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DIMENSIONAL AND PHYSICAL PROPERTIES OF DOUBLE KNITTED FABRICS MADE FROM DIFFERENT COTTONS AND MODAL COTTON BLENDS

الخصائص الفيزيائية و تغير الأبعاد لأقمشة التريكو مزدوجة الغرزة المصنعة من أقطان مختلفة و خلطات متنوعة من القطن و المودال

By

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الخلاصة:

هناك اتجاه حديث لإستخدام الألياف السليلوزية التحويلية و أيضا إستخدام الأقطان الأجنبية بخلطات خيوط مختلفة وخاصة مع شعيرات المودال ، حيث أن هناك سببين لهذا الإتجاة. السبب الأول هو أن المودال هو سليلوز تحويلى مستخرج من شجرة الزان (مصدر طبيعي) ، وأكثر توافقا وملائمة لخلطة مع القطن. في حين أن السبب الثاني هو العجز في شعيرات القطن المصري و التى في بعض الأحيان تضطررنا لإستخدام أقطان أجنبية و كمثال لذلك القطن اليونانى. في هذه الدراسة ،
يتم دراسة تأثير تغيير نسبة المودال عند خلطة بالقطن المصرى أو اليونانى على الخواص الفيزيائية و الأبعاد لأقمشة التريكو المزدوجة. تم إنتاج عينات القماش بإستخدام ثلاثة مستويات لطول الغرزة و بتصميمين قماش مختلفين (ريب و إنترلوك). جميع العينات تم إنتاجها على نفس ماكينة التريكو و تحت نفس ظروف الصباغة والتجهيز. وقد تم تحليل النتائج باستخدام تحليل الانحدار. أظهرت النتائج أن جميع العوامل لها تأثير معنوى على معظم خواص القماش التي شملتها الدراسة. الأقمشة المصنعة من القطن المصري هى الأعلى نسبيا في قوة الانفجار عن القطن اليوناني، في حين الأقمشة المنتجة من 50/50% مودال/قطن لها أقل قيم لقوة الانفجار.

Abstract

There is a new trend to use regenerated cellulosic fibers and also to use foreign cottons with different yarn blends especially with respect to modal fibers, where there are two reasons for these purposes. The first reason is that the modal fibers are made from regenerated cellulose, extracted from beech tree (natural source) and are more reliable and suitable to blend with cotton. While the second reason is the shortage in Egyptian cotton fibers so we sometimes are obliged to use foreign cottons for example Greek cottons.

In this study, the dimensional and physical properties of double knitted fabrics made from different Modal percentage with either; cotton Giza 86 or Greek cotton are investigated and compared. Each fabric type was produced with three levels of loop lengths and also two different fabric structures "rib and interlock". All fabric samples were knitted on the same knitting machine and dyed under the same dyeing and finishing conditions. The results were analyzed using regression analysis. Results show that all factors show significant effect on most of all studied fabric properties. Double knitted fabrics from Egyptian cotton is relatively higher than the Greek cotton in the bursting strength, while fabrics knitted from Modal/cotton 50/50 % blended yarns have the lowest bursting strength values.

Key words: Egyptian cotton, Greek cotton, Modal, blend ratio, Loop length, knitted fabric.

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1- Introduction:

Cellulose is a raw material with a large variety of uses in producing man-made textile fibers like viscose, lyocell and Modal. All regenerated cellulosic fibers have the similar chemical composition; however they vary in molecular weight, density, degree of polymerization, arrangement, and primarily their degree of crystallinity and orientation. The less ordered amorphous regions where the adsorption processes occurred should have a considerable effect on the adsorption properties of these fibers.The level of crystallinity of lyocell fibers is 16%higher as compared with modal fibers and considerably higher 43% compared to viscose fibers, [1].

Modal fibers have the largest contact angle compared with viscose and lyocell where this means it has low sorption characteristics than these fibers. As comparing the cotton and cotton/modal fabrics, there is not much dissimilarity between their water vapour resistances. The same could be seen while comparing the fabrics from viscose and Tencel®. There is a noticeable difference between the resistances of the two sets, where cotton and cotton/modal fabrics give larger resistance to water vapour transfer, [2-3].

Modal is a common name of a modified rayon fiber that has high tenacity and high wet modulus. Modal fiber is a kind of regenerated cellulose fiber. The type of cellulose used for Modal fibers can be obtained from pure beech wood. Modal provides the necessary dimensional stability and the unique cross section with its serrated edges but cotton provides the natural feel enhanced by the convolutionary surface morphology, [4].

Because of being naturally, Modal fiber is used in the production of a wide range of knitted fabrics in recent years. It is very common to blend existing fiber types to get fabrics with better performance and enhanced aesthetic. Modal fiber is often being used in blends with cotton in textile industry. Blending is regularly done using 50/50 groupings. Since Modal fiber looks like to cotton in its cellulosic structure, Modal together with cotton fiber will be compatible in blends [1, 4].

Dimensional control of knitted fabrics has frequently been an important problem for knitted garments. The problem of dimensional unsteadiness was simplified by the work of Doyle [5] and Munden [6]. The dimensional properties of cotton and wool plain knitted fabrics have been given considerable attention [7-9].

Because of the growing use of fiber blends, the influence of blend type and composition on the dimensions of plain and double knitted fabrics has also been researched [10-11], while there is a reasonable amount of information available about dimensional properties of knitted fabrics produced from cotton, wool, viscose, bamboo and other fibers [12-16].

A little research work has been published about the dimensional and physical properties of knitted fabrics produced from modal or blends of modal with cotton [17-18]. Modal/cotton yarn possesses better extensibility properties. Therefore, modal/cotton fabrics show more dimensionally stable state than the others. Results show that bursting strength of the fabrics produced from 100% cotton was generally higher compared to 100% Modal despite of the higher breaking force of the 100 % modal yarn compared to 100% cotton yarn.

Physical properties like abrasion resistance and pilling grade of knitted fabrics produced from different fiber types and yarn spinning systems have been studied in different research works. They reached to a conclusion that an increase in yarn hairiness reduces fabric abrasion resistance and performance [19-20].

The pilling of lyocell fabric perhaps impeded by high fiber/fiber friction in dry state while low in wet state, low degree of fiber swelling and less degree of fibrillation caused by re-orientation of fibril structure, decline in weight loss [21].

Fabrics from modal/cotton blended yarns tend to have the highest bursting strength compared with those produced from bamboo/cotton blended yarns. Pilling grades of fabrics made from bamboo/cotton blended yarns are better than those made from the modal/cotton blended yarns. The explanation for this can be that bamboo/cotton yarn has lower breaking strength and lower twist factor, which may make the pills pull out of fabric surface easily,[18].

The fabric take down tension (TDT) is considered as an essential factor in forming the loops, but it has no significant effect on loop length and real shrinkage for 1*1 rib and interlock fabrics. The effect of the fabric take down tension is temporary and disappears as soon as the fabrics are wetted out [*22-23*]. So, the introducing of this parameter was totally eliminated in this research work.

The loop length is only the sensible parameter to any changes in machine setting. With increasing loop length, fabric weight/m^2 decreases and the fabric shrinkage is increased where the loops are relatively more free. The lengthwise shrinkage always occurs up after relaxation for all kinds of fabrics, while widthwise shrinkage happens only for tighter structure and expansion in width occurs for medium and slack structure [24-26].

2- Material and Methods:

2-1 Material:

In this study 50/50% Modal/Egyptian cotton Giza 86 (50/50 C/M), 50/50% Modal/Greek cotton, 100% Egyptian cotton Giza 86 (100 % C) and 100 % Greek cotton yarns were used to produce double knitted fabrics. The properties of yarns were given in Table 1. Also, the properties of the Egyptian cotton Giza 86 and Greek cottons used in this research work are obvious in the Table 2. For the properties of the Modal fibers, the fiber length is 38 to 40 mm and the fineness is 1.3 dtex.

2-2 Fabric Manufacture:

All fabric samples were knitted on a 20 gauge Zentex Interrib circular knitting machine with 16 inch diameter and 32 feeders.

The loop length was changed at three different levels such as short, medium and long to represent a range of tight, medium and loose knitted fabrics. This has been measured electronically on the machine by using MLT WESCO device while, the yarn input tension was kept constant adjusted for all samples at 5 CN by using the same device. Also, the fabric structure was changed on the Interrib double knitting machine with two different structures which are rib and Interlock.

All fabric samples were dyed in the same dyeing bath and then squeezed using balloon squeezing machine, followed by tensionless drying process and finally all the fabrics were put in the flat form using compressive shrinkage calendar.

2-3 Methodology:

The details of the accomplished design of experiment are shown in tables 3 and 4. Where, table 3 shows the design of experiment of the Egyptian cotton samples, while table 4 clears the design of experiment of the Greek cotton samples.

2-4 Fabric Testing:

After finishing, all the fabric properties were measured after leaving the samples 72 hours in standard conditions (Relative humidity = 65 ± 2% - Temperature = 20 ± 2 c') in the flat form to give them the opportunity to relax without any existing stresses.

The fabric weight, thickness, bursting strength and pilling were measured according to ASTM D 3776, ASTM D 1777, ASTM D6797 and ASTM D3512 respectively. Also, Abrasion Resistance was measured according to ASTM D4158.

Furthermore, the fabric shrinkage was measured according to AATCC 135-2003. The color difference was measured on the data color instrument. Furthermore, the reference which has been taken as a zero level to measure the color difference is the Greek cotton 100% fabric sample.

Finally, handle Force was measured by the fabric hand- meter using the principle of the withdrawing the fabric sample through a circular ring where there is a force generated during withdrawing the sample through this ring. The maximum value of the force happens whe the whole specimen has almost pass through the ring [27].

Table 1. Yarn Properties

	100% Cotton Giza 86	50/50% Modal/Cotton Giza 86	Greek Cotton 100%	50/50% Mo Co
Count (Ne)	29.8	29.4	29.5	
Twist (Turns/inch)	20	20	20.2	
Irregularity (CV %)	11.4	11.1	13	
Thin places (-50%)	0	0	3	
Thick places (+50%)	5	5	34	
Neps	8	19	63	
RKM (Kg*Nm)	23	21.5	15.5	
Elongation %	5	5.9	5.2	
Hairiness (H)	7.2	6.9	7.5	

Table 2. Fiber Properties

	Len	Unif. %	Str.	Elong. %	M
Egyptian cotton Giza 86	32.3	87.0	46.0	5.5	
Greek cotton	28.3	83.0	29.0	7.3	

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13	2.	
14	19.	
15	15.8	
16	20.65	
17	18.1	
18	14.1	
19	21.1	
20	18.8	
21	14.8	
22	19.9	
23	17.3	
24	13.3	1.

4-1 Courses and wale

The following equation predict the courses/cm fabric with R^2 0.976 for cotton types, Y=16.73-1.9 (S = Fabric structure, C = C Loop length)

Also, the following equation w to predict the wales of the prod with R^2 0.974 for different 100 types, Y=20.06-1.83S+0.84C-2.96

It can be seen that from these e that the Egyptian cotton fabric is rel higher than the Greek cotton in the c and wales density for the same f structure. This could be referred to longer fiber length of the Egyptian Giza cotton compared with the Greece cotto Also, It can be seen that the two rib and

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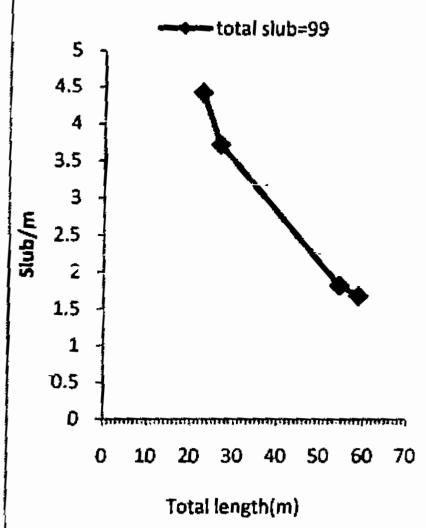

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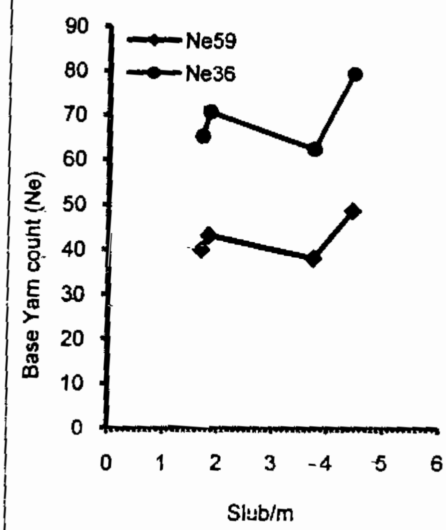

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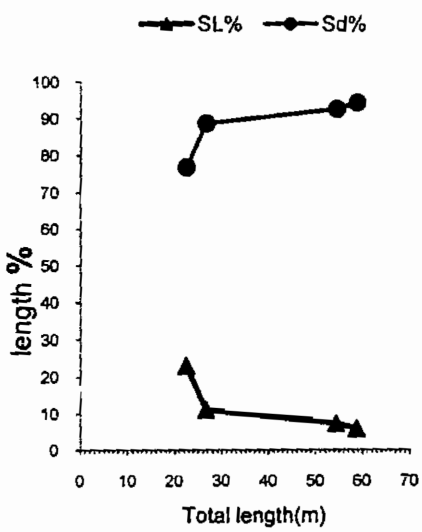

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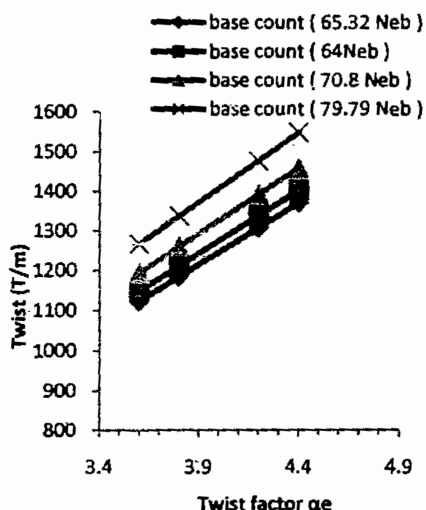
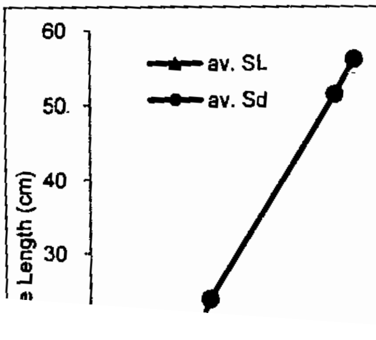
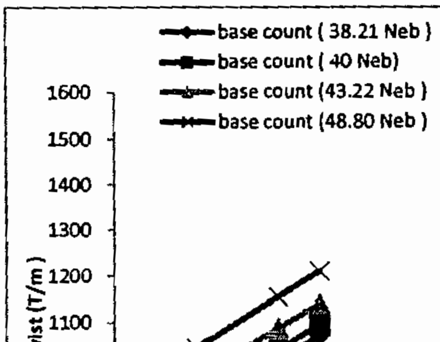


Fig(1.5) Theoritical values of twist (T/m) for base yarn at different levels of twist multiplier (Ne36)





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Twist (Turns/inch)	20	20	20.2	20
Irregularity (CV %)	11.4	11.1	13	11.1
Thin places (-50%)	0	0	3	0
Thick places (+50%)	5	5	34	9
Neps	8	19	63	25
RKM (Kg_f*Nm)	23	21.5	15.5	19
Elongation %	5	5.9	5.2	6.5
Hairiness (H)	7.2	6.9	7.5	7.1

Table 2. Fiber Properties

	Len	Unif. %	Str.	Elong. %	MIC	Mat.%	Rd	+b	Neps/gm
Egyptian cotton Giza 86	32.3	87.0	46.0	5.5	4.4	89	74.0	8.5	70
Greek cotton	28.3	83.0	29.0	7.3	3.6	77	68.0	8.0	266

Table 3. Design of Experiment of Egyptian Cotton Samples

Sample Number	Fabric Structure	Blend Ratio	Loop Length (mm)
1	Interlock	100 % C	3.2
2	Interlock	100 % C	3.6
3	Interlock	100 % C	4
4	Interlock	50/50 C/M	3.2
5	Interlock	50/50 C/M	3.6
6	Interlock	50/50 C/M	4
13	Rib	100 % C	2.4
14	Rib	100 % C	2.7
15	Rib	100 % C	3
16	Rib	50/50 C/M	2.4
17	Rib	50/50 C/M	2.7
18	Rib	50/50 C/M	3

Sample Number	Fabric Structure	Blend Ratio	Loop Length (mm)
1	1	1	-1
2	1	1	0
3	1	1	1
4	1	-1	-1
5	1	-1	0
6	1	-1	1
13	-1	1	-1
14	-1	1	0
15	-1	1	1
16	-1	-1	-1
17	-1	-1	0
18	-1	-1	1

Table 4. Design of Experiment of Greek Cotton Samples

Sample Number	Fabric Structure	Blend Ratio	Loop Length (mm)
7	Interlock	100 % C	3.2
8	Interlock	100 % C	3.6
9	Interlock	100 % C	4
10	Interlock	50/50 C/M	3.2
11	Interlock	50/50 C/M	3.6
12	Interlock	50/50 C/M	4
19	Rib	100 % C	2.4
20	Rib	100 % C	2.7
21	Rib	100 % C	3
22	Rib	50/50 C/M	2.4
23	Rib	50/50 C/M	2.7
24	Rib	50/50 C/M	3

Sample Number	Fabric Structure	Blend Ratio	Loop Length (mm)
7	1	1	-1
8	1	1	0
9	1	1	1
10	1	-1	-1
11	1	-1	0
12	1	-1	1
19	-1	1	-1
20	-1	1	0
21	-1	1	1
22	-1	-1	-1
23	-1	-1	0
24	-1	-1	1

4- Results and Discussion:

Table 5 illustrates the results of the dimensional and physical properties of the knitted fabrics. These results show the performance of the double knitted fabrics with changing cotton types, yarn blend ratio with Modal, yarn feeding rate and fabric structure.

In order to clear the effect of the cotton type, yarn blend ratio, fabric structure and the loop length on values of the tested fabric properties under study, the results were analyzed using simple regression analysis.

Table 5. Results of Fabric Properties

Sample Number	Courses/cm	Wales/cm	Fabric Weight (g/m^2)	Bursting Strength (lb/inch2)	Pilling Grade	Abrasion Resistance (No of revolutions)	Average Handle Force (Kgf)	Fabric Thickness (mm)	Color Difference (ΔE)	Lengthwise Shrinkage % after Fifth Wash	Widthwise Shrinkage % after Fifth Wash
1	17.5	21.4	242	100.4	4.5	29.3	3.4	0.74	1.47	4.4	5.6
2	15.9	19.7	228	91.2	4	25.4	2.82	0.68	1.38	7.6	7.2
3	12.4	16	213	84	3	21.1	2.37	0.59	1.23	9.4	9.4
4	15.7	19	215	80.3	5	22.3	2.8	0.63	2.7	5.9	1.5
5	14.05	17.5	203	70.6	4.5	19.5	2.35	0.59	2.47	9.1	3.2
6	10.9	13.4	174	62.9	4	14.7	2.01	0.49	2.38	11.8	5
7	16.4	19.8	226	98.8	4.5	27.9	3.69	0.72	0.34	5	6.5
8	14.8	18	222	87.6	3.5	25	3	0.66	0	8	8.5
9	11.5	14.5	198	81.1	3	20	2.62	0.55	0.27	10.2	11
10	15	17.9	196	78.1	4.5	21.6	3.15	0.6	2.49	6.5	3.5
11	13.3	15.3	183	68.7	4.5	19	2.55	0.59	2.2	10	5.4
12	10.1	12	160	62	3.5	14.1	2.14	0.53	2.19	13.5	7.5
13	22.1	25.7	196	72.4	4	24.9	2.35	0.62	1.36	2.3	6.4
14	19.7	23.5	175	64.8	4	20	1.89	0.55	1.23	4.45	8.2
15	15.8	19.1	152	55.8	2.5	17.7	1.53	0.5	1.1	6.5	10.1
16	20.65	23.25	173	53.9	4.5	19.6	1.82	0.49	2.7	4	4
17	18.1	21.6	155	44	4.5	15	1.45	0.45	2.4	8	6.1
18	14.1	17	141	36.7	3.5	11.8	1.02	0.4	2.15	8.8	7.7
19	21.1	23.9	192	70.7	4	24	2.48	0.6	1	3.5	7.8
20	18.8	21.6	170	65	3	19.3	2.03	0.52	0.46	5.2	9.2
21	14.8	17.55	149	54.2	2.5	17	1.81	0.48	0.4	7.1	12
22	19.9	22	168	52.5	4.5	19.5	1.93	0.47	2.38	4	4.7
23	17.3	19.8	151	43	4	14.4	1.52	0.43	2.11	7.3	6
24	13.3	15.7	135	34.9	3	11	1.1	0.37	2	10.5	8.3

4-1 Courses and wales density:

The following equation was estimated to predict the courses/cm of the produced fabric with R^2 0.976 for different 100 % cotton types, $Y=16.73-1.98S+0.5C-2.82L$, (S = Fabric structure, C = Cotton type, L = Loop length)

Also, the following equation was estimated to predict the wales of the produced fabric with R^2 0.974 for different 100 % cotton types, $Y=20.06-1.83S+0.84C-2.96L$

It can be seen that from these equations that the Egyptian cotton fabric is relatively higher than the Greek cotton in the courses and wales density for the same fabric structure. This could be referred to the longer fiber length of the Egyptian Giza 86 cotton compared with the Greece cotton. Also, It can be seen that the two rib and interlock structures behave in a similar manner for the decreasing of the courses and wales density with increasing of the loop length. These phenomena may be explained by the longer the loop; the bigger the space required in both directions per loop and the more openness the fabric. Moreover, Figures 1 and 2 show the results of courses/cm and wales/cm for rib and interlock structures plotted against the fabric loop length. It could be noticed from these figures that the fabric design of rib structure has a higher number of courses and wales density than the interlock structure at the same feeding rate. This trend could be referred to the shorter loop length for rib structures than the interlock structures; this shorter loop length makes the loops to be more adjacent to each others

Fig. 1 Relation between yarn loop length and courses/cm

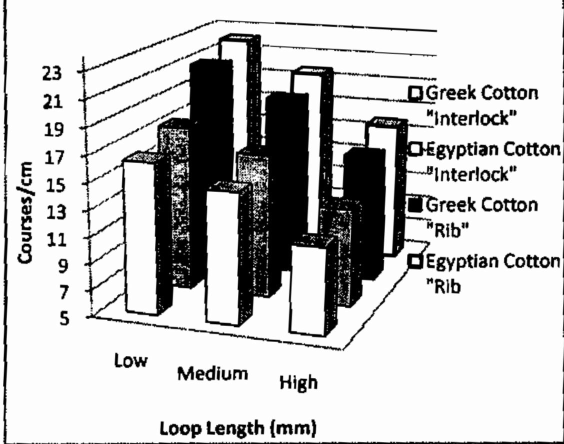
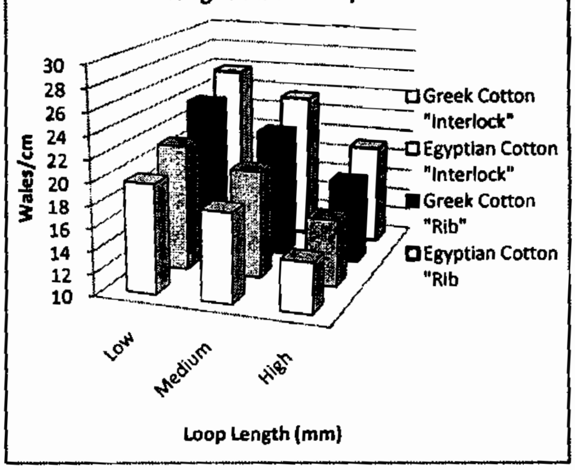


Fig. 2 Relation between yarn loop length and wales/cm



Furthermore, the following equation was estimated to predict the wales/cm of the produced fabric with R^2 0.966 for Egyptian cotton, Y=19.76-1.93S+1.14B-2.98L (S = Fabric structure, B = Blend ratio, L = Loop length)

It could be noticed form this equation that the increase of the Modal percentage causes a decrease in fabric wales density as shown in figure 3 and this mainly due to the higher of the elongation percentage of 50%/50% cotton/modal yarns against the cotton 100%. As a result this leads to the decrease of the wales/cm during the widthwise stretching through the balloon squeezing and compressive shrinkage finishing machines. Where, the compaction technique has the ability to shorten the fabric to reduce the lengthwise shrinkage and force the length of the loop in a knit to become more round in configuration thereby resulting in lower lengthwise shrinkage [28].

4-2 Fabric weight (g/m2)

The following equation was estimated to predict the fabric g/m2 of the produced fabric with R^2 0.977 for different 100 % cotton types, Y=196.9-24.6S+4.08C-18L

It is noticed from this equation that the Egyptian cotton fabric has a higher fabric weight than the Greece cotton at the same loop length, despite of the higher micronaire value accompanied with a longer fiber length of the Egyptian Giza 86 cotton against the Greece cotton. Also, the Egyptian cotton fabric has higher color darkness than the Greece cotton fabric. This difference is related to the higher maturity percentage of the Egyptian cotton 86 than the Greece cotton. Also, this has been noticed from the results of measuring color difference using Data Color device. This darkness shade shows the higher absorbency degree of the Egyptian cotton Giza 86 fabric which reflected in increasing fiber swelling and fabric weight after dyeing process and this confirmed in figure 4.

Fig. 3 Relation between yarn blend ratio and wales/cm

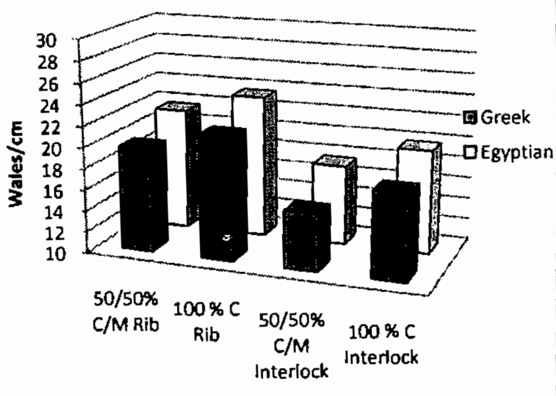
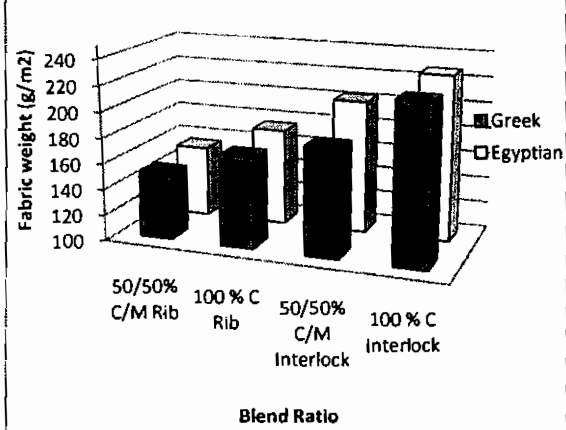


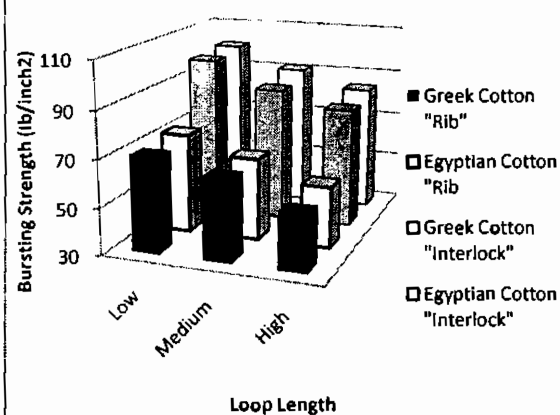
Fig. 4 Relation between yarn blend ratio and fabric weight (g/m²)



4-3 Bursting strength:

The following equation was estimated to predict the bursting strength of the produced fabric with R^2 0.996 for different 100 % cotton types, fabric structure and loop length Y=77.17+13.35S+0.93C-8.4L. It could be seen from the equation that the Egyptian cotton fabric is relatively higher than the Greek cotton in the bursting strength. This could be owed to the longer fiber length and higher tenacity of the Egyptian cotton fibers and also the higher tenacity of the Egyptian cotton yarns than the Greek cotton. It is also noticed that the interlock structure have a higher bursting strength than the rib structure. This could be owing to that the interlock structure has high thickness, high cover factor and high weight which lead to an increase in the bursting strength. Figure 5 shows the relation between yarn loop length and fabric bursting strength for different cotton type and fabric structure. It is clear from this figure that the bursting strength of the Egyptian cotton fabric is more than the Greek cotton fabric for the same fabric structure.

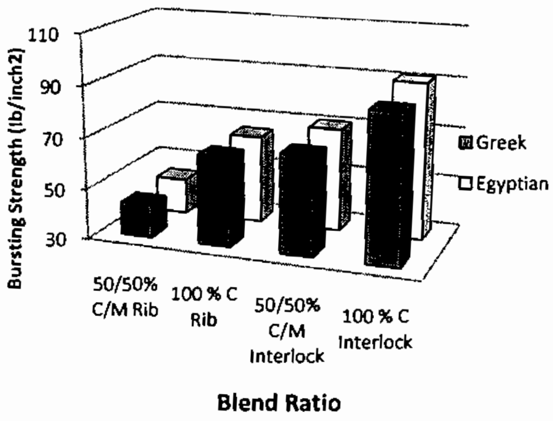
Fig. 5 Relation between yarn loop length and fabric bursting strength



Furthermore, the following equation was estimated to predict the bursting strength of the produced fabric with R^2 0.998 for Egyptian cotton Y=68.08+13.48S+10.01B-8.45L

As it can be seen from the equation that as the modal percentage increases the bursting strength decreases. This might be due to the smoothness of the modal yarns which makes a slippage at the contact point between the loops and as a result the fabric will be easy to burst. From figure 6, it has been noticed that as the ratio of modal increases the value of the fabric bursting strength becomes more.

Fig. 6 Relation between yarn blend ratio and fabric Bursting strength



4-4 Pilling resistance

The following equation was estimated to predict the pilling grade of the produced fabric with R^2 0.872 for different cotton types of 50/50% cotton//modal, Y=4.17+0.17S+0.17C-0.56L

It can be seen that the modal percentage, cotton type and fabric structure affect the pilling grade. It can be seen that the pilling grade for the Egyptian cotton is higher than the Greece cotton which is referred to higher fiber length and yarn uniformity of the Egyptian cotton [19]. Furthermore, Figure 7 clears the relation between yarn blend ratio and fabric pilling for Rib and Interlock structure at different cotton type. It is clears from the figure that pilling grade of double knitted fabrics contained more modal fiber percentage is better than the other fabrics as shown in this equation. This might be owing to the longer fiber length of the modal which may make fewer fibers protruding per unit area. Also, long fibers can be more firmly secured in the yarn, which means a lower pilling tendency of the fabrics constructed from it. Moreover, there is a lower hairiness level of the modal yarn than the cotton yarn. Therefore, there is a lower friction degree during using the Modal fabrics with any other surface and consequently these fabrics tend to form fewer pills.

4-5 Abrasion resistance

The following equation was estimated to predict the abrasion resistance of the produced fabric with R^2 0.981 for different 100 % cotton types, fabric structure and loop length Y=22.63+2.15S+0.43C-3.79L

It could be noticed form this equation that there is an effect for the fabric loop length, blend ratio and cotton type on the resistance of the fabric to the abrasion property. Figure 8 shows the relation between the blend ratio and the fabric abrasion resistance for Rib and Interlock structure at different cotton type. It is cleared that as the modal blend ratio increases inside the knitted fabric, the abrasion resistance decreases This might be due to the higher of the elongation percentage of 100% modal yarns against the other yarns leading to the decrease in wales density and increase in the fabric width during finishing process. As a result the fabric weight per unit area will be decrease. Another reason of that trend is referred to irregular cross sections with serrated edges in the longitudinal lines of the Modal fiber [4, 29]

Fig. 7 Relation between yarn blend ratio and fabric pilling

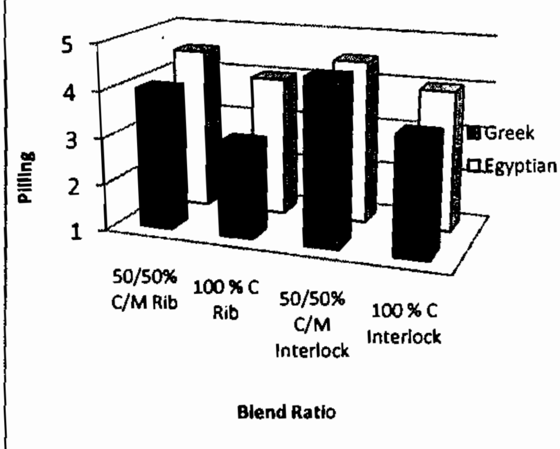
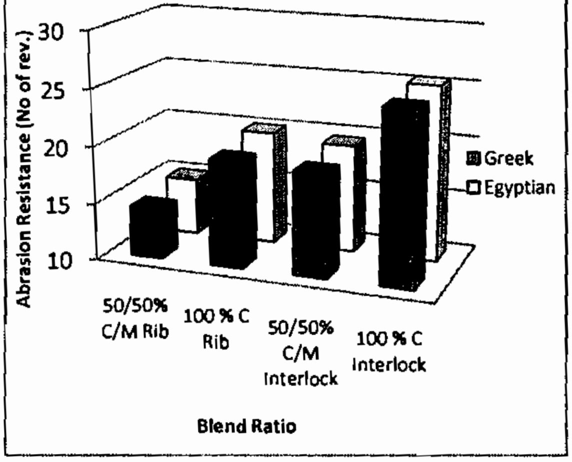


Fig. 8 Relation between yarn blend ratio and fabric abrasion resistance

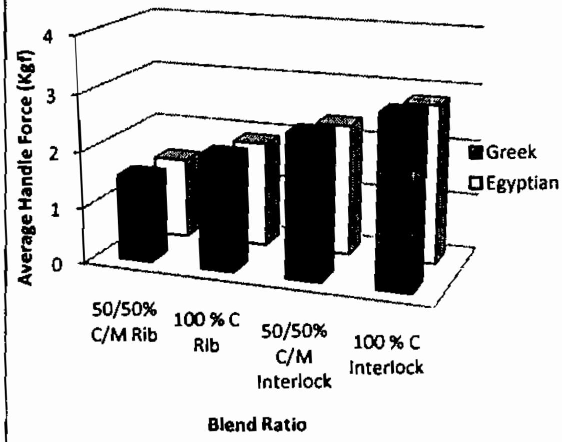


4-6 Fabric Handle force:

The following equation was estimated to predict the fabric handle force of the produced fabric with R^2 0.982 for different 100 % cotton types, Y=2.5+0.48S-0.11C-0.45L

As it can be seen the handle force for the Egyptian cotton is lower than the Greece cotton which is referred to the higher fiber length and yarn uniformity and lower hairiness level of the Egyptian cotton. It is observed that from figure 9 that as the blending ratio with modal fibers increases the handle force decreases.

Fig. 9 Relation between yarn blend ratio and fabric handle



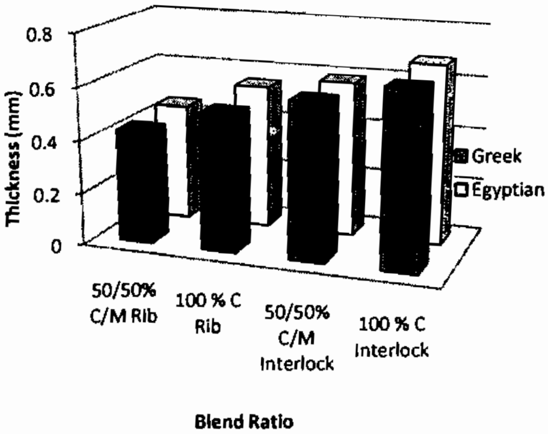
This might be referred to the higher smoothness degree and the lower hairiness level of the modal yarn than the cotton yarn. Therefore, there is a lower friction degree between the Modal fabrics and ring surface during applying the handle test.

4-7 thickness:

The following equation was estimated to predict the fabric thickness of the produced fabric with R^2 0.977 for different 100 % cotton types, Y=0.6+0.06S+0.01C-0.07L

With increasing the blend ratio with cotton the fabric thickness increases as revealed in figure 10. This could be as a result of the decreasing of wales and courses density with increasing the modal blending ratio and consequently the fabric become thinner. It can also see that the interlock structure is thicker than the rib structure for the same blend ratio. This can be interpreted by the fact that the interlock is consists of two intermeshed ribs and more closed structure and its cover factor is higher than the rib structure.

Fig. 10 Relation between yarn blend ratio and fabric thickness



4-8 Color Shade:

The following equation was estimated to predict the color difference of the produced fabric with R^2 0.926 for different cotton types of 50/50% cotton//modal, Y=2.35+0.06S+0.12C-0.19L

It is noticed that from this equation that samples knitted from Greek cottons has a lighter shade color than the others double knitted fabrics formed the Egyptian cottons. This difference in shade is related to the higher maturity percentage of the Egyptian cotton 86 than the Greece cotton, which consequently leads to the higher absorbency degree of the Egyptian cotton Giza 86 fabric. Furthermore, as the modal percentage increases the color difference increases. This could be interpreted by the higher amorphous regions contained inside the modal fibers which give more absorption capability of this fibers to the dyestuff materials.

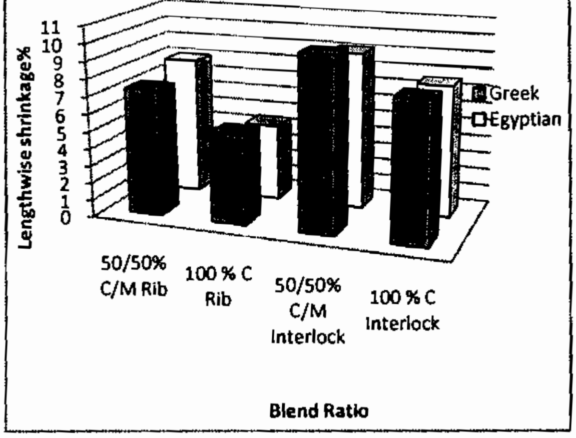
4-9 Fabric Shrinkage:

The following equations were estimated to predict the lengthwise and widthwise shrinkage of the produced fabric:

Where for the lengthwise shrinkage, the R^2 is equal to 0.979 for different 100 % cotton types, Y=6.13+1.29S-0.36C+2.25L

It could be noticed from this equation that the fabric producing from Greek cotton has a higher lengthwise shrinkage than Egyptian Giza 86 cotton. This may be related to the shorter fiber length of the Greece cotton than the Egyptian cotton. This is also cleared in figure (11) which shows the relation between yarn blend ratio and lengthwise shrinkage after fifth washing cycles for Rib and Interlock structure at different cotton types.

Fig. 11 Relation between yarn blend ratio and lengthwise shrinkage



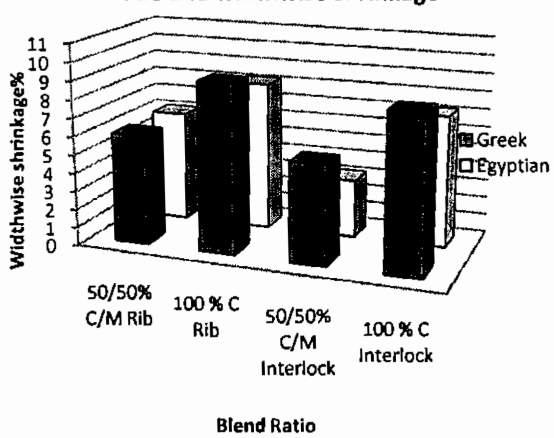
While, for the widthwise shrinkage the R^2 is equal to 0.961 for Egyptian cotton, Y=6.2-0.88S+1.62B+1.83L

As the feeding rate increases the widthwise shrinkage decreases. The reason is the increasing of the loop size and fabric spacing and this reflected in extending the fabric sample in the widthwise direction and decreasing the level of widthwise shrinkage.

Also, for the widthwise shrinkage the R^2 is equal to 0.984 for different 100 % cotton types, Y=8.49-0.46S-0.67C+2.02LIt could be noticed from this equation that the fabric producing from Greece cotton has a higher domestic widthwise shrinkage than Egyptian Giza 86 cotton. This may be also due to the lower fiber length of the Greece cotton than the Egyptian cotton.

Figure 12 shows the relation between yarn blend ratio and widthwise shrinkage after fifth washing cycles for Rib and Interlock structure at different cotton type. The interlock structure has a lower widthwise shrinkage compared with the rib structures. The reason of that trend is referred to the construction of the interlock structure which is considered as two intermeshed ribs and that gives the fabric to be more stable in the widthwise direction. Also, as the blending ratio increases with modal, the widthwise shrinkage decreases as seen in the last figure. This could be owing to the effect of the thermosetting process which applied for the samples containing Modal fibers during processing inside the compressive shrinkage calendar attached with a Teflon sheet.

Fig. 12 Relation between yarn blend ratio and widthwise shrinkage



5-Conclusion:

In this research, dimensional and physical properties of double knitted fabrics produced from different cotton types and different modal/cotton blend ratio were studied. Within this research work, Rib and Interlock fabrics knitted from Egyptian Giza 86 cotton has a relatively higher fabric weight per meter square, bursting strength, abrasion resistance, pilling grade and color deepness than those produced from Greek cotton. Furthermore, fabric handle force and widthwise shrinkage are decreasing for fabrics produced from Egyptian Giza than Greek cotton.

Results show that as the modal % increases for both the Egyptian Giza 86 and Greek cotton yarns inside the double knitted fabric, the wales density, bursting strength, abrasion resistance, handle force and widthwise shrinkage are decreasing while the pilling grade and color difference are increasing.

As the loop length increases the courses/cm, wales/cm, fabric weight (g/m2), fabric thickness, bursting strength, Abrasion resistance, fabric handle force, pilling degree and widthwise shrinkage are decreasing while the lengthwise shrinkage is increasing for Rib and Interlock structure.

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