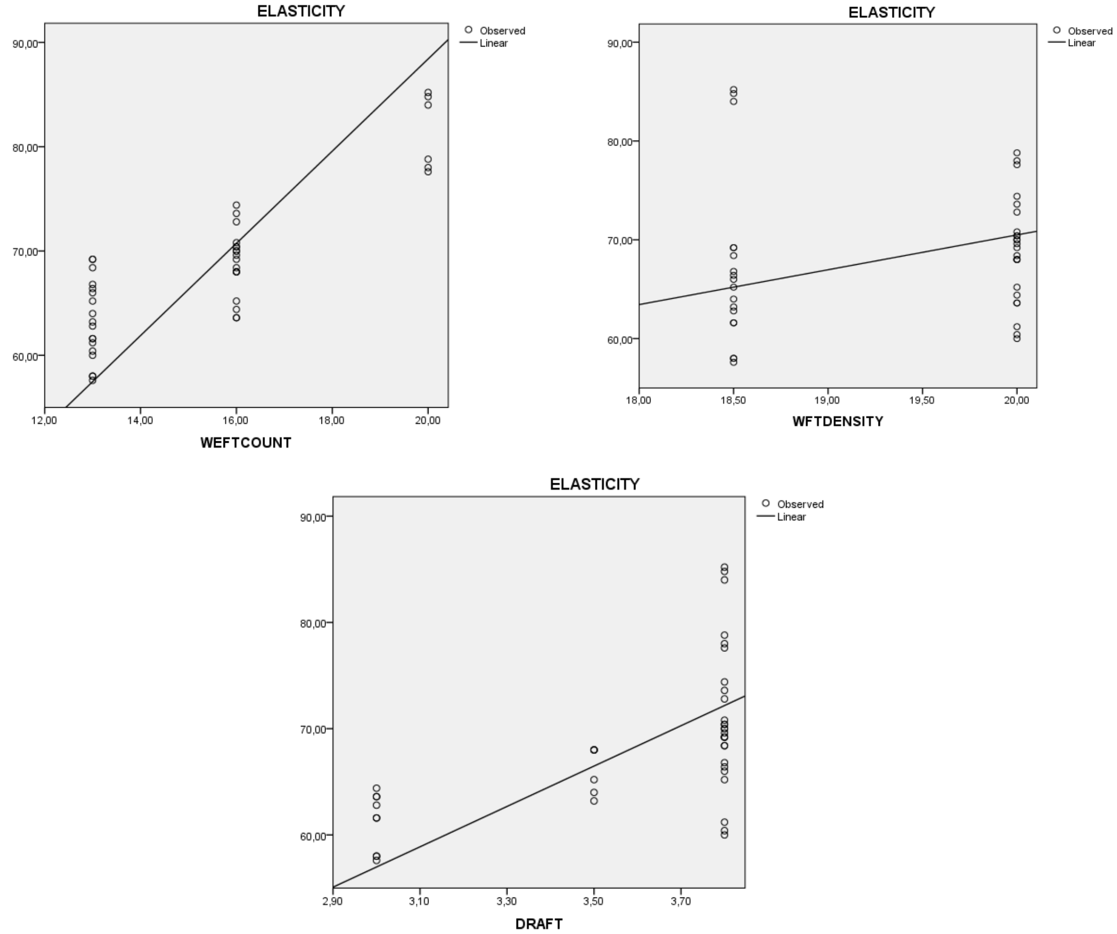


**Figure 3.** Curve fit plots for elasticity

**Table 6.** Regression analysis results for growth

**a)** Model Summary[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,802[a] | ,643 | ,625 | ,98594 |

**b)** Anova Table

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 68,348 | 2 | 34,174 | 35,156 | ,000[b] |
| | Residual | 37,911 | 39 | ,972 | | |
| | Total | 106,259 | 41 | | | |

**c)** Coefficients

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 16,524 | 1,185 | | 13,939 | ,000 |
| | Weft yarn count (WC) | -,376 | ,064 | -,561 | -5,853 | ,000 |
| | Elastane lineer density (E) | -,041 | ,007 | -,610 | -6,361 | ,000 |

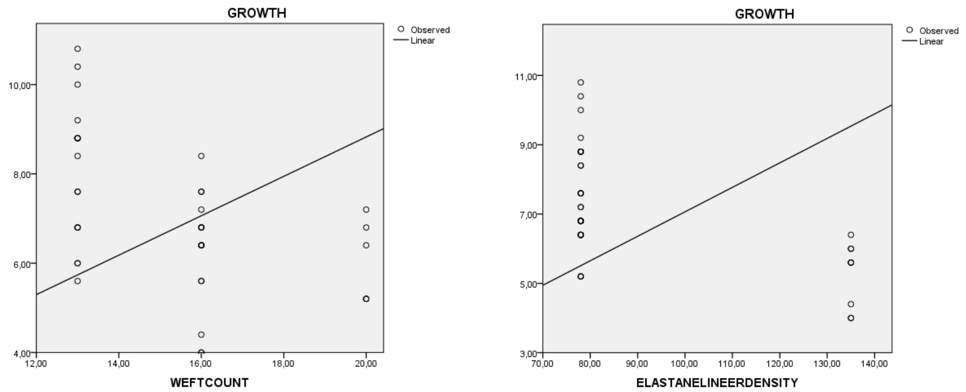


**Figure 4.** Curve fit plots for growth

## 4. CONCLUSION

As a result of the obtained data and the analyses, the following conclusions were reached;

1. It has been clearly determined that the weft yarn count, elastane draft ratio, elastane lineer density, spinning method and density factors have significant relationship with all denim fabric elasticity and growth properties. For this reason, it is necessary to keep these parameters in the denim production processes and fabric designs.

2. In particular, it is observed that the usage of elastane is one of the most effective factors in decreasing the growth value. Elastane lineer density has a significant effect on fabric growth values. Regression analysis show us growth performance is better with 135 dtex elastane after stretching.

3. It is observed that the increase of the draft ratio is a factor increasing the ability of the extension to increase accordingly. Fabric growth and elasticity results increase by increasing weft draft ratio.

4. According to the results obtained in the study, it is seen that there is a significant relationship between composition of yarn and elasticity, growth levels of fabric. While the yarns produced by polyester cotton blend with siro spun method have higher elasticity performance, it has been seen that growth values are less than core spun cotton elastane yarns. This is due to the fact that the polyester fiber, which has a more even surface, has less friction and facilitates the return of the elastane, on the other hand there is high friction of the elastane with cotton.

5. The effect of the same count of elastane in the fabrics produced by thin weft yarn is higher than the fabrics woven with thick weft yarn. The increase in elasticity was observed with the increase of the effect of elastane, while it was determined that there was a decrease in growth values. According to these results, it is observed that elasticity and growth performances are better with thin weft than thick weft yarns in denim fabric containing elastane yarns.

6. It has been observed that the effect of elastane on the fabric increases with the proportional increase of elastane depending on the increase in the weft density. It is concluded that even with a small increase in the weft density, a significant reduction can be obtained in elasticity values.

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