(REFEREED RESEARCH)

SUBJECTIVE AND OBJECTIVE EVALUATIONS OF TERRY FABRICS: EFFECTS OF STRUCTURAL PARAMETERS AND REPEATED LAUNDERING

HAVLU KUMAŞLARDA SUBJEKTİF VE OBJEKTİF DEĞERLENDİRMELER: YAPISAL ÖZELLİKLERİN VE TEKRARLI YIKAMALARIN ETKİSİ

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ABSTRACT

This paper deals with the effect of selected fabric structural parameters and domestic laundering operations on the presence of acceptable quality of woven terry products for both purchasing and servicing. For this aim nine different constructions of terry fabrics are woven with Ne 12/1, Ne 16/1 and Ne 20/1 100% carded cotton ring spun weft yarns in three different weft densities. Fabric samples are subjected to 5, 10, 20 and 40 washing cycles before undergoing the tests; subjective evaluation on preference and fabric objective measurements on softness and thickness. In order to understand the statistical importance of structural parameters and repeated laundering on the preference of woven terry fabrics, ANOVA is performed. It is seen that fabric structural parameters and repeated launderings effect the behaviors of the customers. Also the bending rigidity and thickness values of terry fabrics which are measured with objective methods are compared with subjective foundings. The correlations between subjective ratings and objective evaluations are significantly high.

Keywords: Terry, Subjective Evaluation, Softness, Thickness, Laundering

ÖZET

Bu çalışmada, seçilmiş kumaş yapısal parametrelerinin ve ev tipi çamaşır yıkama işlemlerinin hem satın alma hem de günlük kullanım için kabul edilebilir dokuma havlu ürün kalitesine etkisi araştırılmıştır. Bu amaçla Ne 12/1, Ne 16/1 ve Ne 20/1 atkı iplikleri ile üç farklı atkı sıklığında dokuz farklı kumaş yapısında havlu dokunmuştur. Subjektif ve objektif değerlendirmeler öncesinde kumaş numunelerine 5, 10, 20 ve 40 kez olmak üzere ev tipi çamaşır makinesinde tekrarlı yıkama işlemleri yapılmıştır. İstatistiksel analiz sonucunda, kumaş yapısal parametrelerinin ve tekrarlı yıkamaların müşterilerin havlu seçimindeki davranışlarını etkilediği tespit edilmiştir. Ayrıca havlu kumaşların eğilme dayanımları ve kalınlık değerleri objektif ölçüm metodları ile ölçülmüş, elde edilen sonuçlar subjektif değerlendirme sonuçları ile karşılaştırılmıştır. Subjektif ve objektif değerlendirme sonuçları arasındaki korelasyon önemli ölçüde yüksektir.

Anahtar Kelimeler: Havlu, Subjektif değerlendirme, Yumuşaklık, Kalınlık, Yıkama

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INTRODUCTION

Terry fabrics, towels or bathrobes, quickly absorbs water and are used to dry body. Although terry fabrics can be produced with weaving or knitting, commonly woven terry fabrics are preffered [1]. The increasing diversity in terry fabrics with the developments in terry weaving industry is complicated for manufacturers and customers. Softness and absorbency are the common factors that influence the choice of customers while purchasing towel or bathrobe [2]. The decision of customers is commonly made by touching and evaluation of appearance. Fast and practical such subjective methods are also used during production processes but causes variations in quality. However there is not an objective method or device developed for the evaluation of both tactile properties and appearance. Therefore researches on subjective evaluations which are supported by objective methods are becoming necessity [3, 4].

The literature includes many researches which are performed to determine the relationship between subjective evaluations and objective measurement methods. Subjective methods are similar to the objective measurement methods to evaluate fabric quality referring to the fabric handle which is experienced when a textile is touched, squeezed, rubbed and rated by experts [5, 6]. Softness of fabrics has evaluated by a subjective method called handle judgment. The degree of softness is evaluated by touching and manipulating the fabric with fingers [7]. But the sense of softness is highly subjective. Therefore in many previous studies, for different structures of woven fabrics, softness is determined as the opposite of stiffness and measured by bending length objectively. By this way fabrics which are easily bent are determined as soft. On the other hand fabrics which are resistant to bending are determined as stiff [8-11].

Terry fabrics become dirty after being used for a certain period of time and they are washed to be reused as in other garments. Laundering alters the appearance and may cause dimensional change which may alter the physical properties of garments such as cover factor, thickness and fabric weight [12-14]. Moreover, the physiological comfort is also expected to change during the repeated laundering and researchers studied air permeability, moisture vapor permeability, moisture transport and drying rate characteristics of woven and knitted fabrics [15, 16].

It is essential to research the physical properties in the development of the fabric to determine how the final product makes the purchasers feel. This study deals with a subjective evaluation to determine the effects of weft yarn count, weft density and repeated laundering effects on the preference of terry fabrics. Bending rigidity and thickness of terry fabrics are measured with objective methods and results are compared with subjective foundings.

MATERIAL AND METHOD

Production of Terry Fabrics

In this study it is aimed to investigate the effects of structural parameters and repeated launderings on the behaviors of customers for both purchasing and servicing. For this aim, 100% carded cotton ring spun weft yarns spun as Ne 12/1, Ne 16/1 and Ne 20/1 from same cotton blend are used. In warp direction 100% carded cotton ring spun Ne 20/2 ground warp and Ne 16/1 pile warp are used. Terry fabrics are woven in three different densities with three different weft yarns. In doing so, terry fabrics are produced from same raw materials in nine different constructions. The nine fabrics have almost the same fabric weight and so the results are quite comparable. Finishing processes (bleaching, dying and washing) applied to terry fabrics at the same bath. The structural properties of the finished fabrics used in the research are given in Table 1. Fabric weight and fabric densities of terry samples are measured according to the standards ISO 3801 and ISO 7211-2 respectively. The degree of terry ratio of the loop warp in a non-dimensional form is established as defined in TS 629. From the fabrics in 10x5 cm sample size, 10 pile warp yarns in lengthwise are taken out and straightened. Total length of 10 straightened pile warp in cm is divided by 100 and noted as “Terry ratio”.

Laundering Process

Fabrics which are woven in nine different constructions are washed and dried several times. Washing processes are carried out in a domestic washing machine at 40°C using detergent and softener which are commonly used in the market. In this way, domestic laundry operations performed on the machine, as performed in daily life. After each washing cycle, fabrics are laid on a flat surface to dry for 24 hours. Thus the fabric samples are subjected to 5, 10, 20 and 40 washing cycles before undergoing the tests; subjective evaluation on preference and fabric objective measurements on softness and thickness. Both the subjective assessments and objective measurements are performed on the fabric samples before washing, after 5, 10, 20 and 40 washing cycles respectively. By this way a total of 45 samples are assessed and findings prior to and after the washings are compared.

Subjective Evaluation Method

For subjective evaluation processes the fabrics are cut into dimensions of 10×10 cm. 20 men and 20 women at the age of 18–42 were voluntarily participated to the survey. The aim of the research, fiber types, constructions and finishing methods of fabrics were explained to the panelists before the evaluation. The subjective evaluations are performed in two steps.

In the first step the unwashed fabric samples which are in different constructions presented to participants randomly in pairs. The samples which are presented in pairs are rubbed and squeezed in their hands for about 1-2 minutes. Each panelist handled one of the samples with one hand and the other sample with the other hand so as to compare the samples with each other in terms of primary handle impressions and appearance. If they want they changed the hands. After each evaluation the panelists made a decision and choose one of the samples. In this way totally 1440 evaluations were made by 40 participants.

Table 1. Structural properties of fabrics (*Mp-Mass per unit area; Ngw, Npw, Nw- linear densities of ground warp, pile warp and weft ; dwe-density of weft; dwa-density of warp; TR-Terry ratio*)

Fabric Nr	1	2	3	4	5	6	7	8	9
Mp (gr/m2)	449	445	468	458	471	448	431	446	432
Ngw (Ne)	20/2	20/2	20/2	20/2	20/2	20/2	20/2	20/2	20/2
Npw (Ne)	16/1	16/1	16/1	16/1	16/1	16/1	16/1	16/1	16/1
Nw (Ne)	12/1	16/1	20/1	12/1	16/1	20/1	12/1	16/1	20/1
Dwe(weft/cm)	22	22	22	20	20	20	17,5	17,5	17,5
Dwa(warp/cm)	14	14	14	14	14	14	14	14	14
TR	5,5	6,2	6,5	5,9	6,3	6,6	5,6	6,1	6,2

In the second step all 45 types of samples (9 unwashed, 9 five times washed, 9 ten times washed, 9 twenty times washed, 9 fourty times washed) are presented to the panelists at the same time randomly. Panelists are requested to handle the samples and classified them into two groups, preferred or non-preferred.

Objective Measurement

Bending rigidity is known as one of the most important parameters which effects the softness of the fabric. Fabrics that are easily bent are flexible and not stiff [8, 17]. In order to determine the bending properties of the fabrics, a bending rigidity tester with constant angle is used. Test method is TS 1409 as recommended. The fabric thickness of each terry sample was measured according to TS 7128 EN ISO 5084 using a digital thickness tester which can measure as mm.

RESULTS AND DISCUSSION

Subjective Evaluation Results

The results of the first step of subjective evaluations are given in Table 2. Preference count shows the total number how many times the fabric sample preferred when compared with any other. It is shown that, the preference of panelists is influenced from the weaving construction of terry towels. Thinner the weft yarns and lower the weft densities, higher the preference of towels. Subjective evaluations were performed with 20 men and 20 women participants. Men and women showed similar behaviors in both, first and second, step of subjective evaluations.

Table 3, Table 4 and Table 5 show the second step of subjective evaluation that each sample how many times classified in preferred group. It is obvious that lower the washing cycle, higher the preference of towels.

Objective Measurement Results

The values of general bending rigidity with respect to different fabric constructions and washing cycles are given in Table 6. Invariably, fabrics display markedly lower bending rigidity which are woven with thinner weft yarns among the fabrics which are woven with same weft density. Also fabrics display markedly lower bending rigidity which are woven with lower weft densities among the fabrics which are woven with the same weft yarn. Moreover the bending rigidity of fabrics increase depending on more washing cycles.

As seen in Table 7, thickness values increase in case fabrics are woven with thinner weft yarns at the same weft density and decrease due to washing. But variation in thickness values is not regular comparing fabrics woven using same weft yarns with different weft densities. Also thickness values vary unsteadily especially after 10, 20 and 40 washing cycles.

Table 2. Results of fabric ratings of unwashed fabrics (*Nw- linear density of weft ; dw-density of weft)*

Fabric Nr	1	2	3	4	5	6	7	8	9
Nw (Ne)	12/1	16/1	20/1	12/1	16/1	20/1	12/1	16/1	20/1
Dw (weft/cm)	22	21,6	21,2	20	20	20,2	17,2	17,6	17,2
Preference Count (Man participants)	21	58	80	61	93	102	79	106	110
Preference Count (Woman participants)	8	64	96	60	95	102	83	109	113
Preference Count (Total)	29	122	176	121	188	204	162	215	223

Table 3. The preference count of the samples comparing in terms of weaving constructions and washing cycles (preference of men panelists)

Treatment	Fabric Nr								
	1	2	3	4	5	6	7	8	9
	The preference count of the samples								
Unwashed	13	18	17	15	16	17	14	15	15
5 washing cycle	5	11	17	5	11	11	8	14	12
10 washing cycle	3	11	9	6	10	10	8	9	10
20 washing cycle	3	4	10	5	7	8	3	9	6
40 washing cycle	2	6	5	2	2	6	1	1	6

Table 4. The preference count of the samples comparing in terms of weaving constructions and washing cycles (preference of women panelists)

Treatment	Fabric Nr								
	1	2	3	4	5	6	7	8	9
	The preference count of the samples								
Unwashed	12	17	19	16	17	17	15	18	20
5 washing cycle	5	10	15	6	12	15	8	14	15
10 washing cycle	4	9	11	7	7	14	5	10	10
20 washing cycle	1	6	11	4	5	12	4	8	8
40 washing cycle	2	6	6	1	2	9	3	5	7

Table 5. The preference count of the samples comparing in terms of weaving constructions and washing cycles (preference of 40 total panelists)

Treatment	Fabric Nr								
	1	2	3	4	5	6	7	8	9
	The preference count of the samples								
Unwashed	25	35	36	31	33	34	29	33	35
5 washing cycle	10	21	32	11	23	26	16	28	27
10 washing cycle	7	20	20	13	17	24	13	19	20
20 washing cycle	4	10	21	9	12	20	7	17	14
40 washing cycle	4	12	11	3	4	15	4	6	13

Table 6. General bending rigidity (mg.cm)

Treatment	Fabric Nr								
	1	2	3	4	5	6	7	8	9
	General Bending Rigidity (mg.cm)								
Unwashed	29,47	25,73	24,56	26,59	25,09	22,31	23,62	22,30	19,42
5 washing cycle	37,85	35,26	29,46	30,88	27,83	25,56	28,51	25,15	20,78
10 washing cycle	38,98	36,44	31,09	35,12	32,59	28,16	30,90	27,80	26,12
20 washing cycle	41,79	38,88	37,19	37,97	35,67	32,27	32,88	29,27	27,36
40 washing cycle	44,52	40,52	38,00	43,61	38,05	35,36	37,79	33,34	30,95

Table 7. Thickness (mm)

Treatment	Fabric Nr								
	1	2	3	4	5	6	7	8	9
	Thickness (mm)								
Unwashed	3,51	3,69	3,82	3,59	3,73	3,83	3,43	3,48	3,57
5 washing cycle	2,80	3,39	3,51	3,07	3,42	3,54	3,00	3,40	3,44
10 washing cycle	3,04	3,21	3,39	3,16	3,41	3,43	3,06	3,35	3,33
20 washing cycle	2,83	3,03	3,19	3,05	3,02	3,10	2,84	3,16	3,25
40 washing cycle	2,94	3,19	3,41	3,00	3,16	3,37	2,97	3,18	3,31

Statistical Analysis

The experimental results have statistically evaluated by using SPSS software. Firstly the normality of experimental data is tested with one of the most powerful test of the normality assumption test called Shapiro-Wilk test. As shown in Table 8, Shapiro-Wilk test confirm that the experimental data are normally distributed under 95% confidence level.

Table 8. Tests of normality (Shapiro-Wilk test)

	Treatment Type	Statistic	df	Sig.
Preference Count	Unwashed	,884	9	,174
	5 washing cycles	,933	9	,507
	10 washing cycles	,918	9	,375
	20 washing cycles	,964	9	,834
	40 washing cycles	,850	9	,075
Bending Rigidity	Unwashed	,986	9	,989
	5 washing cycles	,973	9	,922
	10 washing cycles	,962	9	,823
	20 washing cycles	,971	9	,905
	40 washing cycles	,963	9	,831
Thickness	Unwashed	,935	9	,530
	5 washing cycles	,842	9	,060
	10 washing cycles	,888	9	,189
	20 washing cycles	,930	9	,478
	40 washing cycles	,925	9	,431

The one-way ANOVA analysis is carried out to find out significance of washing cycle on preference, bending rigidity and thickness with 95% confidence limits (alpha= 0.05). Table 9 shows that washing cycle has significant effect on preference, bending rigidity and thickness statistically.

As seen from Table 10 the preference count, bending rigidity and thickness values can be assembled into 4, 4 and 3 groups respectively as a result of Duncan post hoc test. Unwashed fabrics are significantly different from fabrics washed. It is observed that washing causes significant decrease in preference count and thickness while causes increase in bending rigidity.

Correlation analysis are carried out to determine the statistical relationship between subjective and objective values and the results are given in Table 11. It is seen that there is a high correlation between preference count, bending rigidity and thickness. Pearson correlation coefficient between the preference count and bending rigidity values are found -0.837, whereas it is found 0,873 between preference count and thickness values. It means that the lower bending rigidity and the higher thickness values provide the higher preference count. However the correlation (r = -0,730) between bending rigidity and thickness is found comparatively lower. As the thickness of the terry fabric increases, the bending rigidity of the terry fabrics decreases. It means higher thickness causes soft terry fabric structure while the mass is constant.

Table 9. Anova results

		Sum of Squares	df	Mean Square	F	Sig.
Preference Count	Between Groups	3123,422	4	780,856	25,266	,000
	Within Groups	1236,222	40	30,906		
	Total	4359,644	44			
Bending Rigidity	Between Groups	997,282	4	249,320	12,981	,000
	Within Groups	768,264	40	19,207		
	Total	1765,546	44			
Thickness	Between Groups	1,667	4	,417	12,761	,000
	Within Groups	1,306	40	,033		
	Total	2,973	44			

Table 10. Duncan Post Hoc test for treatment type (*N-Total number of samples which has same treatment type, 1, 2, 3 and 4 indicate the name of groups*)

Treatment Type	N	Preference Count				Bending Rigidity				Thickness		
		Subset for alpha ,05				Subset for alpha ,05				Subset for alpha ,05		
		1	2	3	4	1	2	3	4	1	2	3
40 washing cycles	9	8,00				38,01				3,170	3,170	
20 washing cycles	9	12,67	12,67			34,80	34,80			3,052		
10 washing cycles	9		17,00	17,00			31,91	31,91			3,264	
5 washing cycles	9			21,56				29,03			3,285	
Unwashed	9				32,33				24,34			3,627
Sig.		0,083	,106	,090	1,000	0,129	0,168	0,171	1,000	,174	,208	1,000

Table 11. The correlation between subjective preference ratings and objective bending rigidity and thickness values

		Preference Count	Bending Rigidity	Thickness
Preference Count	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	45		
Bending Rigidity	Pearson Correlation	-,837**	1	
	Sig. (2-tailed)	,000		
	N	45	45	
Thickness	Pearson Correlation	,873**	-,730**	1
	Sig. (2-tailed)	,000	,000	
	N	45	45	45
**. Correlation is significant at the 0.01 level (2 tailed)				

CONCLUSION

This paper has identified the effects of weft yarn count, weft density and repeated laundering on softness and the predictability of terry fabrics for both purchasing and servicing. Weft yarn count, weft density and repeated launderings are identified as significant factors affecting softness and preference of terry fabrics.

In subjective evaluations, the fabrics are assessed by the panelists individually in terms of primary handle impressions such as softness and they decided on the terry fabrics that they prefer to use in daily life. Fabrics which are woven with thinner weft and lower weft density are preferred to the others. However more washing cycles for any sample would result in lower preference and softness rating.

Bending rigidity and thickness attributes of terry fabrics are tested objectively and the results are analyzed. The correlations between subjective evaluations and objective evaluations are found significantly high. As the bending rigidity is lower and thickness is higher, the preference of the fabric is higher. This means lower bending rigidity and higher thickness values cause soft terry fabric structure while the mass is constant. Consequently, it can be denoted that objective evaluations can be used in comparing handle properties of woven terry fabrics.

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