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Study of the Physical Characteristics for Stretchable Denim Fabrics

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ABSTRACT

In this study the effects of fabric parameters such as fabric weight (GSM), lycra content and weave on characteristics of stretchable denim fabric was studied. The physical and stretch properties such as thickness, tensile strength, flexural rigidity, stretch properties (stretch, growth and elastic recovery) and air permeability of the fabrics were tested. The test result revealed that increasing the fabric weight enhances the comfort and performances of the fabric except the fabric flexural rigidity and air permeability. As Lycra contents in fabric increases flexural rigidity of fabric increased but breaking strength in weft and air permeability get reduced. The different fabric constructional weave has also diverse effect on fabric flexural rigidity and air permeability related to comfort and performance of stretchable denim fabric. Furthermore, increasing in crimp in fabric structure increase the flexural rigidity and decrease in air permeability.

Keywords: Stretch denim, Lycra content, Tensile strength, Flexural rigidity, Stretch

1. INTRODUCTION

The traditional denim is hard-wearing, heavy fabric made from 100% cotton and woven from coarse indigo dyed warp and grey undyed weft yarn. Traditional denim fabric is high density fabrics with a high mass per unit area and a 3/1 or 2/1 -twill weaves construction [1]. Denim has always been used for very durable outdoor work clothing because of its weight, rigidity, and thickness, denim is chosen for casual jackets, skirts, and jeans. Now that so many garment-finishing techniques are applied to denim, its use has broadened into different lifestyles. Now days lycra yarn is added to denim to make the denim elastic [2, 3]. A 1–5% lycra blend with cotton will stretch the fabric over the body for a more comfortable fit [4]. Core spun yarn used as a filling yarn in which core part is lycra filament and sheath fibers cotton is used [5,6]. The performance and comfort factors of garments during usage are very important. Generally, the comfortable stretching of fabrics according to body movements as well as recovery after stretching, are good desirable properties [7,8]. Denim fabrics are woven by interlacing two sets of yarns perpendicular to one another in fabric form. Yarns in the machine direction are called warp yarns or warp ends, and these are interlaced with filling yarns or picks. The sequence or order of interlacing the two sets of yarns can be varied to produce many different weave designs [9]. The finished fabric construction is determined by the number of warp and filling yarns per square inch or centimeter. The yarn counts used will influence fabric properties such as weight, fabric tightness, cover, drape, hand, tensile strength, tear strength, and other fabric properties [10, 11].

Studied the effects of lycra rates on physical and stretch properties of the denim fabric [12]. The results obtained in this study indicated that the amount of lycra has a significant influence on physical and elastic properties of woven fabrics. Fabric contraction increases with the increase in lycra rate. Fabric tensile strength decreases with lycra rate, while fabric breaking elongation increases because of the higher elongation of lycra fibers. Air permeability and tearing strength decreased significantly with the increase in lycra rate. This is because the fabrics will be thicker and more compact with the increase in lycra rate in the woven fabrics. Statistical analysis proved that maximum stretch and fabric elastic recovery increases with lycra rate inside fabric. On the other hand, there is a negative relationship between lycra rate and fabric growth. Studied on the effect of spandex ratio on different fabric physical and mechanical properties such as: breaking strength, breaking extension, shrinkage %, fabric growth and air-permeability [4]. The findings of this study revealed that the ratio of lycra had a significant influence on the physical properties of woven fabrics. Ozdil was studied about the stretch and bagging Properties of denim fabrics containing different rates of elastane. The aim of this study was to investigate the effects of elastane content in denim fabrics on the performance properties of the fabrics. The test results revealed that increasing the amount of elastane usage in denim fabric offers enhanced comfort properties. Studied on effect of weave structure and weft density on the physical and mechanical properties of micro polyester woven Fabrics. The statistics analyzed the effects of weft density and weave structures on the physical and mechanical properties of these fabrics were investigated.

The aim of this work is to investigate the effects of different fabric weight (GSM), lycra content% and fabric weave of stretchable denim fabrics on its physical and stretch properties of the fabrics. For this purpose, the different properties of denim fabrics, including various amounts of elastane content incorporated into core spun yarns in the weft direction were measured.

2. MATERIALS AND METHOD

2.1 MATERIALS

Commercially available three types of denim fabrics varying in the fabric weight, lycra content percentage and fabric design weave are taken into consideration for this study. The details of denim fabrics are given in tables 1, 2 and 3.

Table 1. Characteristics of denim fabrics varying in the fabric weight (GSM)

Fabric weight (GSM)	Lycra content (%)	Fabric weave	Thread density (per inch)		Linear density (Ne)	
			Warp	Weft	Warp	Weft
290	1.5	3/1 RHT	92	59	18	14
340	1.5	3/1 RHT	84	63	10	14
380	1.5	3/1 RHT	91	69	10	16

RHT- Right hand twill

Table 2. Characteristics of denim fabrics varying in lycra content percentage

Lycra content (%)	Fabric weight (GSM)	Fabric weave	Thread density (per inch)		Linear density (Ne)	
			Warp	Weft	Warp	Weft
1.0	340	3/1 RHT	82	50	10	10
1.5	340	3/1 RHT	80	50	8	14
1.7	340	3/1 RHT	83	54	10	16

Table 3. Characteristics of denim fabrics varying in the fabric weave

Fabric weave	Fabric weight (GSM)	Lycra content (%)	Thread density (per inch)		Linear density (Ne)	
			Warp	Weft	Warp	Weft
(3/1,4/1) Combination twill	340	1.5	90	56	10	16
(3/1,2/1) Combination twill	340	1.5	144	56	20	12
3/1 RHT	340	1.5	146	56	20	12

2.2 TEST METHODS

2.2.1 Compressibility and compression recovery percentage-

The thickness of stretchable denim fabric was measured using thickness tester (Karl Schroder KG) under 0.5 kPa pressure following BS EN ISO 9073-2: 1997. For the assessment of fabric compressibility, fabric compression recovery and fabric thickness were also measured at higher pressure (4.0 kPa). Compressibility and compression recovery percentage can be obtained using the following expression:

(i) $$\text{Compressibility\%} = \frac{t1-t2}{t1} \times 100$$

Where, t_1: Media thickness at 0.5 kPa, t_2: Media thickness at 2.0 kPa

(ii) $$\text{Compression recovery\%} = \frac{t3-t2}{t1-t2} \times 100$$

Where, t_1: Media thickness at 0.5 kPa, t_2: Media thickness at 2.0 kPa and t_3: Media thickness at 4.0 kPa.

2.2.2 Flexural rigidity- The flexural rigidity is the measure of fabric stiffness. Denim fabrics are tested for flexural rigidity as per ASTM standard D1388−08 on the basis of principle is cantilever bending of the fabric under its own mass. The test was done on Cantilever Bending Tester. Fabric flexural rigidity is calculated by following expression:

$$\text{Flexural rigidity} = W \times C^{3} \text{ mg-cm}$$

Where, W is fabric weight in g/cm^2, C is bending length in cm.

2.2.3 Breaking strength and breaking elongation percentage - Breaking strength and extension percentage is tested on tensile testing machine at a speed of 300 mm/min. Fabric sample with 25 mm × 150 mm gauge length as per ASTM standard D5035−11 was taken. Ten tests are for each sample.

2.2.4 Stretchable properties- Fabric stretchability properties are related with fabric stretching percentage, fabric growth percentage and elastic recovery percentage. Fabric stretchability properties are tested as per ASTM standard D3107−07. Fabric stretching, fabric growth and elastic recovery values were calculated from these measured outcomes, as follows:

(i) Fabric stretching % = $\frac{B-A}{A} \times 100$

(ii) Fabric growth % = $\frac{C-A}{A} \times 100$

(iii) Elastic recovery % = $\frac{B-C}{B-A} \times 100$

Where, 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) and C: The distance between the marked points after 1-hour relaxation.

2.2.5 Air permeability- Fabric air permeability tests were performed on machine model FX 3300 as per ASTM D737 standard. Total ten readings were taken from each fabric. Read and record the individual test results in SI units as cm^3/cm^2/s.

2.2.6 Fabric weight in gram per square meter- The weight of stretchable denim fabric was measured according to ASTM standard of D6242. The measurement had done with the help of an electronic weighing balance of 0.01 g of accuracy.

3. RESULTS AND DISCUSSION

3.1 Effect of fabric weight (GSM)) on physical and stretch properties of denim fabric

3.1.1 Effect of fabric weight on breaking strength

The effect of fabric weight (GSM)) on breaking strength on both direction of warp and weft fabric is shown in figure 1. It observed that as increasing the fabric weight, the breaking strength of fabric also increases in warp and weft direction. Warp crimp will increase with increase weft density of the fabric. Therefore, higher breaking strength in warp direction than weft direction and this can be explained by the fact that when the load is applied on the test specimen first de-crimping of the yarn is happen then after load wear on the breaking of the yarn in the fabric. Furthermore, increase in weft density and finer yarn in weft direction increase the strength but it's lower than warp due to increased lycra weightage in higher fabric weight (GSM). It is known that lycra is having lower tenacity than cotton fibers.

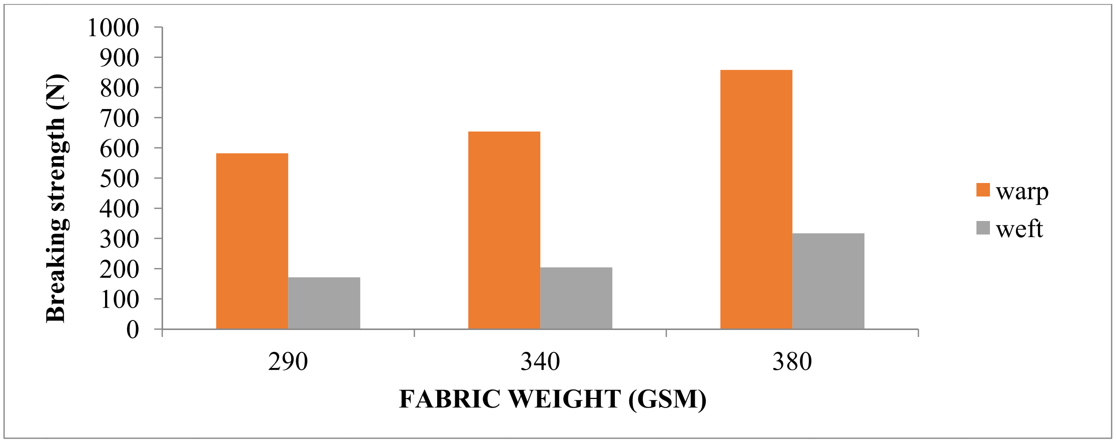

Figure 1. Effect of fabric weight (GSM) on breaking strength

3.1. 2 Effect of fabric weight (GSM) on breaking elongation

The breaking elongation behavior of fabric on both warp and weft direction in respect of their fabric weight are shown in figure 2. It is observed that as increase in fabric weight increases the breaking load of fabric and also increases the breaking elongation percentage in warp direction. At the same time, as increases the fabric weight in weft direction, breaking elongation decreases of fabric. Higher cover factor and coarser warp yarn increases restriction over extension of the fabric in weft direction by offered more inter yarn frictional forces in the fabric. Hence, it is clearly exhibited due to the presence of lycra fiber, which bears lower tensile strength than cotton sheath fiber. It is clearly found that the presence of lycra and its increasing weightage in fabric decreases the breaking elongation but increases stretchability of fabrics.

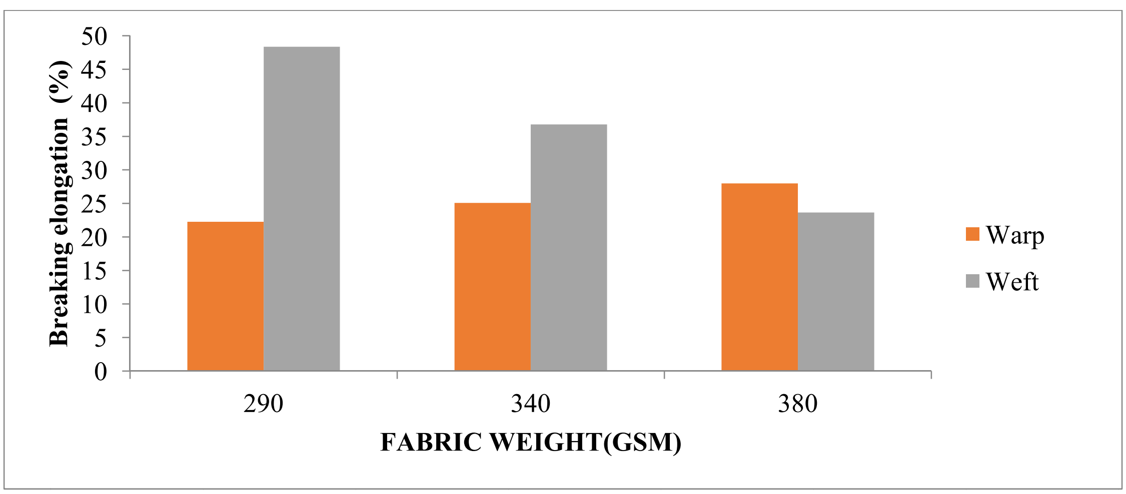

Figure 2. Effect of fabric fabric weight (GSM) on breaking elongation

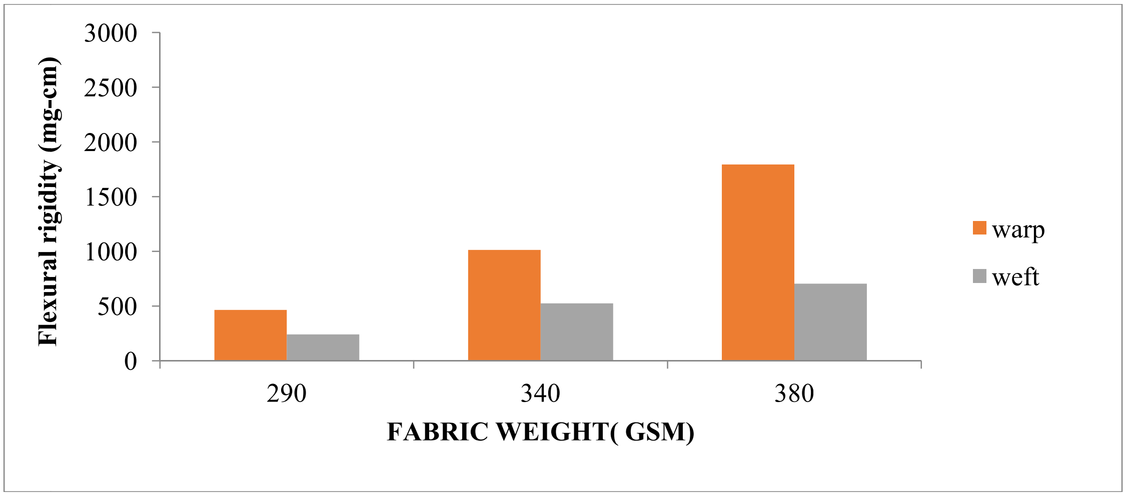

Figure 3. Effect of fabric fabric weight (GSM) on flexural rigidity

3.1.3 Effect of fabric weight (GSM) on Flexural rigidity

The effect of fabric weight (GSM)) on flexural rigidity of stretchable denim fabric in both the direction warp and weft is shown in figure 3. It is observed that the increase in fabric weight (GSM)) significantly increases the flexural rigidity more in warp than the weft direction of fabric. Fabric flexural rigidity is directy propotional to the fabric weight (GSM) of the fabric. More number of thread per inch largely increases the bending rigidity of fabrics. It is also observed that flexural rigidity substantialy increases at higher fabric weight (GSM) (380 gm) in warp direction as the reasons of change in warp density, thicker thread and at the same time higher waviness and consolidation of warp threads by the interlacement of weft thread with increased lycra in yarn structure resulting increases bending resistance of fabrics. It is observed that the lesser increasement in PPI, finer weft yarn and also lycra in the weft thread, reflected to smaller change in flexural rigidity in weft direction than the warp direction.

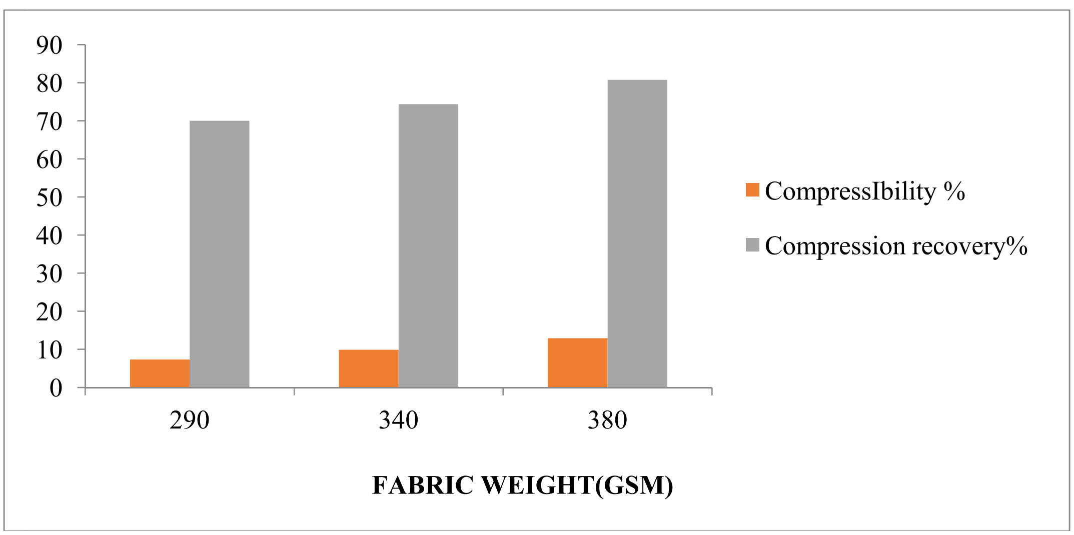

Figure 4. Effect of fabric weight (GSM) on compressibility and compression recovery

3.1.4 Effect of fabric weight (GSM) on Compression recovery and compressibility

The effect of fabric weight (GSM) on the commpresssibility and compression recovery properties of stretchable denim fabric is shown in figure 4. As fabric weight (GSM) increases, the commpresssibility and compression recovery% of stretchable denim fabric also increases. It is understod that more the textile substrate/weight in the structure, more thickness and resilience behaviour of fabrics, which responses larger compression behaviour of stretchable denim fabric. Compression recovery% is higher in higher fabric weight (GSM) fabric is due to increased content % of lycra fibre in structure . So, it is observed that the larger% of crimps developed in higher fabric weight (GSM) fabric due to increased weft density, lycra content in weft yarn make fabric bulkier.

3.1.5 Effect of fabric weight (GSM) on Air permeability

The effect of fabric weight (GSM) on air permeability on denim fabric is shown in figure 5. The decreasing trend is observed for air permeability as fabric weight increases. The lower fabric weight (GSM) fabric is having lowered the ends and picks per inch and lowers the fabric thickness. So, less resistance to air flow is provided by the fabrics. In higher fabric weight (GSM) fabric, higher the ends and picks per inch and higher thickness of fabrics are provided higher resistance to air flow. So, it observed very less air permeability.

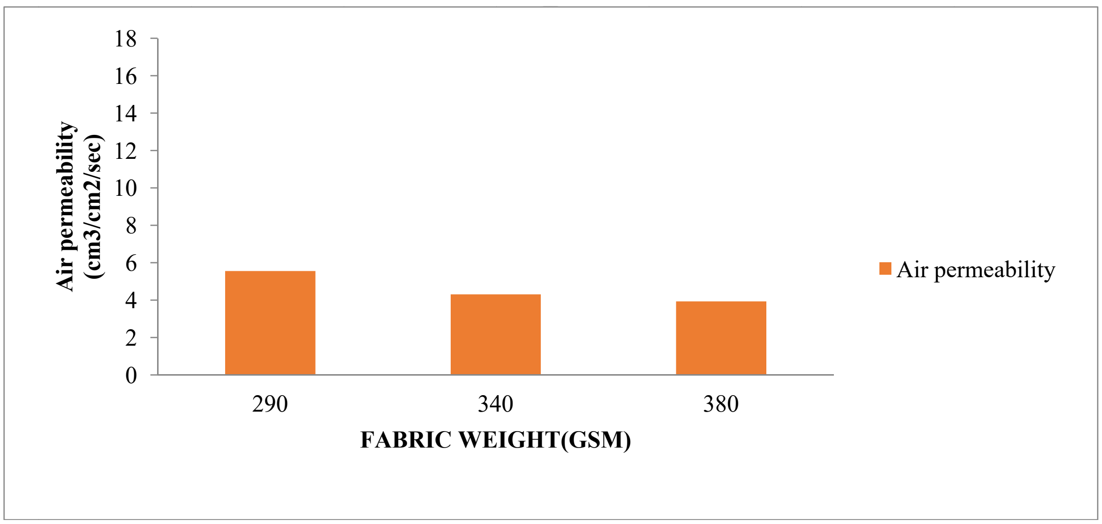

Figure 5. Effect of fabric weight (GSM) on air permeability

3.1.6 Effect of fabric weight (GSM) on Stretchable properties

The effect of fabric weight (GSM)) on stretchable properties of denim fabric is shown in figure 6. It is observed that as the fabric weight increases the stretch and fabric growth% decreased but fabric recovery tends to increases. In higher fabric weight (GSM) fabric PPI is increases. When load is applied on the fabric the inter yarn friction from lower fabric weight (GSM) to higher fabric weight (GSM) fabric increases. So, fabrics stretch and recover more at lower fabric weight (GSM) and vice versa. Fabric recovery and growth value are inversely proportional to each other and lower PPI and presence of lycra in lower fabric weight (GSM) give the lower fabric growth. Lycra effect can be explained by the elastane yarn bears a soft, rubbery isocyanate segment, which has more random coils in yarn structure. So, it controls and reduces the bagging / growth of stretchable fabric.

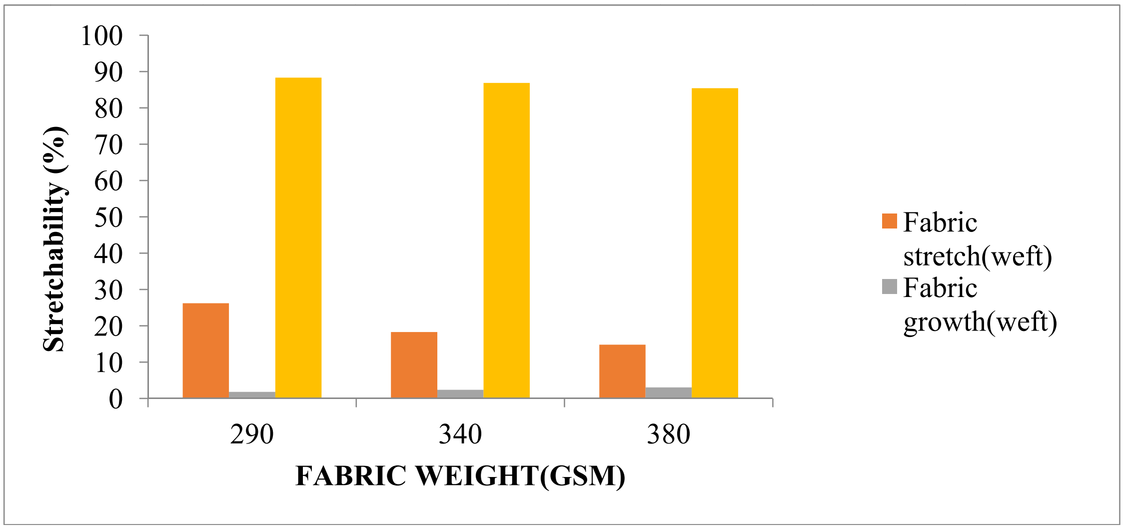

Figure 6. Effect of fabric weight (GSM) on stretchable properties

3.1.7 Effect of fabric weight (GSM) on Stretchable properties after cycling loading

The effect of the cycling loading on stretch, growth and recovery% on stretchable denim fabric varying fabric weight (GSM) in weft direction is shown in figure 7. It is observed that all stretchable properties influenced by the lycra, the stretch and growth both decreases and fabric recovery increases as increase in fabric weight (GSM).

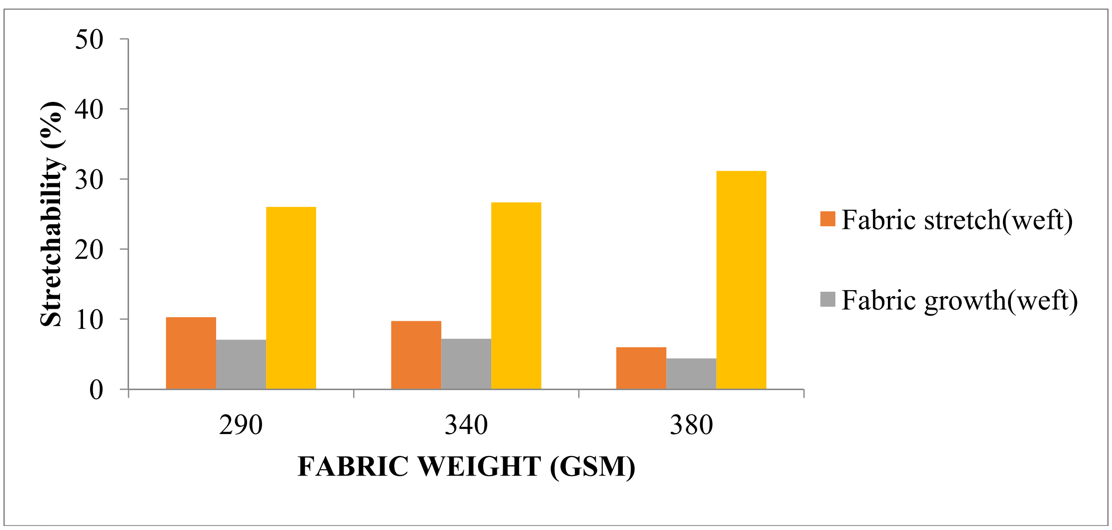

Figure 7. Effect of fabric weight (GSM) on stretchable properties after cycling loading

In cycling loading test fabric stretch and growth decrease as fabric weight (GSM) increase. As we discussed earlier that more is weft density in fabric more is inter yarn friction and that will resist the yarn moment under the load. After, applying the no. of cycles on fabric the more is permanent set and less recovery at lower fabric weight (GSM) of fabric and as fabric weight (GSM) increase the weightage of lycra also increase and that will give the more recovery and less fabric growth.

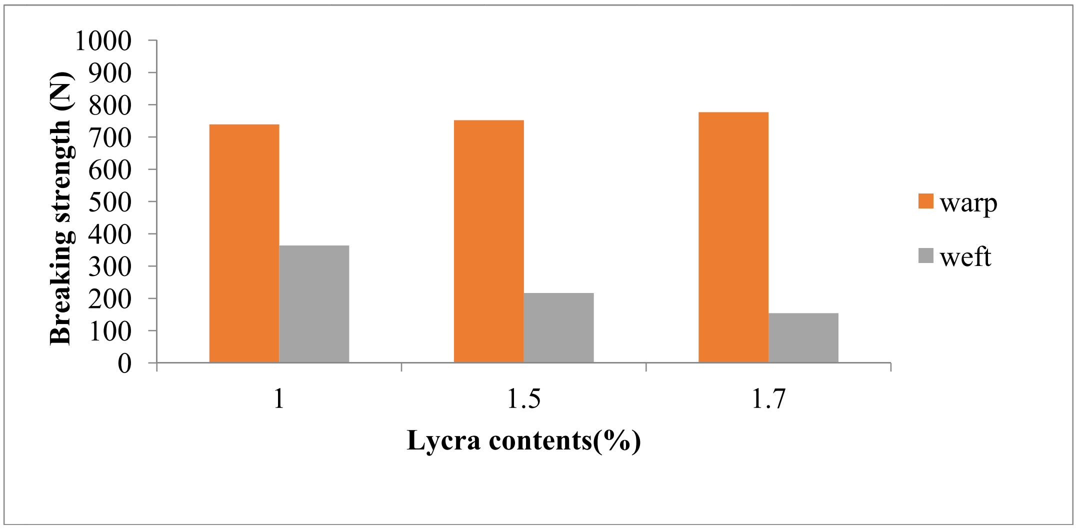

Figure 8. Effect of fabric lycra content percentage on breaking strength

3.2 Effect of Lycra percentage on physical and stretch properties of denim fabric

3.2.1 Effect of Lycra percentage on breaking strength

The effect of lycra content percentage on weft direction showed the significant effect than warp direction. The figure 8 reveal that as lycra contents increases there is very small change in breaking strength of warp wise. The effect of lycra content on breaking strength mainly show only effect on weft of fabric and this is due to lycra yarn used in weft direction only. So, there is small increment in breaking strength in warp of the fabric. The effect of lycra content on weft direction shows the decrease in breaking strength due to presence on lycra in weft only. A decreasing trend is detected confirming that as the amount of lycra increases, the tensile strength of the denim fabrics decreases. This is due to the lower tenacity of lycra fibers compared to cotton fibers. It found that more lycra content in fabrics reduces the fabric breaking strength than cotton-based fabrics. This is one of the negative attributes of lycra fibers.

3.2.2 Effect of Lycra percentage on breaking elongation

It is revealed that as lycra contents increases there is very small changes with decreasing trend observed in warp direction and significant increasing trend in weft direction (Figure 9). The very small changes in fabric breaking elongation percentage in warp direction as lycra content percentage increase because lycra only present in weft yarn. The lycra content% in weft yarns showed the significant changes in extension percentage. This is happened as the breaking elongation of lycra fibers (500%) was higher than that of cotton fibers (7%). Hence, the fabric breaking elongation increases with the increase in lycra content in fabrics.

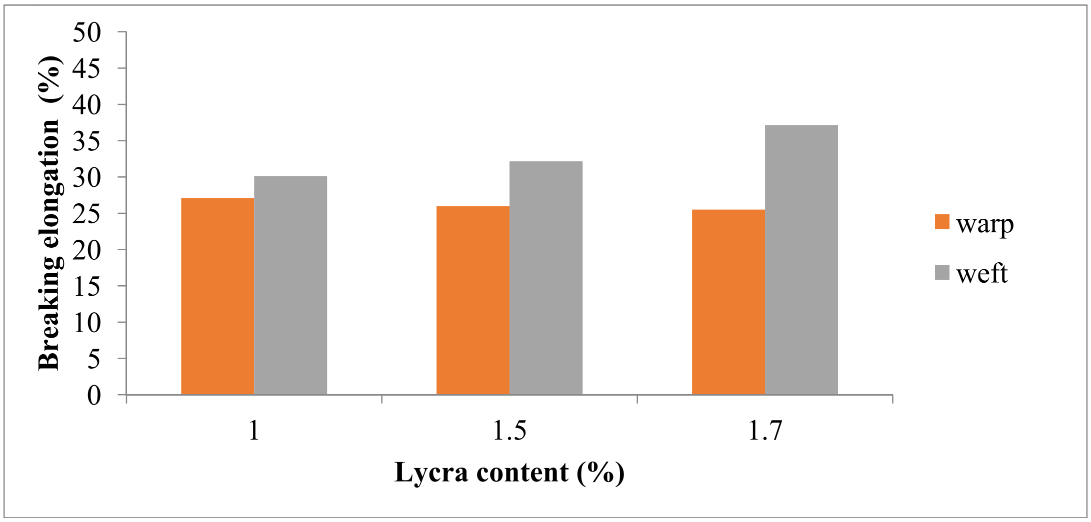

Figure 9. Effect of fabric lycra content percentage on breaking elongation

3.2.3 Effect of Lycra percentage on flexural rigidity

The experimental outcomes showed that the flexural rigidity of denim fabrics increase with an increase in lycra content in warp and weft direction of stretchable denim fabric (Figure 10). Therefore it can be stated that the fabric handle becomes stiffer as the lycra content in the structure of the fabric increases. As discussed earlier weft yarn containing lycra having coil like structure and its tendencing to recover to its length, so the warp yarn come closer and making contraction in fabric.Therefore, the larger flexural rigidity is observed in warp direction than weft direction of fabrics . It is observed that the handle preoperies of fabrics is became harsher as increases the lycra content in fabric matrix.

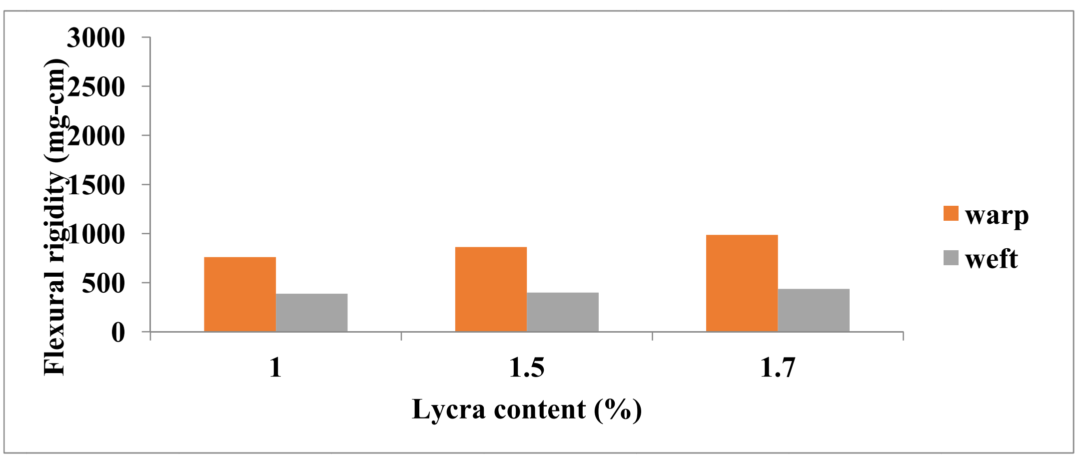

Figure 10. Effect of fabric lycra content percentage on flexural rigidity

3.2.4 Effect of lycra content percentage on compressibility and compression recovery

It is observed from figure 11 that increase in lycra content in weft yarn significantly affects the compression and compressibility properties. It can be stated that the fabric handle becomes stiffer as the elastane ratio in the structure of the fabric increases. The warp yarn is coarser then weft yarn and weft yarn contaning lycra behave like a spring and its tendencing to recover to its length so, weft yarn come closer making contraction in fabric and increase in fabric thickness.

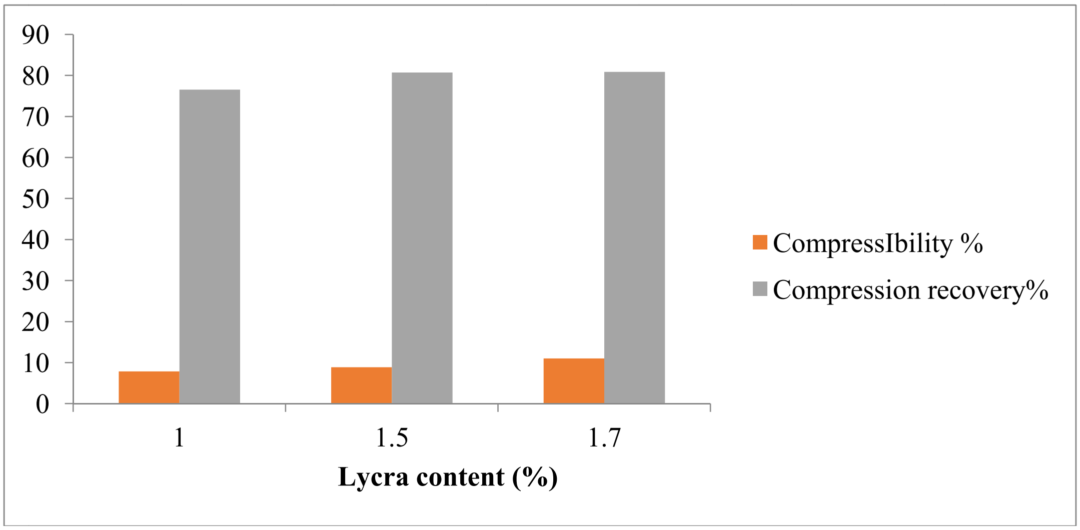

Figure 11. Effect of lycra content percentage on compressibility and compression recovery

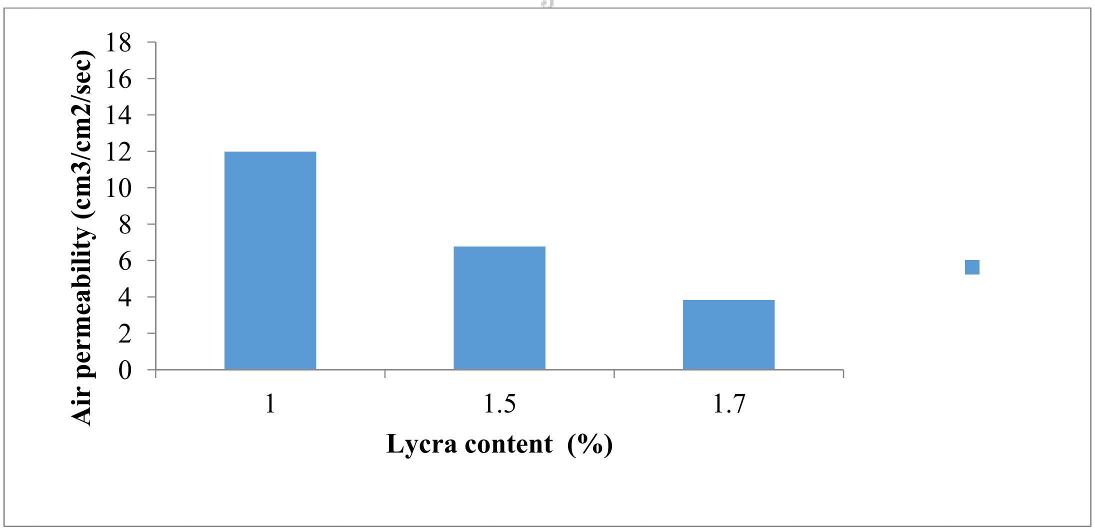

Figure 12. Effect of lycra contents percentage on air permeability

3.2.5 Effect of Lycra percentage on Air permeability

The effect of lycra content on air permeability of denim fabric is shown in figure 12. The lycra content has a profound effect on fabric air permeability. The higher value of air permeability is observed in lower value of lycra content and its value reduced as lycra content increases. The significant influence of lycra content on air permeability may be due to the lycra content in the weft yarn, which in turn leads to the contraction of woven fabrics and it becomes more thicker and compact and less permeable to flow of air.

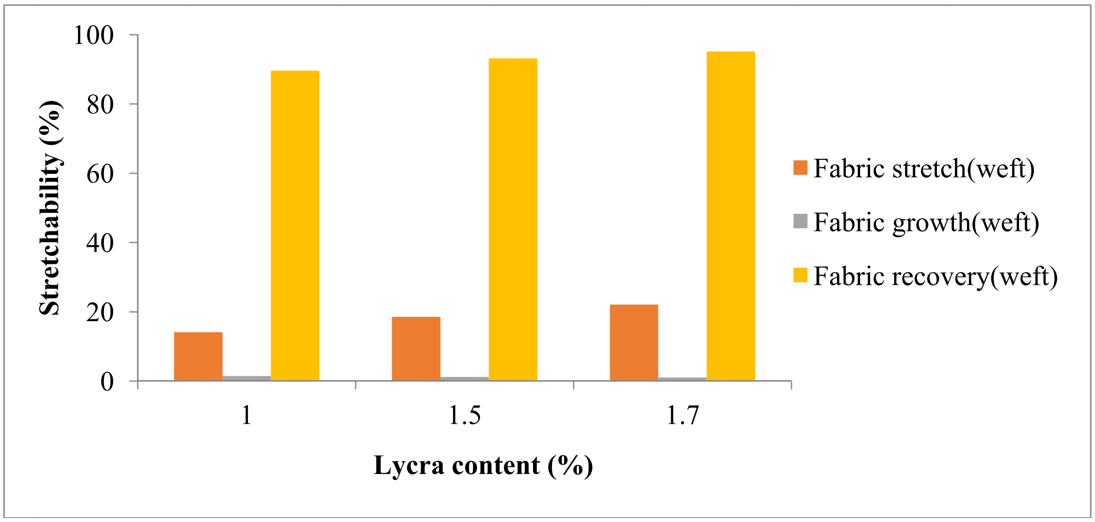

Figure 13. Effect of lycra content percentage on stretchable properties

3.2.6 Effect of lycra content percentage on stretchable properties

Figure 13 depicted the maximum stretching, growth and the elastic recovery values. The experimental outcomes revealed that as the lycra content in denim fabric increases; the maximum stretching and elastic recovery percentage increases, whereas the fabric growth percentage decreases. This trend shows that as the lycra content increases the maximum stretch of the fabric increases. The significant influence of lycra rate on maximum stretch is due to the 500% extension of lycra fibers. Lycra content and elastic recovery assuring that as the lycra contents increases the elastic recovery increases also. These results were to be expected because the lycra in the yarn behaves like a spring, which tends to return to its original length after stretching. As with a spring, the recovery of core-spun lycra yarn is not 100% because the cotton fibers in the sheath of the weft yarn exert transversal pressure on the lycra core and prevent the recovery of the yarn. As the lycra rate increases the fabric growth decreases. Lycra rate on fabric growth can be attributed to the higher extensibility of the elastic complex yarn, which associated with higher lycra amount.

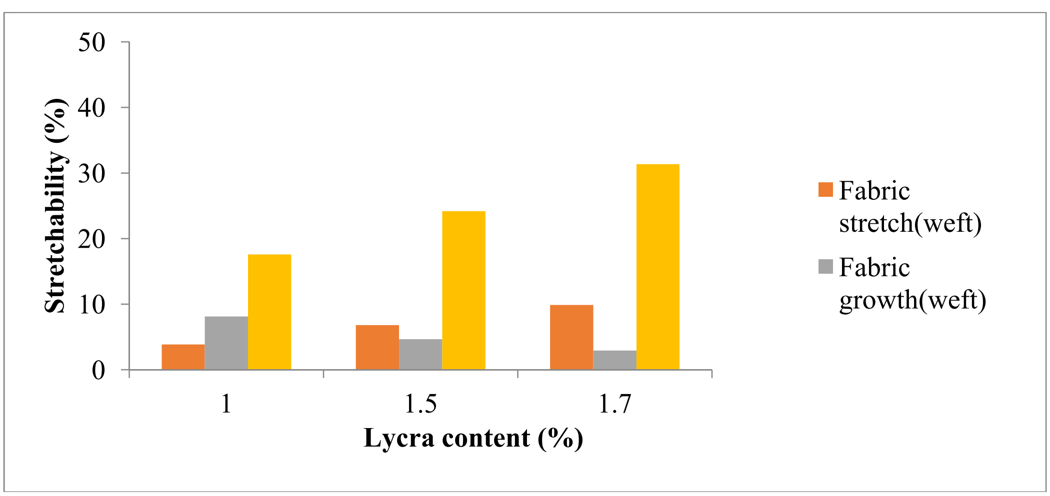

Figure 14. Effect of lycra content percentage on stretch properties after cycling loading

3.2.7 Effect of Lycra percentage on stretch properties after cycling loading

Figure 14 show the effect of cycling loading on stretchable properties of stretchable denim fabric varying lycra content in weft only. As figure shows that fabric stretch and growth percentage tends to decrease and fabric recovery increases as lycra content in fabric increases. As it has been discussed earlier in effect of lycra content percentage on stretchable properties that increasing the lycra content increase the stretch and recovery percentage but decrease in fabric growth percentage. However, the values of stretchable properties (stretch, growth and recovery) in cycling loading test are less than simple stretchable testing. The effect of cycling loading may develop more growth and less recovery in fabric.

3.3. Effect of fabric weave on physical and stretch properties of denim fabric

3.3.1 Effect of fabric weave on breaking strength

The breaking strength of both warp and weft direction of fabric design is minimum for (3/1,4/1) combination twill then increases for (3/1,2/1) combination twill to right hand twill (3/1) RHT (Figure 15). The weave pattern in woven fabrics largely affects the breaking strength. In warp of the fabric warp density is much higher than weft and lycra presence in weft. So, breaking strength is higher in warp than weft of fabric. Fabric weaves with high number of interlacing in (3/1) RHT can transfer the tensile stresses at the cross over points during the applied load and therefore have higher breaking strength than fabric with more floats in weave repeat.

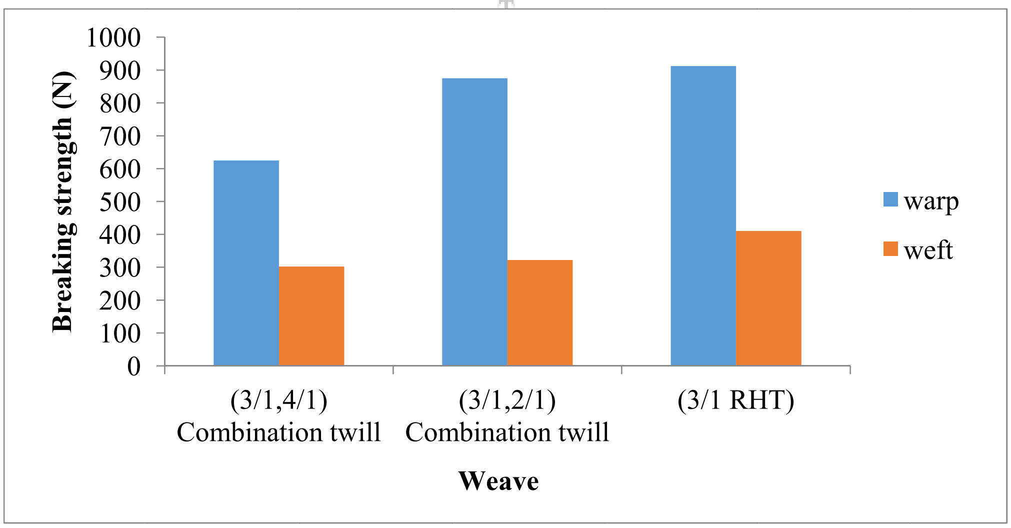

Figure 15. Effect of fabric weave on breaking strength

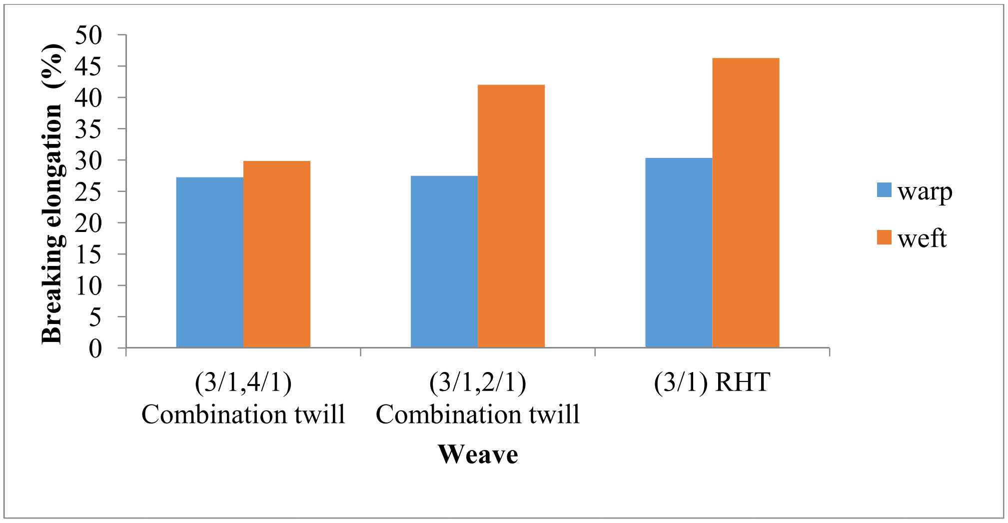

Figure 16. Effect of fabric weave on breaking elongation

3.3.2 Effect of fabric weave on breaking elongation

The warp breaking elongation is lower than weft due to less crimp present in warp of fabric. There are three stages for the extension mechanism (Figure16). The Change in breaking elongation is influenced by frictional resistance (inter yarn friction). The de-crimping region resulting from the straightening of the yarn set in the direction of application of load and the associated increase in crimp in the direction perpendicular to the yarn direction. This is commonly referred to as "crimp interchange". It is observed that smaller float and more interlacements in case of right-hand twill (3/1) RHT is attributed to higher breaking elongation of fabrics.

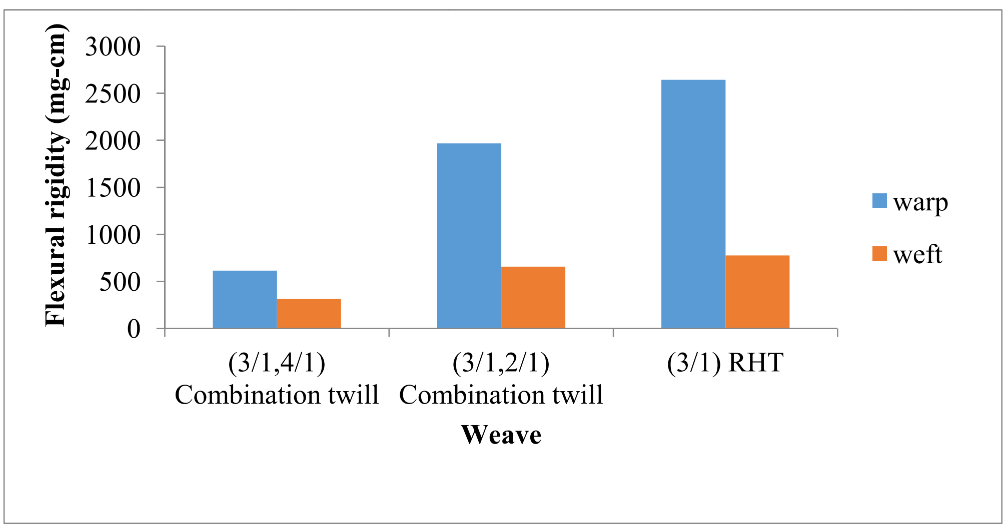

Figure 17. Effect of fabric weave on flexural rigidity

3.3.3 Effect of fabric weave on flexural rigidity

It is studied that the change in fabric flexural rigidity follows the decending order from (3/1,4/1) combination twill, (3/1,2/1) combination twill to (3/1) RHT (Figure 17). The more is warp density than weft give the higher rigidity in warp of the fabric. Weft rigidity increases due to less number of floats, more is intersecting point in structure, that makes compact structure of fabrics. Fabric weaves, which have a higher number of intersections in the repeat, tend to have high crimp and produce a rough fabric. On the other hand, long floats, however, produces smooth fabrics with low crimps levels. Fabric is having long floats allows yarns to move more easily over one another at the cross-overs in fabric matrix. So,fabric with high crimp shows more flexural rigidity.

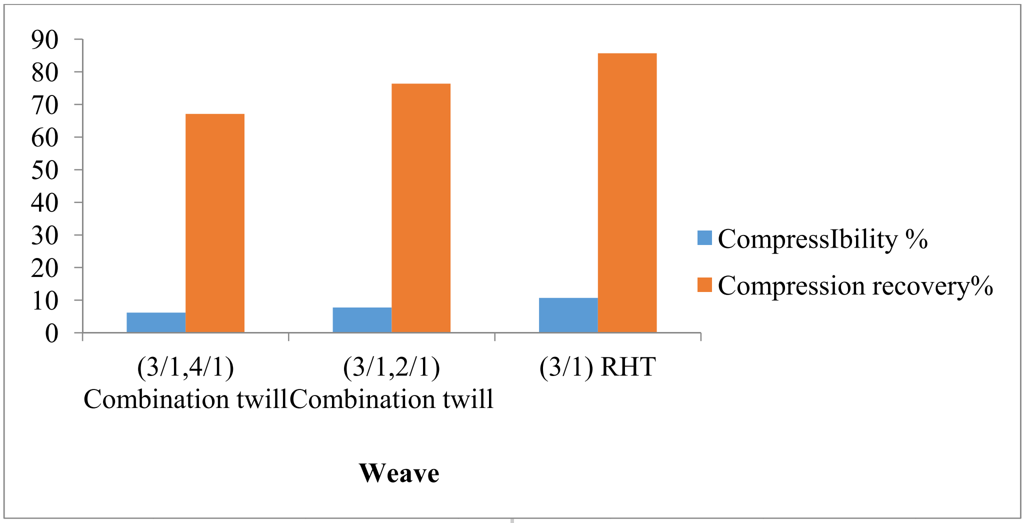

Figure 18. Effect of fabric weave on compression recovery and compressibility

3.3.4 Effect of fabric weave on compression recovery and compressibility

The compressibility and compression recovery percentage is less in case of combination twill (3/1,4/1) followed by another combination twill (3/1,2/1) large for right hand twill weave (3/1) RHT (Figure 18). This is attributed by the number of floats present in fabric weave and that causes the lower crimp/waviness in the warp yarn of the fabric structure with combination twill of (3/1,4/1) and (3/1,2/1) and minimun number of floats and high crimps/waviness of warp yarn attributed to higher value of compressibilty and compression recovery percentage in samples. Hence it is observed that more crimps in yarns of fabric structure, increases the fabric thickness/bulkiness and accordingly affects the compressibility and compression recovery percentage and vice versa.

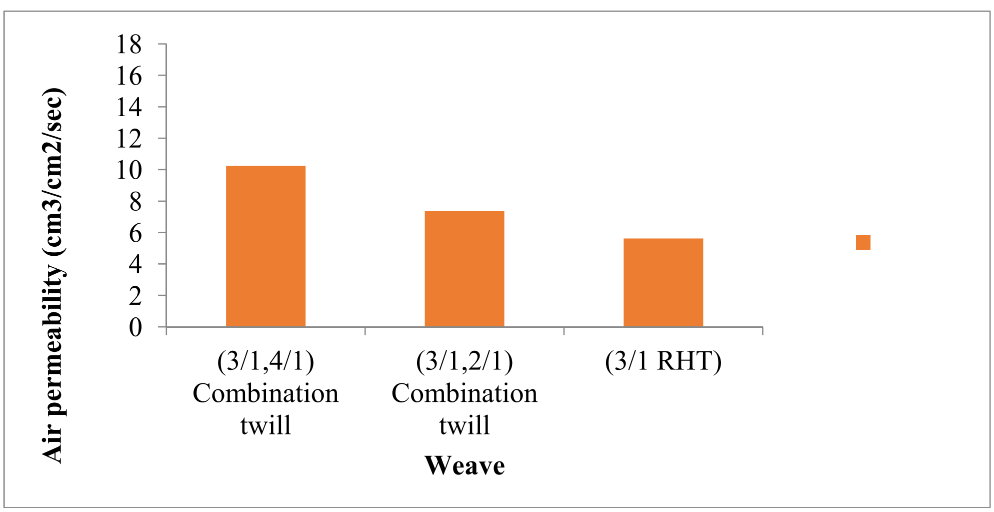

Figure 19. Effect of fabric weave on air permeability

3.3.5 Effect of fabric weave on air permeability

The effect of fabric design on air permeability on denim fabric is shown in figure 19. The decreasing trend is observed in the fabric from (3/1, 4/1) combination twill followed by (3/1,2/1) combination twill to (3/1) RHT. The air permeability depends on weave structure. It is observed that higher air permeability is found in open weave like (3/1, 4/1) combination twill weave as due to less crimp and open structure of fabrics. RHT (3/1) twill fabric is more compact, lower porosity due to more crimp and lycra present in weft reduces the air permeability. Weave pattern with lycra percentage plays a very important role in deciding the air permeability of fabrics and accordingly the applications of garments.

3.3.6 Effect of fabric weave on stretch properties

The effect of fabric design on fabric stretchability properties is shown in figure 20. In (3/1, 4/1) combination twill the number of floats are maximum, so under the load the yarns stretches very less in the direction of load, but in case of (3/1, 2/1) combination twill number of floats are less than previous one so its ability to stretch is more. In right hand twill (3/1) RHT number of floats are minimum than the other two combination twill weave, so higher intersecting point, larger will be yarns stretch in the direction of applied load as explain earlier in concept of breaking elongation. Fabric weave affects the fabric stretchability properties. It is found that more fabric stretches of fabric, more is recovery but less fabric growth due to presence of lycra in weft and it helps to recover from stretch.

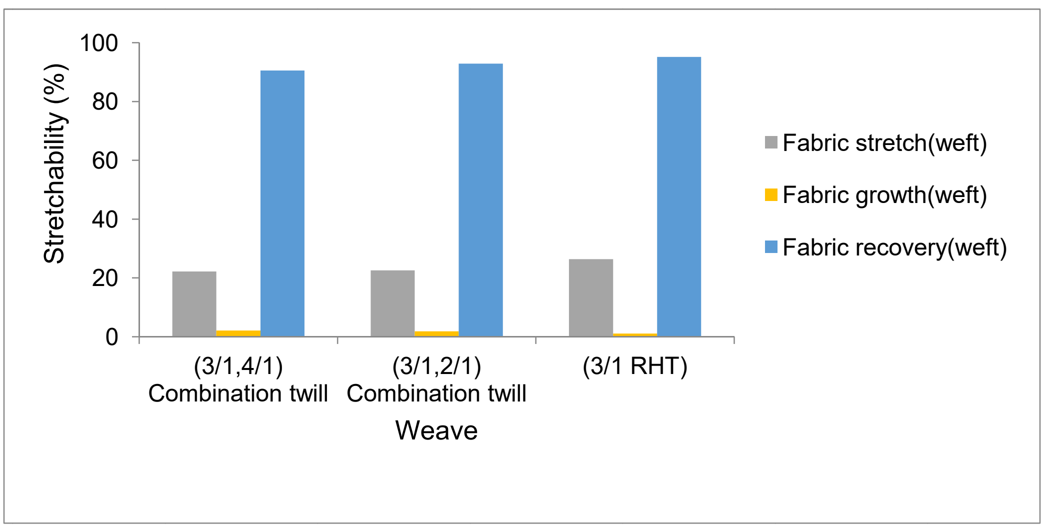

Figure 20: Effect of fabric weave on stretch properties

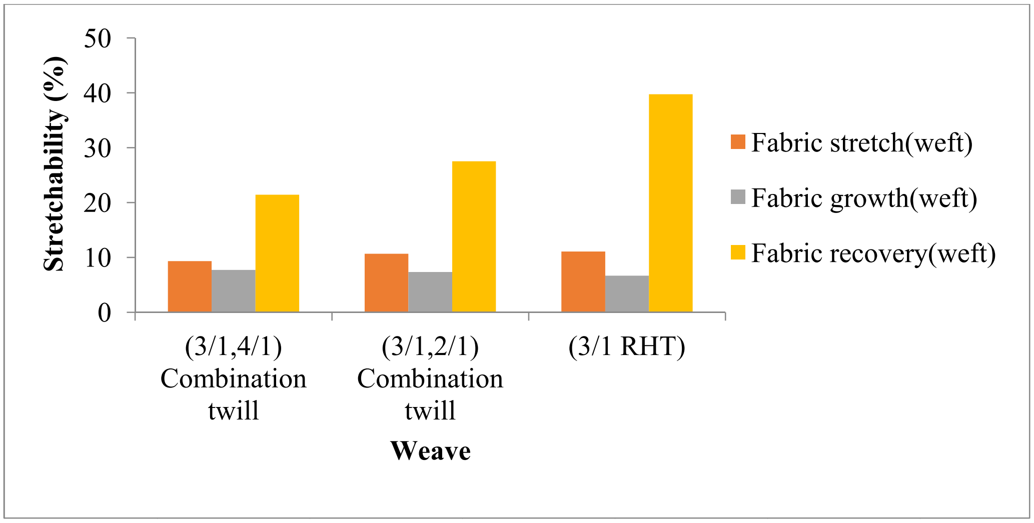

Figure 21. Effect of fabric weave on stretch properties after cycling loading

3.3.7 Effect of fabric weave on stretch properties after cycling loading

In figure 21 the effect of cycling loading on stretchable properties of stretchable denim fabric having different weave structure. The outcomes reveal that as fabric having less no. of floats in structure is tends to more stretch, recovery and less growth value. The Length of floats and number of interlacements in fabric plays important role in contributing the stretchable properties of fabrics. As increasing the number of interlacements and smaller float, increase in fabric stretch and its recovery and decrease in fabric growth due to presence of lycra in weft yarn. Anistropical fabric structure and internal energy decay in lycra structure makes different behavior of fabrics after cycling loading.

Conclusions

Based on the results, it concludes that when the fabric weight increases, its fabric compressibility, and compression recovery percentage, flexural rigidity, breaking strength and elongation percentage increases. The stretch percentage decreases, as increases the fabric weight of denim fabrics, owing to the more inter yarn friction in the fabric; whereas the fabric growth increases due to the less recovery of the fabric. The stretch percentage and fabric growth both decreases after cycling loading of stretchable denim fabric. Air permeability of stretchable denim fabric decreases as increases fabric weight. The compressibility, compression recovery% is increases as elastane content increases in the fabric. The flexural rigidity of fabric increases as increases the amounts of elastane in denim fabrics. As the elastane content increases in fabric the breaking strength of fabric decreases, while fabric breaking elongation increases because of the higher elongation of elastane fibers in weft yarn and there was small change in warp breaking strength and breaking elongation of denim fabrics. As the elastane content increases, the stretch percentage increases, whereas the permanent stretching percentage decreases due to the rather high recovery properties of elastane. Air permeability of fabric significantly decreases with the increase in elastane content in fabric. As fabric weave change from (3/1,4/1) combination twill to (3/1) RHT the number of yarn intersection points increases in fabric, hence increases the fabric compressibility, compression recovery, flexural rigidity, breaking strength and breaking elongation percentage of stretchable denim fabric. Fabric stretch and recovery increases, whereas fabric growth decreases in the fabric from (3/1,4/1) combination twill weave to (3/1) RHT weave as due to changes in the crimp of stretchable denim fabric.

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