

Investigation of Selected Physical Properties of Knitted Fabrics Produced From Macaroni Yarns

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Abstract

Recently there have been new trends in fancy yarns in order to meet consumer demands for drapery, decorative and outerwear fabrics. Macaroni yarns are a promising group of fancy yarn which allows new yarn designs with different raw materials at different yarn counts. In the study, supreme knitted fabrics were produced with macaroni yarns of different raw materials (polyester, acyclic, cotton) at different yarn counts (Nm 2/1, Nm 2.5/1, Nm 3.3/1, Nm 4/1 and Nm 4.5/1). Completely randomised one-factor analysis of variance (ANOVA) was used for determination of the statistical significance of the fabric type on selected physical properties of knitted macaroni fabrics in terms of fabric weight (g/m^2), dimensional change (%) in the wale and course direction, abrasion resistance, and air permeability properties before and after the washing process. According to the results of the statistical analyses performed using the experimental values obtained from the tests, we determined that the fabric weights (g/m^2), dimensional changes (%) in the wale and course direction, abrasion resistance and air permeability properties before and after washing were significantly influenced by the macaroni yarn's structural parameters (such as the yarn count and raw material comprising it).

Key words: fancy yarns, macaroni yarns, dimensional change (%), abrasion resistance, air permeability.

Introduction

Fancy yarns have a wide range of applications, ranging from outerwear fabrics, furnishing fabrics and knitwear to trimmings and decorative fabrics. The popularity of these yarn types comes from their special aesthetic and highly decorative appearance in woven, knitted and other textile materials. Fancy yarns do not have regular characteristics in terms of yarn diameter, bulk or colour, which are deliberately adjusted during production. Hand knitting was a major market for fancy yarns at first, but as knitting machines were developed with electronic control, fancy yarns also came to be used for machine-knitted goods. These structures also provided a fast response to European high street fashion in the demand for items required to be quickly manufactured and delivered [1-2]. Fancy yarns are the most preferred method for enriching yarn diversities. These yarn groups make a difference and give elegance in appearance as well as comfort for upper garment products, as well as contributing to the expansion of product range and providing improvement of ab-

rasion, air permeability, wrinkle and crease recovery and durability properties for home textiles. The basic structure of fancy doubled yarn consists of a core yarn, an effect material and a binding yarn (Figure 1). Binding yarn has the task of holding the structure together. Some other forms developed may be based on the spinning process or on colour effects. The introduction of an individual, variable speed drive for each roller leads to changes in roller speed, thus in the draft, and in turn in the effects' frequency at certain points on the yarn [2].

Macaroni yarn is a type of fancy yarn which is produced from hollow spindle spinning system. As Figure 2 reveals, there are four independent feeding devices of three for effect fibres and one for the core yarns. The effect fibres are fed in sliver form and undergo drawing with the roller drafting system. These effect fibres pass through the rotating hollow spindle after combining with the core yarns. A bobbin which is mounted on the hollow spindle bears the binding yarn and rotates

with the hollow spindle. The binding yarn, which is usually synthetic, is pulled into the hollow spindle from the top. As the hollow spindle rotates, the binding yarn is wrapped around the staple strand and core yarns, which connects the binding yarn holding the core and effect yarns together. It must also be emphasised that there is a twist regulator located at the bottom of the spindle, which prevents the possibility of drafted sliver disintegration before it is wrapped by the binding yarn [3]. The macaroni yarns produced have advantages such as minimum folding tendency, high absorbance, high covering factor, high elasticity, low hairiness etc. [4].

The macaroni yarn structure is displayed in Figure 3. Three yarn components: effect material (a roving), main ground yarn and binding yarn, are used in macaroni yarns [4].

Effect material

Effect material is a very important compound of macaroni yarn. It enhances the

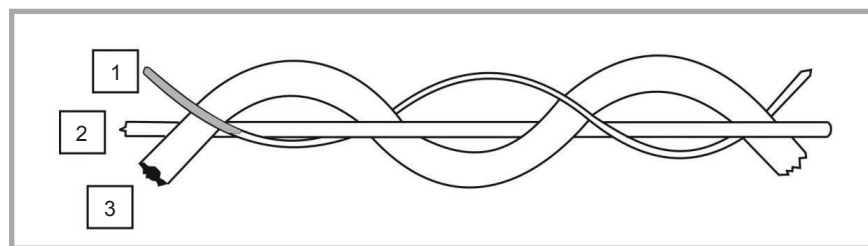


Figure 1. Main structure of fancy yarn: 1) binding yarn, 2) core yarn, 3) effect material.

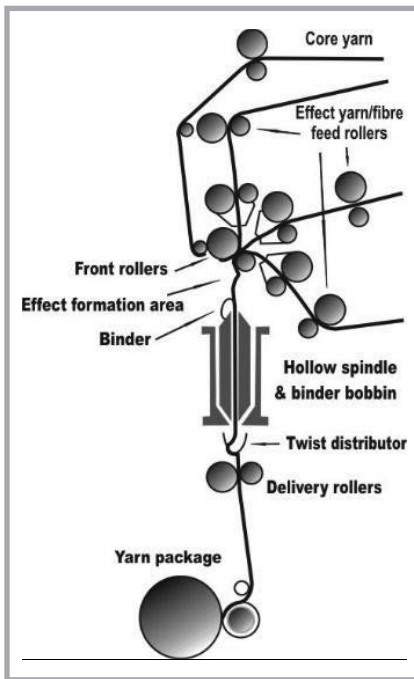


Figure 2. Hollow spindle system [3].

aesthetic property of the yarn; however, it imparts lower strength. As macaroni yarn is produced, this part is easily observed on the surface, providing a different fabric appearance. A roving sliver of 250-2000 tex may be used as the effect material.

Ground yarn

This part forms the basis of macaroni fancy yarns. This yarn is the main controlling part for the yarn length and stability. The effect material is held with the main ground yarn, as well as being wrapped with the binding yarn. It is possible to use almost every yarn type with an appropriate yarn count and twist. Different fibres may be used for the ground yarns.

Binding yarn

This part is responsible for macaroni yarn strength and durability. Binding yarns fix two yarns of effect material and ground yarns by wrapping over them. Although only polyamide yarns can be used as the binding yarn in the beginning, now different types may be used as the binding yarn.

There are some investigations related to fancy yarns which provide superior properties to fabric structures in earlier studies, most of which are related to the production parameters of fancy yarn or the effect of raw materials on the yarn, and hence on fabrics [5-9]. Kavusturan et al. studied the effects of pile and core yarn material types on the abrasion and bending behaviour of chenille knitted fabrics. Different chenille yarns were produced from seven types of pile yarn and two types of core yarn material at the same yarn count. Some comfort fibres such as tencel, bamboo, modal, soybean and 50/50% soybean-tencel, as well as conventional fibres like viscose and cotton were also used. Corn yarn types such as polyester and viscose were also selected. They concluded that abrasion resistance in terms of mass and thickness losses (%) was affected by both the pile and core yarn types, whereas the course and wale direction and fabric bending rigidity properties were not affected by the core yarn fibre types [10]. Petruyte made a study of the influence of technological parameters such as production speed, the supply speed of the effect component and the hollow spindle speed on the periodical effects of fancy yarns. The results indicated that the variables of fancy yarns investigated influenced the number of effects per unit length, found to be sig-

nificant since they determined the fancy yarn character [11]. Grabowska, K. E. & Ciesielska-Wróbel made an investigation of the relation between knop yarn's mechanical parameters and its impact on those of the final products, both yarns and fabrics. The researchers concluded that the linear density of knop yarns increased with an increase in the nominal yarn twist. Furthermore they added that the speed of the rocker influenced the knop effect of the yarn. An increase in the nominal twist and a reduction in the length and thickness of the effects caused an increase in the elongation at break [12]. Ulku et al. also made a study related to the effect of chenille yarn properties on the abrasion resistance of upholstery fabrics. The researchers concluded that twist levels, pile lengths and weaving constructions had a significant effect on the abrasion resistance of upholstery fabrics [13]. Çeven investigated the drape, crease recovery and air permeability behaviours of woven fabrics produced from centipede yarns of different parameters in his studies. The researcher concluded that the drape and crease recovery behaviours as well as the air permeability of woven fabrics from centipede yarns were influenced by the centipede yarn's structural parameters [14-15]. Kumpikaitė et al. made a study analysing the influence of fancy yarn structure on the abrasion resistance and air permeability of woven fabrics with those yarns. According to the investigation results related to the influence of the fancy yarn structure, raw material and fabric weave on the abrasion and air permeability properties of fabrics with fancy yarns, they concluded that the use of fancy yarns in clothing fabrics signally affected their end-use properties [16].

When the literature was investigated, it was discovered that there was a gap in the literature about the properties of knitted fabrics produced from "macaroni yarns", which is a special group of fancy yarns. This study aims to contribute to the literature by investigating the influence of macaroni yarn properties on selected physical properties of knitted fabrics produced to be used as drapery considering the washing effect. Hence the fabric weight (gr/m^2), dimensional changes in the wale and course direction, abrasion resistance in terms of mass and thickness losses (%), and the air permeability of knitted fabrics produced from macaroni yarns were investigated before and after the washing procedure. Because drapery fabrics are exposed to repeated

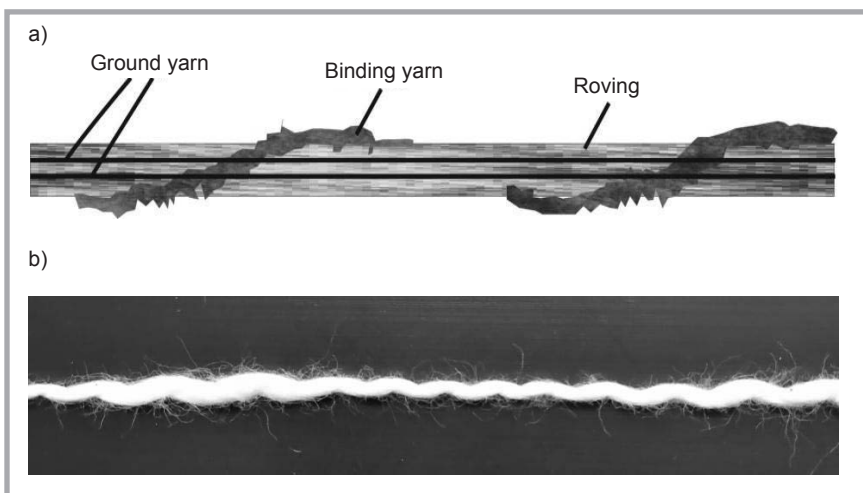


Figure 3. a) Schematic diagram of macaroni yarn, b) macaroni yarn image (2x).

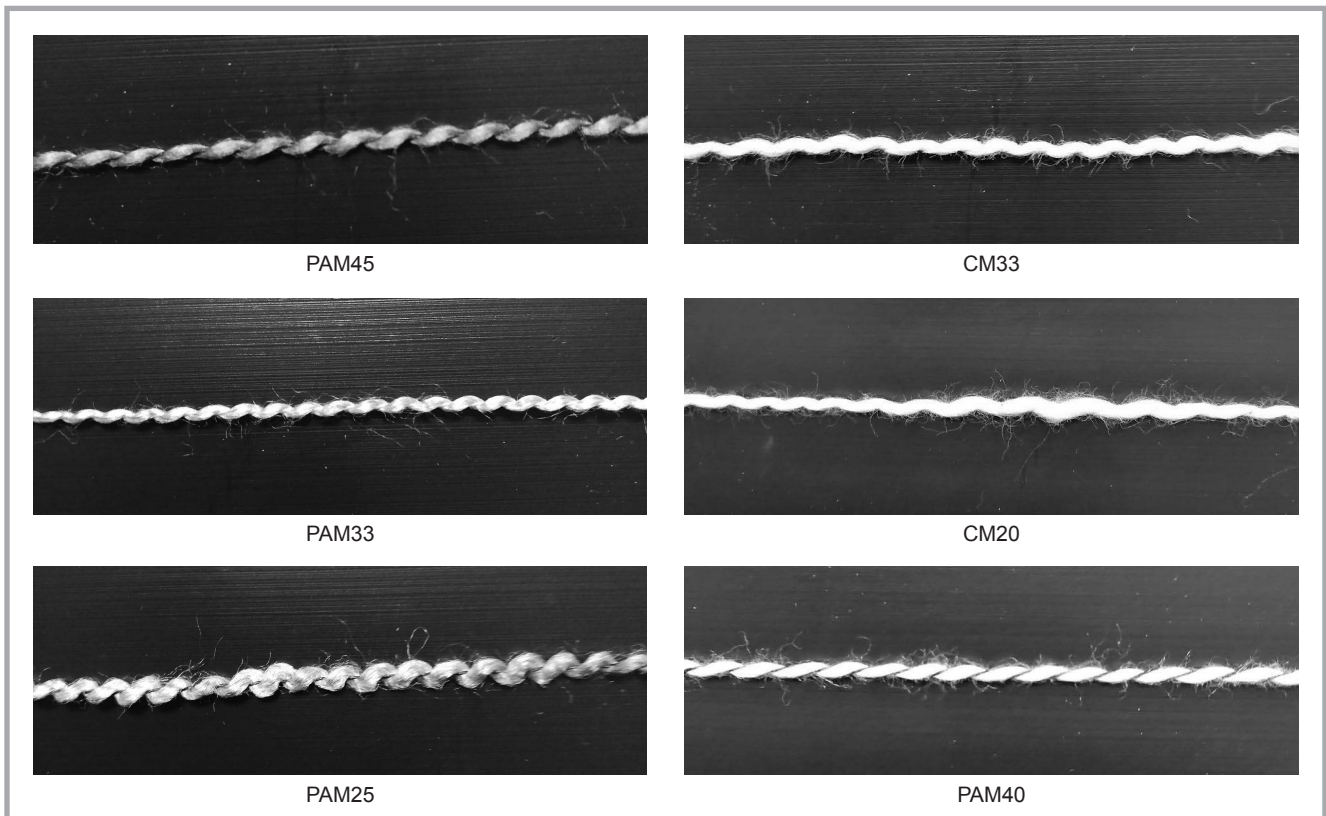


Figure 4. Images of macaroni yarns (2x).

home laundry during daily life, it was thought that the washing process could also be important for the knitted fabrics to reveal the proper abrasion, air permeability and fabric dimensional properties after the process.

Material method

Macaroni yarns were produced on a “Saurer Allma” yarn spinning machine, working with the Hollow spindle principle, at “Fisteks Textile” in Bursa/Turkey, at yarn counts of Nm 2/1, Nm 2.5/1, Nm 3.3/1, Nm 4/1 & Nm 4.5/1 using Polyester-acrylic, 100% cotton and 100% polyester as the raw material for the macaroni yarns. As mentioned above in the literature part, macaroni yarns consist of three compounds, one of which is called “effect material”, fed with the “ground yarn” and “binding yarn”, which wraps over them. *Table 1* shows the codes of the macaroni yarn produced as well as the properties of the ground, binding yarn and effect material comprising it.

Six types of macaroni yarns were used separately for knitted fabrics produced on a 3.5 inch single plate circular knitting machine with a gauge of 18 (Faycon CKM 01-S model) in the laboratory of

the Textile Engineering Department at Uludag University (Bursa, Turkey). All the fabric types were knitted in the same cam setting in order to see the effect of the yarn structure and yarn count on the fabric properties. The knitted fabrics were coded the same as for the macaroni yarns comprising them. For example, PAM45 Coded fabric stands for the knitted fabric produced with PAM45 (Polyester-macaroni yarns of Ne 4.5/1).

Figure 4 shows images of “macaroni” yarns and *Figure 5* – examples of knitted fabrics produced from those yarns.

The knitted fabrics were divided into two pieces in order to be evaluated before and after the washing process. For wet relaxation, dry knitted fabrics were exposed to washing with little motion at an initial temperature of 50 °C for 24 hours [17]. Powder detergent was used for the

Table 1. Macaroni yarn codes and properties.

Yarn codes						
	PAM45	PAM33	PAM25	CM33	CM20	PM40
Yarn name	Polyester acyclic macaroni	Polyester acyclic macaroni	Polyester acyclic macaroni	Cotton macaroni	Cotton macaroni	Polyester macaroni
Yarn count	Nm 4.5	Nm 3.3	Nm 2.5	Nm3.3	Nm 2.0	Nm 4. 0
Yarn twist, tpm	300	300	300	300	300	300
Twist direction	S	S	S	S	S	S
Ground yarn						
Fibre type	Textured polyester	Textured polyester	Textured polyester	Cotton	Cotton	Textured Polyester
Yarn count	300 denier	300 denier	300 denier	Nm 30/2	Nm 30/2	300 denier
Binding yarn						
Fibre type	Textured polyester	Textured polyester	Textured polyester	Cotton	Cotton	Textured polyester
Yarn count	150 denier	150 denier	150 denier	Nm 30/2	Nm 30/2	150 denier
Effect material (roving)						
Raw material	Acrylic	Acrylic	Acrylic	Cotton	Cotton	Polyester
Count	0.8 Nm	0.8 Nm	0.8 Nm	0.8 Nm	0.8 Nm	0.8 Nm

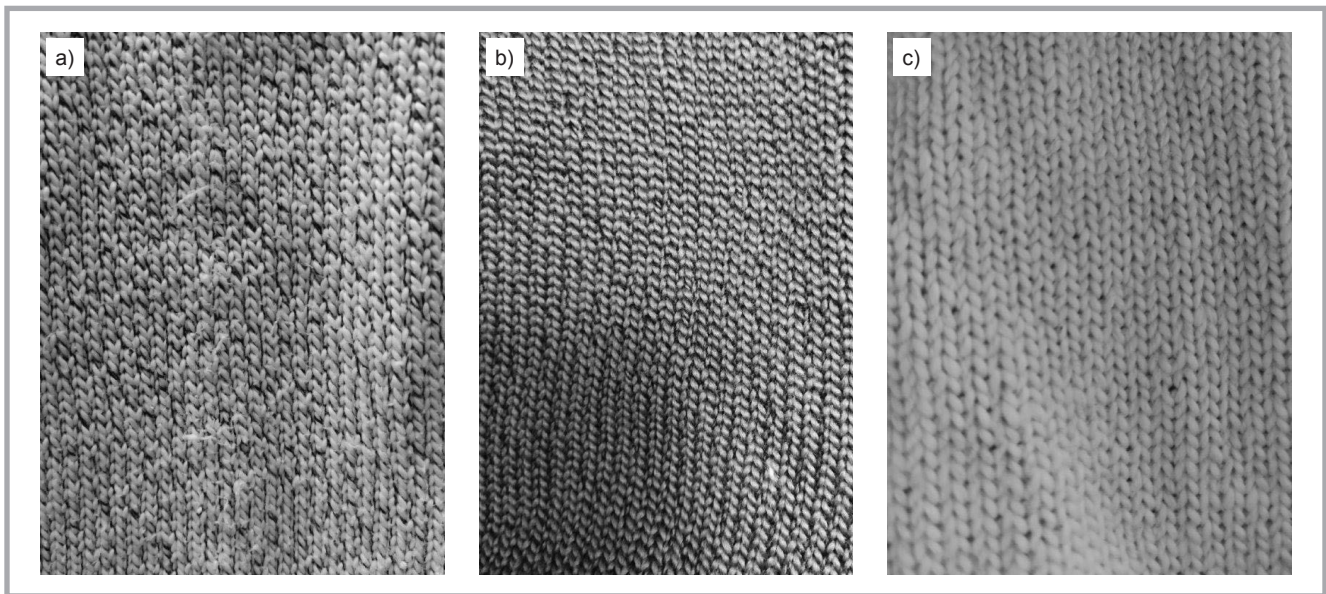


Figure 5. Examples of knitted macaroni fabrics: a) 100% polyester fabric, b) 85% Acrylic 15% polyester, c) 100% cotton (2x).

washing process. After the samples were taken from the washing machine, they were laid on a smooth and flat surface in standard atmospheric conditions for one week and allowed to dry in the room conditions. The following properties of the fabric groups which were exposed to the washing process and of those not exposed were measured when they were in a dry relaxation state in accordance with the relevant standards for dimensional changes (%) in knitted fabrics (ISO 5077): fabric weight (g/m²) (ISO 3801), abrasion resistance (EN ISO 12947) and air permeability (EN ISO 9237) tests [18-21].

Dimensional changes in the wale and course direction, %

Dimensional change after washing has always been declared as a major problem for knitted fabrics. Manufacturers experience difficulties during production due to

this problem. Dimensional change issues with knitted fabrics have such a high incident ratio that they constitute 60% of all production errors [22]. Hence it is crucial to determine the dimensional change of fabrics when subjected to an appropriate combination of specified washing and drying procedures. Benchmarks drawn with indelible ink were placed 25 cm apart, or 50 cm for better precision, in each direction. After laundering and drying, the marks were re-measured and dimensional changes calculated from the formula below;

$$DC(\%) = \frac{100 (B - A)}{A} \quad (1)$$

Where, A is the original dimension and B the dimension after treatment. Changes in the wale wise and course wise direction were calculated separately. Shrinkage is reported as a negative number, while

growth is given as a positive percentage (ISO 5077) [18].

Fabric weight, g/m²

The macaroni knitted fabrics' weight before and after the washing process were calculated according to the ISO 3801 standard. The average results of five measurements were calculated for mean values [19].

Abrasion resistance tests

Fancy yarns are a special yarn group requiring special attention, especially for abrasion resistance. Macaroni knitted fabrics were subjected to an abrasion resistance test using a Martindale Abrasion and Pilling Tester in accordance with ISO 12947. The pressure applied to the fabric during rubbing was 9 kPa, as indicated for knitted fabrics. Abrasion cycles were limited to 10.000 testing cycles. Mass (%) and thickness losses (%) were determined for six different knitted macaroni fabrics before and after the washing process [20].

Air permeability tests

Knitted macaroni fabric samples were subjected to an air permeability using the device SDL ATLAS M021A.

Air permeability values of the fabrics were measured in a 20 cm² test area at 200 Pa air pressure according to the EN ISO 9237 standard. Five different areas from the front of each fabric were measured in the air permeability test (EN ISO 9237) (21).

Table 2. Statistical analysis (Analysis of variance and SNK test) results for the change in fabric weight (g/m²), dimensional change in the wale and course direction, abrasion resistance in terms of mass losses (%) and thickness losses (%), and air permeability properties. **Note:** * statistically significant ($P < 0.05$), (a), (b) & (c) represent the statistical difference ranges according to the SNK test.

Anova and Student-Newman-Keuls Test Results						
Parameter: fabric type	Change in fabric weight, % (after washing)		Dimensional change in wale direction, % after washing		Dimensional change in course direction, % (after washing)	
	P/Sig.	SNK ranges	P/Sig	SNK ranges	P/Sig	SNK ranges
PAM45	0.00 *	0.25 c	0.00*	-0,054 b	0.00*	-0,052 c
PAM33		0.20 c		-0,040 b		-0,120 b
PAM25		0.17 b		+1,038 c		-0,121 b
CM33		0.20 c		-0,036 b		-0,141 a
CM20		0.22 c		-0,140 b		-0,088 b
PM40		0.00 a		-0,440 a		-0,029 c

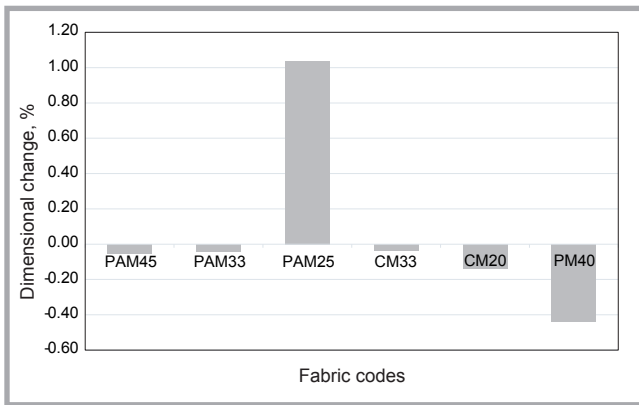


Figure 6. Dimensional change (%) in the wale direction.

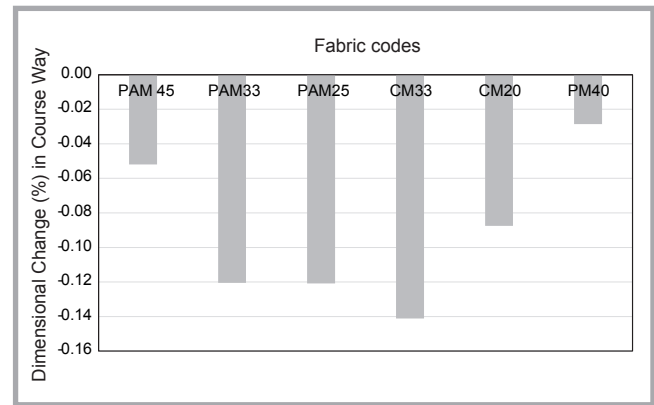


Figure 7. Dimensional change (%) in the course direction.

Statistical evaluation

All statistical procedures were conducted using the SPSS 23.0 Statistical software package. In the study completely randomised one-factor analysis of variance (ANOVA) was used for determination of the statistical significance of the fabric type. The means were compared by means of Student-Newman-Keuls (SNK) tests. The value of the significance level (α) selected for all statistical tests in the study is 0.05. The treatment levels were marked in accordance with the mean values, and any levels marked by a different letter (a, b, c) showed that they were significantly different.

Results and discussion

Analysis of variance and Student-Newman-Keuls test results are given in *Table 2* and *Table 3*.

The results of the ANOVA test given in *Tables 2* and *3* indicate that there were statistically significant (5% significance level) differences between the fabric weight (gr/m^2), dimensional change (%) in the wale and course direction, mass and thickness losses (%) and air perme-

ability (mm/s) values of knitted fabrics (before and after washing process) produced from the six (6) types of macaroni yarns.

Dimensional changes in knitted fabric

Dimensional changes in the knitted macaroni fabrics after the washing process were determined in the wale and course direction according to the dimensional test standard of ISO 5077. *Figure 6* shows the dimensional change in six knitted macaroni fabrics in the wale direction (%). As is observed, PAM25 coded fabrics revealed a dimensional change in the positive direction, which means there was growth, whereas the other five knitted macaroni fabrics revealed a dimensional change in the negative direction i.e. in the wale direction. Additionally PM40 coded fabrics showed the maximum dimensional change (%) in the negative direction, whereas CM33 coded fabrics showed the minimum value in the negative direction. When considering dimensional changes (%) in the knitted macaroni fabrics in the course direction (*Figure 7*), it is observed that all samples reveal a dimensional change (-%). CM33 coded fabrics showed maximum

dimensional change (-%) in the course direction, whereas PM40 coded fabrics showed minimum dimensional change (-%) in the course direction.

The SNK test results given in *Table 2* indicate that the knitted fabrics produced with different types of macaroni yarns possessed statistically different dimensional changes (%) in the wale and course direction. Considering the SNK results of the dimensional changes (%) in the wale direction, PAM25 coded knitted fabrics gave the highest values (%) in a positive way, which means there is an extension observed after the washing process. PM40 had maximum shrinkage (%), whereas CM33 had minimum shrinkage (%) after the washing process. The dimensional change (%) in PAM45, PAM33, CM33 and CM20 fabrics in the wale direction was statistically the same. When it comes to SNK results of dimensional changes (%) in the course direction, the lowest shrinkage was obtained from PM40 coded fabrics, whereas the highest shrinkage was from CM33 coded fabrics. PAM25, PAM33 & CM20 coded fabrics revealed higher shrinkage (statistically of the same level) than the fabric

Table 3. Statistical analysis (Analysis of variance and SNK test) results for abrasion resistance in terms of mass losses (%) and thickness losses (%) and air permeability properties. Note: * statistically significant ($P < 0.05$), (a), (b), (c) & (d) represent the statistical difference ranges according to the SNK test.

Anova and Student-Newman-Keuls test results												
Parameter: fabric type	Mass losses, % before washing		Mass losses, % after washing		Thickness losses, % before washing		Thickness losses, % after washing		Air permeability, mm/s before washing		Air permeability, mm/s after washing	
	P/Sig.	SNK ranges	P/Sig.	SNK ranges	P/Sig.	SNK ranges	P/Sig.	SNK ranges	P/Sig.	SNK ranges	P/Sig.	SNK ranges
PAM45	0.00*	2.07 d	0.00*	1.76 d	0.00*	2.09 c	0.00*	3.69 b	0.00*	1098 c	0.00*	650 c
PAM33		1.99 d		0.95 b		1.88 b		6.55 c		1074 c		670 c
PAM25		1.76 c		1.21 c		1.04 a		4.98 b		330 b		177 b
CM33		1.06 b		0.59 a		1.68 b		4.46 b		370 b		179 b
CM20		1.54 c		1.17 c		1.87 b		9.13 c		104 a		25 a
PM40		0.52 a		1.35 c		2.56 c		0.86 a		1556 d		870 d

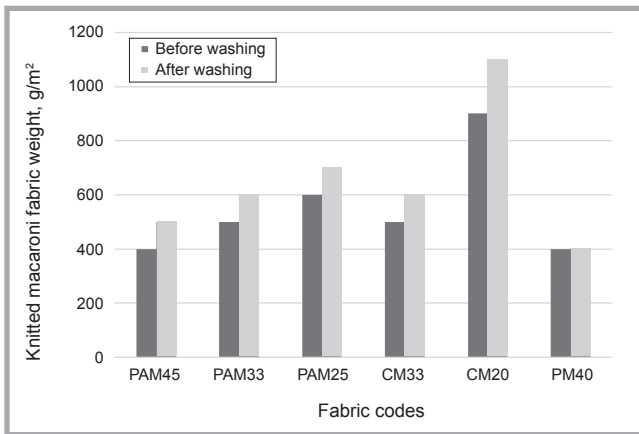


Figure 8. Knitted macaroni fabric weights (g/m^2).

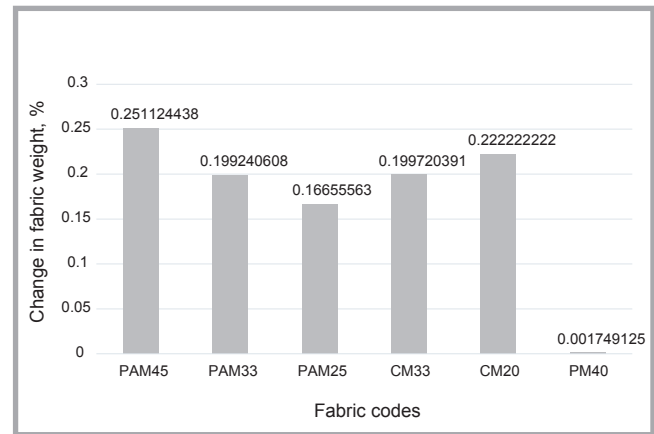


Figure 9. Change in fabric weight (%).

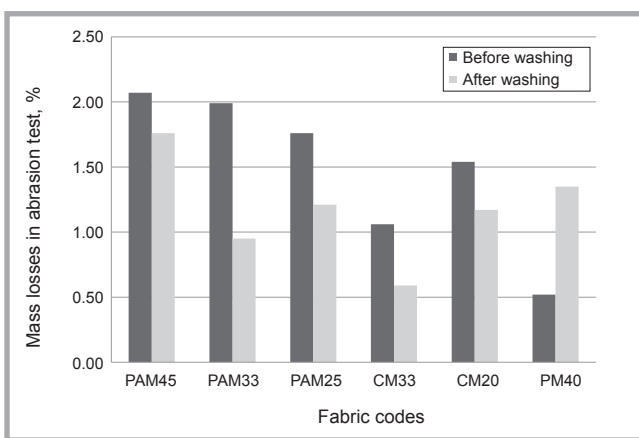


Figure 10. Mass losses (%) of the macaroni knitted fabrics.

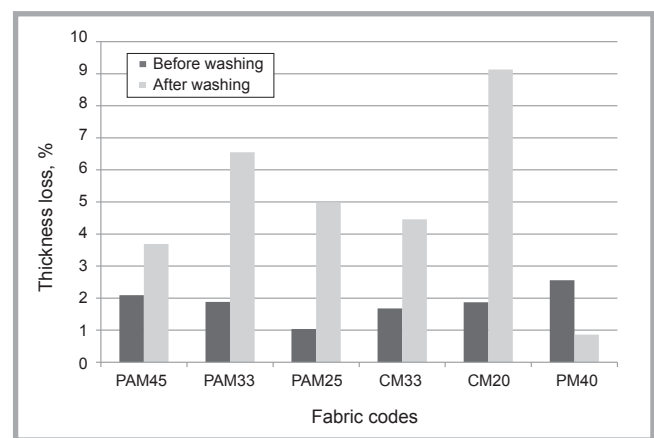


Figure 11. Thickness losses (%) of the macaroni knitted fabrics in the abrasion test

groups of PAM45 and PM40, which were statically at the same level as well.

Fabric weights, g/m^2

Figure 8 reveals the weight (g/m^2) of six different macaroni knitted fabrics before and after the washing process. The highest fabric weight was obtained in the CM20 coded fabrics, whereas the lowest was from PM40 coded fabrics for both conditions. Since the fabric holds water molecules in its structure, there is a clear increase in the weight of all macaroni knitted fabrics, except PM40 coded fabrics, after the washing process (Figure 9). The highest increment in fabric weight was observed in PAM45 coded fabrics, whereas there was almost no change in the PM40 coded fabric's weight after the washing process. This result may be attributed to polyester fibre's hydrophobic character.

The SNK test results given in Table 2 show that the knitted fabrics produced with different types of macaroni yarns produced a statistically different change

in fabric weight. The highest changes in fabric weight (%) were obtained from knitted fabrics produced from PAM45 coded fabrics, whereas the lowest values were found for knitted fabrics produced from PM40 coded fabrics. Additionally the change in fabric weight (%) of PAM45, PAM33 CM33 and CM20 coded knitted fabrics was statistically the same.

Abrasion resistance test results

Regarding the abrasion test conducted with the Martindale abrasion tester, mass loss (%) and thickness loss (%) results of the macaroni knitted fabrics are shown in Figures 10 and 11, respectively, in relation to the washing effect. The highest mass losses (%) were obtained in PAM45 coded fabrics for both conditions i.e. before and after the washing process. The lowest mass loss (%) before the washing process was observed in PM40 coded knitted fabrics, whereas this was the case in CM33 coded knitted fabrics after the washing process. However, the result was not fully consistent with the earlier study of Tekeoglu and Kavustur-

an, which includes the abrasion properties of plain knitted fabrics from macaroni yarns [23]. They claimed that knitted cotton macaroni fabrics and polyester macaroni fabrics revealed similar mass loss (%) values. However, the mass loss (%) of knitted cotton macaroni fabrics (CM33-CM20 coded fabrics) and polyester macaroni fabrics (PM40) differed from each other in our results.

Thickness losses (%) in the abrasion test (Figure 11) revealed that minimum thickness loss (%) values were found in PAM25 coded fabrics, whereas the maximum (%) was found in PM40 coded fabrics before the washing process. Regarding the results after the washing process, maximum thickness loss (%) was found in CM20 coded fabrics, whereas minimum thickness loss (%) was found in PM40 coded macaroni fabrics.

The SNK test results given in Table 3 show that the highest mass losses (%) were obtained from PAM45 coded knitted fabrics – 2.07, which were statically

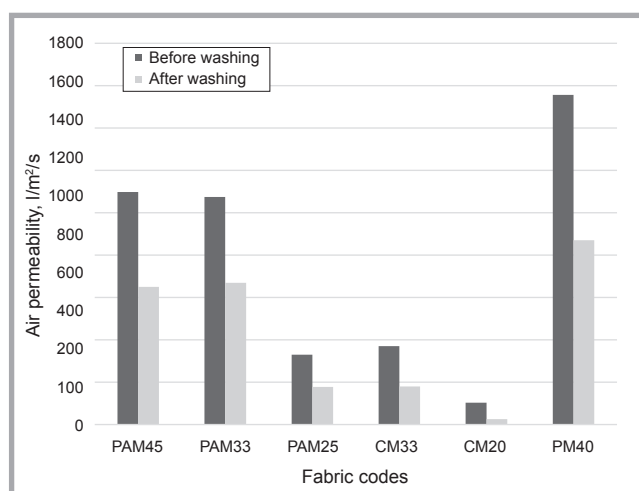
the same as for the PAM33 coded fabrics. On the other hand, the lowest mass losses (%) were found in PM40 coded knitted yarns – 0.52 before the washing process. The results after the washing process reveal that the highest mass losses were found in PAM45 coded knitted fabrics, whereas the lowest mass losses were found in CM33 coded knitted fabrics. The mass loss values (%) of PAM25 coded knitted fabrics were statistically the same as those of CM20 and PM40 coded fabrics after the washing process. When it comes to thickness values before the washing process (*Table 3*), the highest values were obtained from PM40 coded knitted fabrics – 2.56, where the lowest values were obtained from PAM25 coded knitted fabrics – 1.04. The thickness losses (%) of PAM33, CM33 and CM20 coded knitted fabrics were statistically the same. Thickness losses (%) after the washing process (*Table 3*) revealed that the highest SNK values were obtained from CM20 coded fabrics – 9.13, whereas the lowest were from PM40 coded fabrics – 0.86. Thickness losses (%) of PAM45, PAM25 and CM33 coded knitted fabrics were statistically the same at a significance level of 5%

Air permeability test results

Figure 12 shows the air permeability of knitted fabrics before and after the washing process. The highest air permeability was found in PM40 coded fabrics, whereas the lowest were from CM20 coded fabrics for both conditions. The result revealed that there is a high difference between the air permeability of knitted fabrics produced from macaroni yarns of cotton and those produced from macaroni yarns of polyester. On the other hand, when comparing the air permeability of each fabric with the same raw material, such as polyester-acrylic (PAM45-PAM33) or (CM33-CM20), for both conditions – before and after the washing process, there was a decrement in the air permeability values of the polyester-acrylic macaroni fabrics as the macaroni yarn got coarser, which may indicate that besides the raw material, the yarn count is also important for the air permeability results of knitted macaroni fabrics.

SNK ranges of air permeability of the knitted fabrics before and after the washing process are shown in *Table 3*. According to the air permeability results before the washing process, the highest air permeability values were obtained in PM40

Figure 12. Air permeability of knitted macaroni fabrics.



coded fabrics – 1556, whereas the lowest were observed in CM20 coded fabrics – 104. Considering the results after washing process, the highest air permeability (mm/s) was obtained in PM40 coded knitted fabrics, whereas the lowest was found in CM20 coded fabrics. PAM45 and PAM33 coded knitted fabrics were statistically the same and higher than the PAM25 and CM33 coded knitted fabrics, which were statistically the same before and after the washing process.

Conclusions

Yarn production technologies provide a wide product range of different yarn structures. Using macaroni yarns with different raw material at various yarn counts may be one of the solutions for new yarn designs and varieties for a new appearance of knitted fabrics to be used as drapery fabrics. Considering the dimensional changes, abrasion behaviour and air permeability results of the study, the knitted fabrics produced from macaroni yarns were found acceptable to be used for drapery fabrics. People use drapery fabrics for a long time period, which is why air permeability and abrasion behaviour are very important for their performance properties. Since drapery fabrics are exposed to repeated home laundry during daily life, the physical properties, especially dimensional changes after the washing process, should also be considered.

The objective of this study was to investigate selected physical properties of knitted fabrics produced from macaroni yarns in terms of dimensional change (%), abrasion behaviour and air permeability considering the washing process. This study concluded that according to

the dimensional change (%) values, only PAM25 coded fabrics revealed a positive dimensional change (%) in the wale direction, whereas all knitted macaroni fabrics showed a negative dimensional change (%) in the wale and course direction after the washing process. Regarding the fabric weight change (%), PAM45 coded fabrics gave the maximum value, whereas PM40 coded fabrics almost did not reveal any difference after the washing process. Considering the abrasion results, PAM45 coded fabrics had the highest mass losses (%) before and after the washing process, which was attributed to the low abrasion resistance of acrylic fibres. It was also observed that the PM40 coded fabric's abrasion resistance in terms of mass losses (%) decreased with the washing effect, which was attributed to the low dimensional change in fabrics with low hydrophobic characteristics e.g. polyester. CM20 coded fabrics with 100% cotton had a sharp increment in thickness loss (%) in terms of abrasion behaviour after the washing process. When it comes to air permeability results, PM40 coded fabrics with 100% polyester had maximum air permeability values (L/m²/s) for both conditions – before and after the washing process. This study has proved that the compound properties of macaroni yarn structures (ground, binding yarn and effecting material), such as yarn count, may have an effect on the physical properties of the knitted fabrics produced.

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