THE COMPARISON OF QUICK DRYING CHARACTERISTICS OF LIGHT-WEIGHT WARP KNITTED TOWELS

F. Filiz YILDIRIM[1], Esra GELGEÇ[1], Abdullah Can DENİZ[1], Mustafa ÇÖREKCİOĞLU[1], Sema PALAMUTCU[2]

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ABSTRACT

Towels can be produced in the range of 300 to 900 g/m^2 weight and they are generally desired to have high water absorption ability and softness. Although high weighted towels absorb more water, they need too much time for washing and drying processes which cause more energy consumption. Light-weighted towels are washed and dried easily compared to their high weighted counterparts. In this study, light weight warp knitted towels were produced and their quick drying characteristics were investigated and compared to the other medium weighted towels. These fabrics had different fiber blend ratios such as 100% polyester (PES), 90% cotton (CO)-10% polyester (PES), 80% cotton (CO)-20% polyester (PES), 50% cotton (CO)-50% polyester (PES), and 100% cotton. Two different liquid absorbency measurement tests and one drying rate test were carried out to determine the wetting and drying performance properties of warp knitted towel samples. The results exhibit that, all types of towels exhibited good liquid absorption properties except one sided velvet and one sided terry towel types. All warp knitted towels displayed excellent to good drying rates due to their polyester yarn content. 100% polyester fabrics displayed excellent drying rates and excellent liquid absorption properties. Thus, these fabrics can be used as quick drying bathrobes, beach wear and any other applicable product design.

Keywords: warp knitting, light-weight towels, quick drying, absorbency

ÖZET

Havlular genellikle 300 ile 900 gr/m^2 aralığında üretilebilir ve genellikle yüksek su emme yeteneğine sahip olması ve yumuşak olması istenir. Yüksek gramajlı havlular daha fazla su emer, ancak yıkamak ve kurutmak için çok fazla zaman gerekir ki buda daha fazla enerji tüketimine neden olur. Bu çalışmada hafif gramajlı çözgülü örme havlular üretilmiş ve bu kumaşların kuruma özellikleri araştırılmış ve diğer orta gramajlı havlular ile karşılaştırılmıştır. Bu kumaşlar, %100 poliester, %90 pamuk - %10 poliester, %80 pamuk - %20 poliester, %50 pamuk - %50 poliester ve %100 pamuk oranlarında üretilmiştir. Numunelerin ıslanma ve kuruma özelliklerini belirlemek için iki su emicilik ve bir kuruma testi uygulanmıştır. Sonuçlar, tek tarafın kadife tek tarafı bukle havlular dışında hepsinin iyi su emicilik özelliği sergilediğini göstermiştir. Tüm çözgülü örme havlular polyester iplik içerdikleri için mükemmelden iyiye kuruma oranı özelliği göstermiştir. %100 poliester kumaşlar mükemmel kuruma oranı ve su emicilik özellikleri sergilemiştir. Böylece, bu kumaşların hızlı kuruyan bornozlar, plaj kıyafetleri ve benzer ürünlerde kullanılabilir olacağı ön görülmüştür.

[1] Ozanteks Tekstil R&D Centre, Denizli, Turkey, Email: filiz@ozanteks.com.tr
[2] Pamukkale University Textile Engineering Department, Denizli, Turkey

Anahtar Kelimeler: çözgülü örme, düşük gramajlı havlular, hızlı kuruma, su emicilik

1. INTRODUCTION

Terry fabrics are important and popular fabrics that use from hats to socks, handkerchiefs to beach towels, bathrobes to baby cloths etc. These fabrics belong to the group of pile fabrics which have loop piles on one or both sides covering the entire surface (Petrlyte et. al. 2008; Singh and Swadesh, 2016). Although they can be produced by both weaving and knitting, the woven terry fabric still holds the major share in the market. Towels are the type of the terry fabrics and terry fabrics, also towels are known as their high water absorbency properties (Petrlyte et. al. 2008). Although many other factors are very important for towels such as softness or dimensional stability, hydrophilicity is the most significant one. There are a lot of factors that are related to the absorbency of the towels and many researchers investigated these factors (Petrlyte et. al. 2008; Durur and Oner, 2013; Kakde et. al., 2017; Holland, 1943; Swani et. al., 1984; Lord, 1974; Sekerden, 2012; Zervent and Koc, 2006; Ramachandran, 2006)). For improving the absorbency, zero twist yarn, low twist yarn, etc., have been used (Petrlyte et. al. 2008).

In one of these researches, researchers investigated the water absorption properties of the towels manufactured of ring and open end yarns. The rate of water absorption was found the same in towels produced by open end and ring yarns. However, maximum water uptake of open-end yarn towels with lower fabric density and same weight was higher than those produced by ring yarns (Swani et. al., 1984; Uyanik et. al. 2013). In another study, the structural properties affecting the hydrophilicity of the towels were examined (Uyanik et. al. 2013; Goksel, 1987). Another researcher determined that the hydrophilicity was not affected by yarn count and weight of the fabric. Therefore, hydrophilicity affected positively from density and pile length of the fabric (Uyanik et. al. 2013; Bozgeyik, 1991). The softener type is also affected on the hydrophilicity of the towels. Hydrophilicity properties of the printed towels are lower than that of dyed towels (Zervent and Koc, 2006; Uyanik et. al. 2013). Towels made from doubled yarn have the lowest water absorption values due to the twisting properties of the yarns. Increasing warp and weft densities cause decreasing in water absorption percentage. Additionally, while the pile height is increased, water absorption property of the towels is getting increased (Uyanik et. al. 2013; Karahan and Eren, 2006). In studying the dynamic water absorption properties of the towel, one of the most effective factors on water absorption was the type of yarn. Single yarns absorb water faster than double yarns (Uyanik et. al. 2013; Karahan, 2007). In another study, the effect of absorption properties of zero and low twist yarns on the towels was investigated. The results exhibited that, zero twist yarns increases the water absorbency. On the other hand, this yarn type decreases the warp tensile strength (Uyanik et. al. 2013).

The customers prefer comfortable and fresh towels and bathrobes which have light in weight and soft in touch, quick in drying time, and hygienic. For the customers, comfort is an important property and the comfort properties of the towels should be specific. Some of these properties are air permeability, drying time or water absorption (Durur and Oner, 2013). However, many problems are related to the traditional towels. They are designed strictly to absorb water quickly without considering longer drying time requirements. Furthermore, these towels take longer drying times and bacterial growth is induced by moisture in the fabrics and this cause undesired odour (Hanes, 2006). Traditional towels are high-weighted and there are considerably differences between the washing of 450 gr/m^2 towels and 750 gr/m^2 towels in terms of drying time and energy cost. While low-weight towels may be needed to be washed in one cycle, high-weight towels may need to be washed in two cycles in a washing machine. This means that there is a significant amount of electricity, water and washing and softening chemical consumption. In other words, heavy towels do not just increase your procurement cost, but they also significantly increase your energy costs (int, 2017). Having quick-dry and good absorption properties, the towels can be produced with cotton fibers on the pile and polyester fibers on the ground (Waite, 2000).

Polyester yarn use in the towel construction bring the capillarity and wicking terms in to the stage. It is well known that liquid absorption level of polyester fiber is quite low comparing to the cotton fiber inherent absorption property (Kissa, 1996). In case of water transport on polyester yarn or polyester fabrics capillarity phenomenon is used to explain the liquid migration through the fibers. Capillarity is the ability of liquids to penetrate into fine pores with wettable walls and be displaced from those with nonwettable walls (Zhmud et.al, 2000). Capilar wetting occurs through the narrow gaps between fibres and yarns in warp and weft directions, especially in the interstitial area (Knittel and Schollmeyer, 2000). Wicking is explained as ability of a fibre to transfer moisture from one section to another. Transfer of the moisture or liquid is usually occurs along the fibre surface. And it may also happen that, some portion of the liquid is absorbed through the fibre depending on the absorption capacity of the fiber.

Along the penetration of the synthetic fibers in to the market there are more works carried out about the moisture and liquid transfer mechanisms of synthetic fiber based textile products. In the work of Wang (Wang et.al., 2008) polyester filament yarns are evaluated to understand their wicking properties. Yarns, as the semi-finished product between fibers and fabrics are used to explain their moisture transition property, where wicking is often employed to express the moisture transition of yarns (Wang et.al., 2008). In the work of Sarıçam and Kalaoglu (Saricam and Kaloglu, 2014) wicking and drying behaviour of polyester woven fabrics are investigated. The effects of yarn type, weft density, weave structure, thickness and air permeability were evaluated by the application of vertical wicking, transfer wicking and drying tests. Correlation analysis and two sided independent t-tests of the data obtained from experiments and the evaluations reveal that the texturizing process - the alteration of the arrangement and packing of yarns by changing the weft density and weave type, are influential with respect to the wicking performance. Moreover the drying behaviour is influenced by the thickness of the fabric (Saricam and Kaloglu, 2014).

Das studied moisture transmission through textile structure and claims that the liquid transfer involves two sequential processes: wetting and subsequently wicking (Das et. al, 2007). Oztürk has studied wicking properties of cotton-acrylic yarns and knitted fabrics and claim that wetting is defined as the initial behaviour of the fabric when it comes into contact with liquid (Ozturk et. al, 2010) Drying is another important characteristic of fabric in terms of time, energy, environmental influences and comfort, The time required for drying is related to the amount of water held originally, which is dependent on the moisture affinity and water holding capacities of the fibre (Cil et. al, 2009) The liquid transfer mechanism consists of water diffusion and capillary wicking determined by effective capillary pore distribution, pathways and surface tension. The drying rate, on the other hand, is related to the macromolecular structure of fibre (Fanguerio et. al, 2010). Jhanji has studied (Jhanji et al, 2017) moisture management and wicking properties of polyester –cotton knitted fabrics from the view of yarn lineer density. Outer surface and inner surface of the knitted fabric are designed using different yarn thicknesses to search the influence of the yarn linear density on the fabric wicking and moisture management properties.

In this study, cotton, polyester, cotton-polyester woven and warp knitted towel fabric samples were manufactured and analyzed according to their absorbency and quick drying properties. Then, the absorbency and quick-drying properties of these towels were compared.

2. MATERIALS AND METHODS

Twelve warp knitted and seven woven fabrics were used in this study. The warp knitted fabrics were manufactured in KSFB Z4 Mayer warp knitting machine and woven fabrics were manufactured in Vamatex dobby terry weaving machines. The weight values of the fabrics are in the range of 140 to 520 gr/m^2.

The absorbency and quick-drying properties were explored. The absorbency tests were performed according to EN ISO 14697 and AATCC 79 protocol. For determination of drying behavior, 5*5 cm sized samples were prepared. Their faces were placed on top of the sensitive scale and their weights were recorded as dry weight (m_k). 1 ml of water was dropped on the dry sample at a distance of 10 mm and measured weight was recorded as wet weight (m_y). After wetting of the sample fabric is kept at its horizontally laying down position and the change in weight (m_f) with respect to the drying of the fabric was measured and recorded at 10 minute intervals. The water content (K_s) remaining on the fabric after one hour was calculated with Formula 1 [20].

$$\mathrm{K_s}\,\% = \frac{\mathrm{m_f}-\mathrm{m_k}}{m_y-\mathrm{m_k}} \times 100 \qquad [1]$$

3. RESULTS AND DISCUSSION

It should be noted that all samples have different yarn types, densities and constructions (warp knitting and weaving). However, we evaluated the impact of yarn type (polyester or cotton) and density on the absorbency and quick drying properties of these samples. Owing to this reason, the comparisons have been made among these fabrics. Absorbency and quick-dry values of the samples are shown in Table 1 and Figure 1-3.

Table 1. Absorbency and drying properties of fabrics samples

Construction	Fabric Type	Weight (gsm)	No	Absorption Time (sec) AATCC 79	Absorption Time (sec) (EN ISO 14697)	Remainded Water Ratio (%) (FTTS-FA-04)
Warp Knitted	100% Polyester	140	**1**	0,5	1,3	1,3
	100% Polyester	160	**2**	0,4	1	0
	80 % Cotton- 20% Polyester	160	**3**	1,4	4,4	23
	80 % Cotton- 20% Polyester	180	**4**	0,7	1,7	16,7
	80 % Cotton- 20% Polyester	185	**5**	0,7	1,9	27,5
	80 % Cotton- 20% Polyester	200	**6**	0,9	1,7	20,8
	90% Cotton-10% Polyester	160	**7**	0,5	1,3	24,4
	90% Cotton-10% Polyester	190	**8**	0,9	1,5	32,3
	90% Cotton-10% Polyester	200	**9**	0,9	1,5	25,1
	50% Cotton-50% Polyester*	190	**10**	15	42	14,2
	50% Cotton-50% Polyester*	210	**11**	17,8	15,6	18,1
	50% Cotton-50% Polyester*	230	**12**	18,3	17,2	20,8
Woven	100% Cotton Woven	230	**13**	2,4	6,2	46,5
	100% Cotton Woven- White	300	**14**	1,8	3,8	33,3
	100% Cotton Woven- Beige	300	**15**	1,2	3,5	30,9
	100% Cotton Woven- Violet	300	**16**	1,2	4,5	58,4
	100% Cotton Woven- Dark Green	400	**17**	0,6	1,8	28,5
	100% Cotton Woven- Green	450	**18**	1,1	2	34,4
	100% Cotton Woven- Black	520	**19**	2,1	5,1	42,1

* one sided velvet, one sided terry

There are different test methods used for evaluating the water absorption of towels such as, aqueous immersion and drop tests (Sekerden, 2012; Ala, 2017). In these methods, the shorter time in the tests exhibit the higher water absorption values (Zervent and Koc, 2006). Therefore, 100% polyester warp knitted fabric samples are found to be most water absorbent towels and the water absorbency values of these samples are in the range of 0,4 seconds to 1,3 seconds. The micro-polyester yarns are used in the pile of 100% polyester warp knitted fabric samples. Using the micro polyester yarns in the pile provides more water absorbency and shorter absorption times.

A. Absorption Properties

As seen on Figure 1 and Figure 2, all woven samples and some warp knitted samples exhibited very good absorbency values, except one sided velvet-one sided terry towels. As it is known, absorbency values of the uncut pile towels are better than that of velvet ones (Zervent and Koc, 2006). Besides, all absorbency values of the samples, except velvet ones, exhibit very good degrees and these values are commercially acceptable. The highest absorption time value is 18,3 seconds for AATCC 79 test and 42 seconds for EN 14697 test. The lowest absorption time value is 0,4 seconds and 1 seconds according to AATCC 79 and EN 14697, respectively.

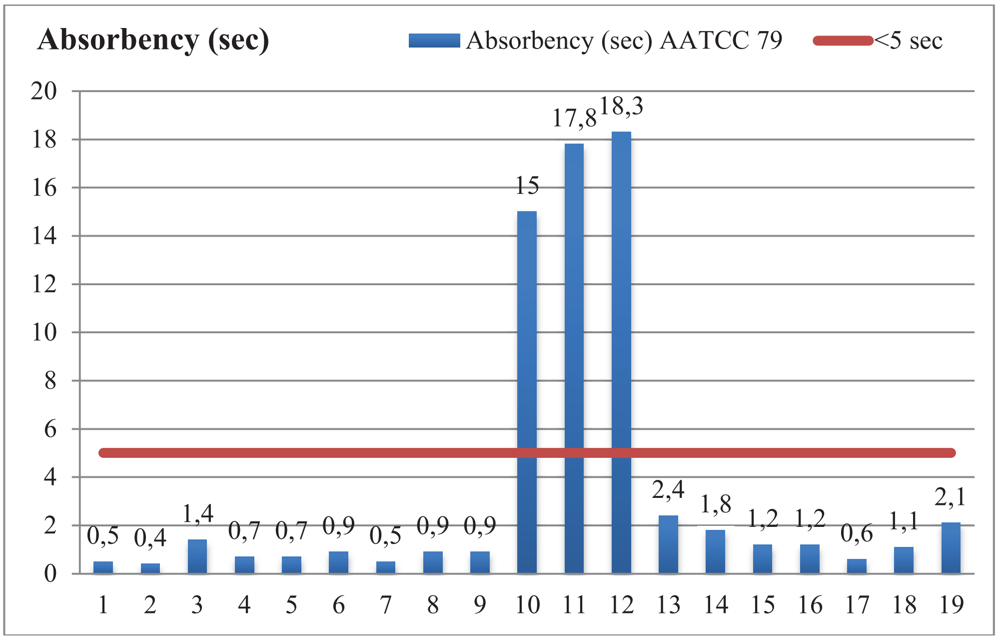

Figure 1. Absorption time of samples according to AATCC 79

100% polyester towel fabrics exhibited maximum absorption due to their micro polyester yarns content in piles. Micro polyester yarns provide piles that allow entering air and moisture into the yarn. These micro polyester yarns increase the softness and absorbency of towels and provide quick drying after washing. The action of splitting microfibers produces polyester fibrils which substantially the same volume and create hydrophilic areas. Thus, the total adjoining surfaces of all the existing fibers increase and this provides a higher amount of water absorption (Uyanik et. al. 2013; El-Hady, 2018). As seen on Figure 1 and 2, Woven fabrics exhibit a bit higher measurement values than that of warp knitted towels except, velvet ones. Wetting depends on the arrangement of fiber surface and wetting liquid (Singh and Behera, 2014).

As seen on literature, absorption properties of the towels depend on various factors. The weight and pile length of the towel affect the absorption properties of the towels. As the weight and pile length of the towel increase, absorption capacity of the towel increases. Yarn type is the one of the most important factors on the towels absorption properties (Uyanik et. al. 2013; Stoyanova Germanova-Krasteva et al. 2013; El-Hady, 2018).

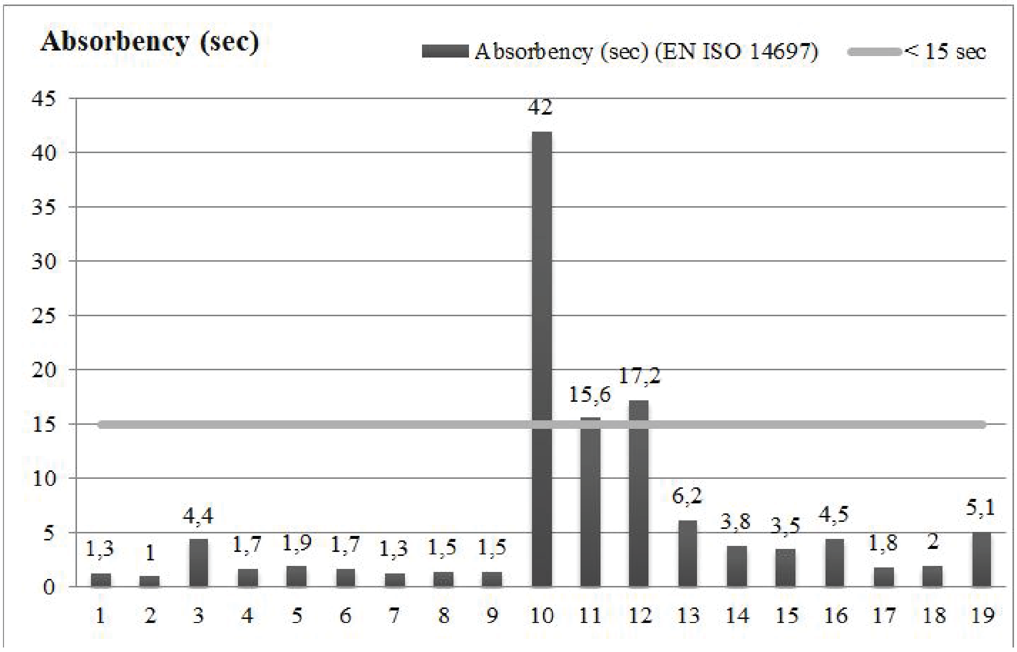

Figure 2. Absorption time of samples according to EN ISO14697

B. Drying Rate Properties

The remained water ratio test results are given in Figure 3. According to this test, when the amount of remaining water in the fabrics within 40 minutes is less than 5%, the fabric exhibits very good drying values.

As seen on Figure 3, 100% polyester warp knitted fabric samples are exhibited less than 5% water remaining ratios. Thanks to the micro-polyester yarns in the pile and polyester yarns on the ground, these fabrics exhibited best drying properties. And also the weights of these fabrics are the lowest. As it is well known, the polyester fibers are hydrophobic and dry quickly (El-Hardy and El-Barky, 2015). Therefore, using these fibers on the towel ground ensures towels to gain quick drying properties. All woven fabrics exhibited good to moderate drying properties. In woven terry towels, cotton fibers were used as ground yarn. Cotton is a hydrophilic yarn, absorbs water and not dries quickly. Hence, all woven fabrics showed worse drying properties than that of warp knitted fabrics. Polyester yarns were used on the ground of in almost all warp knitted samples.

In addition to all these above, it is seen on literature that the fabrics, which consist of synthetic fibers, produced from filament yarns show better drying performance than textiles produced from textured yarns. Additionally, thickness has related to the rate of drying (Saricam and Kaloglu, 2014).In this study, woven towel fabrics are thicker than the warp knitted towel fabrics and their drying properties are generally worse than warp knitted towel fabrics. This result is in parallel with the literature, which states that the drying time is positively correlated with the thickness of the fabric (Saricam and Kaloglu, 2014).

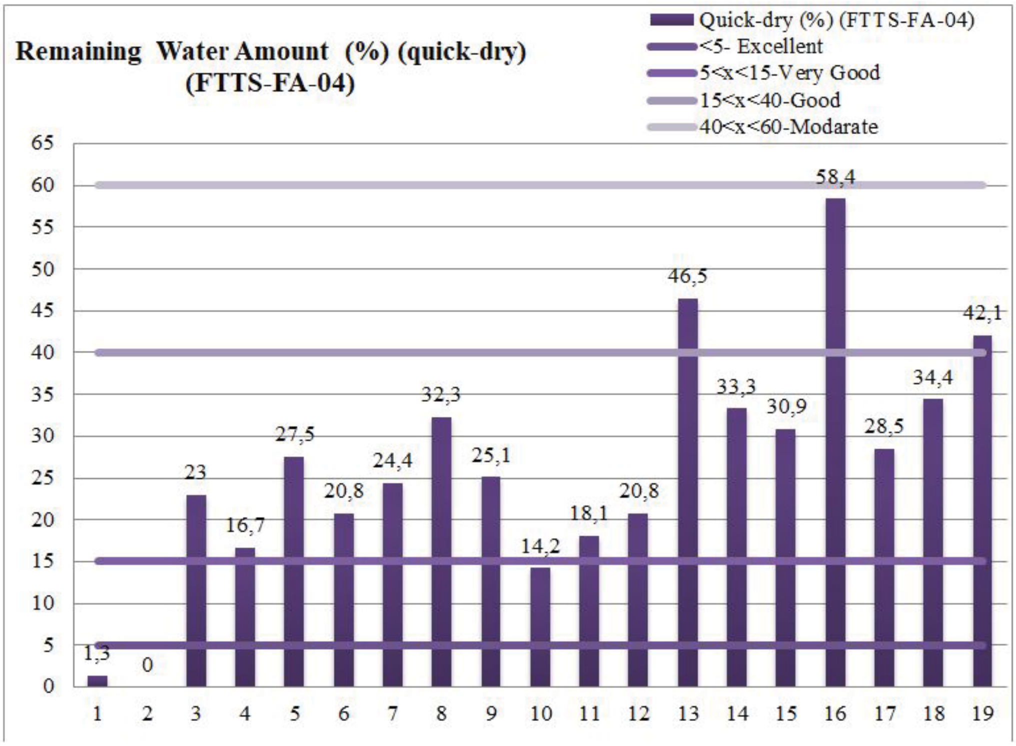

Figure 3. Remained water ratio of samples according to FTTS-FA-004

4. CONCLUSION

Towels are generally desired to have high water absorption ability and softness. Although high weighted towels absorb more water, they need too much time for washing and drying. Therefore they cause more energy consumptions. Light-weight terry towels are washed and dried easily. In this study, light weight warp knitted towels are manufactured and their water absorption and quick drying characteristics are investigated. Then these properties are compared to the other medium weighted towels. 100% polyester warp knitted fabric samples are found to be most water absorbent towels and the water absorbency values of these samples are in the range of 0,4 seconds to 1,3 seconds. And also, 100% polyester warp knitted fabric samples are exhibited less than 5% water remaining ratios.

With this study, it is aimed to develop terry towel fabrics which can absorb water highly and dry easily. Additionally, these fabrics decrease the energy and water consumption because they wash and dry easily. Thus, this study can have a positive impact on the environment. In addition, new bathrobe models will be developed using these terry towel fabrics.

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5. LITERATURE

[1] Ala, D.M, (2017), Investigaiton of wetting and drying properties of cotton woven fabrics, *Ulusal Çukurova Tekstil Kongresi*, UCTEK'2017, 28-29 Eylül 2017, Adana, Türkiye

[2] Bozgeyik, K., (1991). Havlularla İlgili Kalitatif Bir Araştırma, Yüksek Lisans Tezi, Ege Üniversitesi, Fen Bilimleri Enstitüsü, Tekstil Mühendisliği Anabilim Dalı, İzmir, 1991.

Çil MG, Nergis UB, Candan C. (2009), An experimental study of some comfort-related properties of cottonacrylic knitted fabrics. *Textile Res. J.* 2009; 79, 10: 917–923.

[3] Das B, Das A, Kothari VK, Fanguiero R, Araujo M., (2007) Moisture transmission through textiles. Part I: processes involved in moisture transmission and the factors at play. *AUTEX Res. J.*; 7, 2: 194– 216.

[4] Durur, G., & Öner, E. (2013). The Comfort Properties of the Terry Towels Made of Cotton and Polypropylene Yarns, *Journal of Engineered Fabrics & Fibers (JEFF)*, *8*(2)

[5] Fangueiro R, Filgueiras A, Soutinho F, Meidi X., (2010) Wicking behavior and drying capability of functional knitted fabrics. *Textile Res. J.*; 80, 15: 1522–1530.

[6] Goksel, I., (1987). Havlu Dokuma Kumaşların Yapısı, *Tekstil ve Teknik Dergisi*, S:30-36

[7] El-Hady, R. A. (2018), Factors Influencing The Performance Characteristics of Terry Warp-Knitted Towels.

[8] El-Hady, R. A., & El-Baky, R. A. (2015). Performance characteristics of warp knitted lining fabrics used for sportswear. *Life Science Journal*, *12*(3).

[9] Holland, V. B. (1943). A comparison of methods for the determination of water absorbency by terry towels. *Textile Recorder*, 61, 38-42.

[10] Hanes, L.. (2006), Wicking quick-dry anti-microbial towel. *U.S. Patent Application No 11/503,738, 2006.*

[11] Int, 2017, https://www.beltatex.com/faydali-bilgiler/kaliteli-havlu-nasil-anlasilir

[12] Jhanji, Y., Gupta, D., & Kothari, V. K. (2017). Moisture management and wicking properties of polyester-cotton plated knits. *Indian Journal of Fibre & Textile Research (IJFTR)*, *42*(2), 183-188.

[13] Karahan, M, Eren, R., (2006). Experimental Investigation of the Effect of Fabric Parameters on Static Water Absorption in Terry Fabrics, *Fibres& Textiles in Eastern Europe*, April /June, Vol: 14, No: 2 (56) P: 59-63

[14] Karahan,M., (2007). Experimental Investigation of the Effect of Fabric Construction on Dynamic Water Absorption in Terry Fabrics, *Fibres& Textiles in Eastern Europe*, July/ September, Vol: 15, No: 3 (62), P: 74-80,

[15] Kakde, M. V., More, H., Magarwadia, B., & Kejkar, V, (2017), Effect of Pile Density on Physical Properties of Terry Towel Fabric.

[16] Kissa, E., (1996), Wetting and wicking, *Textile Research Journal*, vol. 66, no. 10, pp. 660-668,

[17] Knittel D. and Schollmeyer E., (2000) Notes on future developments for textile finishing processes, *The Journal of The Textile Institute*, vol. 91, part 3, pp. 166–167.

[18] Lord, P. R. (1974). A comparison of the performance of open-end and ring spun yarns in terry toweling. *Textile Research Journal*, *44*(7), 516-522.

[19] Ozturk MK, Nergis B, Candan C. A, (2010) study of wicking properties of cotton-acrylic yarns and knitted fabrics. *Textile Res. J.*; 81, 3: 324-328.

[20] Petrulyte, S., and Renata B, (2008). Investigation into the wetting phenomenon of terry fabrics. *Fibres & Textiles in Eastern Europe,* 16.4, 62-66.

[21] Ramachandran, M. (2015). Application of Natural Fibres in Terry Towel Manufacturing. *International Journal on Textile Engineering and Processes*, *1*(1), 87-91.

[22] Saricam, C., & Kalaoğlu, F. (2014). Investigation of the wicking and drying behaviour of polyester woven fabrics. *Fibres & Textiles in Eastern Europe*.

[23] Singh, J. P. and Behera B.K., (2014). Performance of terry towel-a critical review. Part I: water absorbency. *Journal of Textile and Apparel, Technology and Management*, 9(1)
[24] Singh, Jitendra Pratap, and Swadesh Verma, (2016), Woven Terry Fabrics: Manufacturing and Quality Management. *Woodhead Publishing*,
[25] Sekerden, F. (2012). Effect of pile yarn type on absorbency, stiffness, and abrasion resistance of Bamboo/Cotton and cotton terry towels. *Wood and Fiber Science*, *44*(2), 189-195.
[26] Stoyanova Germanova-Krasteva, D., Dimitrova Kandzhikova, G., & Grigorov Bochev, A. (2013). Influence of terry fabrics structure on dynamic sorption. *International Journal of Clothing Science and Technology*, *25*(4), 243-256.
[27] Swani, N. M., Hari, P. K., & Anandjiwala, R. (1984). Performance Properties of Terry Towels Made from Open-end and Ring-spun Yarns.
[28] Uyanik, S., Ünal, B. Z., & Çelik, N. (2013). Farklı Büküm Tiplerine Sahip Hav İpliklerinin Havlu Performans Özelliklerine Etkisi.
[29] Waite, C. L.. (2000.), "Absorbent towel having quick-dry properties." *U.S. Patent No. 6,062,272. 16 May 2000.*
[30] Wang N., Zha A., and Wang J., (2008) Study on the Wicking Property of Polyester Filament Yarns, *Fibers and Polymers*, Vol.9, No.1, 97-100.
[31] Zervent, B., & KoC, E. (2006). An Experimental Approach on the Performance of Towels-Part II. Degree of Hydrophility and Dimensional Variation. *Fibres and Textiles in Eastern Europe*, *14*(2), 64.
[32] Zhmud B. V., Tiberg F., and Hallstensson K., (2000) "Dynamics of capillary rise," *Journal of Colloid and Interface Science,* vol. 228, no. 2, pp. 263–269,.