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Investigation of Auxetic Performances of Single and Double Layer Fabrics Woven with Braid Weft Yarns of Different Structural Parameters

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ABSTRACT

This study investigated the auxetic performances of single and double layer fabrics woven by using braid weft yarns with different structural parameters. Non-elastane braid weft yarns containing yarn components with different filament numbers and braid weft yarns containing elastane and conventional warp yarns were used in fabrics. To investigate the effects of weave, fabrics with single and double layer structures were woven on an industrial weaving machine. Experimental results showed that the fabrics woven with both non-elastane and elastane braid weft yarns performed an auxetic behavior by giving Negative Poisson's Ratio (NPR) values. It was observed that generally fabrics woven with braid weft yarns containing elastane could improve the auxetic performance. Fabric woven with non-elastane braid yarns of high filament numbers showed a higher NPR. When the effect of the weave on the auxetic performance was examined, a double layer fabric structure was shown to reduce the auxetic effect.

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KEYWORDS

Auxetic effect, negative Poisson's ratio (NPR), braid yarn, elastane, single and double layer woven fabric

1. INTRODUCTION

Poisson's ratio (PR) is defined as the negative ratio of transverse strain to axial strain and is used to predict the deformation of engineering materials under uniaxial stress [1-3]. Materials with a negative Poisson's ratio (NPR) are also called auxetic materials. For example, when a conventional material is subjected to a tensile force, it elongates in the force axis and contracts in other axes, or when a material is subjected to a compressive force, it contracts in the force axis and expands in other axes. As opposed to materials with a positive Poisson's ratio, auxetic materials expand laterally when stretched and contract laterally when compressed [2, 4-8].

Since the Poisson's ratio is a physical parameter independent of material scales, auxetic behavior can be obtained from the molecular to macroscopic levels [2, 9, 10]. The mechanisms of auxetic materials depend on their microstructure, geometric structure, or deformation mechanisms of these structures [5, 8, 11-17].

Textile materials differ in many aspects compared to other engineering materials. For example, they may not show the same behavior in all directions under force. They can easily deform, change shape and elongate without breaking depending on their place of use. In terms of these properties, it is a unique material as to its compatibility with human movements [18]. The deformation behavior of woven fabrics when subjected to tension is an issue that should be considered in predicting the performance of fabrics during use [18, 19]. The breaking behavior of woven fabrics and their deformation under low forces are considered during these products' design and production stages, from clothing to home textiles, from textile-reinforced composites to technical textiles [18].
Deformation under tensile loading is one of the methods that can be used to determine the physical performance of fabrics. In studies [20, 21] on Poisson's ratio of various conventional fabric types, it is stated that conventional fabrics show positive PR values due to lateral contraction under tension.

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Woven fabric structures are textile surfaces formed by the intersection of warp and weft yarns perpendicular to each other. In woven fabrics, both the warp and weft yarns take a crimp due to the displacement caused by the intersection of the warp and weft yarns. When the fabric is stretched in one direction, the yarns in the loading direction straighten. Straightened yarns cause other yarns to receive more crimp perpendicular to the loading direction, resulting in fabric shrinkage in the transverse direction and hence a positive PR occurs [22, 23].

Generally, there are two approaches to the production of auxetic textiles. The first involves using auxetic fibers to produce an auxetic textile structure, while the other is producing textile structures with auxetic properties using suitable yarns made from conventional fibers [2]. The literature states that different combinations of conventional yarns are used as warp and weft yarns to develop auxetic fabrics. In addition, it is stated that the benefit of using conventional yarns in forming auxetic fabrics is that they have higher structural stability than auxetic fibers [24].

It is shown in the studies that the creation of different shrinkage phenomena in woven fabric structures can be achieved by the use of weave pattern combinations with different shrinkage/contraction properties and the use of elastic/non-elastic yarns. The developed auxetic woven fabrics are based on a foldable geometric structure. The basic principle of these geometries is the different shrinkage effects. Elastic yarns are used to provide flexibility and reversibility to the fabric structure, while non-elastic yarns are used as a stabilizing component [25, 26].

In a study, the auxetic performance of a partial stretch plain weave fabric was investigated by inserting non-elastane and elastane conventional weft yarns as forming successively strips in the transverse direction of the fabric. And it was stated that this form gave the fabric a relatively similar foldable geometric structure and therefore showed an auxetic performance [27].

In a study on woven fabrics made of helical auxetic yarns (HAYs) and their essential effects on Poisson's ratio under tension, it is stated that the lower wrapping angle of the HAY and a thinner diameter of the auxetic weft yarn lead to higher auxetic behaviour of the fabric. Also this study states that the weave structure can directly affect the auxeticity of the woven fabric and the structure having longer floats results in a higher auxetic efect. It was also shown that lower tensile modulus of the warp exhibits a higher auxetic effect [28].

In a study on single and double layered bistretch auxetic woven fabrics woven with nonauxetic yarns based on the folded geometry, it is concluded that all the developed fabrics have auxetic behavior in both warp and weft directions. In the double layered auxetic woven fabrics based on parallel in-phase zigzag foldable geometrical structure, it is shown that higher NPR effect when the fabric is stretched along weft direction than warp direction. It is stated that this behavior is different from the results obtained for single layer fabric. Also, this research concludes that the placement of weaves and weft yarn arrangements has an effect on auxetic behavior [29].

In a different study on the auxetic performance of fabrics woven on a hand-weaving loom using braid yarns, it was stated that the fabrics woven with braid weft yarn exhibited an auxetic behavior by giving negative Poisson's ratio up to a certain elongation value under tension in the warp direction. In addition, it was stated that the NPR of fabric was affected by the thickness of the braid yarn and the tightness (compactness) of the fabric [30].

In the investigation of warp directional Poisson's ratio changes of fabrics woven with elastane containing braid weft yarns with different yarn tensions and with conventional and braid warp yarns, it was stated that the fabrics with elastane containing braid weft, the NPR effect could be obtained from the fabrics woven with the conventional warp yarn, but the NPR effect could not be obtained from the fabrics woven with the braid warp yarn. Also, in fabrics woven with conventional warp yarns, it was stated that the NPR effect was obtained from fabric woven with elastane containing braid weft yarns inserted into the fabric with tension. Whereas, the fabric showed nearly zero Poisson's ratio when the braid weft yarn was inserted in slack form. [31].

This study aimes to evaluate the effects of braid weft yarns with different structural parameters and also single and double layer weave structures on the auxetic performance of the fabrics. To investigate the effects of different structural parameters of the component yarns forming the braid weft yarn, non-elastane braid yarns produced with component yarns of different filament numbers and elastane braid yarns containing elastane components were used. To investigate the effect of weave structure, fabrics woven with single and double layer weaves were studied.

2. MATERIAL AND METHOD

2.1 Material

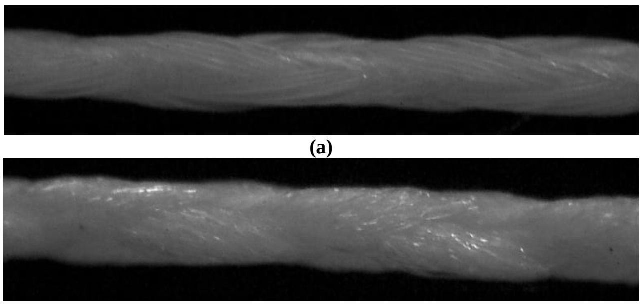
The term braid refers to the placement of the sheath yarns, made of one or more filaments released from the reels placed on the carriers in the braiding machine. They pass diagonally into each other and cross the yarn's axis diagonally without making a full rotation around each other. A basic braid structure is circular, with half of the yarn bundles moving clockwise at a certain angle to the braid yarn axis and other half moving counterclockwise directions by alternately passing over and under the first group bundles [32-34].

This study used braid yarns with different structural properties as weft yarns, and fabrics woven using single and double layer weaves were studied. The structural properties of the fabrics are presented in Table 1. Braid yarns in weft and conventional textured yarns in warp were used. All the fabric samples were produced by using 100% polyester warp and weft yarns.

Circular braid yarns (8 carriers; consisting of 8 sheath yarn components) without elastane, which are used as weft yarn in B and C coded fabric structures, were produced in Kord Endüstriyel İp ve İplik Sanayi ve Ticaret A.Ş. by attaching textured polyester and HT polyester yarns to the carrier in a 1:1 layout. To evaluate the effects of component yarn filament numbers on the auxetic performance of the fabric, the component yarns that made up the non-elastane braid yarns were composed of two different filament numbers (300/10 and 300/96 denier/filament textured polyester yarns).

The images (80 times magnification) of the braid yarns used in B and C coded fabrics under an Insize ISM-PRO digital microscope are presented in Figure 1.

Production of circular braid yarns containing elastane component (braid yarns used in X coded fabric structures) was carried out in a braiding machine with eight sheath yarns (XH110-8-8-90S Braiding Machine) (Figure 2) in Bursa Uludag University Textile Engineering Department Weaving Laboratory. Elastane braid yarns containing polyester/ elastane textured yarns (150/48 denier/filament + 70 denier EL.) were employed as weft yarn seen in Figure 3.



(a)

(b)

Figure 1. Microscopic images of non-elastane braid yarns (Mag: 80X) a) B coded b) C coded

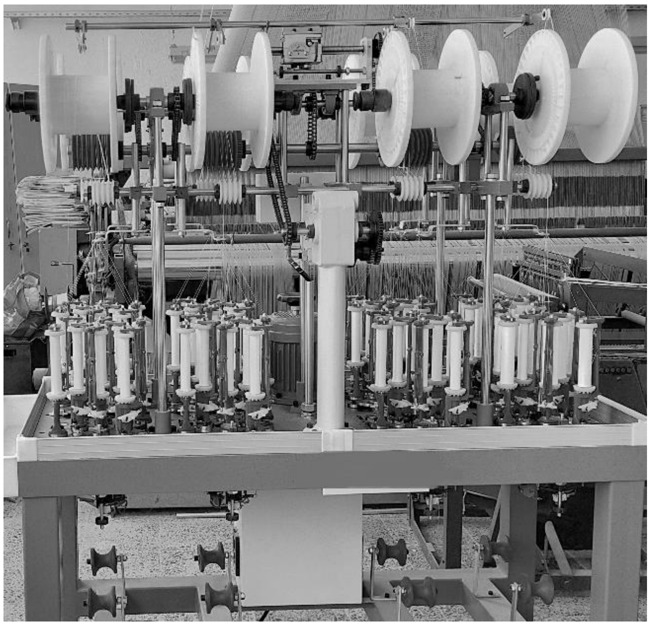


Figure 2. Braiding machine (XH110-8-8-90S)

Table 1. Structural parameters of fabrics

Fabric Code	Weave	Yarn Properties		Yarn Count [denier]		Yarn Density [thread/cm]		Yarn Crimp [%]	
		Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
B-1	Single Layer (plain)	Textured Polyester	Circular braided yarn (non-elastane) with 8 carriers. (4x300/10 denier/filament textured polyester + 4x85/36 denier/filament HT (High Tenacity) polyester)	150	1619	66	10	13.52	6.86
B-2	Double Layer (top and bottom layer: plain)						14	16.58	8.78
C-1	Single Layer (plain)	Textured Polyester	Circular braided yarn (non-elastane) with 8 carriers. (4x300/96 denier/filament textured polyester + 4x85/36 denier/filament HT (High Tenacity) polyester)	150	1748	66	10	13.34	8.24
C-2	Double Layer (top and bottom layer: plain)						14	16.37	9.52
C-3	Double Layer (top and bottom layer: 2/1 twill)						14	12.45	11.21
X-1	Single Layer (plain)	Textured Polyester	Circular braided yarn (containing elastane) with 8 carriers. (8 x 150/48 denier/filament textured polyester (70 denier EL.)	150	2196	66	10	13.96	12.42
X-2	Double Layer (top and bottom layer: plain)						14	14.49	15.56
X-3	Double Layer (top and bottom layer: 2/1 twill)						14	15.22	17.04

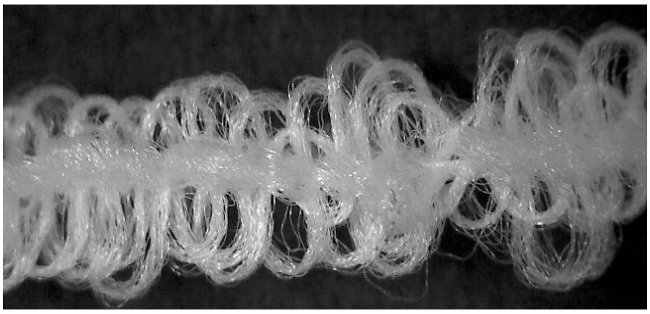
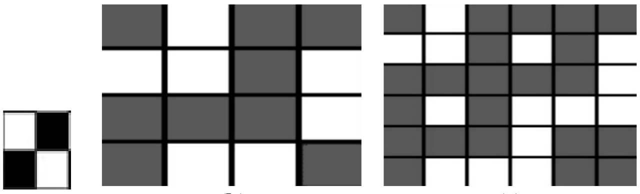


Figure 3. Microscopic images of braid yarn containing elastane (X coded) (Mag: 30X)-)

In our previous studies [30, 31], fabrics with plain weave structure, in which braid yarns were used as weft yarn, were woven on a hand weaving loom. From the results obtained, it was concluded that woven fabrics with braid yarn could show an auxetic behavior under deformation.

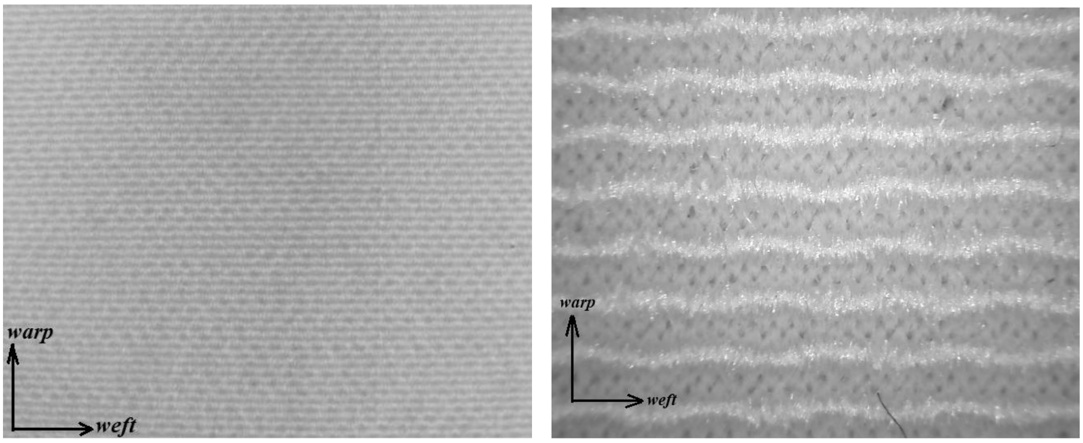
In this study, fabric productions were carried out on industrial weaving machines in Butik Jakar company in Bursa. Figure 4 shows the weave types used in the production of fabrics.



(a) **(b)** **(c)**

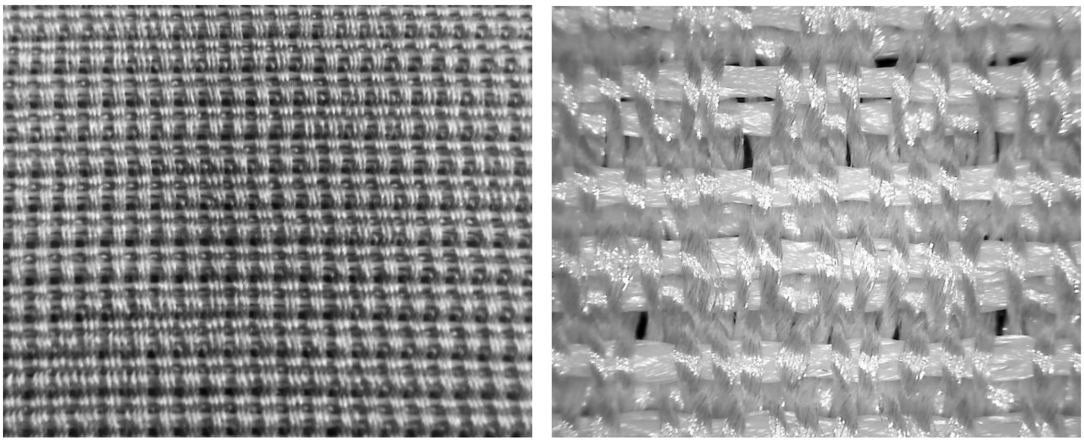
Figure 4. The weave pattern of the fabrics a) Single layer (plain) b) Double layer (top and bottom layer: plain) c) Double layer (top and bottom layer: 2/1 twill)

Photographic and microscopic (Insize ISM-PRO) (50 times magnification) images of woven fabrics with braid weft yarns are presented in Figures 5 to 7.



(a) **(b)**

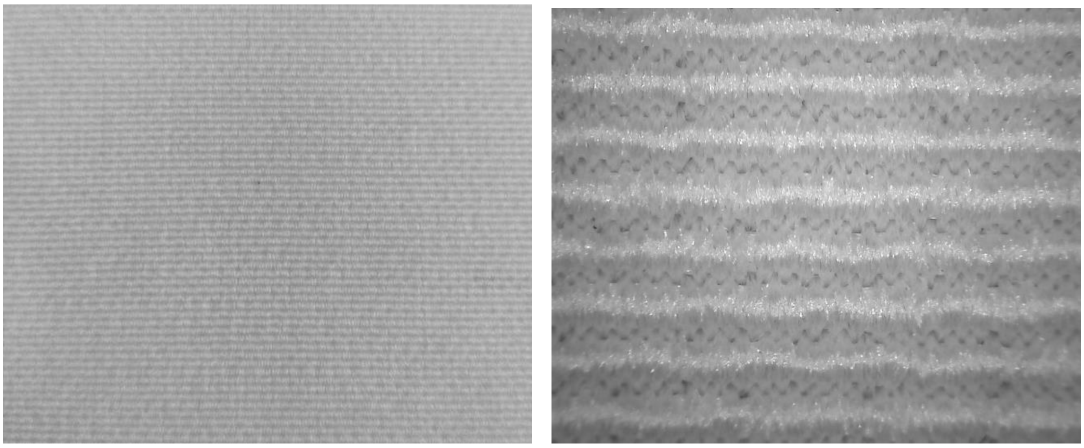
B-1 fabric



(a) **(b)**

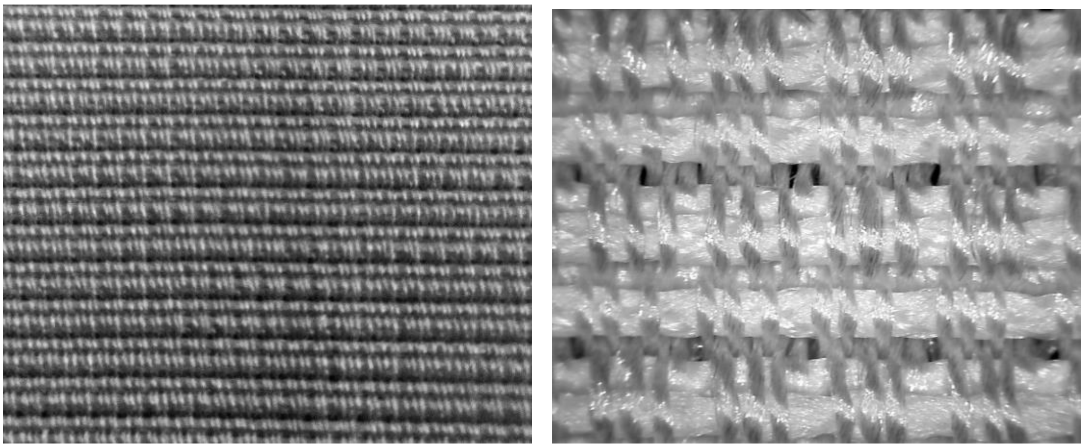
B-2 fabric

Figure 5. a) Photographic b) Microscopic (Mag: 50X) images of B coded fabrics



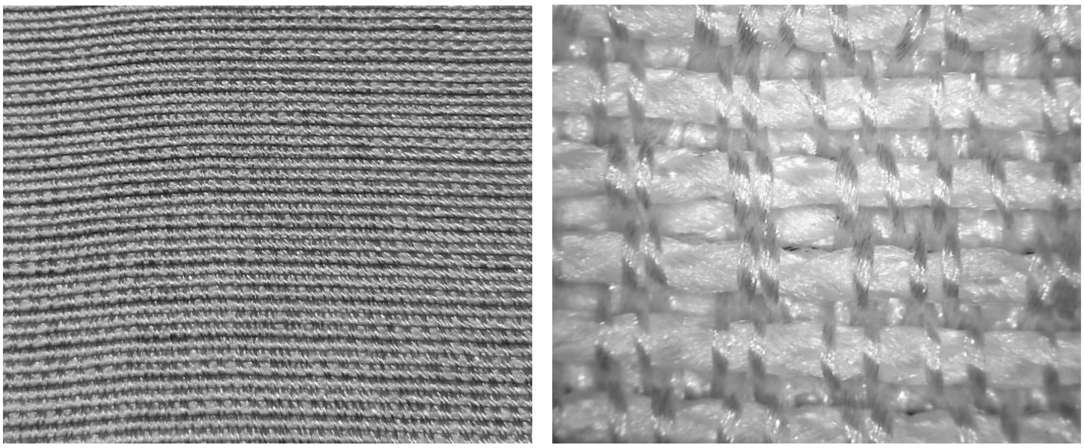
(a) (b)

C-1 fabric



(a) (b)

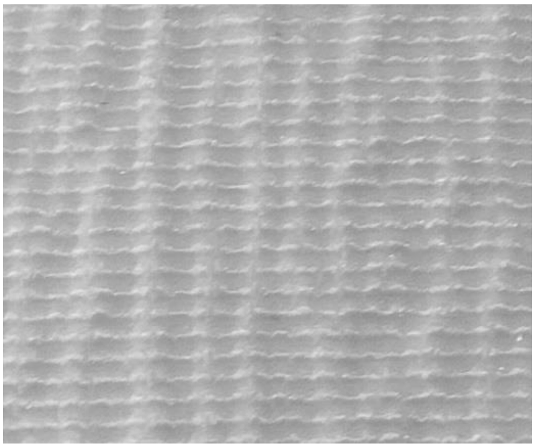
C-2 fabric

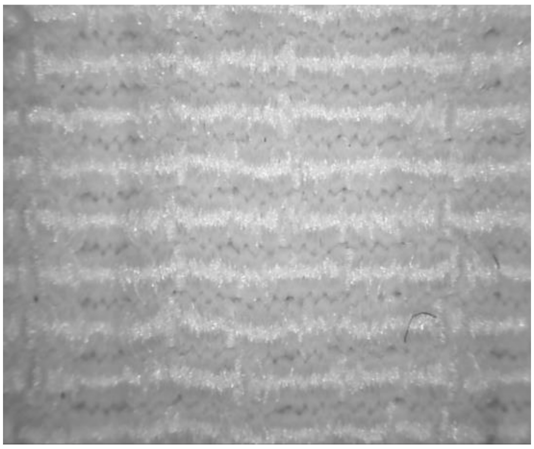


(a) (b)

C-3 fabric

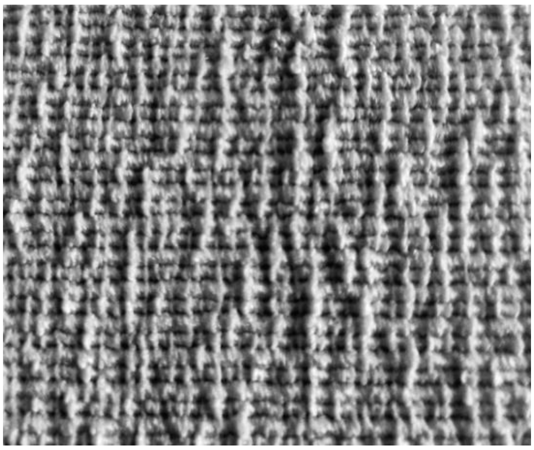
Figure 6. a) Photographic b) Microscopic (Mag: 50X) images of C coded fabrics

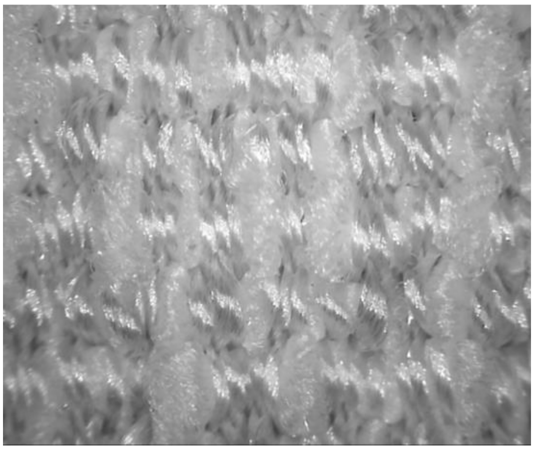




(a) (b)

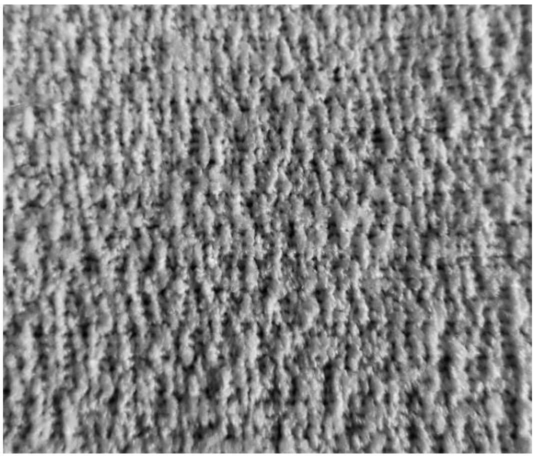
X-1 fabric

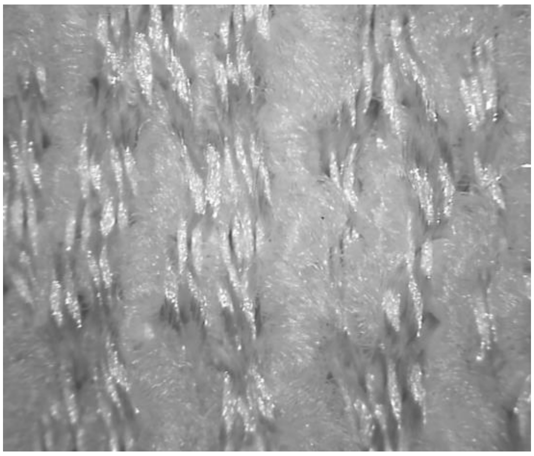




(a) (b)

X-2 fabric





(a) (b)

X-3 fabric

Figure 7. a) Photographic b) Microscopic (Mag: 50X) images of X coded fabrics

2.2 Method

2.2.1 Poisson's ratio measurement of fabrics

To calculate the Poisson's ratios for the evaluation of the auxetic performance of the fabrics, the fabric samples were subjected to elongation in the warp and weft directions in the Shimadzu AG-X plus strength test device, according to the ISO 13934-1 (2013) standard test method [35]. A tensile test at a 10 mm/min speed was applied to fabric samples with a pretension obtained with 0.83 mm elongation. A computer-connected digital camera with optical zoom capability was used to record fabrics' transverse and longitudinal deformation changes under elongation with 5 seconds intervals. A digital microscope photographed fabric samples by applying 10 times magnification (Insize ISM-PRO) (1600 x 1200 pixel resolution) with a time interval of 5 seconds (or at every 0.83 mm elongation value) until a total elongation of 20 mm (for 120 seconds) was reached during the tensile test. The setup of the testing system is presented in Figure 8.

Figure 8. Measurement setup

With the help of markers (Figure 9) placed on the fabric samples at the beginning, the changes in the width (average of x values) and length (average of y values) were calculated by measuring the distances between markers over the images taken every 5 seconds.

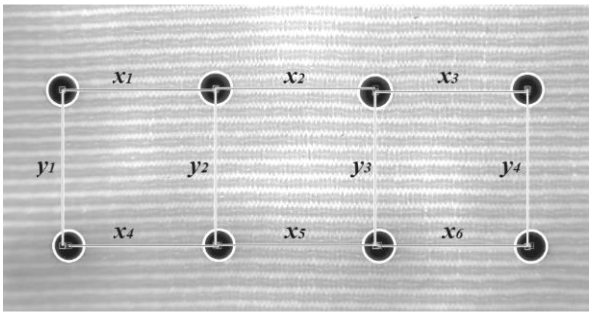


Figure 9. Placement of markers on the samples

The distances between markers placed on the fabric were measured with the help of an image processing method [36] developed using MATLAB for both the free and stretched fabric states to calculate the strains in both sample transverse and longitudinal directions. Poisson's ratio (*v*) was then calculated using Equation (1) as follows [4];

$$v = -\ (\text{transverse strain} / \text{longitudinal strain}) \qquad (1)$$

3. RESULTS AND DISCUSSION

3.1 Effects of the filament number of the yarn components forming the braid weft yarn on Poisson's ratio

The warp directional Poisson's ratio-elongation curves of single layer plain weave fabrics woven with non-elastane braid weft yarns (Figure 1) produced with component yarns of different filament numbers (B-1: 300/10 ve C-1: 300/96 denier/filament) are presented in Figure 10.

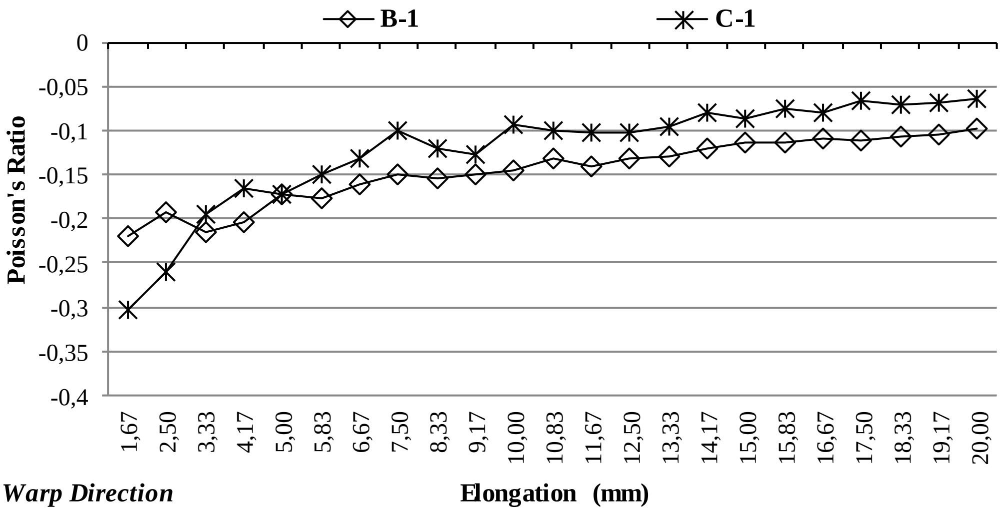


Figure 10. Poisson's ratio–elongation curve of B-1 and C-1 fabrics at warp direction

Figure 10 shows that the fabrics woven in plain weave structure with non-elastane braid weft yarns gave NPR values under 20 mm warp directional elongation. When the effect of the filament numbers of the component yarns forming the braid yarn on the auxetic performance was examined, it was seen that the C-1 fabric woven with braid yarns of high filament numbers, gave a higher NPR value than the B-1 fabric woven with low filament numbers, especially under the initial elongation values. From the results of the previous research [30], it was stated that the thickness of the braid yarn affected the auxetic performance of the fabrics, and the auxetic performance continued under higher elongation values in the fabrics woven with thick braid weft yarn compared to the fabric woven with thin braid weft yarn. A similar result was found in this study. When Table 1 was examined, it was seen that the final yarn count of the C coded braid weft yarn with high filament numbers was slightly higher than the braid yarns with low filament number. Namely, the C coded braid yarn was thicker than the B coded braid yarn. In addition, as could be seen from the images in Figure 1, the fact that braid yarn structures produced with high filament number component yarns created a more voluminous and soft structure compared to braid yarns produced with low filament number component yarns could affect the NPR of the fabrics.

The weft directional Poisson's ratio-elongation curves of single layer plain weave fabrics woven with non-elastane braid weft yarns produced with different filament number component yarns (B-1: 300/10 ve C-1: 300/96 denier/filament) are presented in Figure 11.

Figure 11 shows that the fabrics woven with non-elastane braid weft yarns gave NPR values under weft directional elongation of 5 mm. In particular, the braid weft yarns formed with component yarns of high filament numbers gave very high NPR values (≈ -1) in the C-1 coded fabric structure, and the high NPR values continued throughout 5 mm elongation. B-1 coded fabric formed with component yarns with lower filament numbers had lower NPR values under weft directional elongation.

In weft direction, tests were carried out until 5 mm elongation because fabric structures woven with non-elastane braid weft yarns were distorted after 5 mm elongations. This distort condition might be due to more rigid and thick structure of non-elastane braid weft yarns.

3.2 Evaluation of the effects of weave structures on Poisson's ratio of fabrics

3.2.1 Evaluation of Poisson's ratios of B and C group fabrics woven with non-elastane braid weft yarns

Warp and weft directional Poisson's ratio-elongation curves of fabrics woven in single (B-1: plain weave) and double (B-2: top and bottom layer are plain weave) layer weave structures with non-elastane braid weft yarns are presented in Figure 12 and Figure 13.

In Figure 12, when the effect of single and double layer weaves on the warp directional Poisson's ratios of fabrics woven with non-elastane braid weft yarns were examined, it was seen that NPR values continued throughout 20 mm elongation in single layer structure, and up to 15 mm elongation in double layer weave structure. From the results obtained, it was seen that double layer structure and additional connection points between the layers could reduce the NPR effect.

In Figure 13, when the effect of single and double layer weaves on the weft directional Poisson's ratios of the B-1 and C-1 coded fabrics woven with non-elastane braid weft yarns was examined, it was seen that the NPR values continued throughout 5 mm elongation.

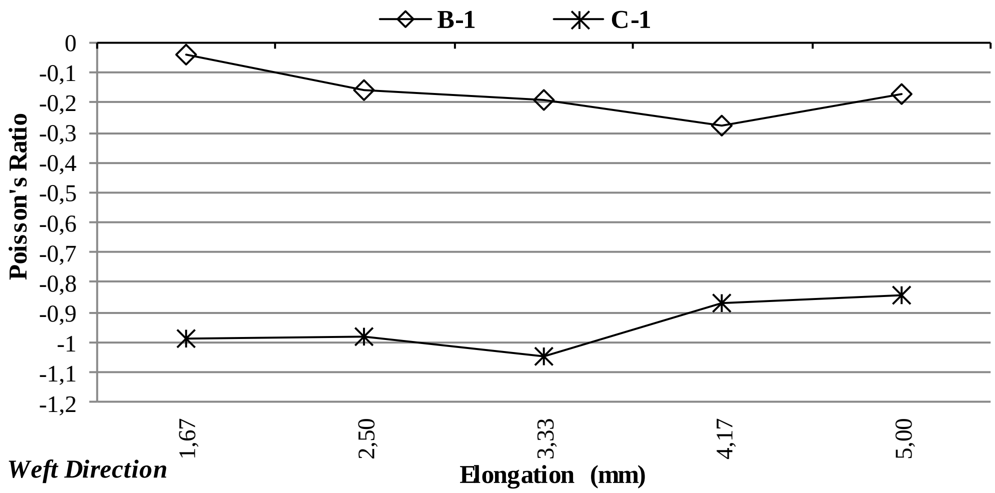


Figure 11. Poisson's ratio–elongation curve of B-1 and C-1 fabrics at weft direction

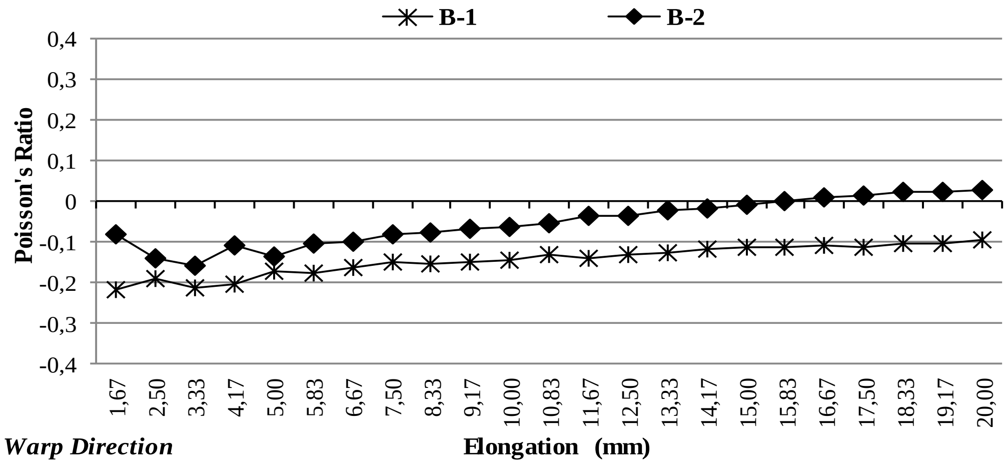


Figure 12. Poisson's ratio–elongation curve of B-1 and B-2 fabrics at warp direction

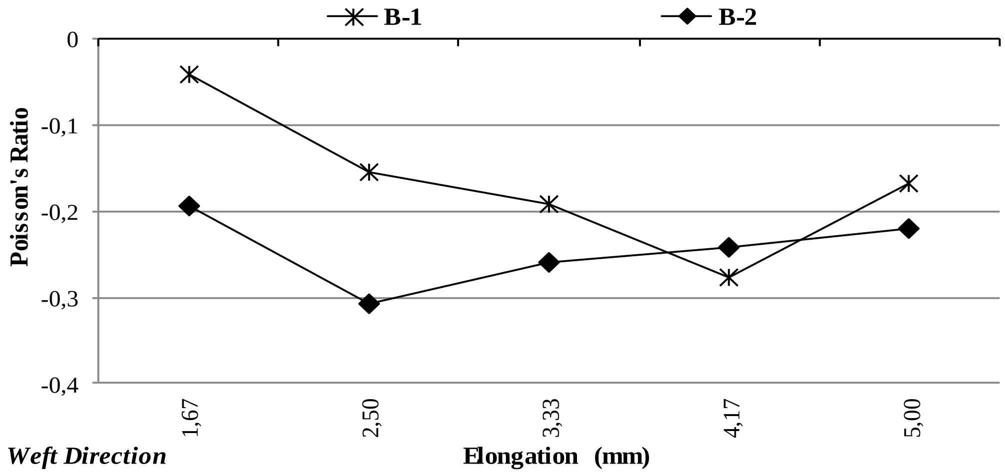


Figure 13. Poisson's ratio–elongation curve of B-1 and B-2 fabrics at weft direction

To evaluate the effects of different weave structures on auxetic performance, the warp and weft directional Poisson's ratio-elongation curves of fabrics woven with non-elastane braid weft yarns in single layer (C-1: plain weave) and double layer (C-2: top and bottom layer are plain weave; C-3: top and bottom layer are 2/1 twill weave) weave structures are presented in Figure 14 and Figure 15.

In Figure 14, when the effect of single and double layer weaves on the warp directional Poisson's ratio of the fabrics woven with non-elastane braid weft yarns was examined, the C-1 coded fabric, which had a single layer plain weave structure showed NPR values throughout 20 mm elongation. The C-2 coded fabric, which had a plain weave on the top and bottom layers, showed NPR values, and Poisson's ratio approached nearly to zero at elongation values of around 20 mm. The C-3 coded fabric, which had a double layer weave structure woven in the top and bottom layer with 2/1 twill weave, gave NPR values up to around 9 mm elongation, and the Poisson's ratio turned to positive values as the elongation continued after 9 mm. The reason for this change can be the lower warp yarn crimp of 2/1 twill weave (Table 1).

Figure 15 shows Poisson's ratio of single and double layer fabrics woven with non-elastane braid weft yarns. The C-1 coded single layer plain weave fabric gave a very high NPR value. In addition, this high NPR values continued throughout 5 mm elongation in weft direction. The C-2 coded fabric, which had a double layer plain weave structure, showed NPR values at initial elongation stage, and the Poisson's ratios turned to positive values as the elongation continued. NPR values were obtained for C-3 coded fabric up to 5 mm weft directional elongation but lower than single layer C-1 coded fabric.

In our previous research [30], positive Poisson's ratios were measured in the weft direction in fabrics woven with non-elastane braid weft yarn. Fabrics used in the previous research were woven on hand weaving looms. The fabrics woven on hand looms had lower warp yarn density and therefore braid weft yarns in the fabric structure did not take measurable yarn crimp. However, as seen in the fabrics examined in this study, the fabrics woven on industrial weaving machines had higher warp yarn density and caused higher crimp in braid weft yarns (Table 1). It was observed, this could cause the weft directional NPR values in fabrics woven with braid weft yarn on industrial looms.

3.2.2 Evaluation of Poisson's ratios of X group fabrics woven with elastane containing braid weft yarns

The auxetic performances of the fabrics woven with elastane containing braid weft yarns were evaluated. Warp and weft directional Poisson's ratio-elongation curves of fabrics woven in single (X-1: plain weave) and double (X-2: top and bottom layer plain weave; X-3: top and bottom layer 2/1 twill weave) layer weave structures are presented in Figure 16 and Figure 17.

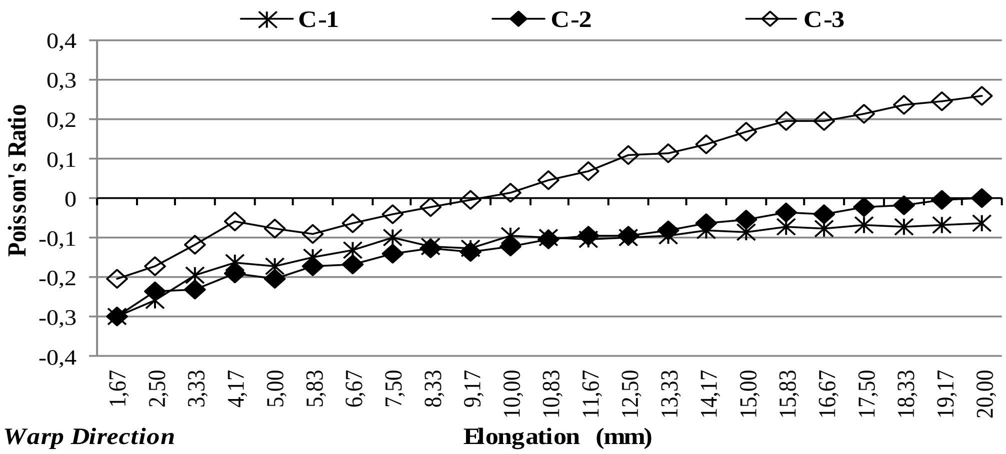


Figure 14. Poisson's ratio–elongation curve of C-1, C-2 and C-3 fabrics at warp direction

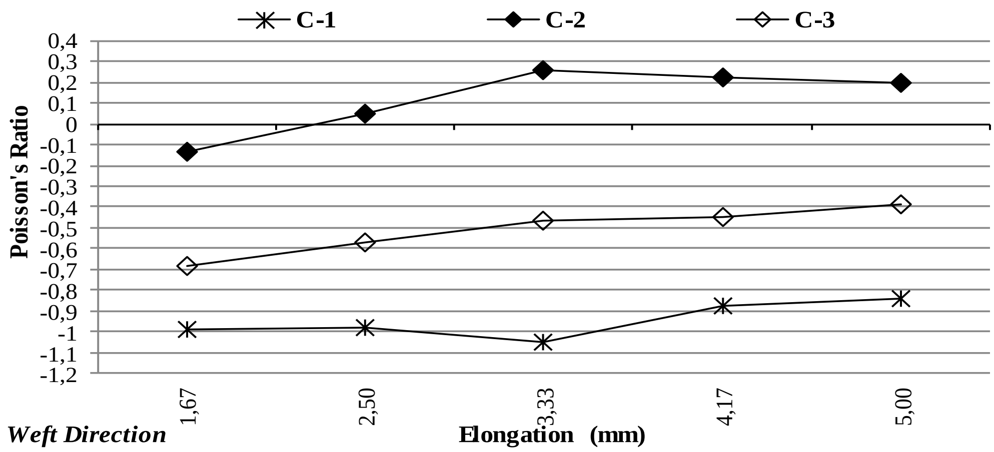


Figure 15. Poisson's ratio–elongation curve of C-1, C-2 and C-3 fabrics at weft direction

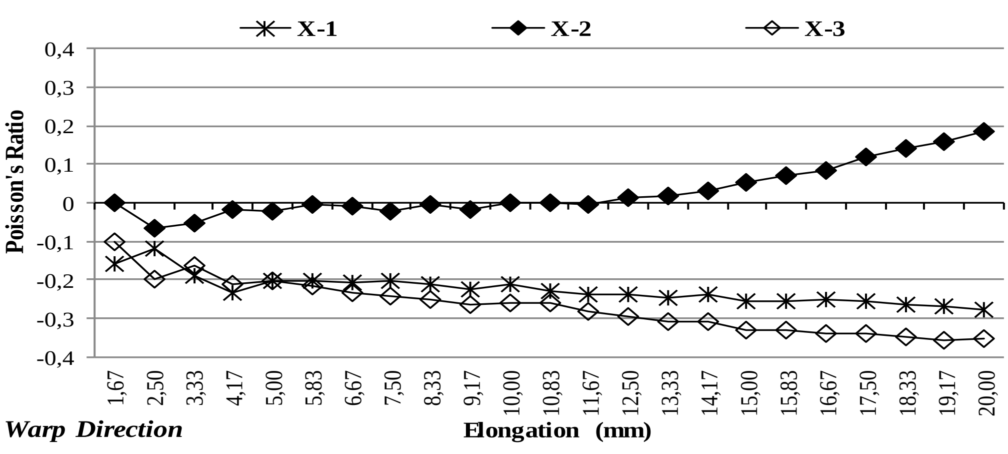


Figure 16. Poisson's ratio–elongation curve of X-1, X-2 and X-3 fabrics at warp direction

In Figure 16, X-1 (single layer fabric woven with plain weave) and X-3 (double layer fabric woven with top and bottom layer 2/1 twill weave) fabrics showed NPR effect throughout 20 mm elongation in the warp direction. X-2 fabric (double layer fabric woven with top and bottom layer plain weave) gave approximately zero Poisson's ratio values under the warp directional elongation until 11.67 mm elongation, and Poisson's ratios showed a positive trend as the elongation continued after this value. It was observed that Poisson's ratios close to zero were obtained in the double layer fabric structure (X-2) woven with elastane containing braid weft yarns, in which the plain weave structure on the top and bottom layers was used. In contrast, NPR values were produced by the fabric structure (X-3) where 2/1 twill weave caused longer yarn floats on the top and bottom layers. This result might be due to the use of a plain weave with high yarn intersections in the top and bottom layers of X-2 coded weave structure and also the formation of a tighter structure due to the effect of the elastane used in the braid weft yarn.

In Figures 14 and 16, when the warp directional Poisson's ratio-elongation curves in fabrics having non-elastane and elastane containing braid weft yarns were examined, NPR values were obtained throughout 20 mm elongation in single layer fabrics with plain weave (C-1 and X-1). However, it was observed that the effect of the weave structure was different in double layer fabrics and the properties of the braid yarns that make up the fabric had an effect on this result. While the NPR effect was observed in the C-2 coded fabric, which had a double layer weave structure woven in plain weave on the top and bottom layers with non-elastane braid yarns, nearly zero Poisson's ratios were observed in the X-2 coded fabric in the same weave structure woven with elastane containing braid yarns. This result suggests that a double layer fabric structure woven with elastane containing braid yarns and with plain weave on the top and bottom layers could limit the effect of transverse expansion under elongation. In addition, it was seen that Poisson's ratio-elongation curve tendencies of the fabrics woven with braid weft yarns containing non-elastane and elastane components (Figure 14 and Figure 16) were different from each other. In Figure 14 and Figure 16, when the effects of the braid weft yarn structure with non-elastane and elastane yarn component on the NPR values were compared, the NPR values of fabrics woven with non-elastane braid weft yarns showed a tendency from negative to positive values under warp directional elongation. In contrast, in the fabric structures woven with elastane containing braid weft yarns (X-1 and X-3 coded fabrics), the NPR values showed a change in negative direction under warp directional elongation.

As could be seen from the NPR results of fabrics woven with elastane containing braid weft yarn, the elastane content had an improving effect on the auxetic performance of the fabrics. Fabrics woven with elastane containing weft yarn contracted in the transverse direction after the weaving process. This contraction effect could create more widening effect of the fabric in the transverse direction under the warp directional elongation of the fabrics. As a result of this, it might significantly affect to improve the auxetic performance of the fabrics.

In Figure 17, when the weft directional Poisson's ratios of the fabrics woven with elastane containing braid weft yarns were examined, it was seen that the NPR effect could be obtained from the fabrics.

To visually present the effect of the change in the transverse direction of the fabrics under elongation, the images of the transverse change of the C-1 and X-1 coded fabrics, which were chosen as the sample under different elongation values up to 20 mm are presented in Figures 18 to 20. In Figures 18-20, the distance between each marker placed on the fabric was measured by manually with the help of an Image J program. Whereas, in calculating the Poisson's ratios given in the all graphics, the distance between each marker was measured with the help of a software developed [36] in MATLAB, and the average values were taken.

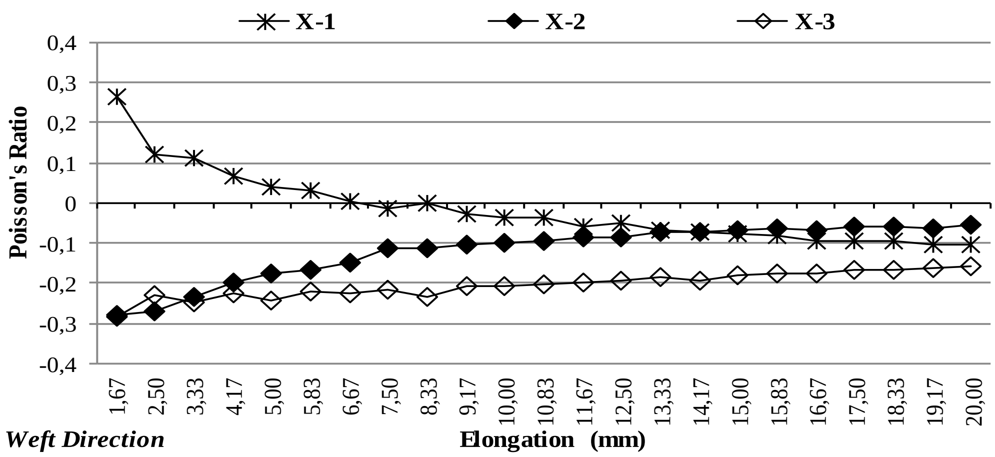
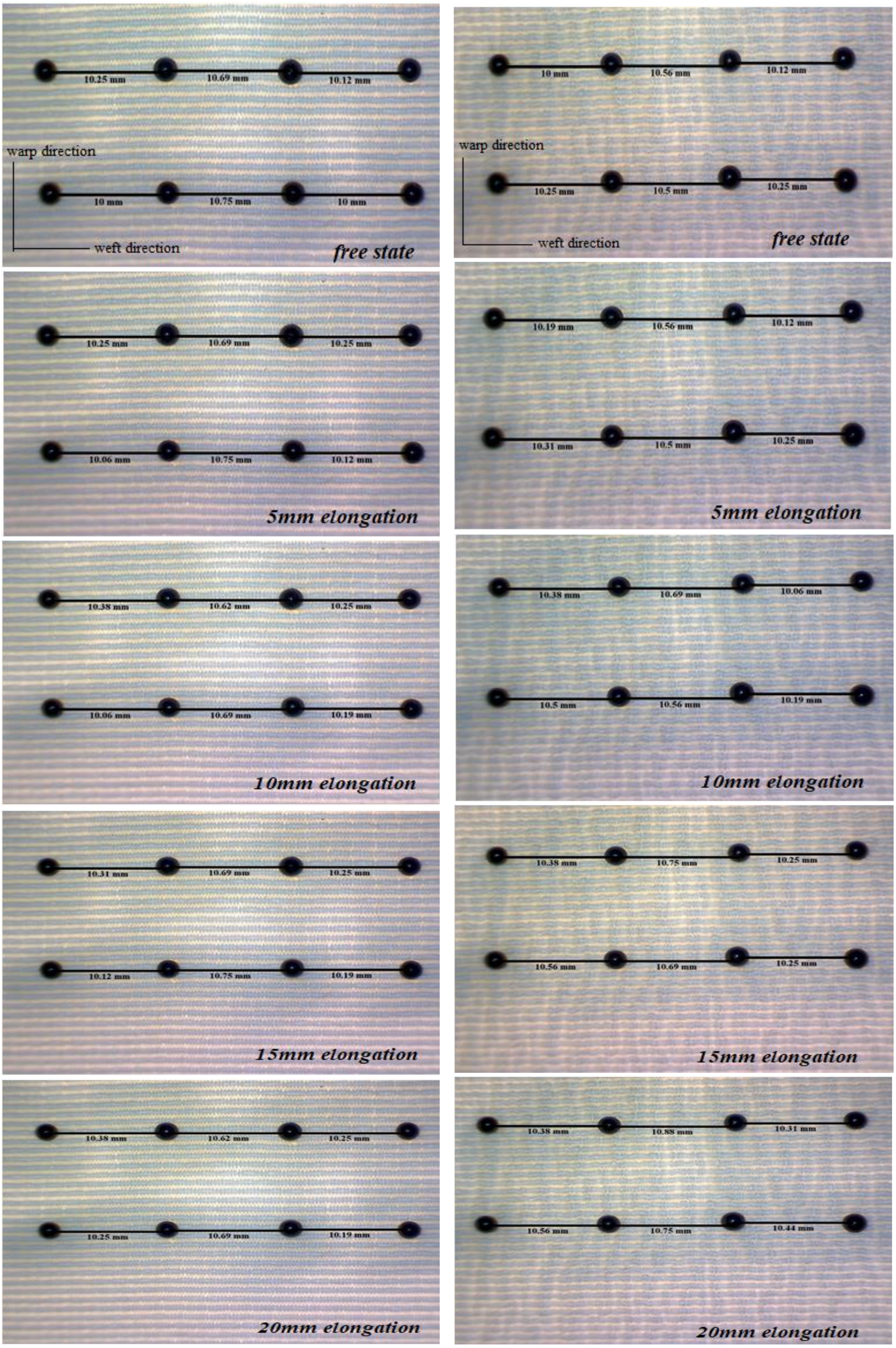
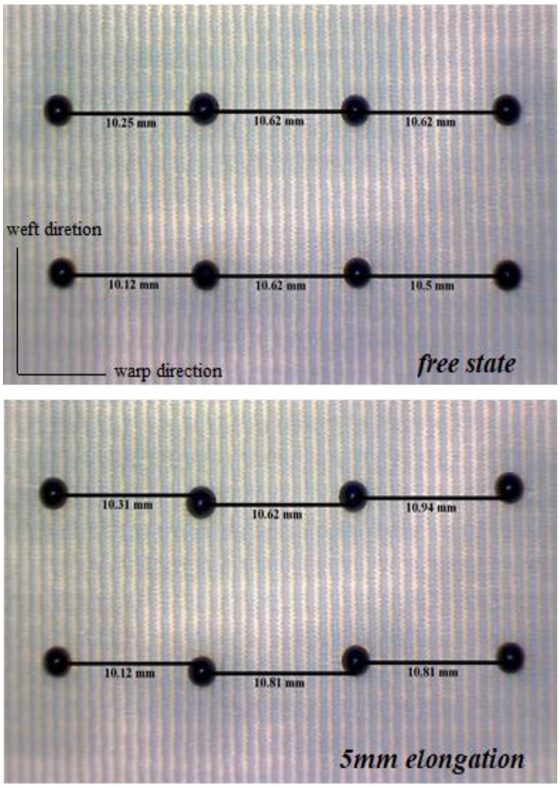


Figure 17. Poisson's ratio–elongation curve of X-1, X-2 and X-3 fabrics at weft direction



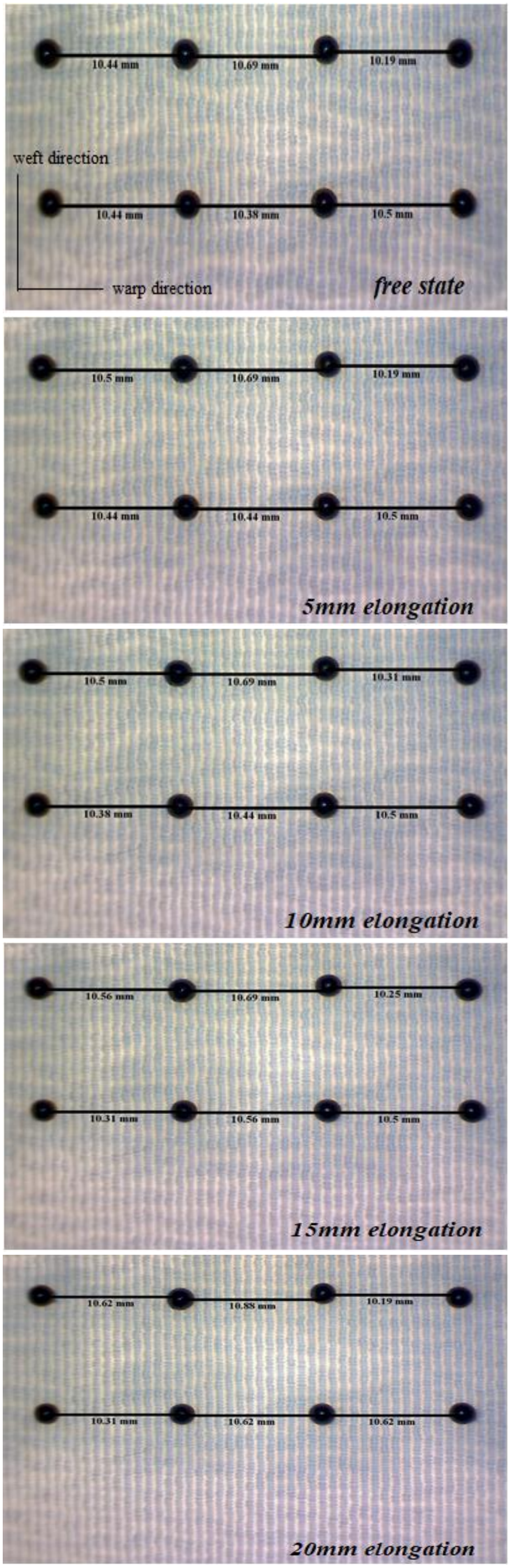
C-1 Fabric **X-1 Fabric**

Figure 18. Changes of the C-1 and X-1 fabrics in the transverse direction under different elongation values in the warp direction



C-1 Fabric

Figure 19. Changes of the C-1 fabric in the transverse direction under different elongation values in the weft direction



X-1 Fabric

Figure 20. Changes of the X-1 fabric in the transverse direction under different elongation values in the weft direction

4. CONCLUSION

This study investigated the auxetic performances of single and double layer fabrics woven using braid yarns with different structural parameters. To investigate the effects of different structural parameters of the component yarns forming the braid weft yarn on the auxetic performance of the fabrics, the fabrics woven with non-elastane braid weft yarns having component yarns with different filament numbers and also with elastane braid weft yarns. To investigate the effect of fabric construction and weave structures, single and double layer fabrics with plain and 2/1 twill weaves were studied. In addition, the production of fabrics was carried out on an industrial weaving machine. Thus, the weaveability of weft braid yarns in industrial weaving machines was observed.

Experimental results showed that the fabrics woven with non-elastane and elastane braid weft yarns both showed an auxetic performance by giving NPR values under warp and weft directional elongations. It was seen that the NPR values continued to exist throughout the 20 mm elongation, especially under warp directional elongation.

When the effect of the filament yarn number of the component yarns forming the braid weft yarn on the auxetic performance of the fabric was examined, the fabric structure woven with braid yarns consisting of component yarns with high filament numbers showed a higher NPR effect.

When a single layer plain weave fabric is compared with a double layer fabric in which the top and bottom layers are plain weave, it was seen that a double layer structure showed a reducing effect on the warp directional NPR values. It was thought that this decrease happened because of the connections between the fabric layers and connection points acted against futher transverse expansion.

When the effects of non-elastane and elastane braid weft yarn structure on the NPR values of the fabrics were compared, the NPR values showed a positive tendency from negative values under warp directional elongation in fabrics woven with non-elastane braid yarns in fabric woven with single layer plain weave. On the other hand, the NPR values under elongation showed increasing absolute values in the fabric structure woven with elastane braid weft yarns. This result might be due to the elastane effect in the fabric structure. It was concluded that the fabric structure which showed more contraction in the transverse direction after the weaving process due to the effect of elastane, behaved in the opposied direction showing widening effect in transverse direction under warp directional force application.

This research has shown that fabric structural parameters and yarn construction could contribute at a significant level to the auxetic behavior of woven fabrics. In designing double layer fabrics, it must be born in mind that connections between the layers reduced auxetic effect of the fabric. For coating fabrics auxetic effect might be helpful to obtain higher covered area under tension during the processing. For some technical applications of woven fabrics auxetic behavior can be exploited and this could be considered in fabric design for such applications.

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