Sait Yılönü,
Belkıs Zervent Ünal*

Investigating the Effects of Core Spun Yarns on the Quick-Dry Property of Towels

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Çukurova University,
The Faculty of Engineering and Architecture,
Department of Textile Engineering,
Adana, Turkey
* E-mail: belzer@cu.edu.tr

Abstract

The purpose of this study was to investigate the effects of core-spun yarn on the quick-dry property of towels. This study focused on five different raw materials (modal, cotton, polyester, bamboo, viscose) which are the most frequently used in towel production. Seven different core yarns and five different conventional yarns were produced with these fibres on a ring spinning machine. These yarns were used in the weft direction of the towels. Samples produced with the same ground and pile warp yarns were subjected to constant dyeing conditions. All samples were tested for strength, softness, hydrophilicity and quick drying. As a result, polyester core yarn on the towels did not negatively affect basic properties such as water absorbency, softness and strength. However, the usage of polyester core yarns provided better quick dry properties than that of conventional yarns.

Key words: *towel, core yarn, softness, quick-dry, strength, water absorbency.*

Introduction

The textile industry comprises apparel, home textiles, technical textiles, etc. The textile and apparel sector is now at the forefront of Turkey's economy. The towel is one of the most important home textile products for the needs of people. The expectations of people have increased with the change in technology. For this reason, all products need to be improved in their usability for people.

Core yarn combines the advantages of different raw materials of fibre. It consists of two parts: the core and sheath. A typical core-spun yarn is shown in ***Figure 1***. Core-sheath composite yarns consisting of a core filament in the center and covered with staple fibres in the sheath are generally called 'core spun yarns'. In conventional core yarn spinning, the core filament, such as polyester, nylon, polyurethane, carbon, etc., provides high strength and other functional characteristics, while the staple fibres, such as cotton, wool, staple synthetic fibres, etc. in the sheath impart a traditional look, feel and comfort [1]. The production of core yarn from polyester-cotton is one of the most important developments in the textile industry. The usage of core yarns is mainly aimed at improving the strength, comfort, durability, aesthetics, and other functional properties of the final yarn [2].

A terry towel is described as a textile product which is made with loop pile on one or both sides, generally covering the entire surface. Considering their end uses, towels should have certain properties such as quick drying, water absorbency, softness, colour fastness and strength, among which hydrophility is the most important quality parameter.

Previous studies about core yarn and towels are summarised below. Örtlek and Babaarslan investigated the hairiness of core-spun yarns containing spandex that were aimed at meeting consumer demands for more comfortable, convenient and versatile textile products [4]. Yang et al. investigated the effects of different sheath structures on the tensile and tenacity properties of ring core-spun yarns [5]. In Sarıoğlu's dissertation, textured PES filaments with the same linear density and different filament fineness were used as the core, and core-spun yarns covered by cotton were produced on a modified ring spinning system. And then the properties of woven fabric produced with these yarns were considered [6]. In a recent study about towels, Koç and Zervent investigated towel performance with physical tests. They also examined water absorbency and dimensional change properties [7]. In 2010, Özmen produced terry fabrics from bamboo and cotton fibres for comparison in terms of handling characteristics [8]. Zervent Ünal developed optimisation models for the production cost and/or performance properties of towel fabrics with selected properties [9]. Ertekin and Kırtay highlighted the strength properties of some technical core yarns for protective textiles [10]. In 2006, Karahan and Eren investigated the effects of fabric parameters on the static water absorption properties of towel fabrics [11]. Uyanık et al. studied the effects of pile yarns with different twist types on towel performance characteristics [12]. In 2009, Petrulyte and Baltakyte conducted a study on the static water absorption properties of towel fabrics with different pile lengths [13]. Özgürel investigated the factors affecting the hydrophilicity as well as the washing and friction fastness of dyed woven towel fabrics [14]. Yılmaz compared the strength performances of woven and warp knitted bathrobe fabrics manufactured with similar specifications during finishing processes [15]. Sarıçam and Kalaoğlu researched the wicking and drying behaviour of polyester woven fabrics [16]. The towel and bathrobe manufacturing process was investigated detaily by Tunç [17]. In 2016, Yılönü investigated the effects of core-spun yarns on towel performance properties [18]. No study was found in the literature about the usage of core yarns in towel fabric production.

This study investigated the effects of the usage of core-spun weft yarns produced with different raw materials on the main performance characteristics (softness, water absorbency, fabric strength, quick dry properties) of towels. As a result, the usage of core yarns in the weft direction in the towel increased the strength, improved the quick dry capability, and did not negatively affect properties such as the hydrophilicity and softness of the samples.

Material and methods

Material

The purpose of this study was to investigate the effects of core-spun yarn on towel performance characteristics. Five different raw materials (modal, cotton, polyester, bamboo, viscose) which are the most frequently used fibres in towel production were selected for this study. 42 tex yarn count was used in the yarn production. Firstly yarns were produced with the five different materials (modal, cotton, polyester, bamboo, viscose) on a conventional ring spinning system. Then five different core yarns were produced using 83 dtex PES as the core and with these fibres as sheath. In addition to these, two different yarns were obtained by using two sheath materials (cotton, viscose) with 61 dtex PES as the core. A total of twelve different yarns were produced in this study (***Table 1***).

Seven different core yarns and five different conventional yarns were produced with a Zinser 351 modified ring spinning machine (Saurer Schlafhorst, Germany). Conventional ring yarn and core yarn production parameters as well as selected yarn properties (measured according to related standard test methods) are given in ***Table 2***.

The core/sheath ratio values given in ***Table 2*** were determined using the TSE (Turkish Standarts Institution) standard TS 4739 "Methods of Identification of Textile Fibres". This standard covers the methods for identification of textile fibres by means of physical and chemical methods as well as microscopes [19]. For example, hydrochloric acid was used to separate polyester from cotton or polyester from viscose in this process.

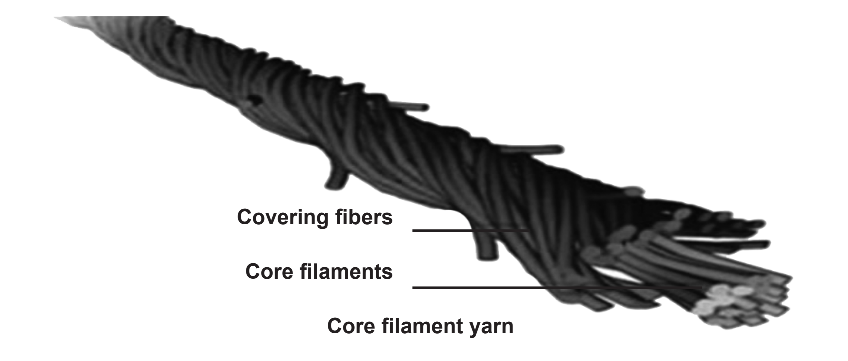


Figure 1. *Typical core-spun yarn [3].*

Table 1. *Properties of conventional and core yarns.*

Code	Raw material	Yarn type	Yarn number, tex	Core number
Co	Cotton	Conventional	42	–
CoC		Core-spun	42	83 dtex (PES)
CoC61		Core-spun	42	61 dtex (PES)
V	Viscon	Conventional	42	–
VC		Core-spun	42	83 dtex (PES)
VC61		Core-spun	42	61 dtex (PES)
B	Bamboo	Conventional	42	–
BC		Core-spun	42	83 dtex (PES)
M	Modal	Conventional	42	–
MC		Core-spun	42	83 dtex (PES)
P	Polyester	Conventional	42	–
PC		Core-spun	42	83 dtex (PES)

These yarns were used in the weft direction to produce towels with a weight of 400 g/m^2 (48 pile length) and 550 g/m^2 (66 pile length), as well as non-pile fabric samples. The same warp yarn and pile yarn were used for all samples. Ground warp yarn – pile yarn properties and production parameters of the towels are given in ***Tables 3*** and ***4***, respectively. The same production parameters were selected for all samples.

Three different fabric samples (towels with 48 pile length, 66 pile length and non-pile fabric) were produced using twelve different yarns in the weft direction (***Table 1***). In the following sections, samples of 400 g/m^2 (48 pile length) are coded as "Towel 1", and samples of 550 g/m^2 (66 pile length) are coded as "Towel 2" for convenience.

All the towel samples were subjected to the same dyeing conditions. The exhaust dyeing process was used with reactive dye stuffs. Following the dyeing process, the towel samples were dried and egalized.

Table 2. *Production parameters and selected yarn properties of the conventional and core yarns.*

Yarn type	Yarn number. tex	Core/ sheath ratio	Twist. turn/m	Flayer number. Ne	Draw ratio	Spindle speed. sp/dk	Strength. cN/tex	Hairiness. H	Hairiness. S3	Unevenness. % CVm
Co	42	–	618	0.5	1.06	1100	17.48	6.93	2345	8.95
CoC	42	%20	618	0.5	1.06	1000	21.83	7.17	2595	9.61
CoC61	42	%17	618	0.5	1.06	1000	15.49	7.65	2571	12.74
V	42	–	618	0.5	1.06	1100	16.59	6.72	1340	8.63
VC	42	%20	618	0.6	1.06	1000	20.26	6.19	1306	8.54
VC61	42	%17	618	0.6	1.06	1000	18.81	5.54	1327	7.99
B	42	–	618	0.6	1.06	1100	15.04	6.45	1346	8.88
BC	42	%20	618	0.6	1.06	1000	19.80	6.29	1572	8.72
M	42	–	618	0.6	1.06	1100	22.68	7.38	2854	8.26
MC	42	%20	618	0.6	1.06	1000	21.32	6.97	3258	7.73
P	42	–	618	0.7	1.06	1100	31.98	7.15	2638	8.87
PC	42	%20	618	0.7	1.06	1000	31.42	6.93	1934	7.83

Table 3. Ground and pile warp yarn properties.

Yarn properties	Ground warp yarn	Pile warp yarn
Raw material	Cotton	Cotton
Yarn type	Open-end	Open-end
Yarn number, tex	30	50
Twist, turns/m	536	403
Tensile strength, cN/tex	14	9.7
Elongation, %	5.63	4.5
Evenness, U%	7.43	9.87
Thin place, -%40 /km	0	0
Thick place, +%50 /km	0	0
Neps, +%200 /km	0	3.8
Hairiness, H	4.87	10.11

Table 4. Production parameters of towels.

		Towel 1, 400 g/m², 48 pile length	Towel 2, 550 g/m², 66 pile length	Non-pile fabric, 260 g/m²
Weft yarn number, tex		42	42	42
Warp yarn number, tex	Ground	30	30	30 and 42
	Pile	50	50	
Weft density, yarn/cm		18	18	18
Warp density, yarn/cm		22	22	22
Sample width, cm		70	70	70

Table 5. Standards of the tests.

Tests	Standards
Stiffness of fabric by the circular bend procedure	ASTM D 4032-94
Textiles – terry towels and terry towel fabrics – specification and methods – water absorbency test (sinking test)	TS EN 14697
Textiles – tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method	TS EN ISO 13934-1: 2002

Method

In this study, strength, quick drying, water absorbency and softness tests were performed to determine the physical and performance characteristics.

Quick dry test

The towel fabrics were exposed to wet processes due to their place of usage i.e. in humid environments such as bathrooms. In this case, bacterial growth, bad smell, etc. can occur on the towel because of humidity. For this reason, drying speed is an important parameter for towels.

The rates of drying of the towel samples were also measured because of the expectation that usage of core yarn would contribute positively to the quick drying abilities of the towels. In the literature review, a standard was not found about the quick drying capability of fabrics. For this reason, a quick drying test method was created in this study by the researchers by taking the opinions of experts in the field. For this purpose, a total of 36 specimens of 70 cm width and 70 cm length were taken from Towel-1, Towel-2 and non-pile fabric samples. These were subjected to washing and free drying processes under the same conditions. The sample fabrics were weighed before washing. All samples were washed based on the parameters given in ***Table 6***. Immediately after washing, the weight of the samples was measured again and the amount of water on them calculated. Then the samples were left to dry in atmospheric conditions, where they would not be affected by each other in the laboratory. The towel samples left to dry were weighed again according to the same order at intervals of one hour, those of non-pile fabric at intervals of 30 minutes, and readings of the weights were recorded. The towel samples were weighed before washing, immediately after, and 1, 2, 3, 4, 5, 6 and 24 hours afterwards. The decreases in the amount of water on the towel samples and accordingly the drying amounts were calculated in percentages. The same process was applied to the non-pile fabric samples at half-hour intervals. Laboratory humidity and temperature changes were recorded by using a Hioki Z2010 Humidity Sensor (Hioki e.e. corporation, Japan) during each weighing until the samples were dried.

Table 6. Washing parameters for the samples.

Parameters	Values
Number of cycles	800 cycles
Temparature	60 °C
Time	65 min.
Detergent amount	20 g

Results and discussion

Tensile strength test results

Towel 1 and Towel 2 were produced with the same parameters except for the pile height, and as a result of which trial strength test values were very close. For this reason, strength tests were performed only on Towel 1 samples in the weft direction. Graphs were created for easier evaluation of the test results, and a graphical representation of the strength test results is given in ***Figure 2***.

As shown in ***Figure 2***, whereas the usage of polyester as the core in viscose, cotton and bamboo core yarns increases the fabric strength, polyester core could not make a significant contribution to the fabric strength in polyester and modal core yarns.

In order to determine the effect of the core/sheath ratio on yarn and fabric properties, core yarns were produced using 61 and 83 dtex polyester and towels were obtained from these yarns. According to the results of the towels produced with these two types of yarns, it is seen that when the core yarns produced using cotton have a small change in the core/sheath ratio, the resistance of these yarns and towels produced from them were affected. But this change did not affect the strength of the viscose yarns nor the towels produced from them.

Stiffness test results

The samples (Towel 1 and Towel 2**)** were tested according to ASTM (American Society for Testing and Materials) D 4032-94 Circular Bending Test Method using a Digital Pneumatic Stiffness Tester (A&T Otexlab, Turkey).

Stiffness test values are shown in ***Figure 3***, according to which, it can be seen that increasing the pile height raises the values of stiffness. It is a common opinion that increasing fabric thickness leads to an increases in the stiffness of the fabric in this test method.

Stiffness values of the towel samples produced with conventional yarn and core yarn were determined as similar. Hence it may be stated that usage of spun polyester core did not negatively affect the softness of the towel fabrics.

Drying ratio/time (after washing) test results

Before starting the washing-drying test for Towel 1, Towel 2 and non-pile fabric samples, firstly a trial washing and drying process was performed to determine the drying times of samples. According to the drying values obtained as a result of the trial wash, weighing intervals of one hour were selected for Towel 1 and Towel 2 and 30 minutes for the non-pile fabric sample. After each weighing, the water loss percentage of the sample fabrics was calculated according to the following formulas.

TWA = Weight after washing – weight before washing
PWL = (100*AWL)/ TWA
TWA: Total water amount in sample
AWL: Amount of water loss (the amount of water loss until the weighing time)
PWL: Percentage of water loss (drying ratio)

After the trial wash-drying, a total drying time (complete drying time) of 3 hours and weighing interval of 30 minutes were selected for the non-pile fabric sample. The drying percentages of all fabrics after 2 hours are compared in ***Figure 4***. This time (after 2 hours) is the measuring time/weighing time prior to the full drying of samples.

According to the drying rates shown in the figure, it was determined that the amount of water which is removed after 2 hours in the samples using core yarn is considerably higher than that of samples produced with conventional yarns (except polyester). For example, after 2 hours, 76% of water on the fabric produced using conventional viscose yarn was removed from the fabric, while this value was measured as 96% in the fabric sample produced using viscose core yarn. Hence it was seen that the fabric with viscose core yarn dried faster than the other fabric. The same was observed for cotton, bamboo and modal fibres.

After the trial washing-drying operations on Towel 1 samples, the drying time was

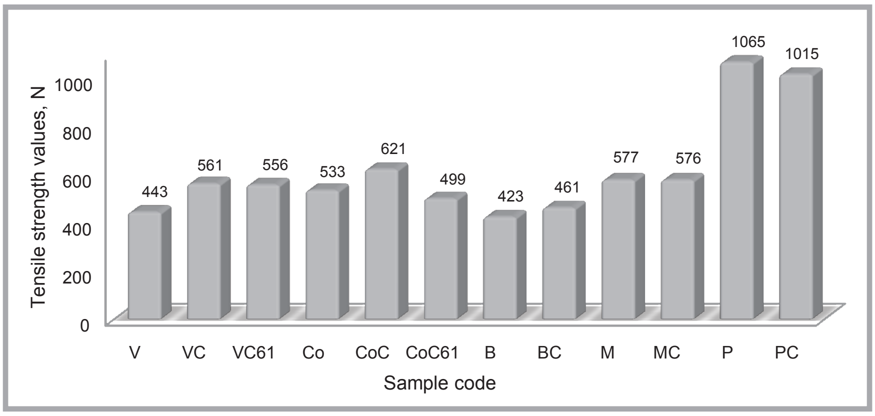
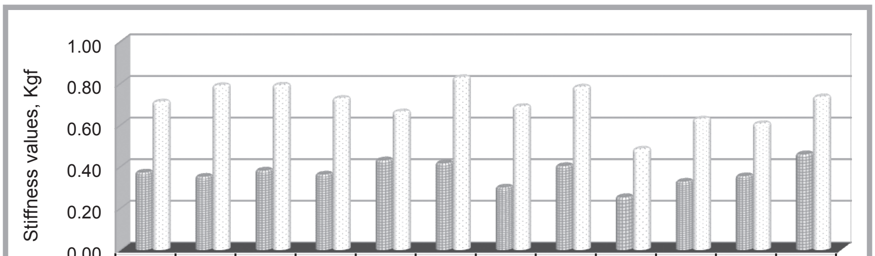


Figure 2. *Tensile strength test values.*



	V	VC	VC61	Co	CoC	CoC61	B	BC	M	MC	P	PC
Towel 1	0.374	0.354	0.384	0.365	0.433	0.419	0.302	0.406	0.256	0.330	0.357	0.462
Towel 2	0.711	0.790	0.792	0.729	0.664	0.829	0.690	0.783	0.485	0.629	0.607	0.736

Figure 3. *Stiffness test values.*

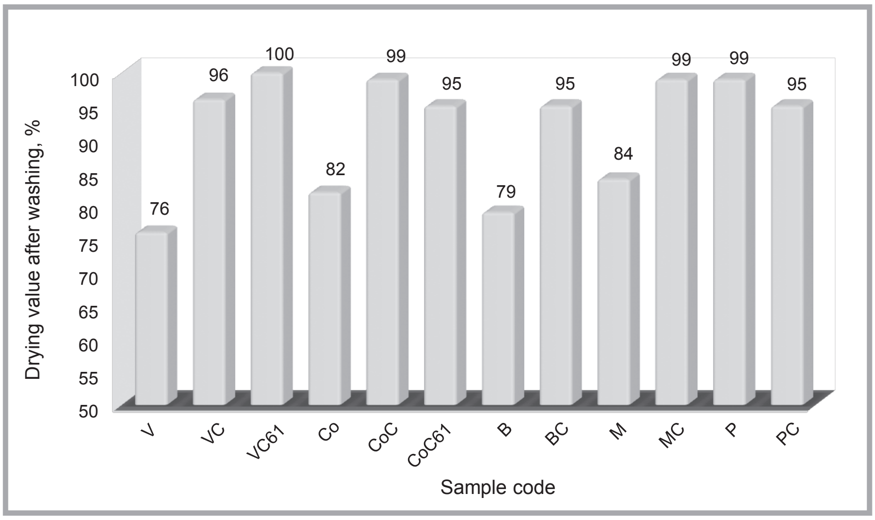


Figure 4. *Drying values (%) of non-pile fabric samples after 2 hours.*

determined as 6 hours and the weighing intervals chosen were 1 hour. ***Figure 5*** shows the percentages of drying after 5 hours following washing, taking into account the sample weights measured one hour prior to the time when the samples were completely dry, in order to compare the amounts of drying in the Towel 1 samples.

According to ***Figure 5***, similar to the non-pile fabric sample results, it was determined that the samples with polyester core yarn dried significantly quickly. It was observed that the highest drying percentage difference was between V and VC61, and the lowest between M and MC. There was a difference of 6% in the cotton yarn, which is the most frequently used in towel production.

The drying times of Towel 2 samples after the trial washings were measured as 8 hours. Thus the weighing interval for

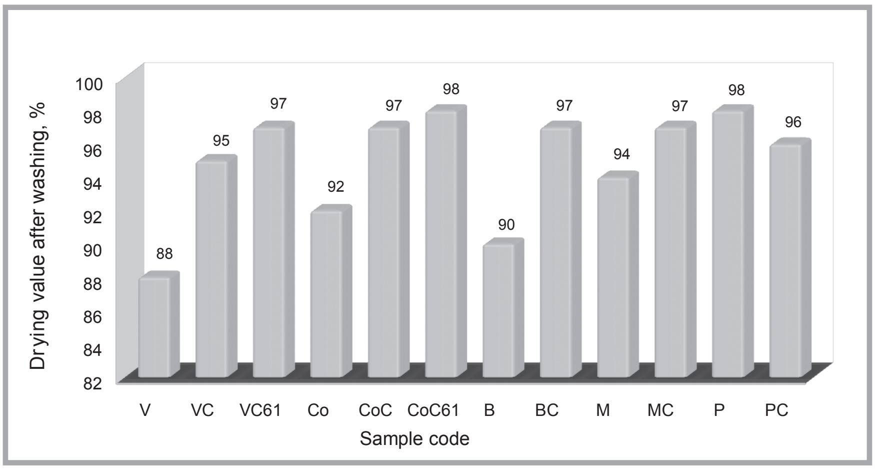


Figure 5. *Drying values (%) of Towel 1 samples after 5 hours.*

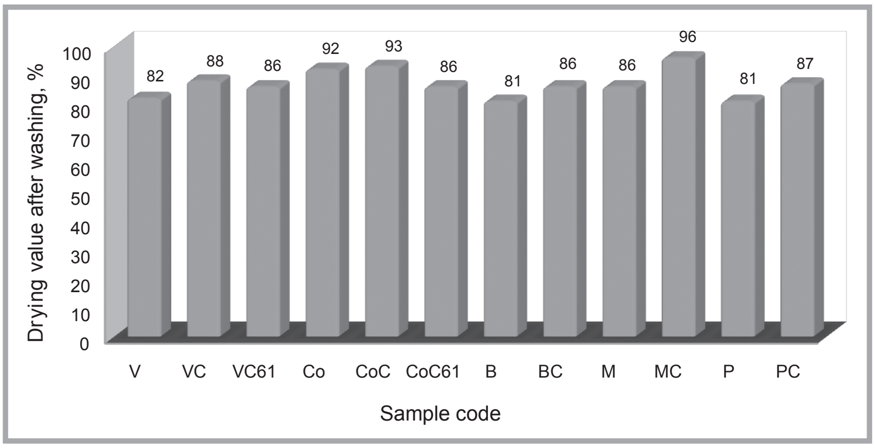
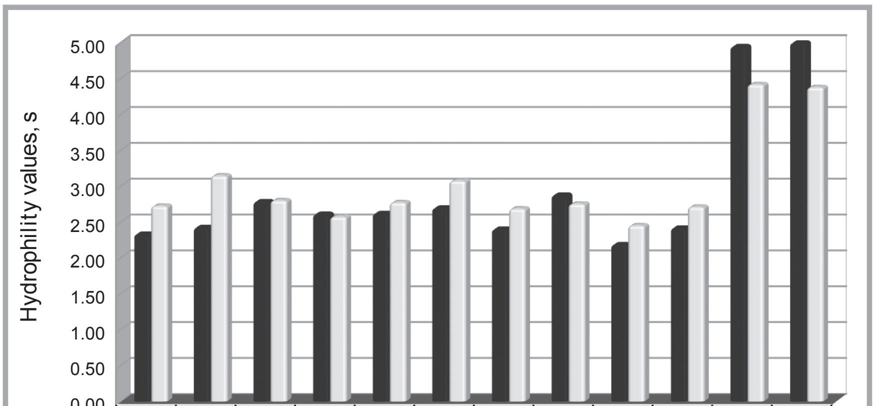


Figure 6. *Drying values (%) of Towel 2 samples after 6 hours.*



	V	VC	VC61	Co	CoC	CoC61	B	BC	M	MC	P	PC
■ Towel 1	2.33	2.43	2.79	2.61	2.62	2.70	2.40	2.88	2.19	2.42	4.95	5.13
▫ Towel 2	2.73	3.15	2.80	2.58	2.77	3.08	2.69	2.75	2.45	2.71	4.42	4.38

Figure 7. *Comparison of water absorbency values.*

Towel 2 samples was selected as 1 hour. To compare the drying amounts of Towel 2 samples, ***Figure 6*** was created, with the drying percentages determined based on weighing after 6 hours.

It was determined that the drying percentages of samples with core yarn were generally higher than those of samples with conventional yarn after 6 hours, which is similar to the results for Towel 1 and non-pile fabric samples. The highest difference in drying percentages was obtained between "M" and "MC" at about 10%. There was no significant difference between the drying percentages of "Co" and "CoC", while an expected result was observed between "V" and "VC".

In contrast to Towel 1 and non-pile fabric samples, it was seen in Towel 2 that the drying percentage of "PC" was higher than that of "P". It may be assumed that the main reason for these variable conditions was that Towel 2 samples had a high pile height, with the pile threads stacked on each other, and thus moisture transfer from the base of the sample became difficult.

Water absorbency test results (sinking test results)

Because of the hydrophobic property of polyester, it was expected that the hydrophilicity of towels would be negatively affected by the usage of polyester core yarn. However, according to the test results, no significant change was determined among the water absorbency values of the samples.

A comparison of hydrophilicity values (Towel 1 and Towel 2) is given in ***Figure 7***. According to the sinking test results, all samples had absorbency values within acceptable limits. It was determined that the sinking times of samples with different pile heights were close to each other.

Conslusions

This study focused on five different raw materials (modal, cotton, polyester, bamboo, viscose) which are the most frequently used fibres in towel production. Seven different core yarns and five different conventional yarns were produced. These yarns were used in the weft direction to produce towels and non-pile fabrics. Water absorbency, softness, strength and quick drying tests were performed to determine the physical and performance characteristics. From this experimental study carried out to investigate the effects of core spun yarn on towel properties, the following conclusions can be drawn.

1. It can be seen that increasing the pile height increased the values of stiffness. Stiffness values of the towel samples produced with conventional yarn and core yarn were determined as similar. Therefore it may be stated that usage of polyester core yarn did not affect the softness of the towel fabrics negatively.
2. As expected, in relation to the yarn strength, it was determined that the tensile strengths of fabrics produced

using core yarn in the weft direction were higher than those of fabrics with conventional yarns.
3. It was determined that the percentage of drying after 2 hours of washing varied between 15% and 20% with the usage of core yarns in non-pile fabric samples. Thus it may be stated that non-pile fabrics produced with core yarns dry faster than ones produced using conventional yarn.
4. Among the drying percentages of Towel 1 samples produced from conventional yarn and core yarn, there was a change of 3% to 9% after 5 hours following washing. The samples produced using core yarn also dried faster. As the most important result of this study, it may be reported that the quick dry properties of fabrics were improved, to a certain extent, even with the usage of polyester core yarns only in the weft direction.
5. Towel 2 samples' test results varied among the different cases, but in general, samples produced from core yarn had the ability of drying faster than the conventional yarn samples. It is thought that the main reason for this variation in cases was that Towel 2 samples had a high pile height, thus the pile threads were stacked on each other, and moisture transfer from the base of the sample became difficult.
6. Polyester is known as a hydrophobic fibre. Therefore it was expected that the hydrophilicity of towels would be negatively affected by the usage of polyester core yarn. However, according to test results, no significant differences were found among the water absorbency values of the samples.
7. In both cotton and viscose yarns, the usage of polyester as the core in different numbers (61 or 83 dtex) did not affect the selected properties (softness, hydrophilicity and quick drying) of Towel 1. However, some variation in the values of Towel 2 was seen. It is thought that these changes were caused not by the core number but by the high pile height.

Consequently the usage of core yarns in the weft direction of the towels increased the strength of the samples and did not affect their properties such as hydrophilicity and softness negatively. According to the quick dry test results, which were the main section of this study, the usage of core yarn in towel production provided a certain improvement in the quick drying ability. For this reason, it can be stated that polyester core yarns can be used in towel production as an alternative and innovative yarn type.

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