EVALUATION OF END USE PROPERTIES OF KNITTED SCARVES IN THE EGYPTIAN MARKET

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Abstract: *In this study some mechanical and comfort properties of eleven cotton, viscose, cotton/Lycra, and viscose/Lycra single jersey knitted fabrics used as scarves in the Egyptian market were measured. Bursting strength, abrasion resistance, air permeability, thermal resistance, water vapour permeability and water permeability were measured. The relation between most of these properties and fabric constructional parameters was found. Regression equations were found to predict each of abrasion resistance, air permeability, and thermal resistance in terms of loop length and stitch density. While water vapour permeability was predicted in terms of fabric thickness and wales per centimeter. Loop length and stitch density are the key factors affecting the mechanical and comfort properties of single jersey knitted fabrics. The effect of percentage Lycra on the properties under study was investigated. An acceptable relation was found between Lycra percent and each of air permeability (R^2=0.65) and water vapour permeability (R^2=0.8). Increasing Lycra percent decreased both air permeability and water vapour permeability. Also a relation between Lycra percent and each of abrasion resistance and thermal resistance was found with (R^2=0.5) for both. Increasing Lycra percent increased both abrasion and thermal resistances. No relation was found between Lycra percent and bursting strength.*

Keywords: *Single jersey knitted fabric, mechanical properties, comfort properties, stitch density, loop length.*

1 INTRODUCTION

Viscose rayon has its silk-like feel and aesthetic property. It can retain its brilliant colors. It has similar properties to that of cotton and other cellulosic fibers. It has moisture absorbance more than cotton [1]. Fabric wicking, air permeability, water vapour permeability, evaporation rate and drying time were measured before and after laundering for six different knitted structures made from 37 tex viscose staple fibers. Fabric structure significantly affects air permeability and fabric wicking. Air permeability and water vapour evaporation rate correlated negatively to fabric thickness. Also they decreased after laundering process. The fabric wicking in both wales and course directions was high in the first five minutes after this the wicking rate decreased. Fabric structure affects the wickability strongly. Also the wickability increased after laundering [2]. Thicker single jersey synthetic fabric with Lycra has higher thermal insulation [3]. Cotton fabrics with longer stitch lengths absorb less energy than those of shorter stitch lengths. So fabric with lower stitch length feels cooler to the initial touch [4]. Lower yarn counts in tex have less thermal resistance and conductivity for rib 1x1 cotton fabrics. The statistical results show that thermal properties did not affected by the fabric tightness. The finer yarns have higher water vapour permeability. Also the water vapour permeability increases when the tightness factor increases [5]. The effect of yarn linear density and stitch length on thermal comfort properties, water vapour permeability and air permeability for 100% bamboo single jersey fabrics were studied. Thicker fabrics have less air permeability resulted from thicker yarn and higher loop length. The air permeability and the water vapour permeability increased with higher yarn counts and higher loop lengths. Also the thermal resistance decreased with the decrease in fabric thickness [6]. In a comparison between viscose and Excel yarns with two yarn counts 15, 20 tex and three stitch densities it was found that the thicker the fabric the lower its air permeability. Excel single jersey fabrics have higher air permeability than viscose fabric. Fabric thickness is a major parameter in determining the evaporation of water vapour [7]. The loop length has a significant effect on air permeability [7, 8]. The air permeability increased when the loop length increased. The same effect between water vapour evaporation and the loop length was found [8]. Two linear equations with high coefficients of determination were concluded to correlate each of air and water vapour permeability with loop length. Also a linear equation between thermal resistance and fabric thickness was concluded with high coefficient of determination [9]. A negative correlation was found between air permeability and fabric thickness [9, 10]. The effect of elastane on single jersey cotton fabrics on air permeability and bursting strength was studied. It was found that cotton elastane blended fabrics (elastane in every course) has very low air permeability compared with 100% cotton fabric knitted from yarn with count 30 Ne. Also the bursting strength for cotton elastane fabric was higher than that of cotton fabric [11].

A study of the effect of fleecy yarn's raw material using denim knitted fabrics with different raw materials (cotton, viscose, modal, tencel, and bamboo) and different counts on bursting strength were studied. Changing the count of the fleecy yarn was more effective on the bursting strength for the studied samples than changing the raw material of the fleecy yarn. Changing fleecy yarn raw material did not affect bursting strength parameter significantly [12].

2 MATERIALS AND METHODS

2.1 Preparation of samples

Eleven finished knitted fabrics suitable for scarves with two different raw materials cotton and viscose were collected from different Egyptian factories with different fabric constructions (three viscose, four cotton, three viscose Lycra and one cotton Lycra) with yarn count 20 tex. The Lycra was found in each course in the four fabrics that contains Lycra. Table 1 shows the fabric specifications of these fabrics.

Table 1 Fabric specifications

Sample No	Sample Code	Material	Lycra [%]	Yarn count [tex]	Structure
1	C1	100% cotton	0	30	single jersey
2	C2	100% cotton	0	30	single jersey
3	C3	100% cotton	0	30	single jersey
4	C4	100% cotton	0	30	single jersey
5	Cl1	cotton/Lycra	7	30	single jersey
6	V1	100% viscose	0	30	single jersey
7	V2	100% viscose	0	30	single jersey
8	V3	100% viscose	0	30	single jersey
9	Vl1	viscose/Lycra	3	30	single jersey
10	Vl2	viscose/Lycra	5	30	single jersey
11	Vl3	viscose/Lycra	3	30	single jersey

2.2 Test methods

Different properties were measured under standard working conditions for the fabrics under study by the following standards.

2.3 Fabric construction parameters

Fabric weight per unit area: Standard procedures for measuring GSM for fabric samples as per (ASTM-D3776) followed by using digital measuring balance [13].

A fabric thickness was measured according to standard (ASTM-D1777) [14].

Stitch density obtained by counting the number of courses and the number of wales in one inch according to standard (ASTM-D3887) [15].

Stitch length of each fabric sample was measured according to (ASTM-D3887) [15].

2.4 Mechanical and comfort properties of fabrics

Bursting strength dimension [kPa] was measured according to (ASTM-D3786) [16].

Abrasion Resistance (cycles) was measured according to (ASTM-D4966) [17].

Air permeability of the fabrics was measured according to (ASTM-D 737) [18].

Thermal resistances of the fabrics were measured on Permetest according to the standard ISO 11092. The thermal resistance was measured in m^2.mK/W [19].

Water vapour permeability of the fabrics was measured on Permetest at National Institute for Standard according to the standard ISO 11092 [19].

Water permeability of the samples was measured according to (JIS L 1092-1986) [20].

3 RESULTS AND DISCUSSION

Table 2 shows the results of the construction parameters of the fabrics under study. Table 3 shows the results of the properties measured of the fabrics under study.

Table 2 Fabric construction parameters

Sample No	Sample code	Weight [gm/m^2]	Wales per cm	Courses per cm	Loop length [mm]	Thickness [mm]
1	C1	117	13	17	2.74	0.390
2	C2	158.5	16	21	2.46	0.410
3	C3	139	16	15	2.73	0.367
4	C4	141.5	14	19	2.59	0.390
5	Cl1	197	14	20	3.34	0.703
6	V1	185	15	22	2.55	0.497
7	V2	148	15	19	2.50	0.397
8	V3	140	15	18	2.60	0.383
9	Vl1	202.5	16	23	2.72	0.470
10	Vl2	235.5	16	27	2.98	0.633
11	Vl3	203.5	17	19	2.95	0.470

Table 3 Fabric physical and mechanical properties

Sample code	Bursting strength [kPa]	Abrasion resistance [cycles]	Air permeability [$cm^3/s/cm^2$]	Thermal resistance [m^2.mK/W]	Relative water vapour permeability [%]	Water permeability [L/s]
C1	680	98.33	112.67	13.64	69.1	0.56
C2	680	73.33	45.37	10.26	67.83	0.57
C3	426.67	67.67	194	17.24	64.57	0.39
C4	580	90	188.3	15.44	69.93	0.36
Cl1	520	346.67	24.3	19.62	58.8	0.53
V1	560	26.67	183	14.12	66.13	0.55
V2	520	50.67	153	10.12	67.73	0.40
V3	473.33	63.33	171	12.36	69.47	0.41
Vl1	553.33	306.67	32.2	17.68	64.3	0.48
Vl2	546.67	356.67	23.17	20.62	60.8	0.53
Vl3	486.67	195	39.6	18.52	62.13	0.39

3.1 Effect of fiber material on different properties

Paired comparison test was applied between cotton and viscose fabrics to calculate the significant difference for all measured properties.

3.2 Bursting strength

Applying paired comparison test between the bursting strength of the four 100% cotton fabrics and the three viscose ones no significant difference was found between them (p value=0.36). This means that changing raw material did not affect bursting strength (agree with [12]). Also no significant difference was found between the three 100% viscose fabrics and the three viscose Lycra fabrics for bursting strength (p value=0.75), (contradicts with [11]). This contradiction may be because [11] used only two samples for comparison (one 100% cotton single jersey fabric and the other was cotton elastane single jersey fabric).

3.3 Abrasion resistance

Although no significant difference was found between fabric weights for the four 100% cotton fabrics and the three viscose ones when applying paired comparison test between them (p value=0.3). A significant difference was found between the abrasion resistance of the four 100% cotton fabrics and the three viscose ones when applying the same test (p value=0.04). Cotton fabrics have higher abrasion resistance than viscose fabrics. Also a significant difference was found between the three 100% viscose fabrics and the three viscose Lycra fabrics for abrasion resistance (p value=0.008).

The following regression equation was concluded to estimate abrasion resistance for the eleven fabrics under study.

$$A.R = -1140.8 + 363.3 \ast loop\ length + 0.98 \ast w \ast c; \quad R^2 = 0.87 \qquad (1)$$

where *A.R* - abrasion resistance, *w* - number of wales per centimeter and *c* - number of courses per centimeter.

From equation (1), it is obvious that both stitch density and loop length have positive effect on abrasion resistance. The more compact fabric with higher stitch density has more abrasion resistance. Compact fabric means more amount of yarn in the unit area which needs more force (more number of cycles) to reach fabric distortion or abrasion. Figure 1 shows the relation between stitch density and abrasion resistance.

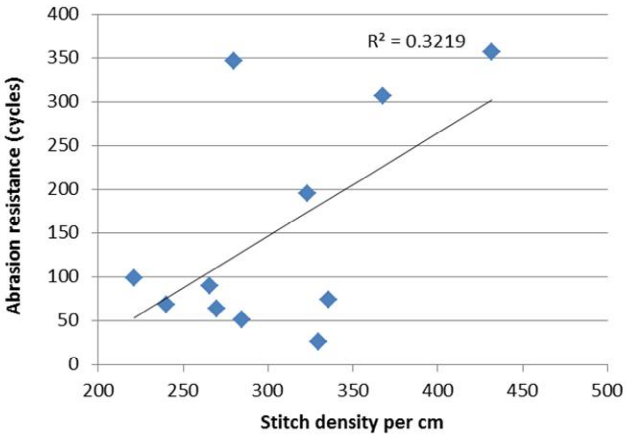

Figure 1 Relation between abrasion resistance and stitch density

It was found that loop length has no relation or correlation with neither courses per centimeter nor stitch density correlation coefficient = 0.1, while it has a good relation with fabric thickness correlation coefficient = 0.7. Fabric thickness increased when stitch length increased (as in Table 3 & Figure 1, reference [8]). This explains why in equation (1) by increasing the loop length the abrasion resistance increased. The increase of fabric thickness with loop length may be to finishing process.

3.4 Air permeability

Applying paired comparison test between the air permeability of the four 100% cotton fabrics and the three viscose ones no significant difference was found between them (p value=0.65). While a significant difference was found between the three 100% viscose fabrics and the three viscose

Lycra fabrics (p value=0.0003). From Table 3, it could be said that viscose Lycra fabrics has significantly lower air permeability than viscose fabrics, because Lycra gives more tight knitted structure, (agree with [11]).

The following regression equation was concluded to estimate the air permeability for the eleven fabrics under study.

$$A.P = 706.2 - 0.65 * w * c - 147 * loop\ length; \quad R^2 = 0.63 \tag{2}$$

where *A.P* - air permeability, *w* - number of wales per centimeter and *c* - number of courses per centimeter.

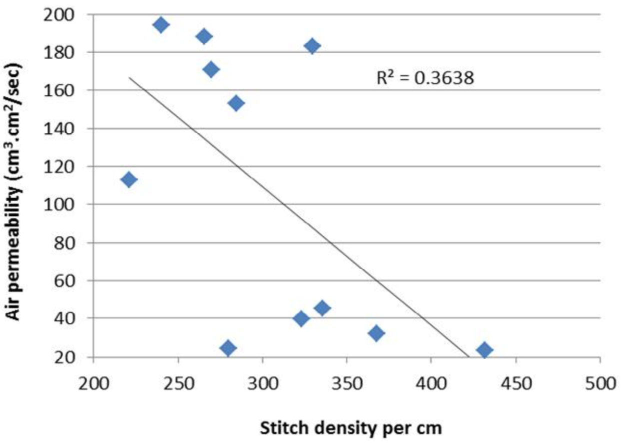

Figure 2 Relation between air permeability and stitch density

From equation (2), it is obvious that both stitch density and loop length have negative effect on air permeability. The higher stitch density leads to more compact structure which means more amount of yarn in the unit area that obstructs the air flow passage which leads to lower air permeability. Figure 2 emphasizes this effect. At the same time the higher loop length leads to higher fabric thickness as discussed before. This means more amount of yarn in the unit area which obstructs the air passage causing less air permeability.

3.5 Thermal resistance

Applying paired comparison test between the thermal resistance of the four 100% cotton fabrics and the three viscose ones no significant difference was found between them (p value=0.38). While a significant difference was found between the three 100% viscose fabrics and the three viscose Lycra fabrics for thermal resistance (p value=0.01). In other words it could be said that viscose Lycra fabrics has significantly higher thermal resistance than viscose fabrics.

The following regression equation was concluded to estimate the thermal resistance for the eleven fabrics under study.

$$T.R = -20 + 11 * loop\ length + 0.02 * w * c; \quad R^2 = 0.76 \tag{3}$$

where *T.R* - thermal resistance, *w* - number of wales per centimeter and *c* - number of courses per centimeter.

From equation (3), it can be concluded that loop length and stitch density are the factors affecting thermal resistance for the fabrics under study. The higher loop length leads to higher fabric thickness as discussed before. This means more amount of yarn in the unit area which leads to higher thermal resistance. Also the higher the stitch density (more compact) structure the lower the thermal resistance.

3.6 Water vapour permeability

Applying paired comparison test between the water vapour permeability of the four 100% cotton fabrics and the three viscose ones no significant difference was found between them (p value=0.96). While a significant difference was found between the three 100% viscose fabrics and the three viscose Lycra fabrics for water vapour permeability (p value=0.02). This means that viscose Lycra samples have significantly higher water vapour permeability than viscose fabrics, because Lycra gives more tight knitted structure.

The following regression equation was concluded to estimate the water vapour permeability for the eleven fabrics under study.

$$W.V.P = 96.4 - 28.7 * thickness - 1.15 * w; \quad R^2 = 0.85 \tag{4}$$

where *W.V P* - water vapour permeability, *w* - number of wales per centimeter.

From equation (4), it is clear that fabric thickness has positive effect on water vapour permeability which means thicker fabrics have lower water vapour permeability (agrees with [7]). Figure 3 emphasizes this effect. Also the more the number of stitches per centimeter the lower the water vapour permeability.

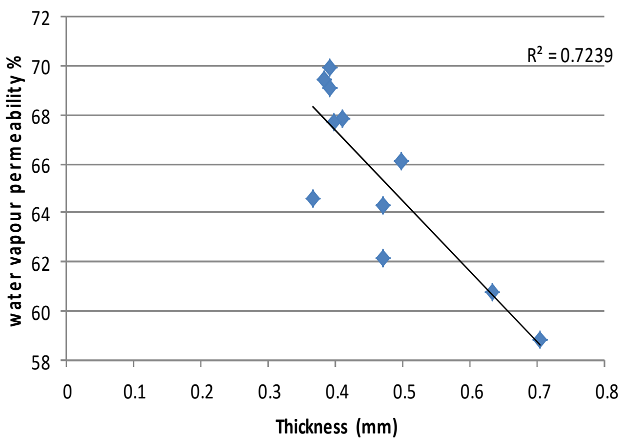

Figure 3 Relation between water vapour permeability and thickness

3.7 *Water permeability*

Applying paired comparison test between the water permeability of the four 100% cotton fabrics and the three viscose ones no significant difference was found between them (p value=0.8). Also no significant difference was found between the three 100% viscose fabrics and the three viscose Lycra fabrics for water permeability (p value=0.8).

3.8 *Effect of Lycra percent on properties under study*

For studying effect of Lycra percent the three viscose Lycra fabrics were used with the cotton Lycra fabric.

The effect of Lycra percent on bursting strength is shown in Figure 4

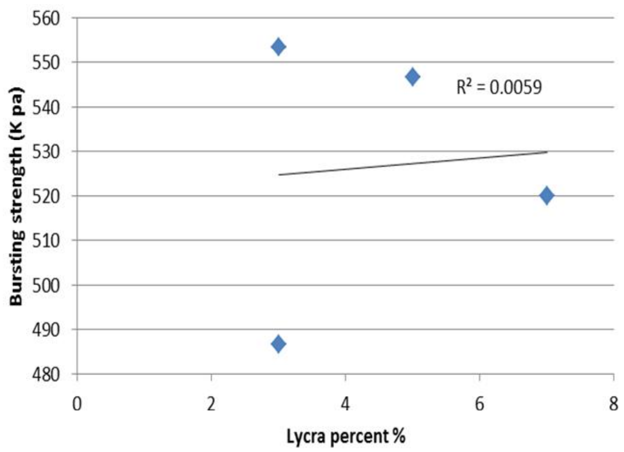

Figure 4 Relation between bursting strength and Lycra percent

From Figure 4, it is obvious that Lycra percent does not affect bursting strength significantly (R^2=0.006).

The effect of Lycra percent on abrasion resistance is shown in Figure 5.

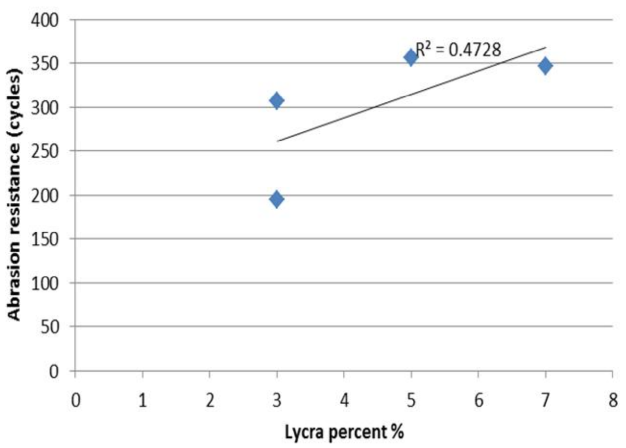

Figure 5 Relation between abrasion resistance and Lycra percent

From Figure 5 it can be said that Lycra percent affect abrasion resistance to some extent R^2=0.5. Abrasion resistance increased with the increase in Lycra percent.

The effect of Lycra percent on air permeability is shown in Figure 6.

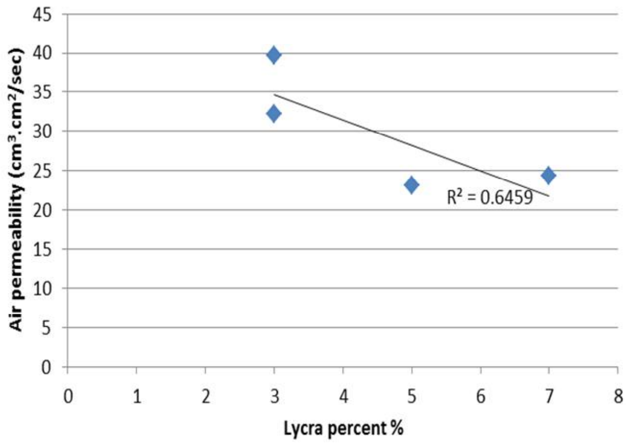

Figure 6 Relation between air permeability and Lycra percent

From Figure 6, it can be said that Lycra percent affects air permeability (R^2=0.65). Air permeability decreased with the increase in Lycra percent.

The effect of Lycra percent on thermal resistance is shown in Figure 7.

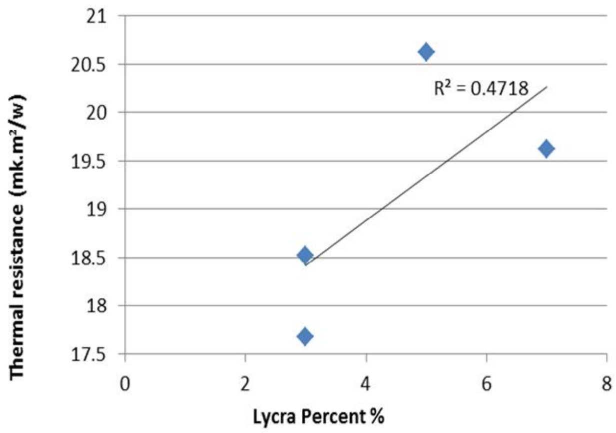

Figure 7 Relation between thermal resistance and Lycra percent

From Figure 7, it can be said that Lycra percent has effect on thermal resistance to some extent with R^2=0.5. Thermal resistance increased with the increase in Lycra percent.

The effect of Lycra percent on water vapour permeability is shown in Figure 8.

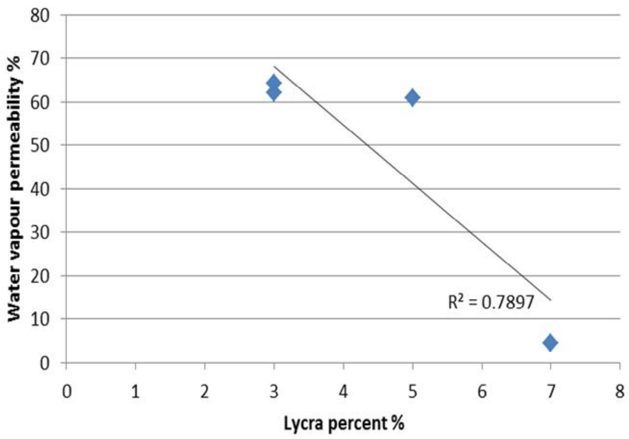

Figure 8 Relation between water vapour permeability and Lycra percent

From Figure 8 it can be said that Lycra percent has good effect on relative water vapour permeability (R^2=0.8). Water vapour permeability decreased with the increase in Lycra percent.

4 SUMMARY

Loop length is a key factor affecting single jersey knitted fabric properties. It affects abrasion resistance, air permeability and thermal resistance.

Stitch density in another key factor for single jersey knitted fabrics which affects abrasion resistance and air permeability.

The higher stitch density gives lower air permeability due to more compact structure which obstructs passage of air passage. Also higher stitch density increases abrasion resistances because of the higher amount of yarn exists in compact structure.

Fabric thickness as well as wales per centimeter affect relative water vapour permeability negatively.

The Lycra percent affects both water vapour permeability and air permeability negatively, while it affects both thermal resistance and abrasion resistance positively. Increasing Lycra percent in fabric decreased both relative water vapour permeability and air permeability. Increasing percent Lycra in the fabric increased both thermal resistance and abrasion resistance. The effect of Lycra percent on air and water vapour permeability is stronger than its effect on both thermal and abrasion resistances. Lycra percent has no effect on bursting strength in this study.

The effect of fiber row material appears only in abrasion resistance property, where cotton fabrics have more abrasion resistance than viscose fabrics, while for the other measured properties the effect of changing fiber row material does not affect these properties significantly.

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