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EFFECT OF SPANDEX ON PHYSICAL PROPERTIES OF LINEN AND COTTONWOVEN FABRICS

A.A. Dawoud*
*Eng. Lecturer – Spinning, weaving & knitting Dept., Faculty of Applied Arts, Helwan University, Egypt

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ABSTRACT

Despite the fact that the general consumer has a preference for choosing apparels made from natural fibers like cotton and linen, there is a tendency for these fabrics to crease. This in turn affects the appearance of the fabrics and thus the overall satisfaction with the fabric. The objective of this paper is to study the effect of spandex yarns on the physical properties of the resultant blended fabrics. 100% cotton and 100% linen fabrics and various blend ratios of cotton/spandex and linen/spandex were tested for crease recovery, Bending stiffness and air permeability. Results showed that spandex has a significant effect on crease recovery of cotton and linen fabrics as both types of fabrics exhibited improved crease recovery. Moreover, bending stiffness of cotton samples was increased by the introduction of spandex yarns at all bending ratios contrarily to linen samples which showed lower bending stiffness at all spandex ratios. Additionally, air permeability showed the same trend as bending stiffness where cotton/spandex blends showed lower air permeability compared to 100% cotton samples, and linen/spandex blends showed higher air permeability compared to 100% cotton samples.

INTRODUCTION

Fabric appearance is a major criterion for its consumer acceptance [1], and despite the fact that there is a clear consumer preference for natural fibres due to their comfort and soft hand, one of the greatest problems with natural cellulosic fabric is its tendency to crease easily during using, and also after washing and drying.This can be explained by a very high orientation of cellulose present in the fibre which results in a generally undesirable appearance.Accordingly, today the textile industry is concentrating on giving new characteristics to natural fibres by blending with other types of fibers to overcome those shortages.This problem should be carefully considered for all cellulosic fibers, especially linen and cotton fabrics, which are widely used for outwear clothing[1], [2].

In recent years the use of woven fabrics of elastin has increased remarkably due to a particular fact that these articles are characterized by excellent wear comfort and fit[3].

As elastic fabrics can stretch far more than normal fabrics, they are preferred in daily clothes to improvecomfort and fitting properties [4]. Cotton based fabricsare widely used in apparel industry because of its excellent properties such as high moisture and antistatic property, being comfortable to wear and easy to dye. On the other side, some other properties of cotton such as flexural stiffness, wrinkle resistance and dimensional stability are not desirable[5]. The properties of cotton are limited due to their natural origins, and therefore Elastin is increasingly used to impart a great level of stretch and more dimensional recovery. Its slight stretch would add to the garment's comfort and resistance to wrinkling[6].

Towards natural, comfortable yet elegant fabrics, linen and linen-blended fabrics have gained prestige and increased in reputation due to its unique characteristicssuch as its excellent aesthetic and drape properties[7][8]. Moreover, as compared with cotton, linen has some advantages like its two to three times higher tenacity when compared to cotton fibers, making it one of the strongest known natural fibers. Additionally, it is better than cotton as a conductor of heat. On the other hand, linen is less elastic than cotton and creases more easily. Adding flax to clothing fabrics helps keep skin cool partly because flax improves moisture wicking, which means channeling moisture away from the skin’s surface more effectively. Wearing 100% cotton clothing during exercise can make skin feel clammy since it does not dry quickly and due to its decreased wicking capabilities [9].

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Since linen is more expensive than cotton, it is important to know the difference between thetwo. High quality linens are smoother with less fuzz on the surface than cotton. Moreover, Linen fibers are longer and more difficult to tear[10].

Lycra is the trade name that DuPontuses for their particular formula ofspandex that they sell to the textile industry [11]. Spandex or lycra (chemically polyuthrene) has become a very popular and emerges as the only choice for the case of the elastomeric behaviour and can be easily blended with different other fiber like cotton, wool, silk or also can be mixed with other manmade polymers like nylon, polyester etc[12]. Another type of widely used elastic fibers is Spandex (also known as elastane) is a manufactured fiber in which the fiber-forming substance is a long chain synthetic elastomer consisting of at least 85% by weight of segmented polyurethane[13].

Under the microscope Spandex fiber appears to be a single, continuous thread; it is in reality a bundle of tiny filaments. It is composed of “soft”, flexible, segments bonded together with “hard”, or rigid, segments. This gives the fiber its built-in lasting elasticity. Moreover spandex yarn can be stretched four to seven times its initial length, yet springs back to its original length once tension is released [recovery rate is over 95%]. Thus this fibre is known for its exceptional elasticity. It is also lighter in weight[14], [15]. Therefore, fabrics containing spandex yarns have a wide application value in the textile market, especially because of their increased extensibility, elasticity, high degree of recovery, good dimensional stability, and simple care[16], [17]. Which in turn leads the prevention of deformation and reduction of bagging effect, as well as the effects of dimensional changes in different parts of the body, extendable and high elastic recovery fabrics have been introduced to the textile market[4].

More specifically in apparel industry, these kinds of fabrics are used for sport cloths, and leisure cloths, hosiery, underwear and swimwear, and body-confirming garment which ensure stable shape under loading during wearing[18].

MATERIALS AND METHODS

In this study, plain1/1 woven fabrics were manufactured to evaluate the effect of spandex content in linen/spandex and cotton /spandex fabrics. Two control samples made of 100% cotton and 100% linen were used. 5%, 15%, and 20% spandex weft yarns were used as a substitution for the cotton and linen weft yarns in both cotton /spandex and linen /spandex fabric samples. This accounts to a total of 6 samples and 2 control samples

For all samples, the warp thread count was 100/2 Ne, and the warp densities were set to 52 warps/cm. On the other hand, weft densities were 20 picks/cm and weft counts were (20, 20and 59 Ne) for cotton, linen and spandex respectively. The fabric constructional specifications are given in Table 1.

The physical properties such crease recovery angle, Bending stiffness(in weft direction as warp specifications were kept constant for all fabric samples)and air permeability of all fabrics have been tested according to standard testing methods ASTM-D1295 , ASTM-D1388 and ASTM-D737 respectively. Moreover weight and thickness were measured according to standard testing methods ASTM-D3776,ASTM-D1777.Test results for all fabrics have been discussed.Test results in this study were assessed statistically using Analysis of variance (ANOVA) in order to evaluate the significance of produced fabrics properties at different levels of spandex ratios.

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Table 1: Constructional parameters of fabrics under study

sample no.	weave structure	Weft material	Blend ratio % (Weft yarn)	Warp (density/ cm)	weft (density/ cm)	Warp count Ne	Weft count Ne
1	Plain1/1	Cotton	100%	52	20	Cotton 100/2	20
2		Cotton: spandex	95%:5%				20/59
3		Cotton: spandex	85%:15%				20/59
4		Cotton: spandex	80%:20%				20/59
5		linen	100%			Linen 100/2	20
6		Linen : spandex	95%:5%				20/59
7		Linen : spandex	85%:15%				20/59
8		Linen : spandex	80%:20%				20/59

RESULTS AND DISCUSSION

Table 2 summarizes the experimental results of crease recovery angle,bending stiffness,air permeability,weightand thickness.One-way variance analysis (ANOVA) was conducted to test results for samples as listed in Tables (3-8).Moreover, only results for crease recovery, bending stiffness carried out in weft direction are listed as all the parameters for the warp are constant across all tested samples.The results are represented graphically and discussed below.

Table 2: Test results of produced fabrics

Sample No.	Crease recovery angle, deg	Stiffness mg.cm	Air permeability (L/m^2s)	Weight (g/ m^2)	Thickness (mm)
1	63.3	40.8	294	150	0.33
2	74.0	38.43	267	142	0.35
3	77.7	34.84	248	141	0.37
4	79.3	30.8	243	140	0.39
5	52	94.4	572	150	0.30
6	59	87.53	627	130	0.31
7	67	82.33	631	130	0.30
8	76	81.9	641	130	0.30

Crease recovery

Crease recovery has a direct influence on human vision perception,it is one of the fundamental properties of fabrics affecting product properties. Figure 1 illustrates the effect of amount spandex ratio on crease recovery angle of the produced woven fabrics.

Results presented in Table (2) show that 100% cottonindicates a better crease recovery ability than 100% linen samples at 63.3 degrees and 52 degreesrespectively. The higher stiffness of linen can be explained by reviewing the difference in the physical structure and shape between cotton and linen. This difference can be observed in the molecular structure of linen which is more ordered than that of cotton and hence it is higher stiffness and lower crease recovery ability.

When examining the effect of substituting cotton or linen weft yarns with spandex on crease recovery, it can be observed that by increasing spandex ratio from 5% to 20% there is an increase in crease recovery by 17% to 25%, and 14%to 46% in the case of cotton and linen respectively. Consequently, crease recovery of linen fabric is improved more by the addition of spandex yarns than that when added to cotton.The enhanced crease recovery resulting from the addition of spandex yarns may be attributed to the fact that the elasticity of spandex yarns is more superior to that of both cotton and linen yarns it substitutes. Accordingly, the crease recovery has been generally.Tables3, 4 for ANOVA analysis show that the effect of spandex content on fabric crease recovery is significant.

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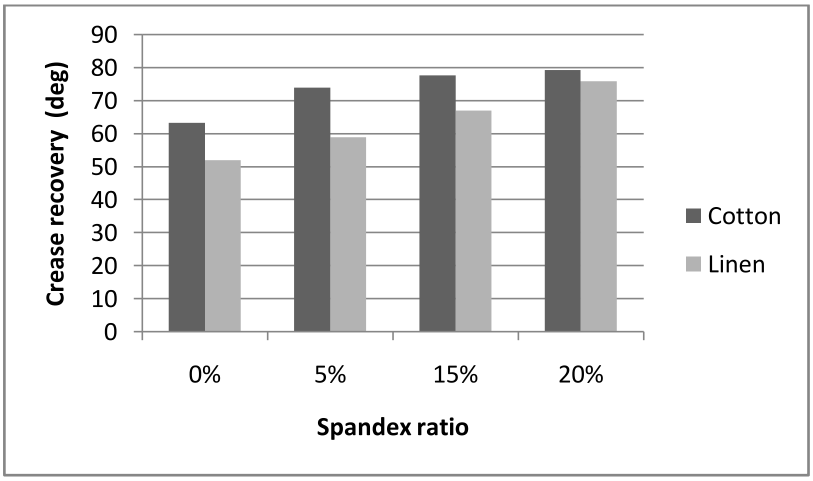

Figure 1. Effect of spandex ratio on fabric crease recovery

Table 3: ANOVA for spandex ratio and crease recovery of cotton fabric

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	464.9167	3	154.9722	16.31287	0.000903	4.066181
Within Groups	76	8	9.5			
Total	540.9167	11				

Table 4: ANOVA for spandex ratio and crease recovery of linen fabric

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
BetweenGroups	*958.5625*	*3*	*319.5208*	*194.1392*	*8.25E-08*	*4.066181*
Within Groups	*13.16667*	*8*	*1.645833*			
Total	*971.7292*	*11*				

Bending stiffness

Bending stiffness is a fabric property that affects the aesthetic and comfortproperties of clothing.Bendingstiffness is one of the most desirable properties to achieve better handle property. Figure 2 illustrates the effect of amount spandex ratio on stiffness of the produced woven fabrics.By reviewing stiffness resultsfor the produced samples it can be concluded that stiffness of 100% linen samples is more than that of the 100% cotton samplesas listed in Table 2. This can be explained by the stiffness of the single linen fibers which are naturally stifferthan that of the cotton fibers due to the presence of pectin content, the high crystallinity of cellulose and the cross-sectional shape of the fibre, which is different from that of the cotton fibre leading to the higher result of stiffness for samples composed from linen yarns. Moreover, when spandex yarns were introduced as a substitution for linen or cotton yarns by a ratio of 5, 15, 20% of the total cotton or linen yarns it was observed that the stiffness of cotton/spandex and linen/spandex samples decreased at all blending ratios when compared to 100% cotton or 100% linen samples. This can be explained by the fact that the stiffness of spandex yarns is less than that of the yarns it replaces due to the better elasticity of spandex yarns which results in decreased stiffness.By reviewing the stiffness results it can be observed that increasing spandex ratio from 5% to 20% leads to a reduction of stiffness from 6 % To 24 % And 3 % To 14 % in cotton and linen fabrics respectively.Tables 5, 6 for ANOVA analysis show that the effect of spandex content on fabric stiffness is significant.

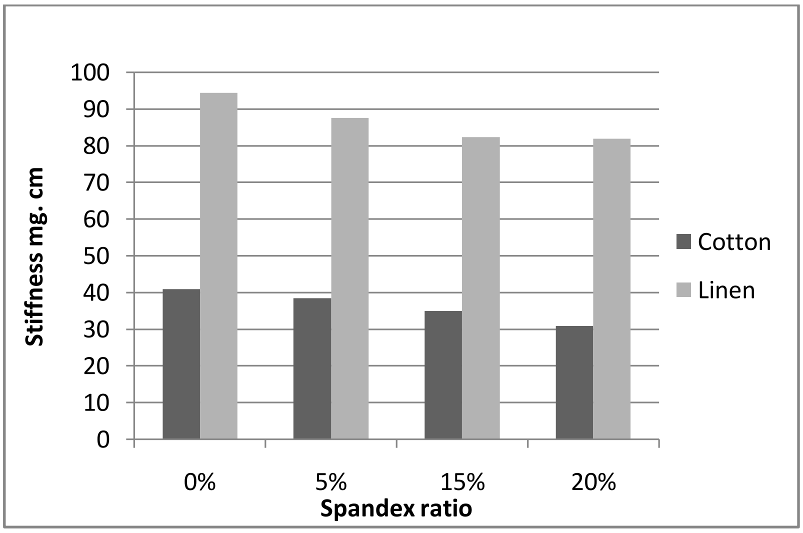

Figure 2. Effect of spandex ratio on fabric bending stiffness

Table 5: ANOVA chart for spandex ratio and bending stiffness test of cotton fabric

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	*958.5625*	*3*	*319.5208*	*194.1392*	*8.25E-08*	*4.066181*
Within Groups	*13.16667*	*8*	*1.645833*			
Total	*971.7292*	*11*				

Table 6: ANOVA chart for spandex ratio and bending stiffness test of linen fabric

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	*171.2033*	*3*	*57.06778*	*52.27583*	*1.34E-05*	*4.066181*
Within Groups	*8.733333*	*8*	*1.091667*			
Total	*179.9367*	*11*				

Air permeability

The results of air permeabilityin terms of the amount of air passing through a unit fabric area per unit timeare given in Table 2. The results show that 100% linen fabrics permit more air to pass through whencompared to 100% cotton fabrics. The reason for the higher permeability in the case of linen fabrics can be attributed to linen fibers being coarser in comparison to cotton fibers which results in higher air permeability due to the decreased number of fibers in linen yarns cross section compared to same yarn count of cotton yarns. These results in more intra yarn spaces in linen which permits more air to pass through samples composed of this type of yarns.Figure 3 illustrates the relationship between the spandex ratio and air permeability. It is clearfor all tested samples that the amount of spandex has a significant effect on the air permeability as shown in Tables 7, 8.In the case of cotton fabrics when the amount of spandex increases the air permeability decreases. The reduction in the fabric air permeability with the increase ofthe amount of spandex can be attributed to the higher compactness and the cloth thickness resultingfrom thehigher amount of spandex which offer resistance to the air permeability. On the other hand,it was found that the air permeability increases when spandex component increases for samples composed from linen yarns. Thiseffect can be attributed to the decrease inweight by the increase of spandex radio as seen in Table 2.In addition,linen yarnshavelow fiber packing density because of their larger diameterwhen compared to cotton fibers. For all the aforementioned reasonsair passes more freely through the yarn cross-section, which results in higher air permeability through linen/spandex samples.

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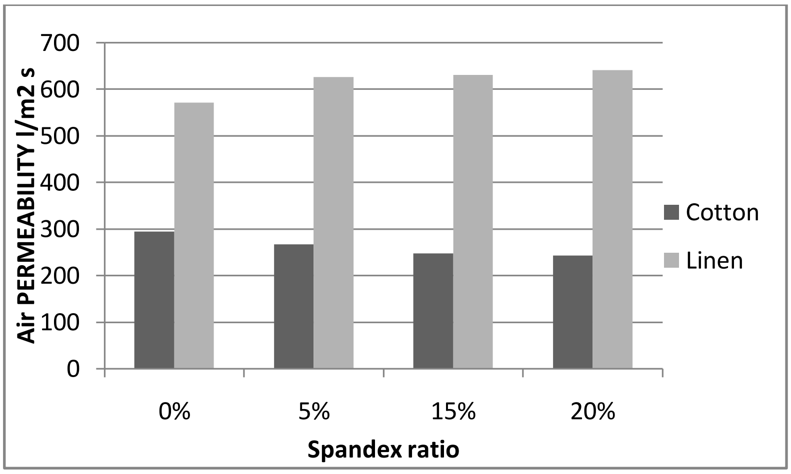

Figure 3. Effect of spandex ratioon fabric air permeability

Table 7: ANOVA chart for spandex ratio and air permeability test of cotton fabric

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	*8914.25*	*3*	*2971.417*	*144.9472*	*2.6E-07*	*4.066181*
Within Groups	*164*	*8*	*20.5*			
Total	*9078.25*	*11*				

Table 8: ANOVA chart for spandex ratio and air permeability testof linen fabric

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	*4631*	*3*	*1543.667*	*50.89011*	*1.48E-05*	*4.066181*
Within Groups	*242.6667*	*8*	*30.33333*			
Total	*4873.667*	*11*				

CONCLUSION

In this study 100% cotton and different blend ratios of cotton/spandex fabrics as well as 100% linen and different blend ratios of linen/spandex fabrics were tested for crease recovery, bending stiffness and air permeability and the following could be concluded:

- By increasing spandex ratio from 5% to 20% there is an increase in fabric crease recovery by 17% to 25% andby 14% to 46%in cotton andlinen samples respectively. Generally, crease recovery of linen is improved more by the addition of spandex yarns than that when added to cotton.
- Stiffnessof 100 % linen and spandex/ linen samples is more than that of the 100% cotton and spandex/cotton samples.Fabric stiffness of cotton/spandex AND linen/spandexdecrease with the increase of spandexratio when compared to 100% cotton or 100% linen samples.

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