“DESIGN AND PRODUCTION WOVEN FABRICS USED IN SURGICAL ROOMS"

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Abstract

This research is mainly concerned with designing woven fabrics used in surgical operation rooms (Nurse’s apparel, durable gowns, swabs, towels, drapes, and bedding). The woven technique was applied to produce these fabrics, using cotton yarns. The produced fabrics were treated with tinosan cell (antibacterial finish). Different parameters were studied including, fabric structure (plain weave 1/1, regular hopsack 3/3 and mock leno), weft set (22,26 and 30 pick/cm) and yarns counts (30/1 and 40/1 English).Their influence on the performance of the end-use fabric and the achieved properties were studied. On the other hand physico-chemical properties including; antibacterial, air permeability, water permeability, handle, thickness and weight, were evaluated according to the final product needs.

I. introduction

Textile has swept over new fields in the last three decades, specially in medicine. The use of textiles in medicine has grown rapidly over the past few years and covers almost every thing. Medical textiles refer to textile products often used in combination with non-textile materials, which are used for the medical care of humans and animals and act as protection for personnel's and equipments in medical care situation. (1) Medical textiles differ from other textile products in that there is often little scope for diversification and design variation (2)

The medical textile section, looked at in its broadest term, is undoubtedly one of the greatest success stories of recent years, The medical and related Hygiene industries have been major users of textiles products for many years. Today there has been a huge increase in both the size of the market and the variety of product available [(3)] and most industry leaders at all levels of the distributions network, say that there is potential for new products and applications. [4] , and this study aims to produce fabrics used in surgical rooms.

-Operating room woven apparel

Normal operating room apparel comprises a scrub suit, consisting of trousers and short sleeved tunic, or a dress; which is clean but normally sterile and will normally be worn all day. Woven cotton has the advantages of being easy to launder and sterilize and relatively comfortable to wear, all fabric used for operation – room apparel must have antistatic properties.

-Nurse's apparel

Nurse's apparel is made of conventional fabrics since no specific requirement is needed other than comfort and durability. These fabrics consist of tissue reinforced with a polyester or polypropylene spun- laid web. [5]

-durable Gowns

Woven cotton fabrics are traditionally used in some surgical gowns because cotton does not produce static electrical charges that can build up and produce electric sparks, however it may release particles from the surgeon and also generate high levels of dust. The general requirements for surgical gowns include liquid repellency, bacterial barrier properties, and flame resistance, static safety and toxicity [6]. The fabrics should also be sufficiently flexible, adequate strength, tear resistance and comfort [7]

- Drapes

Drapes are used in the operating room to cover patients and the area around him to reduce the risk of the wound becoming contaminated. [6] Drapes are made from woven cotton or linen, and usually supplied cut to a variety of different shapes appropriate to different surgical procedures and contain an opening according to the position of the surgical site. [5] The general requirements for surgical drapes include liquid repellency, bacterial barrier, conformability, tactile softness, strength, lint propensity , abrasion resistance, flame resistance, static safety and non toxicity .[6]

- Bedding

The bedding is used in the sence of body whose breath is large in comparison with its thickness, the flexible web may be woven or laid down as a nonwoven fabric. It is preferred that the web be permeable to aid the deposition besides that it can allow access of air to the encased limb .The web most preferably has a porous structure and in the case of woven or non- woven fabrics, the porosity of the web may be conditioned by the method of manufacture, so that this particular characteristic may be predetermined to insulate the burned tissues of the patient form being exposured to air and become contaminated.[8]

-Surgical swabs

A swab is an absorbent textile pad used in general surgery to prepare the site of the operation, to absorb excess blood and body fluids, to pack body cavities during surgery and to clean the incision prior to suturing .The traditional swab which is made of cotton gauze suffers from disadvantages despite its widespread use. The advantages of traditional swabs, in particular are their high absorbency and non linting properties [5].

-Surgical towels

Towel must have high absorptive capacity and excellent drying ability with minimum of moisture strike through. Surgeon may have from about 15 to about 30 grams, of water remaining on his hands and arms after the scrubbing operation, this towel has an absorptive capacity of about 4 to about 7 grams of water and weights. The towel must be demonstrating excellent abrasion resistance, strength, sturdiness and at the same time it must be soft [8]

2. The experimental Work

This research concerns with producing fabrics suitable for surgical rooms . All samples in the research were produced with cotton yarns using three woven structures (plain weave 1/1,regular hopsack 3/3 and mock leno) .Three weft sets were also used (22,26 and 30 pick /cm) , using two different yarns counts (30/1 and 40/1 English)

Table (1) specifications of all samples, produced in this research

No	Property	Specification
1	Warp type	Cotton
2	Weft type	Cotton
3	Count of warp yarns	80/2 English
4	Count of weft yarns	30/1-40/1 English
5	Warp set (ends / cm)	40
6	Weft set (picks / cm)	22,26,30
7	Fabric structures	Plain weave 1/1,regular hopsack 3/3 and mock leno
8	Reed used	20 dents /cm
9	Denting	2 end /dent
10	Finishing	Treatment with tinosan cell

Tests

Several tests were carried out in order to evaluate the produced fabrics, these tests were:-

1-Antibacterial, this test was carried out according to the AATCC standard test method 90-1982 [9]

2- Air permeability, this test was carried out according to the (ASTM-D 4491/92) ASTM-D737-1996[10]

3- Water permeability, this test was carried out according to the ISO 811: 1981[1]

4-Fabric handles B.S.3424: (1987) [12]

5-Fabric thickness, this test was carried out according to the (ASTM-D1777/1996) [13]

6-Fabric weight, this test was carried out according to the ASTM-D 3776- 79 [14]

Finishing treatment

The produced fabrics were undergoing special treatments before being used. These treatments include coating with Tinosan cell as following.

The fabric samples were padded in an aqueous solution containing 0 % ,5%,10 % and 15% Tinosan cell which is nonionic wet ability substance (ejetol) and then squeezed to a wet pick up 100 %.The fabric samples were dried at 40 ^{0} C for 20 min ,then thermo-fixed at 110 ^{0} C for 20 sec.

In this study, antibacterial finishes was applied to the samples. All samples were treated with Tinosan cell with various concentrations, 0 %, 5 %, 10 % and 15 % concentration. Antibacterial finishes were applied to fabrics to prevent the growth of microorganisms exposed to the fabrics during surgical operations.

3. Results and Discussion

Results of experimental tests carried out on the produced samples were statistically analyzed and presented in the following tables and graphs.

Antibacterial test

Samples were treated with Tinosan cell at concentration 0 %, 5%, 10 % and 15 %, it can be seen from table (2) and figure (1) that there is a direct relationship between Tinosan cell concentrations and antibacterial effect. it could be stated that the efficiency of the antibacterial finish is not affected by the repellent finish, but the effectiveness of the repellent finish varies with the add-on level of the antibacterial finish .

1-we can see from table(1) and figure (2) that untreated fabrics did not provide any resistance against microbes.

2- Treatment of fabrics with Tinosan led to improvement in properties of the anti- microbes.

3- It was found that treatment of the fabrics with cellulose-based substance with Tinosan cell provided good microbe resistance and it increases with the increase in concentration. Concentration of 15% of Tinosan cell has recorded the highest resistance rate against microbe.

Antibacterial test

Table (2) relationship between Tinosan cell concentration and the diameter of free activated bacteria zone

No	Tinosan cell concentration	Staph	E. coli
1	0	0	0
2	5	3.8-3.9	3.8-3.8
3	10	5.2-5.7	5.5-5.7
4	15	6.1-7.3	6.3-6.8

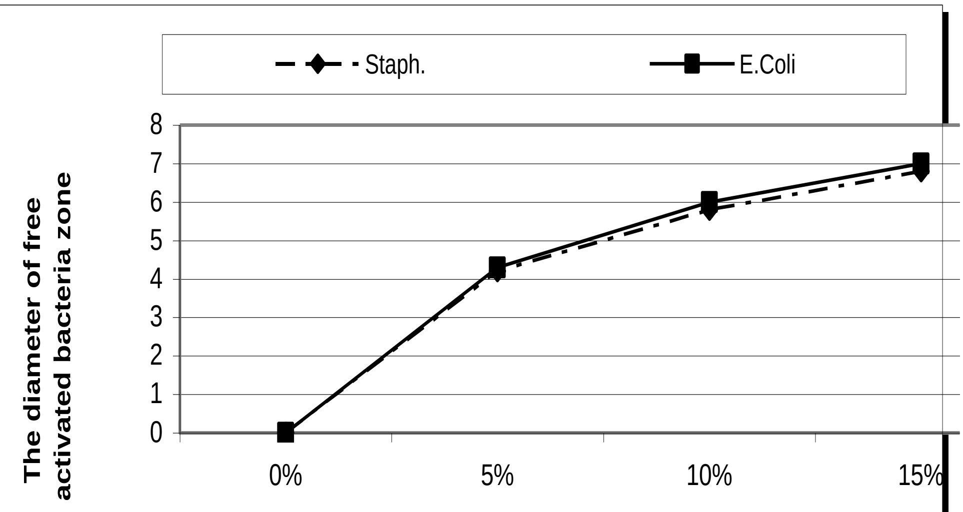

Fig .(1) the relationship between tinosan cell concentration and The diameter of free activated bacteria zone, for produced samples

Table (3) regression equation and correlation coefficient for the effect of Tinosan cell concentration and diameter of the activated bacteria zone, for produced samples.

The variable	Regression equation	Correlation coefficient
Staph	Y=44.6 X+0.73	0.96415
E.Coli	Y= 1.041153X+0.03035	0.99346

Air permeability test

It is clear from the diagrams that regular hopsack 3/3 has obtained the highest rates of air permeability, whereas plain weave 1/1 has obtained the lowest rates, and this is for sake of the increase in the pores for the fabrics produced to hopsack 3/3 weave , lead to produced fabric to be less compacted cause increasing of air spaces in the fabric, causing the increase in the air permeability.

It is also obvious from the statistical analysis of the air permeability results that there is an inverse relationship between number of picks per cm and air permeability. I can report that the increasing in ends and picks cause an obstruction in air passage, causing decreasing in air permeability.

It can be also noticed from the diagrams that samples made of 30/1 English have recorded the lowest rates of air permeability, whereas samples made of 40 /1 English have recorded the highest rates. I can report that yarns of 30/1 English are thicker in diameter than 40 /1 English which decrease the air passage.

From tables and figures it can be noticed that there is an inverse relationship between tinosan concentrations and air permeability. Where it could be reported that the increase in concentration causes a decrease in fabrics pores (blocking of the surface) and so the fabrics become more compacted, and thus decrease in fabric air permeability.

Table (4) results of air permeability test applied to produced samples

Fabric structure	**Weft count**	**Weft set**	**Air permeability (L/m/sec)**	
			Before treatment	**After treatment**
Plain weave 1/1	30/1	22	1250	591
		26	686	259
		30	508	191
	40/1	22	1290	695
		26	842	340
		30	643	230
Regular hopsack 3/3	30/1	22	1990	1556
		26	1570	1150
		30	1190	768
	40/1	22	2010	1668
		26	1590	1330
		30	1250	907
Mock leno	30/1	22	1610	1058
		26	1230	844
		30	923	533
	40/1	22	1630	1122
		26	1280	919
		30	1030	670

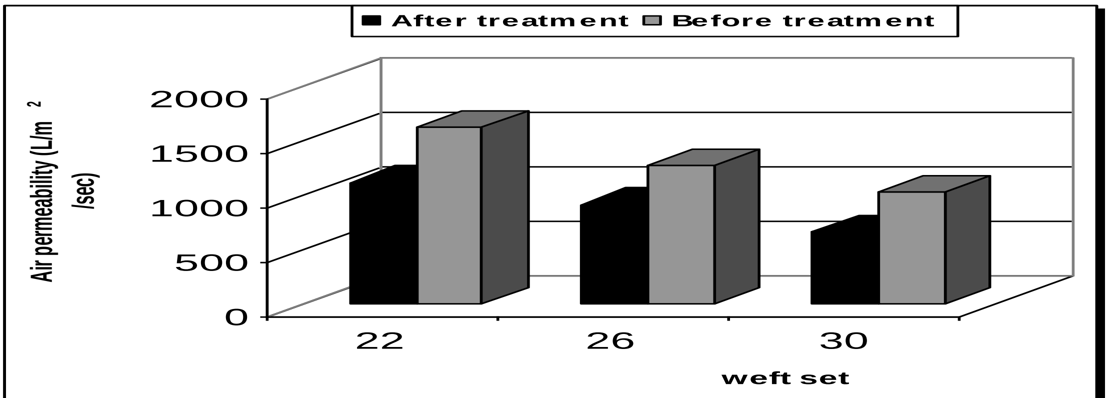

Fig.(2) effect of number of picks/cm on air permeability after and before treatment ,using mock leno structure and weft count , 40/1 English

Table (5) regression equation and correlation coefficient for the effect of number of picks/cm on air permeability, using mock leno structure and weft count 40/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=-1.31538 X+124.6617	-0.99807
Before treatment	Y= -56.5X+2372.667	-0.998278

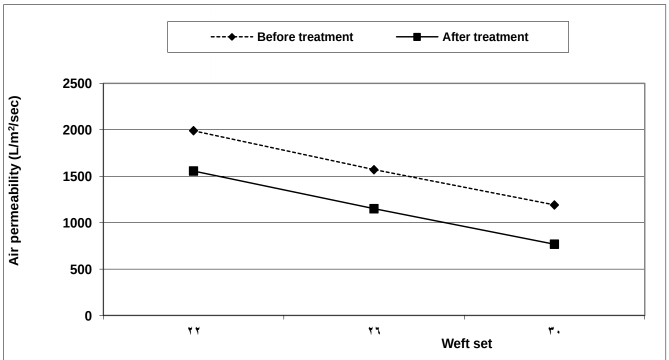

Fig.(3) effect of number of picks/cm on air permeability after and before treatment ,using plain weave 1/1 and weft count 30/1 English

Table (6) regression equation and correlation coefficient for the effect of number of picks/cm on air permeability, using plain weave 1/1 and weft count 30/1 English .

The variable	Regression equation	Correlation coefficient
After treatment	Y=-0.0174 X+32.066008	-0.934457
Before treatment	Y= -0.00989X+34.566	-0.957735

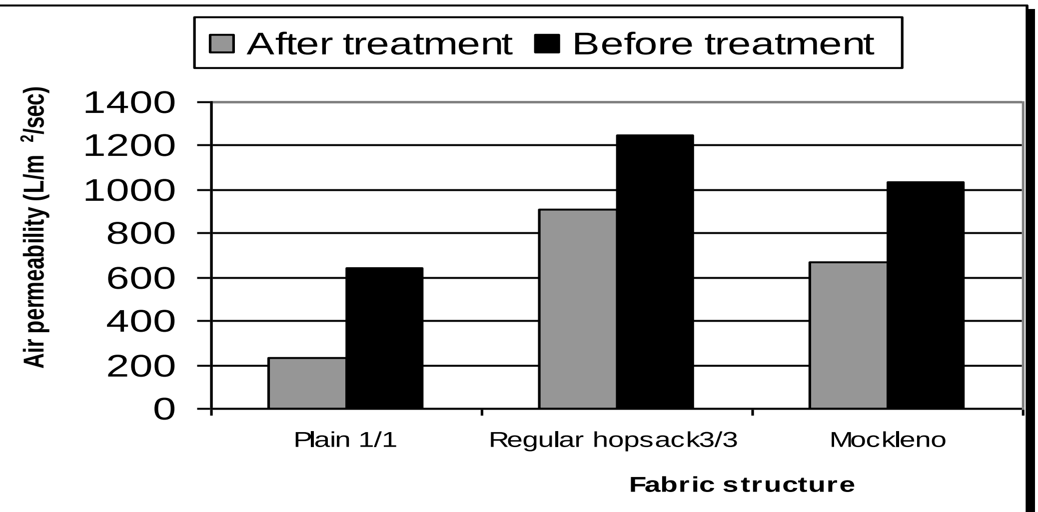

Fig .(4) effect of fabric structure on air permeability ,using 30 picks/cm and weft count 40/1 English

Water permeability test

It is obvious from the diagrams, that plain weave 1/1 has recorded the lowest rates of water permeability, whereas regular hopsack 3/3 has recorded the highest rates. I can report that this is because plain weave 1/1 has more intersections than regular hopsack 3/3 and mock leno, leading the fabric to be more compacted, and spaces in the fabric to be decreased causing decreasing in water permeability.

It is also clear from the diagrams that there is an inverse relationship between number of picks per cm and water permeability. This is for sake of that the increase in number of ends and picks, cause fabrics to be compacted and so prevent the passage of water.

We can also notice that samples made of 30/1 English have obtained the lowest rates of water permeability, whereas samples made of 40/1 English have obtained the highest rates.

This is probably due to that the more diameters the yarns get the less porosity the fabric become and this is because of the increasing of the cover factor

From tables and figures, it can be seen that there is an inverse relationship between tinosan concentrations and water permeability. Where it could be reported that the porosity of the samples has been occluded by the tinosan and so water was prevented from passing.

Table (7) results of water permeability test applied to produce samples

Fabric structure	Weft count	Weft set	Water permeability (ml bar)	
			Before treatment	After treatment
Plain weave 1/1	30/1	22	5.85	2.72
		26	5.5	2.5
		30	4.5	2.35
	40/1	22	3.65	2.6
		26	3.35	2.5
		30	3.2	2.25
Regular hopsack 3/3	30/1	22	3.6	2.0
		26	3.3	1.75
		30	3.1	1.25
	40/1	22	3.25	1.5
		26	3.0	1.25
		30	2.25	1.1
Mock leno	30/1	22	4.0	2.6
		26	3.5	2.3
		30	3.25	2.25
	40/1	22	3.5	2.28
		26	3.15	2.25
		30	3.0	2.25

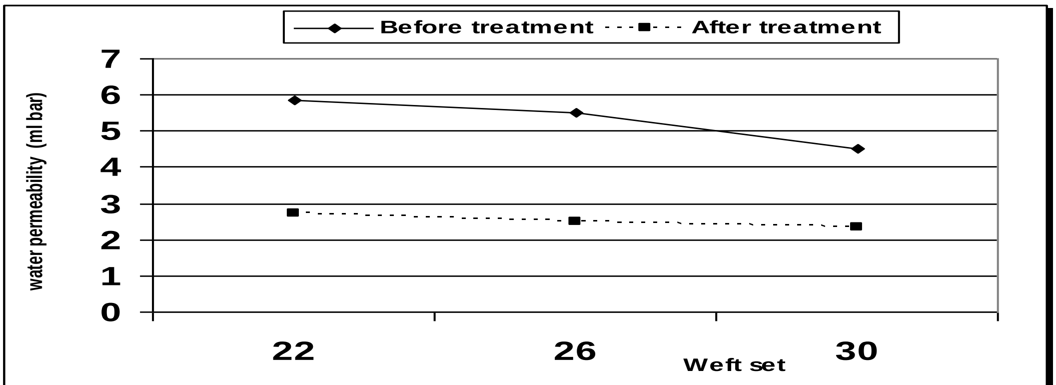

Fig.(5) effect of number of picks/cm on water permeability after and before treatment ,using plain weave 1/1 and weft count 30/1 English

Table (8) regression equation and correlation coefficient for the effect of weft set on water permeability, using plain weave 1/1 and weft count 30/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=-0.04625 X+1.320833	-0.994.87
Before treatment	Y=- 0.016875X+0.8958	-0.963467

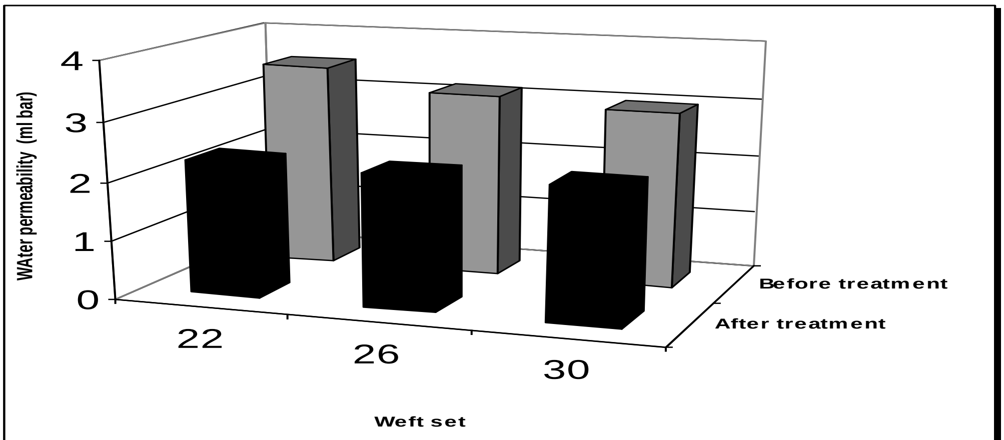

Fig.(6) effect of number of picks/cm on water permeability after and before treatment ,using mock leno structure and weft count 40/1 English

Table (9) regression equation and correlation coefficient for the effect of weft set on water permeability, using plain weave 1/1 and weft count 30/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=-0.0625 X+1.599667	-0.974355
Before treatment	Y=- 0.01625X+1.80416	-0.954919

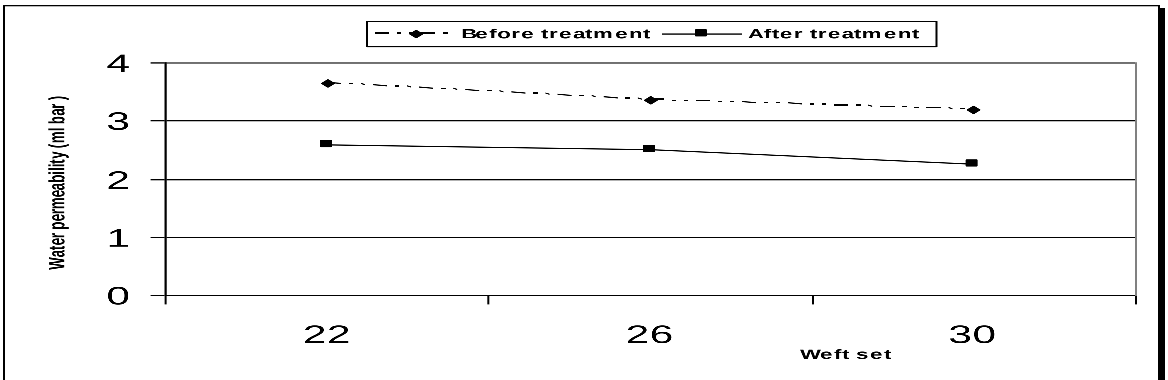

Fig.(7) effect of number of picks/cm on water permeability (par) after and before treatment ,using plain weave 1/1 and weft count 40/1 English

Table (10) regression equation and correlation coefficient for the effect of weft set on water permeability, using regular hopsack 3/3 and weft count 40/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=-1.9375 X+0.05625	-0.91981
Before treatment	Y= -0.09375X+0.77083	-0.91981

Fabric handle test

In fabric handle test , the less angle value ,the more smoother the fabric become .According to this ,it is clear from the diagrams that regular hopsack 3/3 is considered the most smooth fabrics among all woven fabrics followed by mock leno , and then plain weave 1/1.This is probably because regular hopsack weave have the advantage of containing long floats and less intersections besides that it has ridges and hollows and so reduce the friction between the body and fabrics, besides that the warp and weft threads float freely on both sides, so that frication points between the tested fabrics and the standard woolen fabric ,used in the test are minimized allowing easily sliding of fabric down the slope. After antibacterial treatment the fabrics smoothness is less because the treatment made in alkali and high temperature, these factors cause decrease in fabric smoothness. Softness material should be added in antibacterial treatment bath to increase the fabric smoothness.

Table (11) results of handle test applied to produced samples

Fabric structure	**Weft count**	**Weft set**	**Handle (^{0})**	
			Before treatment	**After treatment**
Plain weave 1/1	30/1	22	41.5	44
		26	42.8	45
		30	43	45<
	40/1	22	40	43
		26	41.5	44
		30	42.5	45
Regular hopsack 3/3	30/1	22	40	42
		26	40.5	43
		30	41.3	44
	40/1	22	39	41
		26	39.6	42
		30	39.8	43
Mock leno	30/1	22	41.3	43
		26	42.75	44
		30	43	45
	40/1	22	39.3	42
		26	39.8	43
		30	41.8	44

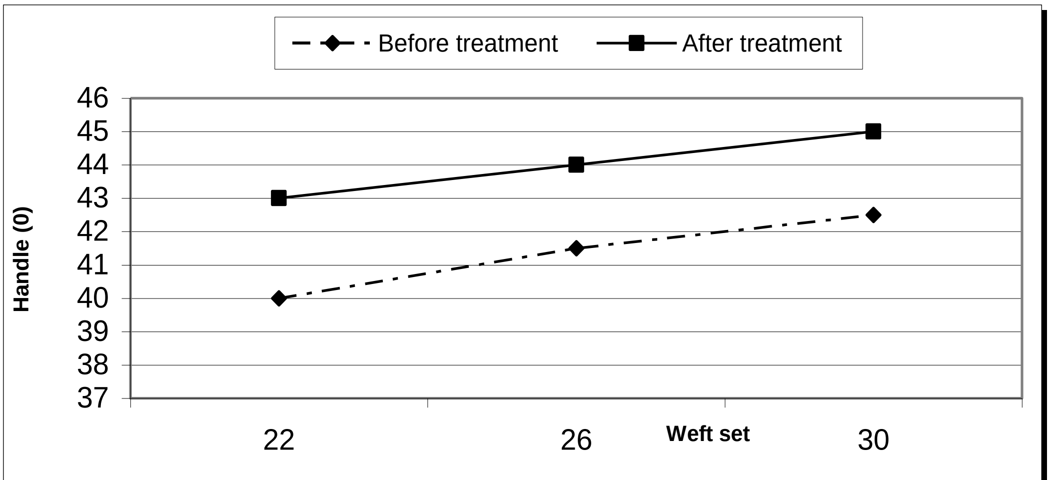

Fig .(8) effect of number of picks /cm on fabric handle after and before treatment ,using plain weave 1/1 and weft count 30/1 English

Table (12) regression equation and correlation coefficient for the effect of weft set on fabric handle, using plain weave 1/1 and weft count 30/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=0.0125X+41.41667	0.866025
Before treatment	Y= 0.01875X+37.558337	0.920864

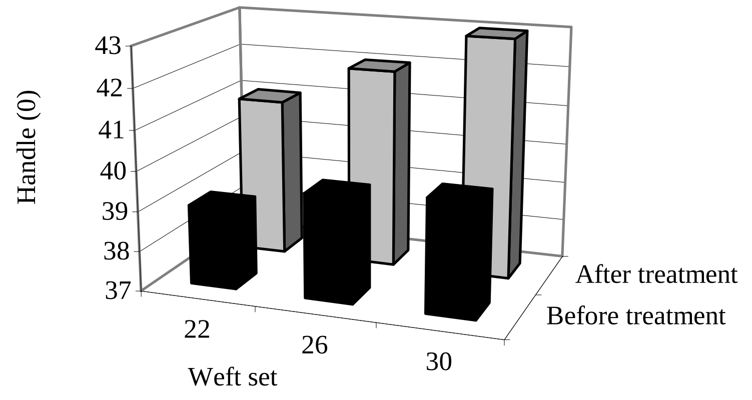

Fig.(9) effect of weft set on fabric handle ,using weft count 40/1 English and regular hopsack 3/3

Table (13) regression equation and correlation coefficient for the effect of weft set on fabric handle, using regular hopsack 3/3 and weft count 40/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=0. 25X+35.5	1
Before treatment	Y= 0.1X+36.86667	0.960769

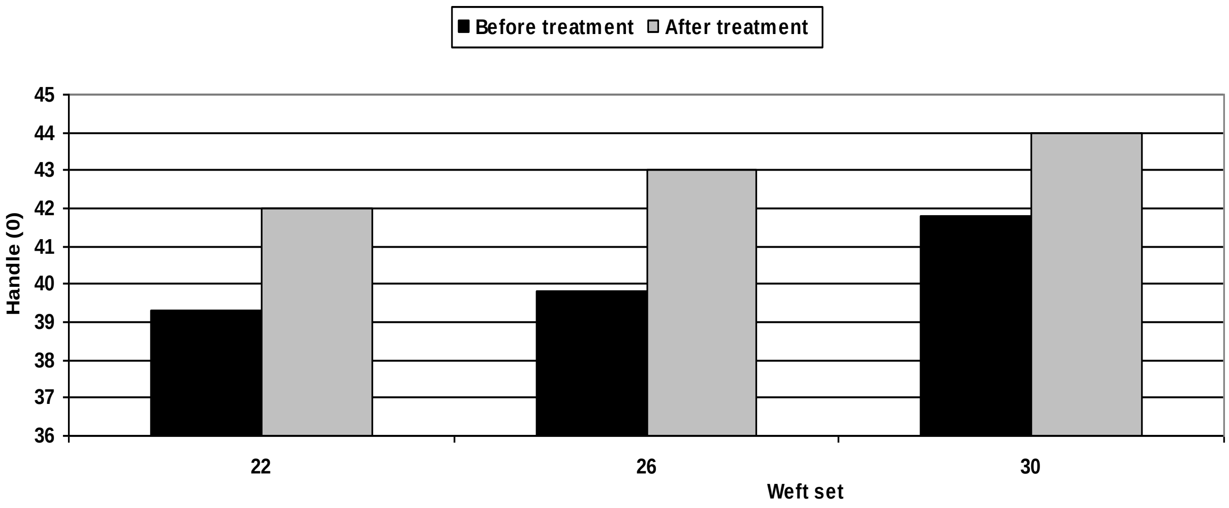

Fig.(10) effect of weft set on fabric handle ,using mock leno structure and weft count 40/1 Engligh

Table (14) regression equation and correlation coefficient for the effect of weft set on fabric handle, using mock leno structure, and weft count 40/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y= 0.25X+36.5	0.944911
Before treatment	Y=0. 3125X+32.175	1

Thickness test

It is clear from the diagrams, that regular hopsack 3/3 has recorded the highest rates of thickness, followed by mock leno and then plain weave 1/1 , which achieved the lowest rates , and it was found that the difference between them was insignificant.

This is mainly for sake of that hopsack 3/3 weave have more float than mock leno and then plain weave 1/1, which gives it the advantage of having ridges on fabric surface giving hopsack 3/3 weave the ability of being thicker than the other structures .

Another reason for these differences in thickness is yarn count, as samples with count 30/1 English have recorded the highest thickness followed by samples with 40/1 English, This is due to that diameter of 30/1 English are thicker than yarns of 40/1 English, causing the produced samples to be thicker .It was also found that the more yarns per unit area the more thicker the samples become, so samples with 30 picks per cm have recorded the highest rates of thickness, whereas samples with 22 picks per cm have recorded the lowest rates. And from the statistical analysis of thickness test, it can be noticed that there is a direct relationship between tinosan concentrations and thickness. As the increase of concentrations causes an increase in weight and hence an increase in thickness.

Table (15) results of thickness test applied to produced samples

Fabric structure	Weft count	Weft set	Thickness (mm)	
			Before treatment	After treatment
Plain weave 1/1	30/1	22	0.29	0.31
		26	0.305	0.32
		30	0.31	0.34

	40/1	22	0.27	0.303
		26	0.28	0.298
		30	0.29	0.313
Regular hopsack 3/3	30/1	22	0.448	0.47
		26	0.452	0.49
		30	0453	0.498
	40/1	22	0.405	0.46
		26	0.411	0.46
		30	0.412	0.466
Mock leno	30/1	22	0.39	0.42
		26	0.40	0.441
		30	0.41	0.45
	40/1	22	0.35	0.385
		26	0.36	0.39
		30	0.37	0.40

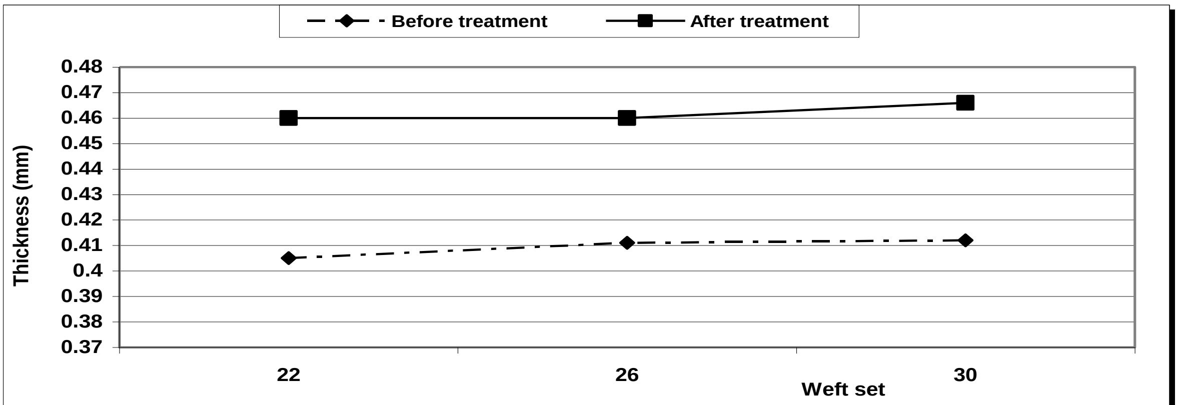

Fig.(11) effect of weft set on thickness ,using regular hopsack 3/3 and weft set 30/1 English

Table (16) regression equation and correlation coefficient for the effect of weft set on thickness using regular hopsack 3/3 and weft count 30/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=0. 00075X+0.4425	0.866025
Before treatment	Y= 0.00087X+0.38658	0.924473

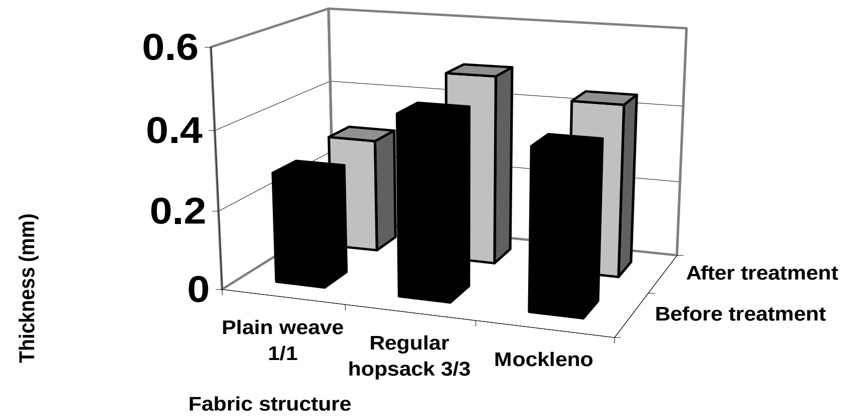

Fig .(12) effect of fabric structure on thickness ,using 26 weft /cm and weft count 40/1 Engligh

Weight test

It is clear from the diagrams that there were insignificant differences in weight between the three structures.

It is also clear that samples produced of 30/1 English have recorded the highest weight followed by samples with 40/1 English, this is for sake of that yarns of 30/1 English are thicker than yarns of 40/1 English, causing the produced samples to be increased in weight.

It was also found that the more yarns per unit area the thicker the samples become, so samples with 30 picks per cm have recorded the highest weight, whereas samples of 22 picks per cm have recorded the lowest weight.

It is also obvious from the statistical analysis of weight test that there is a direct relationship between tinosan concentrations and weight .I can state that the increase of concentration ratio cause an increase in weight.

Table (17) results of weight test fabric applied to produced samples

Fabric structure	Weft count	Weft set	Thickness (mm)	
			Before treatment	After treatment
Plain weave 1/1	30/1	22	105	111
		26	113	127
		30	118.8	131
	40/1	22	89.9	98
		26	100	108.9
		30	103.7	113.5
Regular hopsack 3/3	30/1	22	100.8	106.8
		26	105.5	113.5
		30	113	122
	40/1	22	88	92.87
		26	91	97.6
		30	99	106
Mock leno	30/1	22	102.5	112
		26	108	119.69

		30	118	128.66
	40/1	22	91.5	98
		26	96	104.9
		30	102	112.5

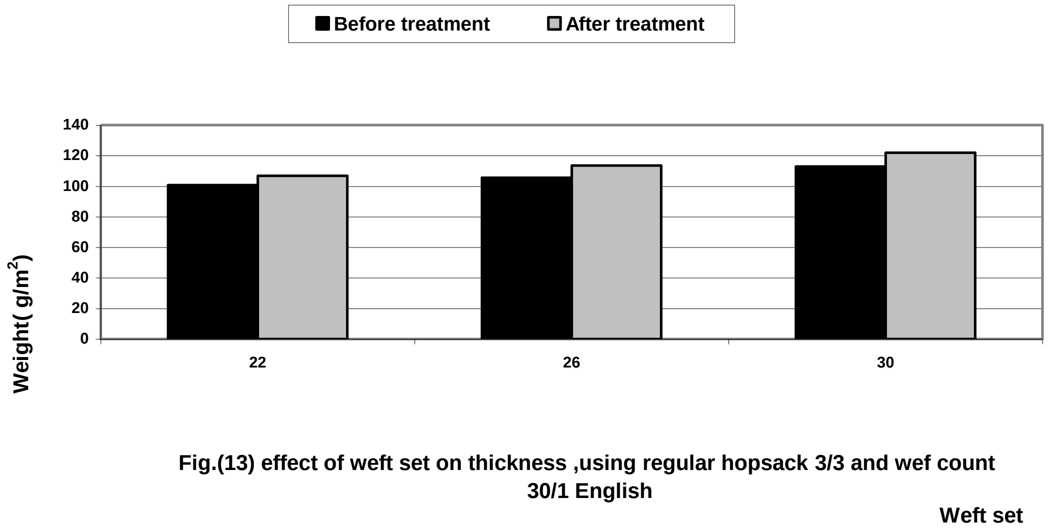

Fig.(13) effect of weft set on thickness ,using regular hopsack 3/3 and wef count 30/1 English

Table (18) regression equation and correlation coefficient for the effect of weft set on weight, using regular hopsack 3/3 and weft count 30/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=1. 525X+66.078333	0.991335
Before treatment	Y= 1.9X+64. 7	0.997671

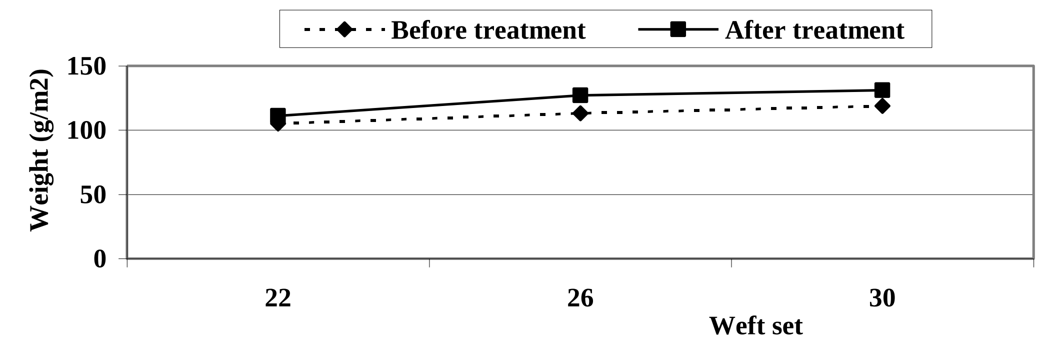

Fig.(14) effect of weft set on weight ,using mock leno structure and weft count 40/1 English

Table (19) regression equation and correlation coefficient for the effect of weft set on weight, using mock leno and weft count 40/1 English.

The variable	Regression equation	Correlation coefficient
After treatment	Y=1. 8125X+58500833	0.999612

Before treatment	Y= 1.3125X+63.375	0.996616

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