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Relation between Extension and Bursting Strength Properties of the Denim Viewed Knitted Fabrics Produced by Cellulosic Fibers

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Abstract

Denim viewed knitted fabrics are softer, cheaper, and more elastic than woven denim fabrics. Clothes which are produced by these fabrics adapt the body movement easily because of their flexible structure. Since these fabrics are produced with elastomeric yarn, their stretching property is quite high. Definitely, denim viewed knitted fabrics have to withstand to pressure during stretching. This resistance is defined in accordance with the bursting resistances of the fabrics. Therefore, in this study it is aimed to find out the relation between extension and bursting strength properties of denim viewed knitted fabrics. For this purpose eighteen different denim viewed knitted fabrics were produced and their extension and bursting strength tests were evaluated. Extension tests were performed by Titan tester by loop method along both widthwise and lengthwise and bursting strength tests were performed by Truburst tester. Since the bursting resistances of the fabrics are affected by elasticity of the fabrics, the correlation of this resistance and elasticity are investigated in this paper by assessing the test results graphically and statistically.

Key words: bursting strength extension, cellulosic fibre, denim viewed knitted fabric, fleecy yarn.

Introduction

The term flexibility includes elasticity, extension and elongation terms. Recovery is defined as permanent elongation or defines whether a fabric is stretch or not. In literature stretch and elasticity terms have been used interchangeably, however stretching of a fabric means as the capability of the fabric's extension or elongation. Total extension amount depends on applied force or used fibre type. Stretching is amount of the extension of the fabric under determined force but elasticity is the fabric's recovery after stretching. The amount of recovery depends on the structure of material and the time of applied force. Practically, elastic-

ity determines the permanent elongation or deformation after applied force. If there is no permanent elongation, deformation does not form and material turns back to its original shape [1].

Denim viewed knitted fabrics are produced by double fleece circular knitting machine by the loop, tuck and miss stitches combinations. Three different yarns are used as face yarn, fleecy yarn and elastomeric yarn in elasted fleecy fabrics. To reach the woven denim view the yarn used on the face side of the fabric should be dyed to indigo color while the fleecy yarn used in the inner side of the fabric should be gray. Woven denim clothes have been very popular so knit-

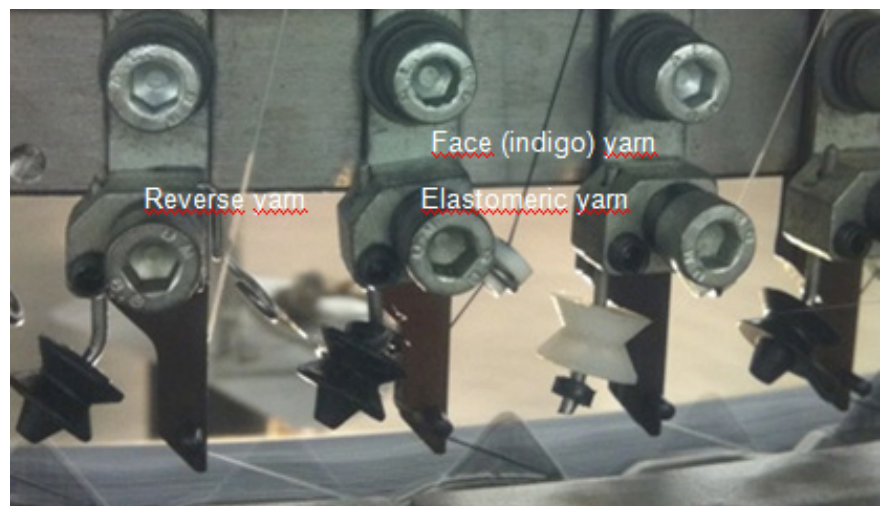


Figure 1. Adding of face, elastomeric and reverse yarns inside to the fabrics.

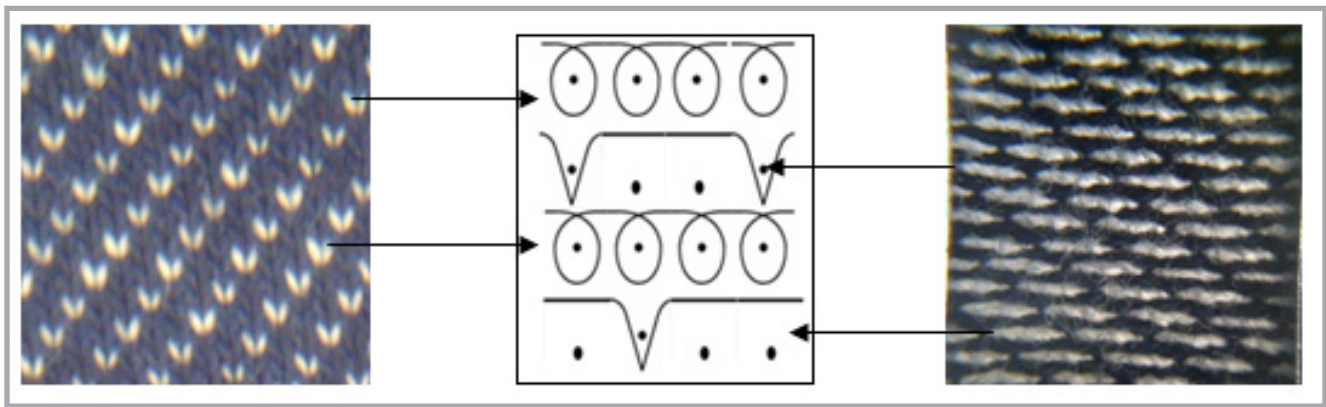


Figure 2. The face side (a), the pattern (b) and the back side (c) of the samples.

ting manufacturers have tried to use indigo dyed yarn in knitted fabrics to reach woven view. However, either dyeing processes or produced yarn's twist properties were not convenient for knitting so there were not sufficient systematic studies about these fabrics. According to the available researches [2 - 8] denim viewed knitted fabrics have similar characteristics to woven denim fabrics but the strength of woven denim fabrics higher than that of denim viewed knitted fabrics. Woven denim fabrics are more

resistant to launderings than knitted ones. Shin (2004) designed knitted denim trousers which were suitable to each season and compared their properties to woven denim fabrics. He reported that this type of trouser was more advantageous than woven type except dimensional stability and strength properties [4]. Gokernasan et al. (2012) tried to find the knitted fabric type which resembled the woven denim fabric with the view and performance properties. Therefore, they produced knitted fabrics with different patterns and

properties. They explained that diagonal two-fleece fabric was the most convenient one [5].

As known woven denim garments are very popular and on the other hand people often prefer knitted garments so it is thought that denim viewed knitted garments can provides many advantages to the users like elasticity, comfort, strength and softness. In this study, it is aimed to analyze the strength and the elasticity of the denim viewed knitted fabrics which were produced by cellulosic fibres.

Table 1. Quality parameters of yarns used in the sample knitted fabrics.

Yarns	Quality parameters					
	Unevenness, %	Coefficient of variation m., %	Hairiness H	Elongation, %	Strength, cN/tex	Breaking force, cN
Face yarn cotton (19.7 tex)	9.26	11.5	3.84	5.51	22.63	436.9
Bamboo20	8.78	11.05	4.03	10.35	14.37	416.3
Tencel20	8.4	10.58	5.15	5.36	16.28	471.5
Modal20	8.00	10.09	4.16	8.02	21.52	623.3
Viscose20	8.17	10.29	4.36	9.64	15.36	444.9
Cotton20	8.59	10.82	4.48	6.14	14.35	415.5
Bamboo30	11.09	13.98	4.08	10.46	14.60	281.9
Tencel30	9.07	11.43	4.63	5.62	18.53	357.7
Modal30	11.22	14.14	4.54	6.82	17.75	342.6
Viscose30	10.37	13.21	4.82	8.47	13.54	261.4
Cotton30	10.5	13.27	4.16	5.12	13.45	259.6

Table 2. Structural parameters of sample knitted fabrics.

Samples	Course per cm	Wale per cm	Loop shape factor	Stitch density	Thickness, mm	Weight, g/m ²
Bamboo20	21	12	1.75	252	0.68	201
Tencel20	21	13	1.62	273	0.72	200
Modal20	20	13	1.54	260	0.67	194
Viscose20	22	12	1.83	264	0.69	197
Cotton20	21	12	1.75	252	0.74	196
Bamboo30	21	13	1.62	273	0.66	169
Tencel30	21	12	1.75	252	0.70	179
Modal30	20	13	1.54	260	0.64	170
Viscose30	22	12	1.83	264	0.66	165
Cotton30	21	12	1.75	252	0.70	167

Material and method

The samples in this paper were knitted as diagonal fleeced fabrics with the denim view. Three different yarn types were used in each fabric. One type was used on the face of the fabric. This yarn (face yarn) was 19.7 tex, 100% cotton, ring spun and indigo dyed. Second yarn was elastomer and the count of it was 44.4 dtex. The last type (fleecy yarn) was used on the reverse side of the fabric. These yarns varied as count 29.5 and 19.7 tex, as raw material cotton, modal, viscose, tencel, bamboo. They were vortex spun and used as gray. The face yarn and elastomer were added to fabric together while the reverse one was added alone as seen in Figure 1 and the pattern was shown in Figure 2.

All the samples were produced with the circular knitting machine with 22 gauge 30" diameter using constant setting values. After knitting process, pre-fixation, cold washing, and sanforizing processes were applied to the gray sample knitted fabrics.

Strength and elongation tests of the yarns were measured with Uster tester and

structural characteristics of the samples were measured with international standards (ISO14971, ISO 12127, ISO 5084, ISO 6939). The bursting resistance of the samples was measured with Truburst while the elasticity of the fabrics was measured by Titan with loop method according to international standards (BS EN ISO 13938-2, BS 4952).

■ Results and Discussion

Properties of yarns

Owing to the fact that the strength and the elasticity of the knitted fabrics depend on the strength and elongation of the yarns, the yarns were tested and evaluated. The quality parameters of face yarn which was 19.7 tex, ring spun, 100% cotton and rope indigo dyed was presented in *Table 1*. Similarly, quality parameters of fleecy yarns which were vortex spun, 19.7 and 29.5 tex and gray were presented in *Table 1* too.

According to the values given in *Table 1*, the strength of face yarn's was quite higher than that of fleecy yarns while the elongation was vice versa. This table show that modal yarns used in this study were considerably strong and bamboo yarns used in this study were fairly elastic. In accordance with this table coarser yarns were stronger and less elastic than the finer yarns.

Structural characteristics

Knitted fabrics form by loops and the characteristics of the loops inside the fabric like density, shape and the numbers change the structure of the fabrics. Beside these characteristics the weight and the thickness of the knitted fabrics are distinctive on the performance properties of them. For this aim all the structural analyses of them were done and illustrated on *Table 2*. In this table the number 20 or 30 refers to the fleecy yarn's count as 29.5 or 19.7 tex. The results of the measurements were evaluated according to the relation between bursting strength and elasticity of the fabrics.

Bursting strength

Strength is very important parameter for all textile structures. Because of these knitted fabrics are produced to design as denim, the importance of strength become prominent more. The strength of sample knitted fabrics was measured by bursting strength test method. In burst-

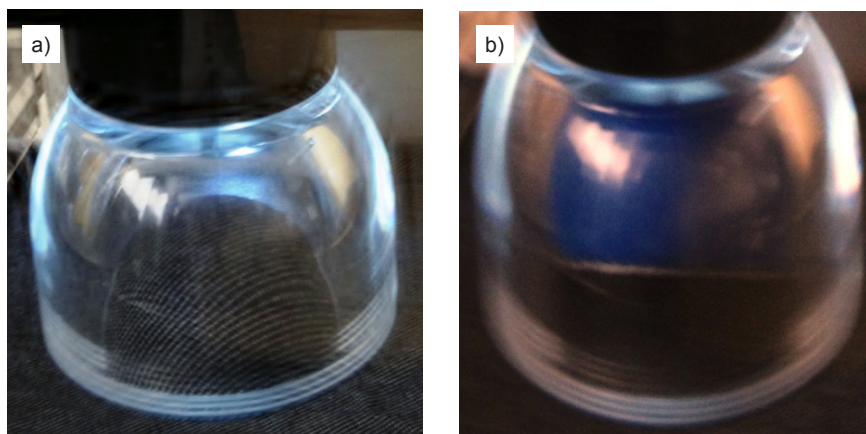


Figure 3. Bursting strength test a) Fabric stretching, b) Burst formation.

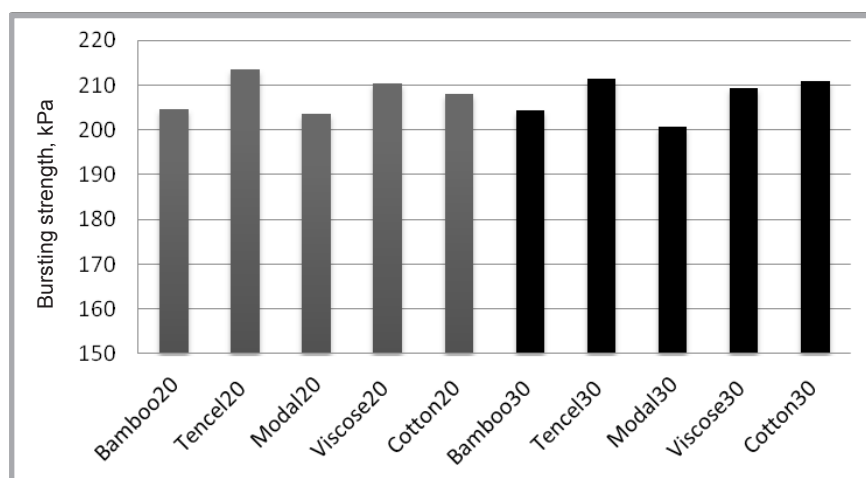


Figure 4. Bursting strength test results of sample knitted fabrics.

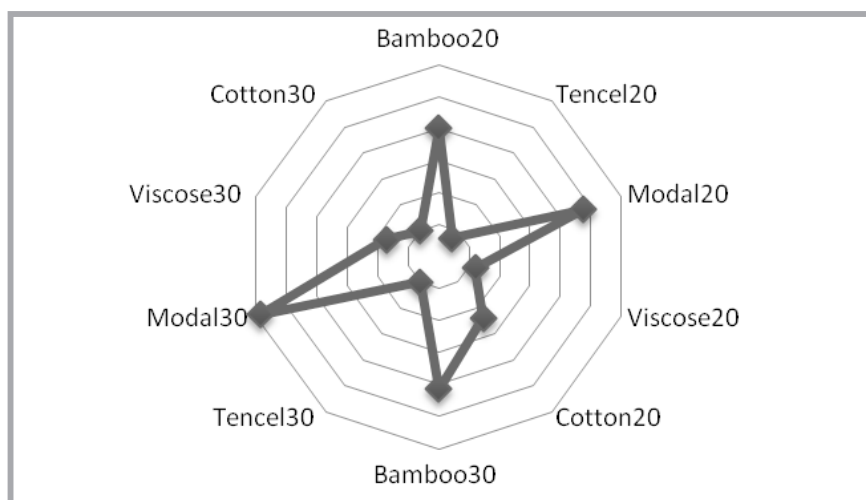


Figure 5. Relative difference of bursting strength values.

ing strength test the vertical pressure was applied to the fabric multi-dimensionally and by the effect of this pressure the fabric and the diaphragm were stretched up to maximum dimension (*Figure 3.a*) and the loops brake at the point that the strength of the yarns are the lowest (*Figure 3.b*). Owing to the fact that

there was more than one broken loop at the same time, it is called as “bursting”. In the bursting strength property of the fabric the elongation and the strength of the yarn, the structure of the fabric are the effective parameters. It is thought that firstly weakest yarn is broken but it is not actually correct. Stronger yarns are less



Figure 6. Extension test by loop method.

elastic and reach the elastic limit quickly and break [9].

Bursting strength average test results were examined and illustrated as a graph in Figure 4.

According to this figure the bursting strength values of the samples were

closer to each other. To define the amount of the relative difference of the fabrics the sample cotton 30 was chosen as reference point because in this sample both face and fleecy yarns were 100% cotton and 19.7 tex. The relative difference was measured according to the Equation 1.

$$RD_{BS} = \frac{S_{BS} - C30_{BS}}{C30_{BS}} \times 100\% \quad (1)$$

In this equation RD_{BS} refers to the relative difference of bursting strength, S_{BS} refers to the any sample's bursting strength and $C30_{BS}$ refers to the bursting strength of sample Cotton30. The relative difference of the samples were calculated and presented in Figure 5 as a graph.

According to the Figure 5 among all the samples, the samples Tencel30, Tencel20, Viscose20 and Viscose30 have quite similar bursting strength values to the sample Cotton30. When the fleecy yarn breaking strength values of these samples were examined it was seen that only yarn strength was not a significant effect on the bursting strength.

Extension

Elasticity is an important property for the sportswear and tight clothes. It is known that if the elasticity of the garment is 5 - 30%, this garment is called as easy stretchable garment and if the elasticity of the garment is 30 - 50 %, this garment is called as very stretchable garment [10]. Briefly, anybody can move easily in a stretch garment and this garment have to keep this property during its using life [1]. In this study the extension of the samples were determined at a specified force by loop method. During the test, pretension was adjusted as 2 N and extension rated was adjusted as 500 mm/min than the samples were extended two cycles with 20 N loading up to pull with 120 N load cell (Figure 6).

The extensions at force of 20 N were measured both lengthwise and widthwise directions. Then all the extension results

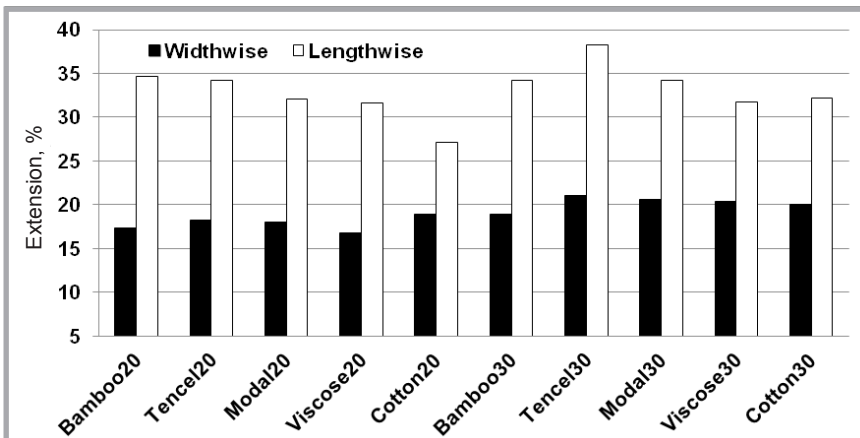


Figure 7. Extension of sample knitted fabrics.

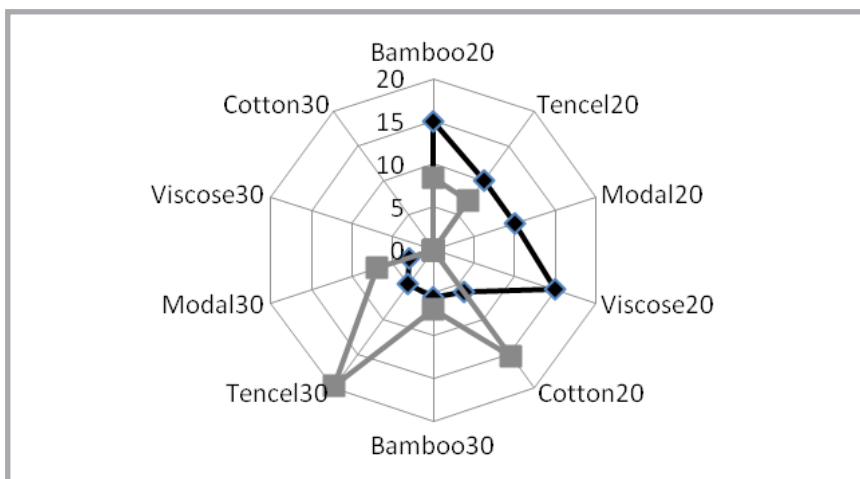


Figure 8. Relative difference of extension values.

Table 3. Two-way ANOVA test results of the samples.

	Dependent variable	Type III sum of squares	Degree of freedom	Mean square	F	Sig.	Partial eta squared
Bursting strength, kPa	Fleecy yarn's raw material	8270.084	4	2067.521	14.680	0.000	0.395
	Fleecy yarn's count	23608.322	1	23608.322	167.630	0.000	0.651
	Interaction of factors	4732.120	4	1183.030	8.400	0.000	0.272
Widthwise extension, %	Fleecy yarn's raw material	16.003	4	4.001	21.981	0.000	0.687
	Fleecy yarn's count	69.125	1	69.125	379.801	0.000	0.905
	Interaction of factors	10.456	4	2.614	14.362	0.000	0.590
Lengthwise extension, %	Fleecy yarn's raw material	256.457	4	64.114	205.901	0.000	0.954
	Fleecy yarn's count	60.127	1	60.127	193.095	0.000	0.828
	Interaction of factors	57.901	4	14.475	46.487	0.000	0.823

as percentage were shown in **Figure 7** as a graph.

When the **Figure 7** was examined it was seen that the lengthwise extension of the samples were double of the widthwise extension of them. According to the lengthwise extension test results, all the samples were easy stretchable and according to the widthwise extension test results, all the samples were very stretchable. The reason of this difference was the miss stitches which were used to produce fleecy fabrics. While the fabric was stretched widthwise, actually float fleecy yarns were tried to stretch. Therefore, if the elongation ratio of fleecy yarn was low, the widthwise extension of the fabric would be low. Lengthwise extension means the stretching of face yarns. And, the elastan was added to the fabric with face yarn. To determine the extension relative difference of the samples from Cotton30 **Equations 2** and **3** were used.

$$RD_{EL} = \frac{S_{EL} - C30_{EL}}{C30_{EL}} \times 100\% \quad (2)$$

$$RD_{EW} = \frac{S_{EW} - C30_{EW}}{C30_{EW}} \times 100\% \quad (3)$$

In **Equation 2**, RD_{EL} refers to the relative difference of lengthwise extension, S_{EL} refers to the any sample's lengthwise extension and $C30_{EL}$ refers to the lengthwise extension of sample Cotton30. In **Equation 3**, RD_{EW} refers to the relative difference of widthwise extension, S_{EW} refers to the any sample's widthwise extension and $C30_{EW}$ refers to the widthwise extension of sample Cotton30. The extension relative differences of the sam-

ples were calculated and presented in **Figure 8** as a graph.

According to the **Figure 8** Tencel30, Viscose30 and Modal30 had similar widthwise extension values to the Cotton30 so it was thought that characteristics of these fabrics were closer to each other.

Statistical analyses

To comment the mathematical test results statistically SPSS 17 package programme was used. The statistical difference was assessed by two-way ANOVA with $\alpha = 0.05$ and the dependent variables were fleecy yarn's raw material, fleecy yarn's count and their interaction. And correlation test was applied to define the interaction between extension, bursting strength, bursting distance, yarn strength and elongation and structural parameter statistically. The two-way ANOVA test results were presented in **Table 3** and correlation analyses results were given in **Table 4**.

In accordance with the values given in **Table 3** bursting strength and extension of all the samples were significantly different each other. Changing the count of the fleecy yarn was more effective on the bursting strength of the samples than changing the raw material of the fleecy yarn. Similarly, widthwise extensions of the samples were affected from fleecy yarn's count more. However, for lengthwise extension both changing fleecy yarn's raw material was as effective as changing fleecy yarn's count.

The values given in **Table 4** showed that change in the thickness caused an increasing in the bursting strength value

with the ratio 65%. When the fabric unit weight increased the width extension increased too. There was positive relationship between bursting dimension and length extension with the ratio of 72%. Therefore it was thought that statistically the thickness and weight were the important parameters for bursting strength and the extension of the sample knitted fabrics.

Conclusions

The aim of this study was to find out the compatibility of denim viewed knitted fabrics to the use as denim jeans according to the strength and extension properties of these fabrics. Especially denim fabrics were produced by cotton fibres but in this study regenerated cellulosic fibres were used and compared the test results to the fabrics produced by cotton fibre. Results showed that all the fabrics were compatible to the use according to the strength values (TS 11266). The lengthwise extension of the samples was notably high so the clothes which would be produced by these fabrics can withstand to burst pressure without any hole thanks to the extension of the fabrics.

Any fleecy fabric bursts after extending to lengthwise up to maximum level and the lengthwise extension of the fabric relates between the elasticity of the face yarn and the amount of elastomer yarn used in the fabric. Finally according to the test results in this study, changing fleecy yarn raw material did not affect bursting strength parameter significantly. Cotton and regenerated cellulosic yarns behave similarly especially as fleecy yarn. The count of fleecy yarn was more important than the raw material of fleecy yarn on the extension of the fabrics. Among the sample knitted fabrics the samples which include modal and bamboo illustrated lower bursting strength values than cotton30. The reason of this

Table 4. Correlation test results of the samples.

Variations		Type	Level	%
Thickness	Bursting strength	Positive	0.05	65
Weight	Widthwise extension		0.01	87
Bursting Dimension	Lengthwise extension		0.05	72

phenomenon was lower thickness values of them.

Finally, it is concluded that between bursting strength and extension of the samples there is no determined relation. Although, extension is very effective parameter on the bursting strength property of the knitted fabrics, it does not directly affect it according to tested results.

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