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Handle Evaluation of Men's Suitings Produced in Turkey

Abstract
This article explains subjective evaluation techniques for stiffness, thickness and smoothness, which are the components of handle of suitings, and subjective assessments using these techniques. Another objective of this research was to study the fabric handle of worsted suitings produced in Turkey. For this purpose a preliminary study was made to determine the words to define fabric attributes used in Turkey. Thickness, stiffness and smoothness were chosen as the components of the fabric handle of worsted men's suitings. Subjective assessment techniques were developed to assess the chosen attributes. These techniques were applied to 73 fabric samples with the help of an expert jury. The concordances of the subjective test results were investigated by the Kendall concordance test and correlation analyses were carried out to examine the relations between the subjective test results. The assessment of the fabrics by the jury using the techniques was in good agreement. A total handle of 100% wool and wool/polyester blend worsted men's suitings produced in Turkey has a grade of 3.47 on a five-point rating scale. A database was prepared for the handle of worsted men's suitings produced in Turkey.

Key words: *handle, subjective assessment, suiting, thickness, stiffness, roughness.*

Introduction

Recent technological developments have created an increasing variety of fabric qualities, causing difficulties in evaluation and selection processes both for manufacturers and consumers. Consumers use the hand-feel evaluation techniques while shopping for apparel or fabric. These techniques are also used in textile production; however, as subjective methods of decision, they may possibly result in serious quality variations and can conflict with consumer expectations. In spite of these critical consequences, subjective evaluation techniques are widely used for tactile properties, particularly as fabric handle, around the world. The primary reason for this situation is the lack of a single device that can test the tactile properties, such as handle, in an objective way. Therefore, to be able to produce fabrics with similar handle and to achieve consistency, fabric handle must be evaluated by subjective methods and the findings should be supported by objective measurements. This requires the initiation of standard subjective evaluation techniques that are simple, practical and which can be implemented in the same way by everyone. This study aimed to develop subjective evaluation techniques and to apply these techniques to evaluate handle components. Another objective of this research was to study the fabric handle of worsted suitings produced in Turkey and also to reflect the viewpoint of a different culture on fabric handle.

Literature review

Subjective evaluation of the tactile properties of fabrics is a subject which many researchers have studied for years, and still has importance, but is also open to improvement. The studies on the subjective assessment of tactile properties started with Binns in 1926 and are still continuing today. This evaluation technique, which is entirely based on a personal point of view, is affected by the inspector's own assessment, his/her disposition, age, gender, level of experience, as well as by factors such as climate, fashion, cultural and economic background, and racial differences. In addition to the studies of Dawes and Owen [1], Howorth and Oliver [1], David et al. [1] and Brand [2], Kawabata [3, 4] Kawabata ve Niwa [5] also did research on this subject. The initial studies focused on the words that were used to define fabric handle or other tactile properties. In the studies, these words were determined, explained, and grouped based on the end-use of fabrics. In addition, extensive studies were made in order to standardise subjective evaluation methods.

In 1971, Kawabata and Niwa founded HESC (Hand Evaluation and Standardization Committee) and conducted studies on standardisation of fabric handle, which have significant value in today's literature. The following researchers have also performed important studies on subjective evaluation methods: Ellis and Garnsworthy [6], Winakor and Kim [7], Mahar et al. [8], Elder et al. [9, 10], Mahar and Postle [11], Mahar et al. [12] . Especially Mahar et al. and Mahar and Postle [11, 12] emphasised that different ways of assessing fabric hand or other handle components, differing cultures and other human factors affect fabric handle.

Bishop [1] made an extensive review of fabric sensory properties in 1996. In this study, the most important fabric properties related to fabric handle were considered to be smoothness (28%), and softness (22%), while the importance of the remaining properties?? (the total number of which is 21). A lot of researchers such as Strazdiene and Gutauskas [13] affirmed this opinion in their articles.

In 1997, Harada et al. attempted to determine some rules that need to be followed

for subjective evaluation [14]. Researches indicated primarily that a standard evaluation method should be easily applicable to any fabric sample. Alimaa et al. [15] searched for the most objective evaluation methods for some tactile fabric properties they selected, such as bending rigidity, fabric thickness and friction. Accordingly, they introduced subjective evaluation techniques that were similar to the techniques used for the objective measurement of mechanical properties. Ryu et al. [16] determined the most preferred ladies suitings in terms of fabric handle using a wide sample population. Cardello et al. [17] did thorough research on the tactile and objective properties affecting the comfort of military uniforms. When the examined properties and related definitions were reviewed, it was noticed that the majority of assessments were planned to simulate real inspection conditions. Philippe et al. [18] applied the descriptive analysis method that was originally used in the food industry to describe acceptance levels in purchasing a product. With this method, researchers aimed to maximize the information achieved in their subjective assessments, while minimising the number of properties. Philippe et al. presented a different aspect by allowing the sample population to determine the words that are used to define the handle, as well as the order of evaluation.

Experimental

For all fabric types it is important to evaluate the tactile properties of fabric. However, where clothing is concerned, these properties have greater importance. This was the reason why 100% wool and wool/polyester blend worsted men's suitings were used as materials in this study. 73 sample swatches were collected from well-known companies that had a significant share in Turkey's wool fabric production. The fabrics of these companies are also well-known internationally. As a preliminary experimental study, these swatches were analysed for the following basic structural parameters: fiber content, type of weave, fabric unit weight and fabric sett. First the samples were grouped into twos, based on fiber content, and then again into twos, based on weave: "plain weave or plain weave derivatives" and "twill weave or twill weave derivatives". Table 1. summarises the information on the structural parameters of the test fabrics.

15×15 cm samples were cut from each fabric sample for subjective tests. Prior to the tests, all the samples were conditioned for a minimum of 24 hours under standard athmospheric conditions (20 ± 2 ºC temperature, 65 ± 2% relative humidity). Later, procedures that would be used in subjective assessments were prepared, and a jury that would perform the assessments was formed.

In subjective assessments, it is possible to work with a jury of either experts that have knowledge and experience in the field or non-experts that have no experience. In this study, the subjective assessment techniques that had been developed were applied by a jury of experts. The jury consisted of 13 female and 5 male members between the ages of 23 and 65, who were either lecturers, research assistants or graduate students at a department of textile engineering. During the tests, each tactile property was evaluated by each jury member at three different times. Consequently, each jury member conducted 12 assessment sessions.

In order to have a precise evaluation, some details needed to be clarified. Therefore, a number of procedures were created, which covered and clarified important details. With the help of these procedures, assessment techniques were introduced that were simple, practical and could be easily understood by anyone. The aim was to have these techniques recognised as standard subjective assessment methods.

The procedures specified the definiton of each property that was to be evaluated, the assessment technique, the assessment time allowed for a handle attribute, the rating scale and assessment work order. In addition, a form was prepared to record the assessments.

Deciding on the assessment criteria (components of handle)

This was one of the important steps in the study. To select the assessment criteria, the words describing fabric properties or fabric handle that were widely used in Turkey were first researched. Two groups of questions were prepared and sent to men's suiting manufacturers whose products are very famous in Turkey. The questions were asked in order to determine the following: words used regarding fabric handle, a definition of fabric handle, the way the handle is checked, the properties emphasised during fabric selection, and finishing processes that are thought to have an effect on handle. The first group of questions were answered by authorities who were in charge of fabric selection and garment design, whereas the second group were answered by finishing superiors.

When the answers were examined, it was found that:

- Two superiors described the handle as "what you feel when you touch the fabric".
- Other superiors described the handle as "the opinion you have when you touch or see the fabric".
- Only one superior did not have a description for fabric handle.
- The words "thickness, thinness, softness, stiffness, slippery, roughness, tightness, fullness, pliable" are the ones most used to express feelings about a fabric.

Based on the information gathered from the men's suiting manufacturers and paying due regard to literature on this subject, it was concluded that for men's suiting fabrics, the important attributes of fabric handle can be grouped by bipolar attributes, such as thickness/thinness, softness/stiffness, roughness/smoothness. These attributes are accepted as the components of the fabric handle of men's suitings.

Table 1. *Information on the structural parameters of tested fabric: a - fabric thickness at 5 g/cm² pressure.*

Fiber content	Weave	Number of samples	Fabric unit weight, g/m²	Fabric sett,		Fabric thickness[a], mm
				ends/cm	picks/cm	
100% Wool	Plain or plain derivatives	13	135.2 – 286.2	14.7 – 37.3	13.2 – 32.0	0.24 – 0.87
	Twill or twill derivatives	30	155.7 – 311.4	26.3 – 54.7	23.0 – 39.3	0.28 – 0.75
Wool/ polyester blend	Plain or plain derivatives	13	135.2 – 227.6	21.0 – 36.7	20.5 – 32.0	0.28 – 0.53
	Twill or twill derivatives	17	156.8 – 282.0	26.7 – 39.3	24.0 – 31.3	0.33 – 0.76

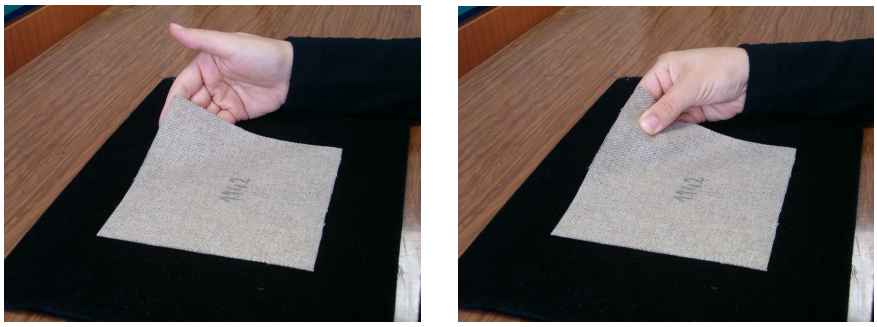

Figure 1. *Subjective assessment technique for thickness property* [*19*].

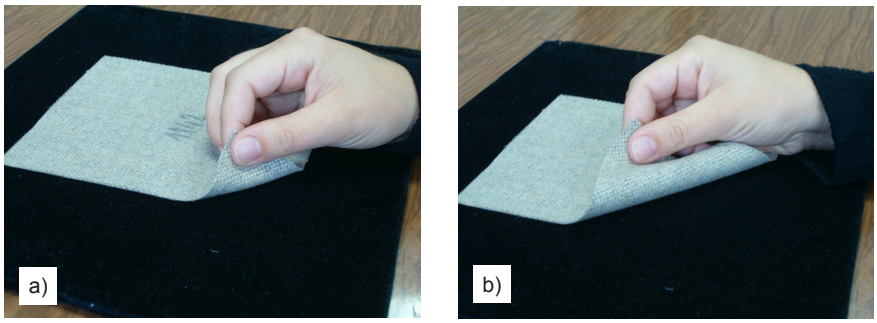

Figure 2. *a) Grasp of the fabric for softness-stiffness property, b) Subjective assessment technique for softness-stiffness property* [*19*].

Figure 3. *Subjective assessment technique for roughness-smoothness property* [*19*].

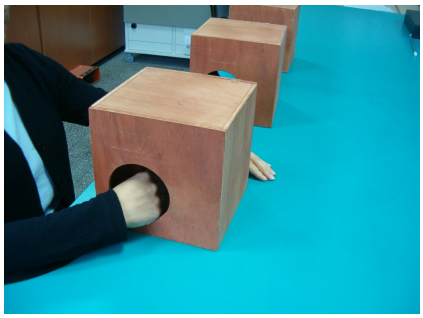

Figure 4. *Jury member under test conditions* [*19*].

Subjective assessment techniques for handle components

Following the determination of the assessment criteria, the criteria were defined. The objective properties, which the criteria were related to, were also determined. Considering the objective measurement method, subjective assessment techniques for each handle component were prepared. Initial tests were performed in order to determine whether the assessment techniques could be easily understood and applied by everyone . Based on the initial tests, followings are the assessment techniques to be applied were determined as follows:

Subjective assessment technique for thickness/thinness property:

In the subjective assessment procedure, the thickness of the fabric is described as the distance between the face and back of the fabric. The smaller the distance, the thinner the fabric is, likewise the bigger the distance, the thicker the fabric is. Based on the recognition and objective method, the jury holds the fabric in the most used hand, squeezes it with the thumb and index finger and defines the thickness according to what he/she feels Figure 1.

Subjective assessment technique for softness-stiffness property:

In the subjective assessment procedure, this property is associated with bending. Fabrics easily bent are described as soft where the ones resistant to bending are described as stiff. Based on the assessment technique, the jury member holds the fabric between the thumb and the other four fingers of his/her most used hand. While moving the fabric back and forth, he/she assess the resistance. The more the resistance, the stiffer the fabric is, likewise, the less the resistance, the softer the fabric is Figure 2.

Subjective assessment technique for roughness-smoothness (surface smoothness) property:

In the subjective assessment procedure roughness is described with indentations and ridges on the fabric surface. Based on the assessment technique, the jury member moves the fingers of his/her most used hand on the fabric surface freely and tries to sense the indentations and ridges. Meanwhile, to prevent the fabric from rotating under his/her fingers, he/she presses the fabric on the edge with the other hand Figure 3. The more the indentations/ridges, the rougher the fabric is.

In these studies, the jury may make assessments only seeing, only touching or both seeing and touching the fabric. In this study, the jury decided not to see the fabric during assessments to prevent the effect of colour and appearance on the assessments. Therefore, wooden boxes with holes on the facing sides, through which the hands can easily go , were prepared. Fabric samples were placed in these boxes prior to assessments. This helped the jury to assess the fabric without seeing it (Figure 4).

Determination of control fabric, rating scale and time for assessments

There are two main approaches in ranking samples:

1) To have the jury members put the samples in order of merit
2) To have the jury members make comparisons between items in pairs and obtain a ranking based on these paired comparisons. For the latter the jury needs to establish all the possible pairs and make pairwise comparisons. Due to the number of samples, the second approach was considered rather time consuming. Therefore, it was decided to apply the first method, and a rating scale was prepared to assist the jury in their assessments. Control fabrics were also selected for the jury to practise before the actual assessments.

For this purpose, the objective test results that are given in Table 2 were used to select the control fabrics. The fabric thickness and fabric bending rigidity of the samples were measured [20, 21]

Table 2. *Measurement method for the attributes related to handle components and objective values for control fabrics; a - fabric thickness under 5g/cm² pressure, b - average of mean roughness values on/for the warp and weft direction, c - when all fabrics in that group are considered, d - when plain weave or plain weave derivatives are considered, e - when twill weave or twill weave derivatives are considered.*

Attribute	Parameter for objective measurement and the measurement tool	Objective values of control fabric			Scale value
Thickness–Thinness	Fabric Thickness[a], mm Fabric thickness tester	100% Wool	Min.[c]	0.24	1
			Max.[c]	0.87	10
		Wool/polyester blend	Min.[c]	0.28	1
			Max.[c]	0.76	10
Softness-Stiffness	General fabric bending rigidity, mg·cm Shirley Stiffness Tester	100% Wool	Min.[c]	274.78	1
			Max.[c]	1160.95	10
		Wool/polyester blend	Min.[c]	199.80	1
			Max.[c]	1028.27	10
Roughness-Smoothness	Mean roughness[b], μ Mitutoyo SJ 301 model surface roughness tester	100% Wool	Min.[d]	15.86	1
			Max.[d]	26.73	10
			Min.[e]	14.69	1
			Max.[e]	46.99	10
		Wool/polyester blend	Min.[d]	17.69	1
			Max.[d]	25.96	10
			Min.[e]	15.75	1
			Max.[e]	33.93	10

Table 3. *Rating scale and time allowed for assessments.*

Attribute	Rating Scale	Time, s
Thickness -Thinness	1 . . . . 5 . . . . 10 thinnest medium thickest	15
Softness-Stiffness	1 . . . . 5 . . . . 10 softest medium stiffest	20
Roughness-Smoothness	1 . . . . 5 . . . . 10 smoothest medium roughest	15
Total Handle	1 . . . . 3 . . . . 5 not proper medium most proper	15

Test results for objective properties that are related to handle components were arranged in ascending order for each parameter. The fabrics with minimum, maximum and medium values were determined and used for initial tests to select the control fabric.

At the end of the initial test sessions, it was observed that the jury used the fabrics with the lowest and the highest test results more effectively. Therefore, it was decided to use the fabric with minimum and maximum values as control fabric.

Table 2 shows the objective measurement method for the attributes that are related to handle components, the objective values for the control fabric, and the rating scale.

A ten point scale with numbers from 1 to 10 was used. Prior to the assessments, jury members were provided with control fabrics that had the values 1 and 10, were asked to make control tests and to assess the other fabrics based on these. For the assessment of total handle, the jury was not given a control fabric. Therefore, a five point scale with numbers from 1 to 5 was used. The Time for the subjective tests was set based on the initial tests. Table 3 shows the rating scale, the meaning of the ranking numbers and the time allowed for assessments.

Subjective tests

Although the procedure is the same for the assessments of handle components and total handle, there are some differences in assessment techniques and rating scales. The following explains the work flows for the assessments of handle components and total handle.

Subjective assessment of handle components

Prior to each assessment, the jury member was asked to wash and dry her/his hands with the non-moisturising soap and paper towel provided. Afterward, she/he was taken to the assessment location, given the procedure for the property to be assessed and provided with the control fabrics. The jury member was informed on how the control fabrics were chosen, which control fabrics had the scores 1 and 10, and how many more control fabrics she/he would be given for the assessment.

Based on the procedure above, the jury member was allowed to practise with the control fabrics as long as she/he needed to and started the assessment after she/he was ready. Samples were placed in the boxes, and each sample was assessed according to the procedure, in the allowed time for the specific property. Subsequently, the result was recorded on a form. This process was repeated until both the control fabric and samples were assessed. The jury member did not leave the site until the test session was completed. The jury members performed three test sessions a day for only one attribute, allowing a minimum of 2 and a maximum of 5 day breaks between sessions.

Subjective assessment of total handle

For subjective assessment of fabric handle, sample fabrics were grouped in twos based on the fabric unit weight per square meter. Fabrics with a weight between 100 and 200 g/m² were defined as lightweight, whereas fabrics with a weight between 200 and 320 g/m² were defined as medium-weight. Table 4 shows the groups and the number of fabrics in each group.

This procedure differs from the previous assessment in three areas. The first difference is that the jury was not given a specific method, meaning that she/he was allowed to evaluate the fabric in his/her own way. Second, the jury was not provided with a control fabric as no research has ever taken place on fabric handle standardization in Turkey, and no standard fabric exists for such tests. The third difference was the rating scale.

Prior to each assessment, the procedure was the same for handle components. The procedure referred to handle as meaning the "total handle", which was defined as all the feelings that a person felt when he/she touched a fabric.

After reading the procedure and asking questions (if any), the jury member was informed about end-use of the fabrics, as well as their fibre content and fabric weight group. The jury member was asked

Table 4. *Sample fabric groups for subjective assessment of handle.*

Fiber content	Fabric unit weight	Number of Samples
100% Wool	100-200 g/m^2 (light weight)	31
	200-320 g/m^2 (medium weight)	12
Wool/ Polyester blend	100-200g/m^2 (light weight)	17
	200-320 g/m^2 (medium weight)	13

Table 5. *Kendall's coefficients of concordance (W) for jury members; all concordance coefficients other than the ones marked (*) are important for α = 0.01.*

Jury Nr.	Thickness	Stiffness	Roughness	Total handle
1	0.823	0.799	0.596	0.729
2	0.761	0.738	0.705	0.592
3	0.744	0.781	0.665	0.590
4	0.686	0.765	0.677	0.598
5	0.686	0.628	0.754	0.625
6	0.796	0.801	0.715	0.651
7	0.751	0.595	0.604	0.398*
8	0.757	0.785	0.752	0.631
9	0.844	0.733	0.741	0.665
10	0.639	0.639	0.661	0.627
11	0.738	0.716	0.605	0.659
12	0.723	0.701	0.647	0.629
13	0.739	0.666	0.703	0.650
14	0.738	0.817	0.650	0.609
15	0.834	0.715	0.741	0.805
16	0.793	0.788	0.693	0.657
17	0.701	0.613	0.617	0.416*
18	0.732	0.728	0.704	0.680
Overall	**0.783**	**0.738**	**0.546**	**0.275**

to assess the total handle for men's suitings and started the assessment after he/she said he/she was ready. Each sample, which was placed in the control box, was assessed in the time allowed and the result was recorded on a form. The process was repeated until all the samples were assessed in one session. The jury members performed three assessment runs, allowing a minimum of 2 and a maximum of 5 day breaks between sessions.

Statistical evaluation

The data obtained from the tests were evaluated with an SPSS 13.0 Statistical Application Package. Kendall's Coefficient of Concordance (W) was calculated to determine the agreement between the replicates of jury members and agreement among jury members. The Spearman correlation coefficient was calculated to study the relationship between the attributes that were assessed subjectively, and to study the relationship between objective and subjective test results.

Results and discussion

Agreement between the replicates of jury members

Kendall's coefficient of concordance test was applied to verify the agreement of jury members in their replicates. The results are shown in Table 5 for each jury member. The table shows the coefficients of concordance (W) based on three assessments for each attribute. When the results are studied, it can be concluded that the jury performed consistent assessments for 73 fabric samples.

In addition, the coefficients of concordance needed to be tested for a specific significance level. All the coefficients of concordance, which were obtained from individual assessments of thickness, stiffness and roughness, were important at α = 0.01 significance level. Great and important W values indicate that agreement between the jury members' own assessments has a higher probability than being due to coincidence [22]. Consequently, it can be said that the jury members followed the same technique, applied the standards during assessments, and obtained results that are repeatable. Based on the values for total handle in Table 5, it is seen that the coefficients of concordance for the assessments for Jury 7 and Jury 17 are not dependable. Coefficicients of concordance for all the other assessments are important at α = 0.01 significance level.

Agreement among jury members

In order to determine the agreement among jury members, it was first studied whether each jury conducted consistent assessments. Therefore, the assessment results of Jury 7 and Jury 17 were ignored while calculating the concordance coefficients shown in Table 6. The concordance coefficients given in the table are for factors that can affect subjective results (fibre content, weave, gender, number of replicate) as well as for the total handle.

Based on a Kendall's concordance test that was conducted to obtain subjective test results, the jury members performed consistent assessments for thickness, stiffness, and roughness. In subjective thickness assessments, some jury members obtained coefficients of concordance greater than W = 0.8, and in subjective stiffness and subjective roughness assessments some members obtained coefficients of concordance greater than W = 0.7. The study shows that coefficients of concordance for total handle varied between 0.352 and 0.779, which is a larger range compared to the other attributes. This result is very interesting because the subjective evaluation of total handle was not based on a specific method or a subjective evaluation technique in this study. For the jury panel, subjective thickness has the highest coefficient of concordance, whereas the total handle has the lowest.

It is noticed that the coefficients of concordance for the jury's first, second and third replicates are close to each other. When the assessments are examined for male and female jury members, it is seen that coefficients of concordance are mutual closed for the attributes, however the coefficient for total handle is much higher for male members than females. Also, with respect to weave type, the coefficient for subjective roughness is higher for 'plain or plain derivatives' than twill or twill derivatives', whereas it is lower for subjective thickness.

Table 6. *Kendall's Coefficients of Concordance (W) for Jury; All Kendall's concordance coefficients are important at α=0.01 significance level.*

Factor		Attribute			
		Thickness	Stiffness	Roughness	Total handle
Fiber Content	100%Wool	0.798	0.704	0.569	0.234
	Wool/polyester blend	0.818	0.812	0.625	0.344
Weave	Plain or plain derivatives	0.687	0.737	0.610	0.282
	Twill or twill derivatives	0.779	0.717	0.573	0.300
Gender	Male	0.856	0.725	0.647	0.431
	Female	0.797	0.785	0.609	0.267
Number of replicates	First replicate	0.604	0.541	0.379	0.206
	Second replicate	0.639	0.593	0.448	0.202
	Third replicate	0.644	0.591	0.466	0.240
Overall		**0.798**	**0.753**	**0.587**	**0.281**

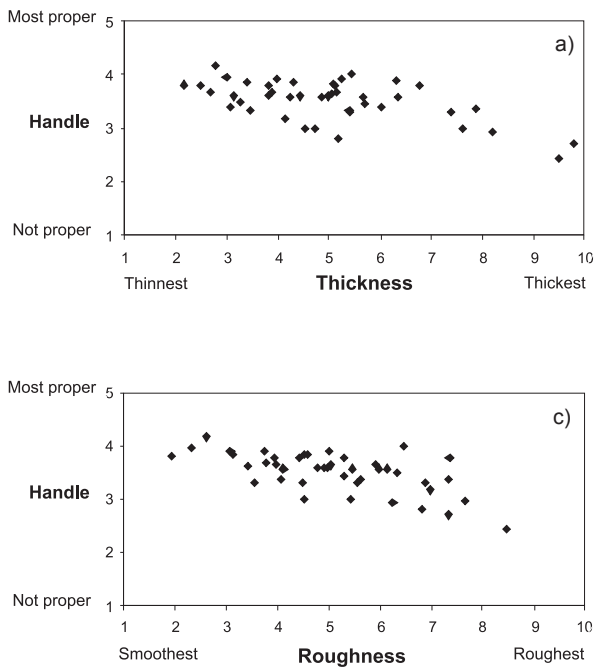

Figure 4. *Relationship between subjective; a) thickness – total handle, b) stiffness – total handle, c) roughness – total handle.*

Relation between subjective and objective test results

Correlation analyses were carried out to examine the relations between subjective and objective results. After the assessments of two jury members were ignored, averages of the three assessments of 16 jury members for 73 fabric samples were calculated again. These values were used for Spearman correlation tests.

An interesting finding from the results is the agreement between the subjective and objective test results. Spearman correlation coefficients were calculated to examine the relations between subjective and objective results. The Spearman correlation coefficients are 0.794 between objective and subjective thickness, 0.874 between objective and subjective stiffness and 0.339 between objective and subjective roughness. All the correlation coefficients are important at $\alpha = 0.01$ significance level.

When the jury rankings were examined according to these findings, it was seen that the jury had made successful assessments. As regards the thickness attribute, the jury assessed the 100% wool control fabric as the thinnest fabric which had the minimum thickness, and the jury assessed the fabric which was in the second rank in descending order according to thickness results, as the thickest one. For wool/polyester blend fabrics, the jury assessed a fabric as the thinnest one which was only 0.06 mm thicker than the thinnest control fabric. They correctly assessed the thickest control fabric as the thickest of the samples .

The jury also made successful assessments for softness-stiffness attributes. For 100% wool and wool/polyester blend fabrics, the jury assessed the fabric which obtained third rank in ascending order according to fabric bending rigidity. They also showed the second stiffest fabric according to fabric bending rigidity as the stiffness. For the roughness-smoothness attribute, the jury assessed the fabric that had the second lowest value of Ra (average absolute deviation) as the smoothest for 100% wool fabrics of plain weave and plain weave derivatives.

Relation between subjective test results

Correlation analyses were carried out to examine the relations between subjective results. All correlation coefficients between the total handle, thickness, stiffness and roughness are negative due to the means of numbers in the rating scale. The reason for the negative correlation values, which is related to the means of the numbers used in the rating scale, is shown in Figure 4 with scatter charts.

When Figure 4.a is examined, it is seen that while thickness values increase (1 thinnest, 10 thickest) handle values decrease, meaning that handle is considered to be worse when the fabric is thicker. In addition, the correlation coefficient between thickness and handle is the smallest among those of three handle components. When Figure 4.b is examined, it is seen that while stiffness values increase (1 softest, 10 stiffest) handle values decrease, meaning that handle is considered to be worse when the fabric is stiffer. When Figure 4.c is examined, it is seen that while roughness values increase (1 smoothest, 10 roughest) handle values decrease, meaning that handle is considered to be worse when the fabric is rougher. Among the three handle components, the highest correlation coefficient exists between roughness and total fabric handle.

The Spearman correlation coefficients are shown in Table 7. All correlation coefficients in the table are important at α=0.01 significance level. Based on the correlation analysis that was applied to the assessment results, which were obtained with the assessment techniques introduced, the highest correlation coefficient (r_s = 0.875) exists between stiffness and thickness, whereas the lowest (r_s = -0.398) exists between thickness and handle. Total handle has the highest correlation with subjective roughness (r_s = -0.631), indicating that the Turkish sensory panel consider roughness as the most correlated fabric attribute with total fabric handle. Its negative correlation

Table 7. *Spearman correlation coefficients between subjective results; All correlation coefficients in the table are important at α = 0.01 significance level.*

Feature	Stiffness	Roughness	Thickness	Total handle
Stiffness	1	-	-	-
Roughness	0.606	1	-	-
Thickness	0.875	0.670	1	-
Total handle	-0.519	-0.631	-0.398	1

coefficient can be expressed when the fabric is rougher, this increases its ratings towards 10 and the total handle will decrease because of this fact. This result confirms the opinion that roughness is an important attribute for total handle, and this study emphasises again the effect of roughness on handle preference. For roughness, the Turkish sensory panel are in a good agreement with literature.

The correlation coefficients between stiffness and total handle are similar to Kawabata's research [3]. But Turkish people think that there is a stronger relation between stiffness and total handle. The Turkish sensory panel evaluated stiffness and handle with a correlation coefficient r= -0.519, and this correlation coefficient has a lower value than that of the Japanese panel (r = -0.2515). It is clear that there is a negative correlation between these properties, and this means that when the fabric is stiffer, the total handle value will be less. The tendency is similar but this study shows that stiffness is an important attribute for total handle for the Turkish panel.

If the absolute values of coefficients are taken into consideration, it can be seen that there are some differences between the subjective results achieved in Japan and in this study. The interesting result is for Fukurami and thickness. This is because Fukurami (fullness and softness) is a desired attribute for the total handle of men's winter suitings and also Fukurami has an extensive meaning in comparison to thickness. Many researches show that if Fukurami has a higher value, this means that the total handle value will be higher. But in our study r = -0.398 between the total handle and the value for thickness. This result shows that the thicker the fabric , the lower total handle will be.

The results of this study are also interesting when compared to to the results of the research done by Mahar et.al [13, 23]. In their international handle survey, the same fabrics were evaluated by different national panels such as Japanese, Australian, New Zealand, Indian, from the United States and Chinese (Shanghai and Tianjin/Beijing). For winter weight fabrics each panel of judges rates fabric surface smoothness as the most important of the three primary characteristics (Numeri (smoothness), Koshi (stiffness) and Fukurami (fullness and softness)) in their study. The results of the Turkish panel are in a good agreement with their study with respect to to the coefficients between smoothness and total handle. The low negative correlation coefficients between winter fabric hand and fabric stiffness (from -0.40 to 0.31) indicate that each panel of judges tends to prefer fabrics with lower stiffness [13]. For the Turkish panel, the correlation coefficient between stiffness and total handle is r = -0.519, and this result shows that stiffness is more correlated with total handle in comparison to fabric thickness (for total handle and thickness r = -0.398).

According to the results of Mahar et. al, the absolute value of the fabric stiffness correlations is much less than fabric smoothness, as well as fabric fullness and softness values. Fabric stiffness appears to be by far the least important (though still a significant) factor in the assessment of winter fabric hand [13]. This situation is different from our study because in this study stiffness is the second attribute following fabric roughness.

Total handle values

In this study 73 fabric samples were used and the samples consisted of two raw materials, which were wool and wool/polyester blended, and all of them were worsted fabrics; 54.8% of the samples were worsted, an 45.2% were polyester-wool blended.

The mean values of subjective evaluation results of fabrics according to fabric unit weight and fiber content are summarized in Table 8. In this table, it is interesting that the means of subjective results are very close to each other when the results of worsted men's suiting fabrics used in this study are examined according to fire content. There is a similar tendency for wool and wool/polyester fabrics when we examine the results in fabric unit weight groups. An interesting result is the difference between the subjective results of light weight and medium weight fabrics. The Turkish sensory panel evaluated medium weight fabrics as being stiffer (6.54 and 6.74), rougher (5.82 and 5.81) and thicker (6.90 and 6.07) on a ten point scale when the results are compared with the results of light weight fabrics.

If we compare the results of medium weight fabrics with the winter suitings results of Prof. Kawabata's research, it is seen that there is a difference between them. In "The Standardisation and Analysis of Hand Evaluation"[3] the mean values of Koshi (Stiffness), Numeri (Smoothness) and Fukurami (fullness and softness) are 4.94, 5.08 and 4.96 respectively. The Turkish panel evaluated the fabrics used in this study as being stiffer, rougher and thicker (Table 8).

Table 8. *The mean values of subjective test results of fabrics according to/in relation to fabric unit weight and fiber content.*

Feature	100% Wool		Wool/Polyester blended	
	Light weight fabrics (100-200 g/m^2)	Medium weight fabrics (200-320 g/m^2)	Light weight fabrics (100-200 g/m^2)	Medium weight fabrics (200-320 g/m^2)
Stiffness	4.26	6.54	4.33	6.74
Smoothness	4.82	5.82	4.57	5.81
Thickness	4.28	6.90	3.70	6.07
THV	3.56	3.39	3.48	3.19

Table 9. *The subjective results of the fabrics having the lowest and highest total handle values.*

Feature	Total handle	Thickness	Stiffness	Roughness
The subjective results of the fabric having the highest total handle value	4.13	2.87	2.85	3.04
The subjective results of the fabric having the lowest total handle value	2.30	9.28	8.31	8.96

When all the mean values are examined, it is seen that 100% wool lightweight fabrics have the highest mean value for total handle while wool/polyester blended medium weight fabrics have the lowest mean value for total handle in Table 8.

The mean thickness value of 73 worsted men's suitings produced in Turkey is 4.9; this is based on a ten point rating scale with a mean stiffness value of 5.2 and a mean roughness value of 5.2. The mean total handle value has a grade of 3.47 on a five point rating scale. This means that the handle of the worsted fabrics produced in Turkey is between "medium" and "proper". As regards fibre content, it is seen that mean thickness, stiffness, roughness and total handle values of 100% wool fabrics are 5.0, 4.9, 5.1, 3.5 respectively, and for wool/polyester blend fabrics these values are 4.7, 5.4, 5.1, 3.3, respectively.

When the total handle values were examined in comparison with the subjective test results, it was seen that the jury assessed a thin, soft and smooth fabric as the best for the total handle value, whereas they assessed a thick, stiff and rough fabric as the worst. The fabric which had the highest total handle value was made of 100% wool, and the fabric which had the lowest total handle value was of a wool/polyester blend. Table 9 shows the subjective test results of the fabrics which had the lowest and highest total handle values.

Conclusion

In this study, thickness, stiffness, roughness were determined as the criteria for subjective assessments of men's suitings. The aim was also to introduce standard techniques to evaluate these criteria. The subjective assessment techniques introduced here were tested on 73 samples of 100% wool and wool/polyester blend worsted men's suitings with a jury of 18 experts.

When the results are examined in general, it can be concluded that the consistency of the assessments, which were performed using the assessment techniques proposed, is not due to coincidence. Furthermore, the jury members followed the same technique, applying the same standards, and the results obtained are reproducible. It is suggested that the assessment techniques that this study introduces can be useful for authorities who make decisions during the stages of production, sourcing/buying, as well as design. It is planned to conduct future studies in order to introduce new techniques or examine the effectiveness of techniques introduced for different end-uses, for different fibre contents, with expert or non-expert jury members. The mean total handle value of the fabrics used in this study has a grade of 3.47 on a five point rating scale. This means that the handle of the worsted fabrics produced in Turkey is between "medium" and "proper". Also, the authors are considering making new studies on the handle of fabrics produced for different end uses in Turkey.

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