

# AN INVESTIGATION OF PERFORMANCE PROPERTIES OF CURTAIN FABRICS PRODUCED WITH DIFFERENT TYPES OF POLYESTER YARNS

## FARKLI TİPTE POLYESTER İPLİKLERLE ÜRETİLMİŞ PERDELİK KUMAŞLARIN PERFORMANS ÖZELLİKLERİNİN ARAŞTIRILMASI

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### ABSTRACT

In recent years, curtain has come to a very important place in home textile industry. Curtain, drapery, upholstery, table cloth, sheets and pillowcases, bath accessories, napkins and chair wraps appears to take place within a wide range of home textiles. The textile fabrics most commonly used for home furnishing can be listed as cotton, rayon, linen, nylon, polyester, and their blends. Different techniques have been used by home textile manufacturers to enhance the decorative aspect of the home furnishing products. The most preferred fabrics in home textiles are polyester based fabrics for high durability and ease of use properties. In this study, curtain polyester fabrics with seven different types of weft yarns were woven as samples for the experiments. 300/192 denier 100 % Polyester tight spot (linen like) warp yarn was chosen for all fabrics. The aim of this study is to investigate the breaking strength, breaking elongation, abrasion resistance and air permeability properties of curtain fabrics woven with different types of polyester yarns.

**Keywords:** Curtain, polyester, air permeability, abrasion resistance, breaking strength.

### ÖZET

Son yıllarda perde, ev tekstili endüstrisi içerisinde oldukça önemli bir yere gelmiştir. Perde, döşemelik kumaş, masa örtüsü, yatak örtüsü, banyo aksesuarları, peçete ve koltuk şalları gibi geniş bir ürün çeşitliliğinin ev tekstilinde yer aldığı görülmektedir. Ev dekorasyonunda en çok kullanılan kumaşlar, pamuk, rayon, keten, nylon, polyester ile bunların bileşimleridir. Ev tekstili üreticileri tarafından ev tekstili ürünlerinde dekoratif etkiyi artırmak için değişik teknikler kullanılmıştır. Ev tekstili ürünlerinde en fazla tercih edilen kumaşların yüksek dayanım ve kullanım kolaylığı açısından polyester esaslı kumaşlar olduğu görülmektedir. Bu çalışmada deneylerde kullanılmak için, yedi farklı özellikte atkı ipliği kullanılarak yedi farklı perdelik polyester kumaş dokutulmuştur. 300/192 denye % 100 polyester tight spot çözgü ipliği tüm numunelerde kullanılmıştır. Bu çalışmanın amacı farklı yapılarda polyester ipliklerden dokunmuş perdelik kumaşların kopma dayanımı, kopma uzaması, aşınma dayanımı ve hava geçirgenliği özelliklerinin araştırılmasıdır.

**Anahtar Kelimeler:** Perde, polyester, hava geçirgenliği, aşınma dayanımı, kopma dayanımı.

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### 1. INTRODUCTION

Home textiles can be defined as the textiles used for home furnishing. The basic items may be grouped as sheets and pillow cases, blankets, terry towels, curtains, table cloths, carpets and rugs. The fabrics are used for home textiles consists of both natural and man-made fibres like cotton, linen, rayon, polyester or blends of any combination of these fibres.

Curtains are identified according to types based on thread counts. The higher the count, the closer and more uniform the weave, the more compact the weave the greater the resistance to use. They are produced in various ways, designs and patterns. Curtain fabrics are used for two main purposes; first is sound absorption, thermal insulation, softening light emissions and protection of furniture from the harmful effect of sun rays (UV) especially in modern

buildings. The second is aesthetic represented in addition of art touch as an aesthetic value (1,2).

Performances of any textile structure mostly depend on its behaviour against subjected forces in different directions. Strength tests are the most employed method in order to evaluate the performances of textile materials during usage and processing. All home textiles fabrics bend and fold with remarkable ease during use and laundering often to relatively high curvatures. Breaking strength, abrasion resistance, air permeability, wrinkle and crease recovery are particularly important for home textiles fabrics. Standard performance properties are very important for curtain and drapery fabrics. ASTM D 3691 is related with standard performance specification for woven, lace and knit household curtain and drapery fabrics (3,4). For getting all the advantages of fabric used for curtains, it must have properties such as light fastness, resistance to seam slippage, resistance to staining, pilling, flame retardancy, etc (5).

References to curtain are generally related to fabrics woven with a plain weave of polyester or more often cotton/polyester blended yarns. It may be noted that curtain fabrics are also made to a laminated extent of linen, silk, acetate and nylon; the constructions vary from plain to satin weave or knitted (6,7). Curtain fabrics blended from polyester yarns recorded the highest readings for light reflection; whereas fabrics blended from polyacrylic yarns recorded the least readings. Curtain fabrics blended from cotton yarns have verified the highest readings for air permeability; whereas fabrics blended from polypropylene yarns recorded the least readings (8).

Factors which affect breaking strength, abrasion resistance and air permeability include fibre content and properties, yarn structure (e.g. spinning system, yarn twist and yarn linear density), fabric structure and weight and chemical and mechanical treatments imposed during dyeing and finishing processes, particularly in as much as the later affect the fibre friction and resistance to flexing (9,10,11).

In this study, we investigated breaking strength, breaking elongation, abrasion resistance and air permeability of curtain fabrics woven with polyester yarns having different structures. However there is no research on performance properties of curtain fabrics produced with different types of polyester yarns in the literature. This study aims to fill this gap by contributing to the investigation of the influence of

polyester yarn type on breaking strength, breaking elongation, abrasion and air permeability properties of woven fabrics produced with these yarns.

## 2. MATERIAL AND METHOD

### 2.1. Material

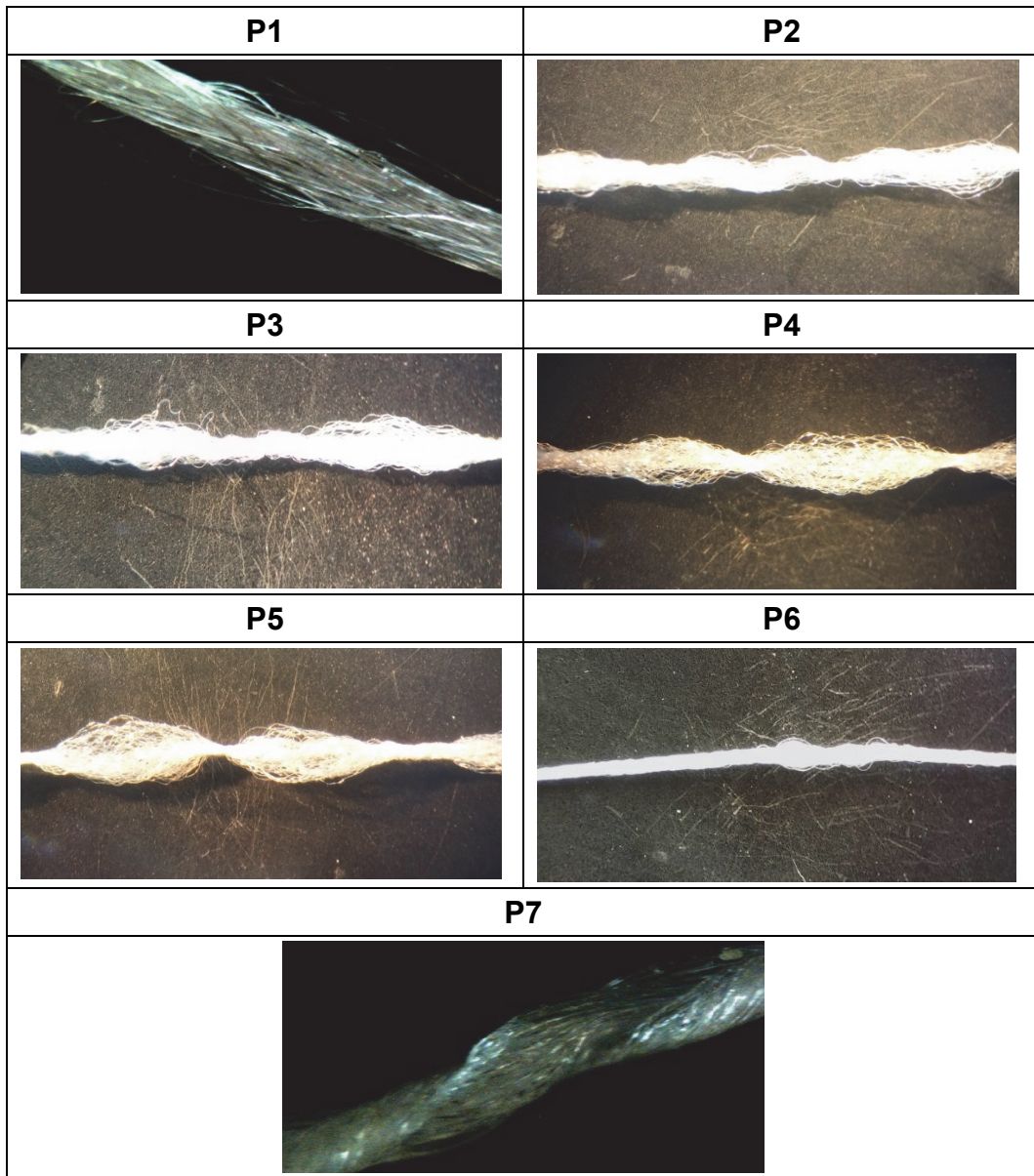
Seven different types of polyester yarns having same yarn count of 300 denier but varying in their structures were selected in order to determine the influence of polyester yarn types on tensile behavior, abrasion resistance and air permeability properties of fabrics produced with these yarns. Characteristics of the polyester yarns are listed in Table 1.

Air Jet Textured Polyester Yarn (P1): Air-jet texturizing process is a mechanical method that uses a cold air-stream to produce bulked yarns of low extensibility. These yarns resemble spun yarns in their appearance and physical characteristics. Air textured yarn is very bulky with permanent crimps and loops. Interlacing of filaments in the jet can cause the loops to be locked into the yarn, so that twist is unnecessary. Textured Polyester Yarn (P2): Texturizing processes make yarns more opaque; improve appearance and texture, and increase warmth and absorbency. 100 % Cationic Textured Polyester Yarn (P3): Polyester can be coloured using cationic dyes thanks to the reactive groups integrated into the yarn. From the production point of view, it allows to dye at lower temperatures than required by a normal polyester around 100°C instead of 130°C without using carriers which adversely affect the colour fastness, especially on products stored for a relatively long time after dyeing or on products being thermo-fixed without pre-washing. 50/50 % Cationic Polyester/Polyester Regular Intermingled Yarn (P4): 50/50 % Cationic Polyester/Polyester yarn is permanently intermingled with regular intervals. 50/50 % Cationic Polyester/Polyester Irregular Intermingled Yarn (P5): 50/50 % Cationic Polyester/Polyester yarn is permanently intermingled with irregular intervals. Tight Spot (Linen Like) Polyester Yarn (P6): The surfaces of the fabrics produced with this type of yarns resemble those produced with linen yarns. This type of yarn is especially used for the production of home textile fabrics. Two folded Polyester Yarn (P7): Two flat polyester yarns are folded and twisted.

Microscopic photos of polyester yarn types used in this study are shown in Figure 1.

**Table 1.** The properties of polyester yarns used in the study

Yarn Code	Yarn Type	Yarn Count (Denier)	Tenacity (cN/tex)	Std. dev.	Elongation (%)	Std. dev.
P1	Air Jet Textured Polyester Yarn	300/96	33.42	1.67	25.54	1.35
P2	Textured Polyester Yarn	300/96	35.74	0.55	33.66	1.05
P3	100 % Cationic Textured Polyester Yarn	300/96	27.31	0.47	39.68	0.99
P4	50/50% Cationic Polyester/Polyester Regular Intermingled Yarn	300/144	31.16	1.06	27.84	0.98
P5	50/50% Cationic Polyester/Polyester Irregular Intermingled Yarn	300/144	32.32	0.36	28.74	0.72
P6	Tight Spot (Linen Like) Polyester Yarn	300/192	36.72	1.49	45.88	2.72
P7	Two folded Polyester Yarn (200 tpm)	300/192	20.07	1.97	23.86	2.20



**Figure 1.** Microscopic photos of polyester yarn types

Afterwards, seven different curtain fabrics from different types of polyester yarns were woven on a water jet type Tsudokoma weaving machine using these yarns as filling in the fabric construction. The fabric weave type was selected as etamine which is a loose weave used especially for clothing and curtains. Photographs of etamine weave and a type of curtain fabric used in this study are shown in Figure 2.

The warp yarn was 100 % Polyester Tight Spot (Linen Like) yarn, 300 denier/ 192 f. To avoid variables, the warp yarn was chosen identical to the yarn employed for the filling. The warp and weft direction densities were 26 ends/cm and 24 picks/cm respectively.

The fabric samples were divided to three groups. These were;

- First group ; fabric samples with P1, P2 and P3 yarns (300/96 denier polyester)

- Second group; fabric samples with P4 and P5 yarns (300/144 denier polyester)

- Third group ; fabric samples with P6 and P7 yarns (300/192 denier polyester)

At first group; P1, P2 and P3 yarns have the same yarn count but have different production process. Air-jet textured polyester yarn (P1); the air-textured yarns resemble spun yarns in their appearance and physical characteristics. Air textured yarn is very bulky with permanent crimps and loops. Interlacing of filaments in the jet can cause the loops to be locked into the yarn, so that twist is unnecessary. Textured polyester yarn (P2), have random loops or other fine distortions along the lengths of the filaments, primarily giving the yarn increased bulk with or without increased stretch. Cationic textured yarn (P3), polyester can be colored using cationic dyes thanks to the reactive groups integrated into the yarn. From the production point of view, it allows to dye at lower temperatures than required by a normal polyester (around 100°C instead of 130°C) without



using carriers. Second group; P4 and P5 yarns are the same number but have different production process. 50/50 % Cationic Polyester/Polyester Regular Intermingled Yarn (P4) and 50/50 % Cationic Polyester/Polyester Irregular Intermingled Yarn (P5) have some different properties because of irregular intermingles on the yarns. The microscopic photos at Figure 1 show that the structures of these yarns are different because of the regularity of intermingles along the yarn. Third group; Tight Spot (Linen Like) Polyester Yarn (P6) and Two folded Polyester Yarn with 200 tpm (P7) have also different characteristics because of their structures.

## 2.2. Method

The tests carried out during the research are listed below. These were yarn and fabric tensile tests, abrasion resistance and air permeability. Prior to the air permeability tests, all fabric samples were conditioned for 24 hours in standard atmospheric conditions (at a temperature of  $20 \pm 2$  °C and relative humidity of  $65 \pm 2\%$ ).

### Tensile Properties

Tensile tests of the yarns were performed according to ISO 2062 standard method and tensile tests of the fabric samples were performed according to EN ISO 13934-1 standard method on an Instron tensile tester (Model 4301). Test parameters were: 500 mm gauge length, 10 cN pre-tension, 5 kg load cell and 500 mm/min test speed for yarn samples. Tenacity of produced yarns was calculated after all

measurements were done by using breaking strength (cN) and yarn count (tex) values. Ten tests were performed for each yarn type. The values are recorded for the mean. Test parameters for the fabrics samples were 50 mm fabric width, 200 mm gauge length between the clamps and 100 mm/min speed of extension. Breaking strength (kN) and breaking elongation (%) of the weft wise fabrics were measured.

### Abrasion Resistance

Abrasion resistance tests of the woven fabric samples were carried out with the help of a Martindale Abrasion Tester (SDL ATLAS, England) in accordance with ISO 12947-3. Conventional wool abradant fabric was used. The pressure imposed on the fabric during rubbing was 12 kPa. The abrasion resistances of the fabrics were evaluated according to their mass loss (%). To determine the mass loss, the cut samples were weighted at the beginning and after 20000 abrasion cycles. At the initial stage, the absolute mass loss values in mg were determined. Mass loss ratios were obtained by the proportion of the mass loss of the samples to the initial mass of the samples. Measurements were repeated four times for each fabric sample.

$$\% \text{ Mass loss} = [(m_1 - m_2) / m_1] \times 100 \quad (1)$$

where:

$m_1$  = mass of specimen at the beginning of the abrasion test

$m_2$  = mass of specimen at the end of the abrasion test

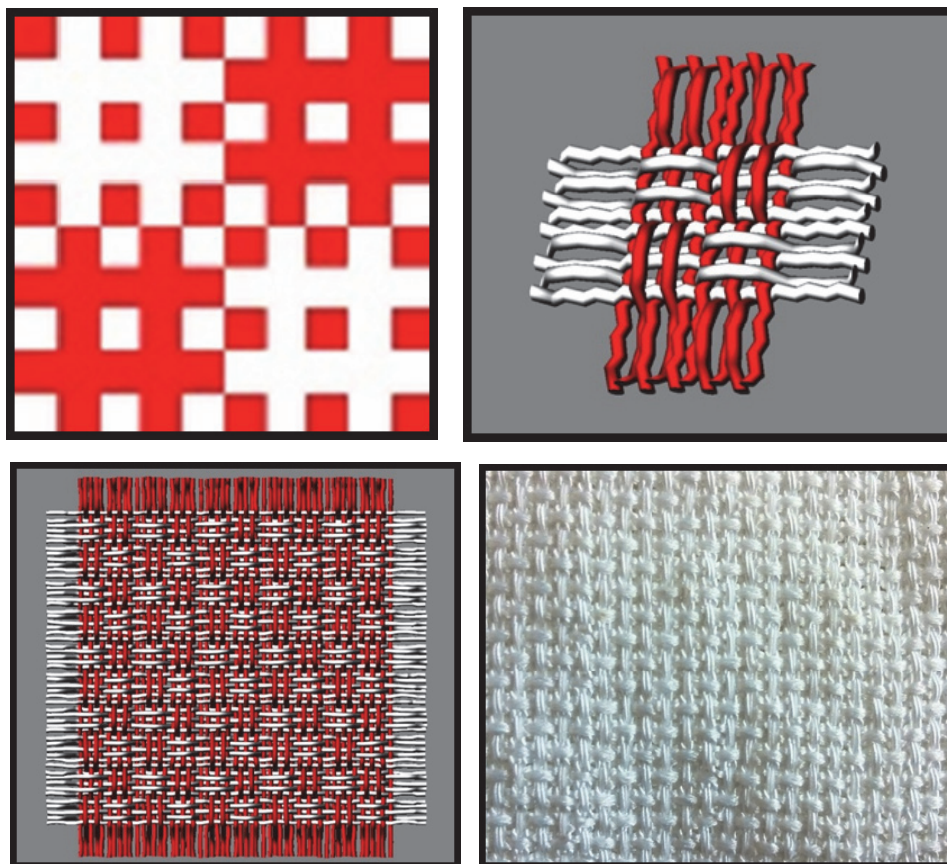


Figure 2. Photographs of etamine weave and curtain fabric used

### Air Permeability

Air permeability tests of the woven fabrics were performed according to ISO 9237 standard using a SDL Atlas Digital Air Permeability Tester Model M 021A. The pressure level is of critical importance. The pre-selected test pressure was automatically maintained by the digital tester before the measurement. 200 Pa (200 Pascal) pressure drop was used in testing air permeability. The test area was 20 cm<sup>2</sup> for all samples. Pre-selected unit of measure was dm<sup>3</sup>/s. Measurements were repeated ten times for each fabric type.

The air permeability (mm/s) was determined as follows (10):

$$R = \left( \frac{\bar{q}_V}{A} \right) \cdot 167, \quad (2)$$

where:

- $\bar{q}_V$  — an arithmetical average of the debit of air flow, dm<sup>3</sup>/min;
- A — test area, cm<sup>2</sup>;
- 167 — coefficient of conversion from dm<sup>3</sup>/min to cm<sup>3</sup>/s and then from cm/s to mm/s

### 2.3. Statistical Evaluation

The SPSS 17.0 Statistical software package was used for conducting all statistical procedures. Completely randomized single-factor (one way) multivariate analysis of variance (ANOVA) as a fixed model was applied to data in order to investigate the statistical importance of polyester yarn type parameter on breaking strength, breaking elongation, abrasion resistance and air permeability properties of fabrics from these yarns. The means were compared by Student-Newman-Keuls (SNK) tests. The value of significance level ( $\alpha$ ) selected for all statistical tests is 0.05. The treatment levels were marked in accordance with the mean values, and levels marked by different letter (a, b, c) showed that they were significantly different.

### 3. RESULTS AND DISCUSSION

Analysis of variance and Student-Newman-Keuls test results are given in Table 2. The results of the of ANOVA test given in Table 2 indicated that; there were statistically significant (5% significance level) differences between the fabric breaking strength between the fabric breaking elongation, between the air permeability and between the abrasion resistance of fabrics from different types of polyester yarns.

#### Breaking Strength and Breaking Elongation Results:

It can be seen from Figure 3 that the minimum fabric breaking strength was measured for the fabric produced with P7 coded yarn (two folded polyester yarn with 200 tpm) as 0.53 kN while the maximum fabric breaking strength was measured for the fabric produced with P5 coded yarn (50/50 % cationic polyester/polyester irregular intermingled yarn) as 1.1 kN. Two folded Polyester Yarn (200 tpm) have a twisted structure and it is known that increasing twist level at filament yarns results in a decrease at the breaking strength of yarns. As a result of this the fabrics produced from this yarn have lower weft wise fabric breaking strength. The reason of the maximum breaking strength measured for the P5 coded yarn which has irregular intermingles can be attributed to the fact that the irregular nips in the yarn structure makes the yarn resistant to breaking stress.

The SNK test results given in Table 2 revealed that, the woven fabrics produced with different types of polyester yarns possessed statistically different fabric breaking strength values. Fabric breaking load of fabric produced with P7 coded yarn was significantly different from those of fabrics produced with other yarns having codes of P1, P2, P3, P4, P5 and P6 respectively. There was not any significant difference between the breaking strength values of fabrics produced with P1, P2, P3, P4, P5 and P6 coded yarns.

Fabric strength, as a characteristic in determining performance and durability, is generally not as important in apparel as in applications such as upholstery, sheeting, home textiles, shirting materials and industrial textiles. It also provides a basis of comparison for similar fabrics and a means of assessing any damage caused by chemical and mechanical treatments, for example dyeing and finishing.

**Table 2.** Statistical analysis (Analysis of variance and SNK test) results for tensile, abrasion and air permeability properties

Anova and Student-Newman-Keuls Test Results								
Parameter: Yarn type	Fabric Breaking Strength (kN)		Fabric Breaking Elongation (%)		Fabric Abrasion (%)		Air permeability (mm/s)	
	P/Sig.	SNK ranges	P/Sig.	SNK ranges	P/Sig.	SNK ranges	P/Sig.	SNK ranges
P1	0.000 *	0.81 b	0.000 *	35.79 a	0.000 *	3.20 ab	0.000 *	1775 b
P2		0.95 b		57.33 b		2.90 a		1487 a
P3		1.03 b		39.93 a		3.93 b		1375 a
P4		0.97 b		40.45 a		3.09 ab		1515 a
P5		1.10 b		46.32 a		4.80 c		1375 a
P6		0.98 b		58.83 b		3.06 ab		1911 c
P7		0.53 a		39.91 a		5.70 d		3014 d

\*: statistically significant ( $P < 0.05$ )

(a), (b), (c), (d), represent the statistical difference ranges according to SNK test.

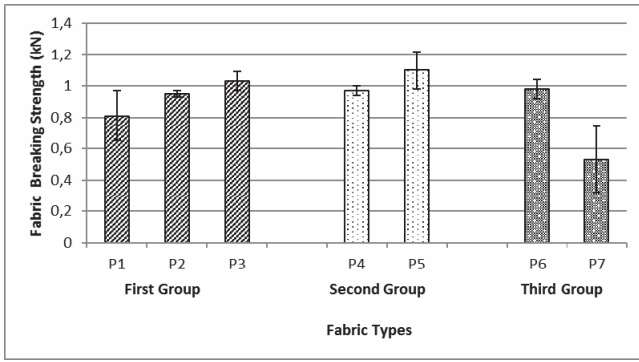


Figure 3. Fabric breaking strength results of curtain fabrics

The degree of yarn strength utilization in the fabric depends upon a number of yarn and fabric structural parameters, with the relationship between yarn and fabric strength being highly complex. A good example is the increased fabric strength of compact yarns (1).

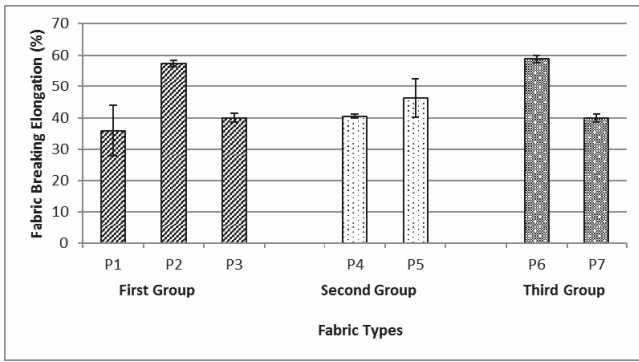


Figure 4. Fabric breaking elongation results of curtain fabrics

It can be seen from Figure 4 that the minimum fabric breaking elongation was measured for the fabric produced with P1 coded yarn (air jet textured polyester yarn) as 35.79 % while the maximum fabric breaking elongation was measured for the fabric produced with P6 coded yarn (tight spot polyester yarn) as 58.83 %.

The result for this situation is that, air jet textured yarns have unique surface structure and greater bulk than the parent yarns. The internal structure of the yarn is such that the tenacity and initial modules are substantially reduced and there is a certain amount of instability present in the macro structure of the yarn. Provided the instability is not very high, the extension at peak load is reduced (12). The reason for the maximum fabric breaking elongation for P6 coded yarn (tight spot polyester yarn) is that spots in the yarn make the structure instable.

The SNK test results given in Table 2 revealed that, the woven fabrics produced with different types of polyester yarns possessed statistically different fabric breaking elongation values.

Breaking elongation of fabric produced with P1, P3, P4, P5, P7 coded yarns were statistically same and different from those produced with P2 and P6 coded yarns. There was not any significant difference between the breaking elongation values of fabrics produced with P2 and P6 coded yarns.

### Abrasion Test Results

Abrasion is the mechanical deterioration and progressive loss of substance of a fabric resulting from the fabric rubbing against itself or another surface, usually in turn resulting from the removal of damaged/broken fibre fragments and complete fibres, and to some extent due to frictional wear (7).

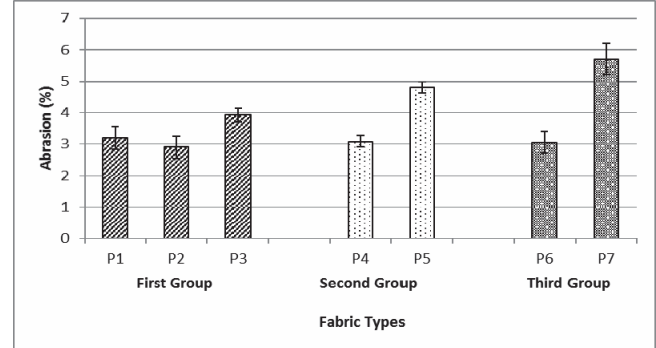


Figure 5. Abrasion test results of curtain fabrics

It can be seen from Figure 5 that the minimum mass loss due to abrasion was obtained as 2.9 % for the fabric produced with P2 coded yarn (textured polyester yarn) while the maximum mass loss due to abrasion was measured as 5.7 % for the fabric produced with P7 coded yarn (two folded polyester yarn with 200 tpm). This result can be attributed the fact that due to the integration of the filaments in the textured yarn structure, fabrics from these yarns possess greater resistance to surface abrasion while those from two folded polyester yarn with 200 tpm possess lower abrasion resistance because of the low twist level and flat surface property.

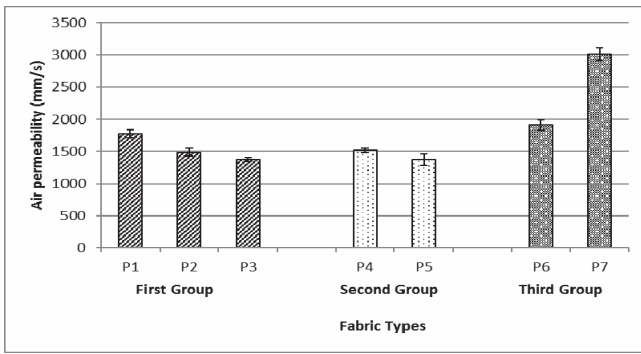
The SNK test results given in Table 2 revealed that, the woven fabrics produced with different types of polyester yarns possessed statistically different mass loss values. Mass loss of fabrics produced with P1, P2, P4 and P6 coded yarns were statistically same. Fabrics with P3, P5 and P7 coded yarns possessed statistically significant different mass loss values from each other.

It is important to mention that, where different yarns are used in the warp and weft directions, the abrasion resistance will be determined by the properties of the yarns exposed to the most wear, for example the yarns predominating on the surface in the case of flat abrasion.

The yarn structure, such as twist, linear density, friction, crimp, number of plies (e.g. singles, two-ply, etc), smoothness and the presence of wrapper or binding fibres can affect fabric abrasion resistance. If the yarn structure enables the abrading load to be more evenly spread over a large surface area and more energy to be absorbed, it will increase abrasion resistance.

### Air Permeability Results

For certain application and conditions, a curtain fabric is required to be windproof. This is normally assessed by measuring air permeability. Yarn twist factor, compactness and smoothness having important effects on fabric air permeability.



**Figure 6.** Air permeability test results of curtain fabrics

It can be seen from Figure 6 that the minimum air permeability was obtained for the fabrics produced with P3 and P5 coded yarns (50/50 % cationic polyester/polyester irregular intermingled yarn and 100 % cationic textured polyester yarn) as 1375mm/s while the maximum air permeability was obtained for the fabric produced with P7 coded yarn (two folded polyester yarn with 200 tpm) as 3014 mm/s. Textured yarns have bulkier structure than flat and/or folded flat yarns. This situation leads to lower air permeability property.

The SNK test results given in Table 2 revealed that, the woven fabrics produced with different types of polyester yarns possessed statistically different air permeability values.

Air permeability of fabric produced with P2, P3, P4, P5 coded yarns were statistically same. There was significant difference between the air permeability values of fabrics produced with P1, P5 and P7 coded yarns. These three set of fabrics' values were also statistically different from those of the first group of fabrics (P2, P3, P4, P5)

Figure 6 shows that fabrics produced from % 100 cationic textured polyester yarns have verified the lowest readings for air permeability property, followed by fabrics produced from 50/50 % cationic polyester/polyester irregular intermingling yarn, after that fabrics produced from textured polyester yarn and 50/50 cationic polyester/polyester regular intermingled yarn and textured polyester yarn.

Fabrics produced from air jet textured, tight spot and two folded polyester yarn have verified that highest readings for air permeability property. These results concerning with the evenness and hairiness of yarns. Texture and intermingled processes make the yarns more voluminous.

#### 4. CONCLUSION

Curtains are generally made of cotton, linen, rayon, polyester or blends of any combination of these fibres. They

are produced in various ways, designs and patterns. In recent years, curtain has come to a very important place in home textile industry. Covering and curtains in drapery family are probably the most basic method for decorating and controlling temperature and light. People use curtains in their homes a long time period. So that air permeability, tensile and abrasion behaviour are very important for their performance properties.

In this study, we investigated the breaking strength, breaking elongation, abrasion resistance and air permeability of curtain fabrics woven with different types of polyester yarns.

Factors which affect breaking strength, abrasion resistance and air permeability include fibre content and properties, yarn structure (e.g. spinning system, yarn twist and yarn linear density) and fabric structure.

This study provided that, fabrics produced from 50/50 % cationic polyester irregular intermingled yarns has verified the highest readings for the breaking strength whereas fabrics produced from folded polyester yarn recorded the least readings for breaking strength. Also, fabrics produced from tight spot polyester yarns have highest breaking elongation while those produced from air jet textured polyester yarns have the least breaking elongation. The fabrics produced from folded polyester yarns have the highest air permeability results while those produced from 50/50 % cationic polyester irregular intermingled yarns and from 100 % cationic textured polyester yarns have the least air permeability results. The study also provided that the fabrics from textured polyester yarns have the least readings for abrasion property (% mass loss) while those from 50/50% cationic polyester/polyester irregular intermingled yarns have the highest readings. Another result was fabrics woven with tight spot yarns recorded the best result for both breaking strength, breaking elongation properties.

This study has evidenced that yarn structure, such as twist, linear density, friction, crimp, number of plies (e.g. singles, two-ply, etc), smoothness and the presence of wrapper or binding fibres can affect curtain fabric performance properties.

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