(REFEREED RESEARCH)

HANDLE PROPERTIES OF THE WOVEN FABRICS MADE OF COMPACT YARNS

KOMPAKT İPLİKLERDEN ÜRETİLMİŞ DOKUMA KUMAŞLARIN TUTUM ÖZELLİKLERİ

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ABSTRACT

The target of the current work is to examine the effects of different kinds of finishing treatments on the hand properties of the woven fabrics produced with compact spun yarns. Plain, twill and satin fabrics were produced with 100% cotton compact yarns in two yarn counts of 20 tex and 12 tex. All the fabrics were divided into two groups and mercerization process was applied to the one of the groups. The mercerized fabrics were dyed and printed with reactive dyestuffs. The other non mercerized groups of fabrics were divided into three such as reactive dyed, reactive printed and pigment printed. As a result, 30 different fabrics were obtained. In order to measure the handle properties of the fabrics objectively, Shirley stiffness tester, circular bending rigidity tester and thickness tester were used. It was determined that yarn count, fabric weave and finishing treatment have a statistically significant effect on handle properties of the fabrics woven with compact spun yarns.

Key Words: Compact yarn, Woven fabric, Handle properties, Finishing treatments, Stiffness, Bending.

ÖZET

Bu çalışmanın amacı, kompakt eğrilmiş ipliklerden üretilen dokuma kumaşların tutum özelliklerine etki eden bazı faktörlerin incelenmesidir. 20 tex ve 12 tex iplik numaralarında %100 pamuklu kompakt iplikleriyle bezayağı, dimi ve saten doku tiplerinde kumaşlar üretilmiştir. Kumaşlar iki gruba ayrılmış ve gruplardan birine merserizasyon işlemi yapılmıştır. Merserizasyon işlemi görmüş kumaşlar, reaktif boyama ve reaktif baskı işlemlerinden geçirilmiştir. Merserizasyon işlemi görmemiş kumaşlar ise, reaktif boyama, reaktif baskı ve pigment baskı işlemlerinden geçirilmiştir. Sonuç olarak 30 farklı kumaş elde edilmiştir. Kumaşların tutum özelliklerini objektif olarak ölçmek amacıyla Shirley sertlik ölçer, dairesel eğilme ölçeri ve kalınlık ölçer test aletleri kullanılmıştır. Kompakt eğrilmiş ipliklerle dokunan kumaşların tutum özelliklerine iplik numarasının, kumaş dokusunun ve terbiye işlemlerinin istatistiksel olarak önemli bir etkisinin olduğu belirlenmiştir.

Anahtar Kelimeler: Kompakt iplik, Dokuma kumaş, Tutum özellikleri, Terbiye işlemleri, Sertlik, Eğilme.

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1. INTRODUCTION

The ideal fabric is the fabric which satisfies good hand, possibility of making good appearance and mechanical comfort for wear (1,2). Thus, the fabric hand (touch feeling of a fabric), related to the concept of comfort, style, and appearance are the most important properties of the textile end products. The clothing comfort can be considered from different points of view such as psychological, tactile and thermal. The tactile aspect of comfort is related with the surface and mechanical properties of the fabric such as prickliness, itchiness, stiffness, softness, smoothness, roughness and scratchiness (3).

Fabric hand can be approached through subjective evaluation and objective measurements. The traditional method of evaluating fabric quality via using fabric mechanical parameters was the handle judgment of fabric by subjective method (4,5). Generally in order to evaluate the handle of the fabric, fingers are slid on the surface of the fabric, compressed between the thumb and sign finger. Tightening of the fabric between fingers gives idea about thickness, bulkiness, compressibility, thermal absorptive and surface properties of the fabrics, whereas slipping of the fingers on the surface of the fabrics with a pressure renders about structure and elongation of the fabrics (6). Therefore, several instruments are developed for objective measurement of the handle by means of measuring mechanical and structural properties such as drape, bending and compression characteristics of the fabrics.

There are several parameters that affect the fabric handle such as fibre characteristics, yarn and fabric construction and finishing treatments mainly. Cay and Vassiliadis (7) has already investigated that woven fabric density has a significant effect on the handle properties of the fabric. Aliouche and Viallier (8) have already proved that hairiness has an important effect on tactile feelings such as surface roughness and fabric compression. Yan et al., (9) has already investigated the effect of bleaching on the mechanical properties of fabrics and determined that bleached fabrics have a coarse handle and a lower fullness than those of the unbleached. Manich et al., (10) has also examined the finishing effects on the compression of woven fabrics. They found that the finishing treatment of gray goods leads to a fuller and more compact fabric structure given the increase in fabric density (46%) and in the cover factor image analysis (9%), the decrease in thickness (33%). The effect of washing/ironing cycles on the properties of cotton weaves was investigated and the results show that the spread of hand rating in washed/ironed samples is higher, probably owing to changes of bulkiness and deformability. Apart from this, the hand, shrinkage and surface roughness is dependent mainly on the type of fabric (11). In another study, the effect of a durable flame-retardant finishing on the mechanical properties of cotton knitted fabrics was investigated and it is found that the compression characteristics of the fabrics increased and the fabrics became rather hard in compressional deformation. They also concluded as the changes in the surface properties of the fabrics are small, the effect of the finishing stages seems to be weak (12).

Numerous researches have been carried out in the field of compact ring spinning technology and the properties of the yarns, knitted and woven fabrics produced with compact yarns (13, 14, 15, 16, 17). However there are not so many works on the handle properties of the fabrics produced with compact ring spun yarns.

The present work is focused on the effects of yarn count, fabric structure and different finishing treatments on the handle properties of woven fabrics produced with compact ring spun yarns. The structural characteristics, such as yarn count and fabric weave, can be related with the surface properties and the thickness of the fabric. Different finishing treatments of the fabrics may have an effect on tactile characteristics. Thus, it is expected that the use of different yarn counts, fabric weaves and finishing treatments introduce divergence in the handle properties of the produced fabrics.

2. MATERIAL AND METHOD

In the scope of this study, for the production of the woven fabrics, 100% cotton compact ring spun yarns were produced from the same cotton blend in the yarn counts of 20 tex and 12 tex with the yarn twist multiplier of α_{tex}=4311 and α_{tex}=4216 respectively. Compact ring spun yarns were produced on Rieter K44 spinning machine. Yarns were woven in three types of weave on the air jet Toyota weaving machine. By considering the yarn count, warp and weft densities of the fabrics were adjusted. As a result, six different fabrics were produced and the fabric specifications are given in Figure 1 and Table I.

After the fabric production, in order to see the effects of finishing treatments, the fabrics were divided into two groups as mercerized and non-mercerized. After mercerization process, one of fabric groups was dyed with reactive dyestuff while the

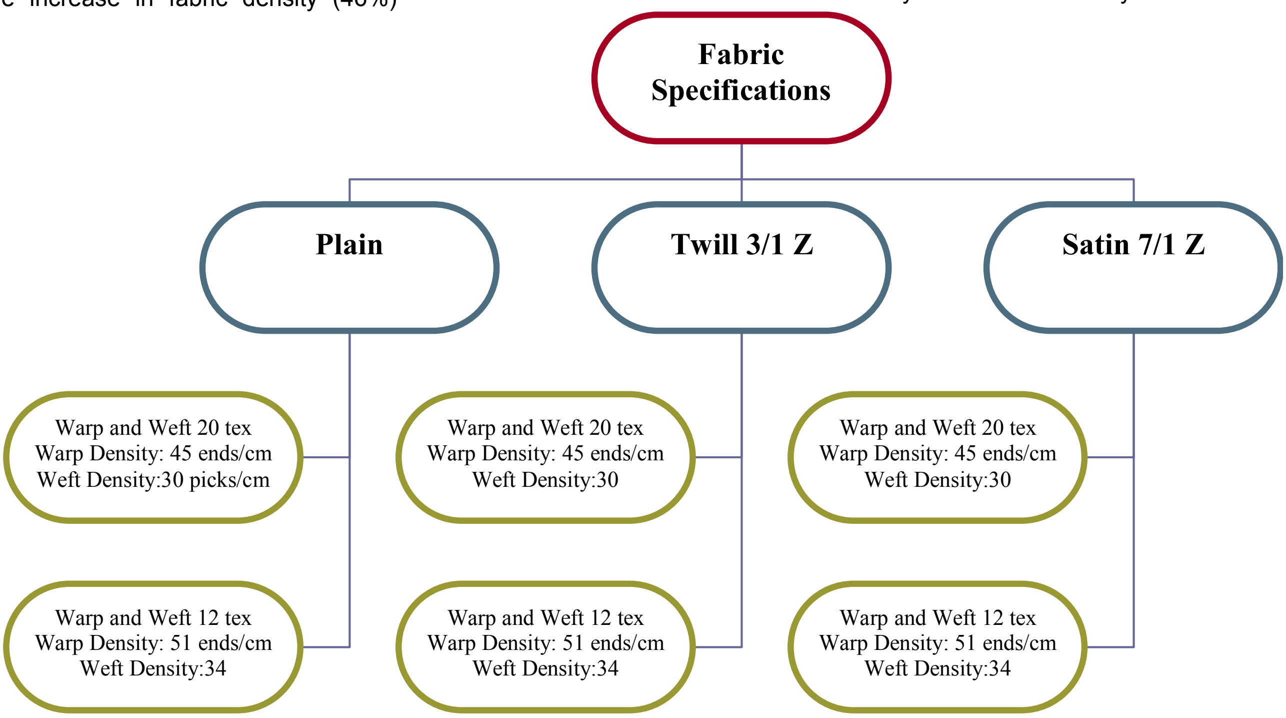

Figure 1. Fabric properties

Table 1. Fabric Weights per unit area (g/m^2)

Finishing Processes	Plain		Twil		Satin	
	20 tex	12 tex	20 tex	12 tex	20 tex	12 tex
Reactive Dyeing	165	110	157	108	154	105
Mercerised Reactive Dyeing.	160	106	160	109	156	109
Reactive Printing	165	113	158	111	158	106
Mercerised Reactive Printing.	164	112	159	105	156	104
Pigment Printing	169	115	166	119	165	112

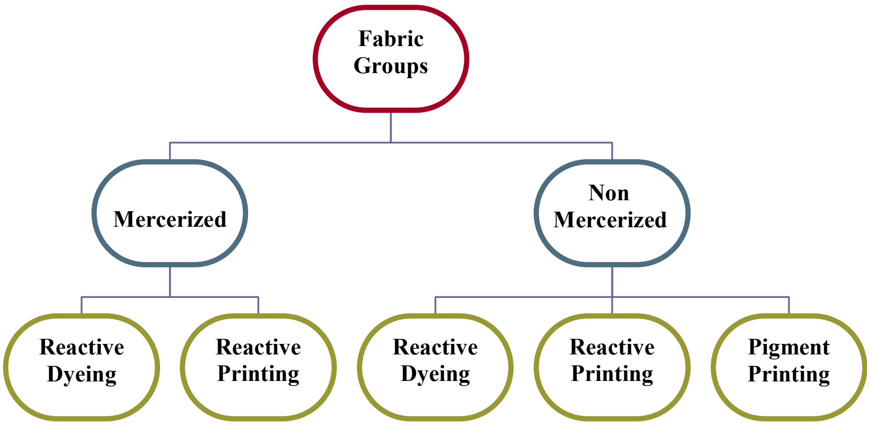

Figure 2. Fabric groups according to the finishing processes

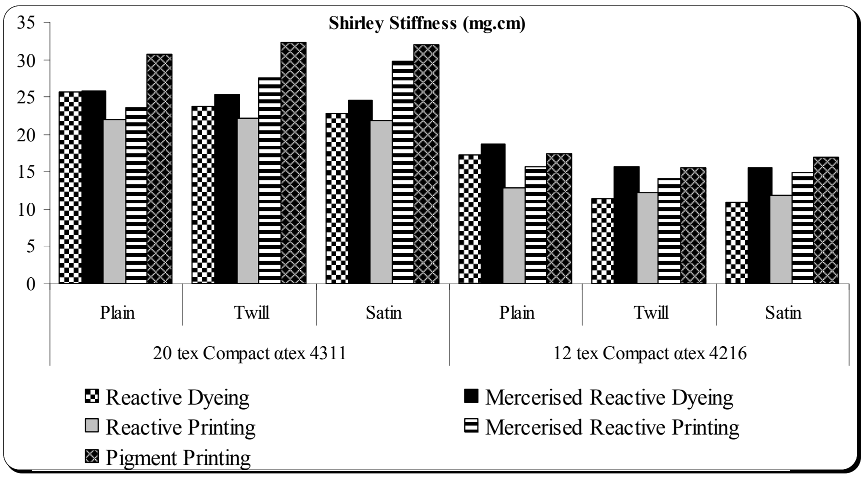

Figure 3. Bending rigidity of the fabrics (mg.cm)

second group was printed with reactive dyestuff. The non mercerized fabrics were divided into three groups such as reactive dyed, reactive printed and pigment printed. As a result, total of 30 fabrics were obtained (Figure 2).

Bending rigidity measurements were done by using Shirley stiffness tester according to ASTM 1388 (18). For each fabric groups, 3 trials were done; as a result 90 results were obtained. In the instrument, the strip sample in the form of 2,5x15 cm is hold from one side, whereas the other side is let to hang down by its own weight. The relation between the length of overhanging strip, the angle that it bends to and bending rigidity (G) of the fabric is a complex one which was solved empirically by Peirce and formulated as below (19).

$$G = WL^3\left(\frac{\cos\frac{1}{2}\theta}{8\tan\theta}\right) \quad C = L\left(\frac{\cos\frac{1}{2}\theta}{8\tan\theta}\right)^{1/3}$$

G: Bending Rigidity (mg.cm)

L: length of fabric overhanging (cm)

θ: Bending angle (°)

C: Bending length (cm)

W: Fabric weight (g/m^2)

The choice of deflection angle (θ) as 41.5^0 is primarily based on the ease of calculation of bending length as half of the length of fabric overhanging (L). The equation for bending length was derived by Peirce based on the elastic theory and corrected by experimental data. Finally, the fabric bending rigidity (G) is calculated from bending length C, and fabric weight per unit area (W) (20);

$$G = WC^3$$

Bending rigidity of the fabrics in multiaxial directions was carried out in circular bending tester, developed according to ASTM 4032 (21). In this method, the force which is generated while pushing a fabric specimen through a ring is measured. 6 trails for each variant were done.

Five trails were done for each sample in order to get an idea about the thickness of the fabrics. The thickness of the woven fabrics was measured under the pressures of 3 g/cm^2 (T_3) and 65 g/cm^2 (T_{65}) according to ASTM 1777 (22) and the compression of the fabrics were calculated according to following formula:

$$\boxed{Compression\,(mm) = T_3 - T_{65}\,(mm)}$$

Variation analysis (MANOVA) was carried out in order to determine whether the effect of yarn counts, fabric weaves and finishing treatments are statistically important or not.

3. RESULTS AND DISCUSSIONS

In Figure 3, Figure 4 and Figure 5, bending rigidity (mg.cm), circular bending rigidity (gf) and compression values (mm) of the reactive dyed and printed, mercerized reactive dyed and printed, pigment printed, plain, twill and satin fabrics from 20 tex and 12 tex compact ring spun yarns are presented, respectively.

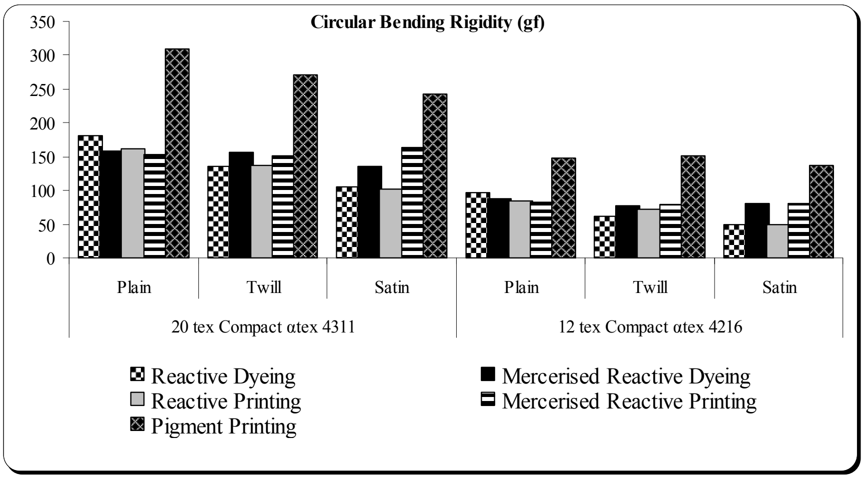

Figure 4. Circular bending rigidity of the fabrics (gf)

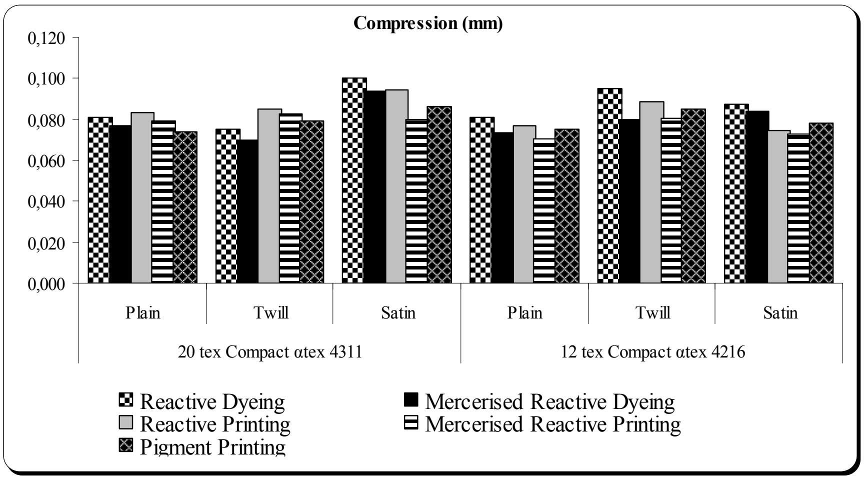

Figure 5. Compression of the fabrics (mm)

Table 2. MANOVA analysis of the fabrics

	Bending Rigidity		Circular Bending Rigidity		Compression (mm)	
Parameters	**df**	**p**	**df**	**p**	**df**	**p**
Yarn Count	1	0,000	1	0,000	1	0,000
Fabric Weave	2	0,000	2	0,000	2	0,045
Finishing Processes	4	0,000	4	0,000	4	0,000
Yarn Count* Fabric Weave	2	0,442	2	0,003	2	0,000
Yarn Count* Finishing Processes	4	0,000	4	0,000	4	0,007
Fabric Weave* Finishing Processes	8	0,000	8	0,000	8	0,002
All Three Way	8	0,000	8	0,075	8	0,000
Error	60		150		120	
Total	90		180		150	
α=0.05, p: significance value, df: degree of freedom (n-1)						

The effects of yarn count, fabric weave and finishing processes on sensorial related measurements were analyzed via using analysis of variance and the results are given in Table 2. All these aforementioned parameters have a statistically significant effect on bending rigidity, circular bending rigidity and relative compression rate values, as it can be also seen from the p (significance value) values.

According to the MANOVA analyses, when the main and interaction effects of so called parameters are examined, except the interaction of yarn count and fabric weave, all the parameters have statistically significant effect on the bending rigidity. For the circular bending rigidity, except all three way interaction (yarn count, fabric weave, finishing processes), all the parameters are statistically significant. For the compression property, all of the parameters are significant. Below, these three parameters' effects on these properties are explained in details.

3.1 Yarn Count Effect

As it can be seen from Figure 3 and Figure 4, bending rigidity and circular bending rigidity of the fabrics produced with 20 tex compact ring yarns are higher than that of the fabrics produced with 12 tex yarns. Bending properties of a fabric are determined by the yarn bending behavior, the weave of the fabric and the finishing treatments applied (23). Yarn bending rigidity has already been discussed by several researchers and Owen and Livesey (24), and Platt et al. (25) stated that yarn bending rigidity is proportional to fourth power of yarn radius. As the fabrics produced via using the same cotton blends, the only parameter which will affect the bending rigidities of the yarns is yarn radius. Thus, having different values of yarn radius due to the difference of yarn count, these discussed yarns will have different bending rigidities. Also because of the difference in the yarn counts and warp and weft densities between the fabrics woven with 20 tex and 12 tex, the fabric weights per unit area are different. Thus this is the other reason which causes a difference in bending rigidity of the fabrics woven with 20 tex and 12 tex according to Peirce's bending rigidity model.

As illustrated in Figure 5, in terms of yarn count, owing to the difference in yarn radius, compression of the fabrics woven with 20 tex is slightly higher than that of fabrics woven with 12 tex.

3.2 Fabric Weave Effect

Fabric weave has a significant effect on the bending rigidity due to the different floats of the yarns. In this study, the fabrics were in the form of plain, 3/1 twill and 7/1 satin. In a plain weave, the ends and picks float over one thread, causing each float to be surrounded (tightened) by 4 interlacing points. In such case, floats are comparatively small, interlacing points are high and free spaces between yarns are zero, making the fabric to be relatively firm (giving the yarns no freedom to move). On the contrary, in a 3/1 twill weave, the ends and picks float over 3 consecutive threads without any interlacing. Such a condition makes the float to be longer and existence of free space makes the fabric loose. These circumstances are also acceptable for 7/1 satin weave in which the floats are longer than that of plain and 3/1 twill weaves, make the fabric most loosely compared to plain and 3/1 twill weaves. Thus, increasing of yarn floats in a weave makes the fabric looser which causes decreasing of bending rigidity.

Fabric thickness increases in turn of plain, twill and satin weave structure. Thickness changing of the fabrics gives an idea about the bulkiness of the fabric under different pressures. As explained the effect of fabric weave on bending rigidity, the same influence is valid for compression that is due to the longer yarn floats in 7/1 satin fabrics compared to plain, 3/1 twill fabrics, the bulkiness of the fabrics is higher.

3.3 Finishing Treatment Effect

Finishing treatment has a statistically significant effect on the bending and compression of the fabrics. Mercerization and especially pigment printing processes compared to reactive dyeing and printing processes, increase the bending rigidity values of the fabrics. Mercerization causes a change in the cotton fibre structure. After mercerization cotton fibres become straighter and also swell which causes an increment in the fibre radius. Due to these reasons, the bending rigidity of the yarns will change and this change will affect the bending rigidity of the fabrics. Pigment printing also increases the bending rigidity of the fabrics due to the binder used in the pigment printing treatment. Use of binder makes the fabric tougher which results having high values of bending rigidity. These influences are all in the same tendency in the all kinds of fabrics.

Since mercerizing process increase the stability of the fabric construction, the measured values of compression are lower compared to non-mercerized fabrics. Besides as mercerized fabrics shrink due to the caustic soda treatment compared to non-mercerized fabrics, the weave sett of the mercerized fabrics are higher than that of the non-mercerized. The least effect of mercerization process on compressibility of the fabric is detected in plain fabrics. Pigment printing generates an adhesive film on the fabric surface which decreases the elasticity and therefore causes lower compression values.

4. CONCLUSION

Up to now, several studies have been carried out in order to analyze the various handle properties of the woven fabrics. In this study, as a difference from the recent studies, it is aimed to compare the handle properties of the fabrics made of compact ring spun yarns in different yarn counts and fabric weave after several finishing processes. For the evaluation of the handle of the fabrics objectively, statistical analysis was done by using the test results of Shirley stiffness tester, circular bending rigidity tester and thickness tester. The result of this study led to the following conclusions:

- It can be stated that the bending stiffness and compression of the fabrics produced with 20 tex are higher than that of the fabrics produced with 12 tex compact ring spun yarns, besides the differences are statistically significant.
- Fabric weave has a statistically significant effect on the bending rigidity and compression of the fabrics owing to the different yarn floats in the weave.

All finishing processes affect the fabric handle in the way of stiffening the fabric; however pigment printing is the most effective finishing process. Although mercerization before dyeing and printing results in improvements in various fabric properties, this process influences the fabric softness in a negative way.

REFERENCES

1. Kawabata, S., Masako, N., 1994, "High Quality Fabrics for Garments", *International Journal of Clothing Science and Technology*, Vol. 6 (5), pp.20-25.
2. Kawabata, S., Masako N., Yoshihiro, Y., 1999, "A guide line for manufacturing ideal fabrics", *International Journal of Clothing Science and Technology*, Vol. 11(2/3), pp.134-140.
3. LI, Y. 2001, Clothing Comfort, "*The Science of Clothing Comfort*", Edited by J. M. Layton, The Textile Institute, ISBN 1 870372247, Oxford UK., pp. 1-4
4. Vassiliadis, S., G., Venetsanos, D.T., Provatidis, C., G., 2005, "Optimization Aspects on the Hand of the Fabrics", *Textile Research Journal,* Vol. 75(9), pp. 653-661
5. Vassiliadis S., Gurkan P., Kallivretaki A., Provatidis C., 2006, "Subjective Hand Evaluation of Fabrics Produced with Compact and Ring Spun Yarns", 37th International Symposium on Novelties in Textiles, Ljubljana, Slovenia.
6. Saville B.P., 1999, Objective Evaluation of Fabric Handle, "*Physical Testing of Textiles*", The Textile Institute, Woodhead Publishing Ltd., Cambridge-England., pp 256-259
7. Cay, A., Vassiliadis, S., 2006, "Effects of Warp-Weft Density Variation on Fabric Hand", 37th International Symposium on Novelties in Textiles, Ljubljana, Slovenia.
8. Aliouche, D., Viallier, P., 2000, "Mechanical and Tactile Compression of Fabrics: Influence on Handle", *Textile Research Journal*, Vol. 70 (11), pp. 939-944.
9. Yan, K., Höcker, H., Schafer, K., 2000, "Handle of Bleached Knitted Fabric Made from Fine Yak Hair", *Textile Research Journal*, Vol. 70(8), pp. 734-738.
10. Manich, A.M., Martí, M., Saurí, R. M., Castellar M. D., 2006, "Effect of Finishing on Woven Fabric Structure and Compressional and Cyclic Multiaxial Strain Properties", *Textile Research Journal*, Vol. 76(1), pp. 86-93.
11. Militky, J., Bajzik, V., "Influence of Washing/Ironing Cycles on Selected Properties of Cotton Type Weaves", *International Journal of Clothing Science and Technology*, Vol. 9(3), pp. 193-199.

12. Mamalis, P., Andreopoulos, A., N. Spyrellis, 2001, "The Effect Of A Durable Flame-Retardant Finishing On The Mechanical Properties Of Cotton Knitted Fabrics", *International Journal of Clothing Science and Technology*, Vol. 13 (2), pp. 132-144.

13. Mavruz, S., Oğulata, R.T., 2001, "Kompakt İplik Eğirme Teknolojisi ve Mevcut Deneyimler Işığında Genel Değerlendirmesi", *Tekstil ve Konfeksiyon*, Yıl:18(3), s:197-205.

14. Çeken, F., Göktepe, F., 2005, "Comparison of the Properties of Knitted Fabrics Produced by Conventional and Compact Ring-Spun Yarns" *Fibres &Textiles in Eastern Europe*, January/March, Vol.13, No:1(49).

15. Kretzschmar, D.S., Özgüney, A.T., Özçelik, G., Özerdem, A., 2007, "The Comparison of Cotton Knitted Fabric Properties Made of Compact and Conventional Ring Yarns Before and After the Dyeing Process", *Textile Research Journal*, Vol 77 (4), pp.233-241.

16. Taskin C., Özgüney A.T., Gürkan P., Özcelik G., Özerdem A., Comparison of Woven Fabrics' Properties from Traditional and Compact Ring-Spun Yarns after Dyeing Processes, *Fibres &Textiles in Eastern Europe*, 2007, No:1(61).

17. Taşkın, C., Özgüney A.T., Gürkan P., Özcelik G., 2006, "Kompakt Ve Konvansiyonel Ring İpliklerinden Dokunmuş Pamuklu Kumaşlarin Farklı Terbiye İşlemleri Sonrası Boncuklanma Özelliklerinin Karşılaştırılması", *Tekstil ve Konfeksiyon*, Yıl:16(2), s:123-128.

18. ASTM D1388- Test methods for Stiffness of Fabrics.

19. Gider, A., 1997, "An Online Fabric Database to Link Fabric Drape and End-Use Properties", Master of Science Thesis, Istanbul Technical University.

20. Zhou, N., Ghosh, T.K., 1998, "Online Measurement of Fabric Bending Behaviour: Background Need and Potential Solutions", *International Journal of Clothing Science and Technology*, Vol. 10 (2), pp. 143-156.

21. ASTM D4032- Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure.

22. ASTM D1777- Standard Test Method for Thickness of Textile Materials.

23. Hu, J., 2004, "Structure and Mechanics of Woven Fabrics", Woodhead Publishing Ltd., Cambridge-England.

24. Owen, J. D., Livesey, R. G., 1964, "Cloth Stiffness and Hysterisis in Bending", *Journal of Textile Institute*, Vol. 55, 516.

25. Platt, M. M., Klein, W. G., Hamburger, W. J., 1958, "Mechanics of Elastic Performance of Textile Materials: Part XIV", *Textile Research Journal*, Vol.28, 611.

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