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The Effect of Production Parameters of Face to Face Warp Velvet Fabric on Abrasion Resistance and Colour Properties

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ABSTRACT

Nowadays, velvet fabrics are widely used in upper clothing, curtains and especially upholsteries. One of the most important problems encountered in them is the distancing of the piles from the surface of the fabric and the other is discoloration over time. In addition to the fabric properties, yarn and fiber properties also affect this situation. In this article, the effect of production parameters on fabric abrasion was investigated in face to face warp velvet fabrics. The abrasion resistance of 100% cotton (10, 15, and 20 thousand rpm (rotation per minute)) and 100% polyester (30, 45, and 60 thousand rpm (rotation per minute)) velvet fabrics has been tested. The fabrics were produced using 3 different weft yarn counts (150, 300, and 450 deniers for polyester and 6, 12, and 20 Ne for cotton), 3 different weft densities (20, 22, and 24 picks/cm for polyester and 11, 13, and 15 picks/cm for cotton), 3 different pile heights (2, 3, and 4 cm) and two different pile connection types (V and W), and the abrasion of the fabrics was tested with a Martindale device. The results were analyzed. In addition, The effects of production parameters on fabric color were investigated in face to face warp velvet fabrics. Cotton fabrics were dyed with reactive blue, yellow and red, while polyester fabrics were dyed with disperse blue, yellow and red. Color properties and gloss have been tested and the results were analyzed. According to the test results, the increase in weft yarn count (increasing denier/decreasing Ne) causes an increase in abrasion resistance, while the increase in pile height reduces the abrasion resistance. The W bonded fabrics were found to be more resistant to abrasion than the V bonded fabrics. The color properties of the fabrics produced were tested in spectrophotometer test devices and the effects of production parameters were analyzed. It was determined that deep colors such as blue and red have an effect on color properties, while light colors such as raw fabric and yellow velvet fabric do not have a significant effect. It was also detected that raw and yellow velvet fabrics have more gloss than blue and red velvet fabrics.

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KEYWORDS

Velvet fabric, pile loss, abrasion resistance, color properties, gloss, fabric production parameters

1. INTRODUCTION

1.1. Velvet Fabric Information

Velvet is a type of woven fabric with a pile surface. If the pile yarns on the fabric surface are given from the weft direction, this fabric type is defined as weft velvet, and if the pile yarns on the fabric surface are given from the warp direction, this fabric type is defined as warp velvet. Generally, weft velvet fabrics are used in the clothing industry, and warp velvet fabrics are used in home textiles [1].

1.2. Production Parameters of Velvet Fabric

The most important parameter that creates velvet fabrics is the pile layer on the fabric surface, other important parameters are the warp and weft yarns that make up the ground. Besides these parameters, the type of yarn (cotton, linen, viscose, pes), yarn production methods (ring, open end), twist in the yarn (T/m) used in the pile and on the ground are important. In addition, many parameters such as the ground weave (plain, twill, satin), pile connection type (V, U, W), creating pile from weft or warp (weft, warp velvet), pile height and pile density in the fabric are among the factors affecting the structure of the velvet fabric [2, 3].

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1.3. Production Techniques Used in Velvet Fabrics

1. Weft Velvet
2. Warp Velvet
   a) Warp velvet production with a single layer system
   b) Warp velvet production with face to face system
      Single shuttle warp velvet production
      Double shuttle warp velvet production

Since face to face double shuttle warp velvet is used within the article, only face to face production will be emphasized among the velvet production methods [2, 3].

Double shuttle face to face warp velvet production

It is the system used in modern warp velvet fabric. In this system, the ground warp beams can be prepared separately. Pile warp beams are only used in dobby looms. The pile is fed from the creel on jacquard looms [4]. A pile surface is formed by cutting the pile warps that connect between two fabrics with the help of a knife [1]. Weft insertion is done on both fabrics at the same time. Two separate sheddings are opened on the loom, one for the top and the other for bottom fabric. In this way, it is possible to weave more fabric at the same time.

Van de Wiele, Güsken and Günne are the machines that weave warp velvet fabric. Van de Wiele is the best known company producing the machines that weave warp velvet fabric. There are crankshaft, beating up and rapier in the main parts. In these machines, weft insertion is done with rapiers. The rapiers are driven by parts consisting of the crankshaft and gearbox. The female rapier brings the weft from the weft scissors to the half of the fabric, and the male rapier transfers the weft to the other end of the fabric. Velvet weaving machines generally work with a negative weft transfer system. The beating up ensures the compression of the weft during the weaving process [5].

1.4. Pile Connection Types Used in Velvets

V Connection Type: The pile connection formed on one weft is called V connection. The weft yarn continues by skipping one by one. V connection is preferred when a tight pile layer is desired on the fabric [6].

U Connection Type: The pile connection formed on two weft yarns is called U connection. It is produced to obtain sparse pile velvet fabrics compared to V connection [6].

W Connection Type: The pile connection formed on three wefts is called W connection. It is the preferred connection type in the production of sparse pile velvet fabrics. The best result is obtained (on ground fabric) with plain weave connection [6].

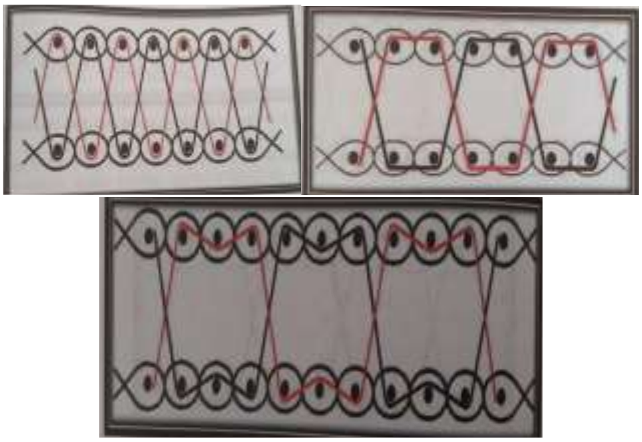

Figure 1. V connection type (left), U connection type (middle), W connection type (right) for face to face Warp Velvet

2. MATERIAL AND METHOD

2.1. Materials and Devices

2.1.1. Fabrics: Table 1 and Table 2 give information on velvet fabrics made of 100% polyester and cotton in different constructions. 8 pieces of 100% polyester and 8 pieces of 100% cotton velvet fabric were produced by changing the dark-colored parameters over the main fabric written in light colors in the table.

2.1.2. Chemicals: In the dyeing process, disperse dyestuff (blue 56, yellow 211 and red 167), reactive dyestuff (blue 221, yellow 145 and red 21), water, salt, soda, acid and dispersant were used [16].

2.1.3. Devices

Martindale fabric abrasion device is a device with 8 abrasive heads, each head uses a 12 kpa weight for abrasing, a 140 mm felt and standard fabric chamber, 38 mm sample and foam insertion head, and a electronic display. In addition, 38 mm and 140 mm cutters are available separately from the device as spares [30, 31, 32].

Drying oven, (Thermal brand) is a device with an independent safety thermostat that can dry at the desired temperature between 0-200°C. The volume of the device is 53 liters. The inner surface of the device is stainless steel, and the temperature indicator is digital.

Table 1. Polyester fabric properties.

%100 Polyester Fabric Sample: 1-8	Production Method: Face to face weaving
Yarn type and count used in weft	300/72 polyester **(150/72-450/432 denier)**
Yarn type and count used in warp	300/288 denier polyester
Yarn type and count used in pile	300/288 denier polyester
Weft density	20 picks/cm **(22-24 picks/cm)**
Warp density	25 picks/cm
Pile height	2 mm **(3-4 mm)**
Pile connection type	W **(V)**
Produced machine type	Vtr Vande Wiele

Table 2. Cotton fabric properties

%100 Cotton Fabric Sample: 9-16	Production Method: Face to face weaving
Yarn type and count used in weft	6/1 Ne cotton **(12-20 Ne)**
Yarn type and count used in warp	30/2 Ne cotton
Yarn type and count used in pile	28/2 Ne cotton
Weft density	15 picks/cm **(11-13 picks/cm)**
Warp density	19 picks/cm
Pile height	2 mm **(3-4 mm)**
Pile connection type	V**(W)**
Produced machine type	Vtr Vande Wiele

Table 3. Polyester and cotton velvet fabrics codes

Polyester Fabrics	Codes	Cotton Fabrics	Codes
Polyester/20 (picks/cm) density/300 denier weft/2 mm pile height/W pile connection **(Sample 1)**	P/20 pck/300 D w/2 p h/W p c	Cotton/15 (picks/cm) density/6-1 Ne weft/2 mm pile height/V pile connection **(Sample 9)**	C/15 pck/6-1 Ne w/2 p h/V p c
Polyester/22 (picks/cm) density/300 denier weft/2 mm pile height/W pile connection **(Sample 2)**	P/22 pck/300 D w/2 p h/W p c	Cotton/13 (picks/cm) density/6-1 Ne weft/2 mm pile height/V pile connection **(Sample 10)**	C/13 pck/6-1 Ne w/2 p h/V p c
Polyester/24 (picks/cm) density/300 denier weft/2 mm pile height/W pile connection **(Sample 3)**	P/24 pck/300 D w/2 p h/W p c	Cotton/15 (picks/cm) density/6-1 Ne weft/3 mm pile height/V pile connection **(Sample 11)**	C/15 pck/6-1 Ne w/3 p h/V p c
Polyester/20 (picks/cm) density/150 denier weft/2 mm pile height/W pile connection **(Sample 4)**	P/20 pck/150 D w/2 p h/W p c	Cotton/15 (picks/cm) density/6-1 Ne weft/4 mm pile height/V pile connection **(Sample 12)**	C/15 pck/6-1 Ne w/4 p h/V p c
Polyester/20 (picks/cm) density/450 denier weft/2 mm pile height/W pile connection **(Sample 5)**	P/20 pck/450 D w/2 p h/W p c	Cotton/11 (picks/cm) density/6-1 Ne weft/2 mm pile height/V pile connection **(Sample 13)**	C/11 pck/6-1 Ne w/2 p h/V p c
Polyester/20 (picks/cm) density/300 denier weft/3 mm pile height/W pile connection **(Sample 6)**	P/20 pck/300 D w/3 p h/W p c	Cotton/15 (picks/cm) density/12-1 Ne weft/2 mm pile height/V pile connection **(Sample 14)**	C/15 pck/12-1 Ne w/2 p h/V p c
Polyester/20 (picks/cm) density/300 denier weft/4 mm pile height/W pile connection **(Sample 7)**	P/20 pck/300 D w/4 p h/W p c	Cotton/15 (picks/cm) density/20-1 Ne weft/2 mm pile height/V pile connection **(Sample 15)**	C/15 pck/20-1 Ne w/2 p h/V p c
Polyester/20 (picks/cm) density/300 denier weft/2 mm pile height/V pile connection **(Sample 8)**	P/20 pck/300 D w/2 p h/V p c	Cotton/15 (picks/cm) density/6-1 Ne weft/2 mm pile height/W pile connection **(Sample 16)**	C/15 pck/6-1 Ne w/2 p h/W p c

Table 4. Polyester and cotton velvet fabrics samples

Sample				Sample			
Sample 1 polyester (raw)	L* 74.65	L* 9.38	L* 33.86	Sample 9 cotton (raw)	L* 64.38	L* 35.05	L* 38.84
	30000 rpm Mass loss 2.34%	45000 rpm Mass loss 3.48%	60000 rpm Mass loss 6.19%		10000 rpm Mass loss 27.00%	15000 rpm Mass loss 28.15%	20000 rpm Mass loss 30.75 %
Sample 2 polyester (raw)	L* 73.40	L* 5.49	L* 26.41	Sample 10 cotton (raw)	L* 60.27	L* 37.10	L* 39.46
	30000 rpm Mass loss 1.42%	45000 rpm Mass loss 2.66%	60000 rpm Mass loss 4.28%		10000 rpm Mass loss 29.34%	15000 rpm Mass loss 30.85 %	20000 rpm Mass loss 33.77 %
Sample 3 polyester (raw)	L* 73.29	L* 3.75	L* 26.26	Sample 11 cotton (raw)	L* 60.59	L* 24.25	L* 34.02
	30000 rpm Mass loss 1.30%	45000 rpm Mass loss 2.32%	60000 rpm Mass loss 3.44%		10000 rpm Mass loss 28.49%	15000 rpm Mass loss 29.57 %	20000 rpm Mass loss 31.07 %
Sample 4 polyester (raw)	L* 74.74	L* 12.12	L* 29.19	Sample 12 cotton (raw)	L* 61.40	L* 36.36	L* 35.12
	30000 rpm Mass loss 3.70%	45000 rpm Mass loss 8.46%	60000 rpm Mass loss 13.87 %		10000 rpm Mass loss 29.25 %	15000 rpm Mass loss 30.25 %	20000 rpm Mass loss 31.57%
Sample 5 polyester (raw)	L* 75.18	L* 13.75	L* 31.38	S ample 13 cotton (raw)	L* 63.85	L* 38.09	L* 40.69
	30000 rpm Mass loss 1.98%	45000 rpm Mass loss 3.59%	60000 rpm Mass loss 4.77 %		10000 rpm Mass loss 27.13%	15000 rpm Mass loss 30.38%	20000 rpm Mass loss 34.62 %
Sample 6 polyester (raw)	L* 75.14	L* 5.29	L* 28.45	Sample 14 cotton (raw)	L* 64.30	L* 27.63	L* 38.42
	30000 rpm Mass loss 3.16%	45000 rpm Mass loss 4.43 %	60000 rpm Mass loss 7.17 %		10000 rpm Mass loss 32.59 %	15000 rpm Mass loss 35.42 %	20000 rpm Mass loss 38.66%
Sample 7 polyester (raw)	L* 72.82	L* 4.98	L* 27.93	Sample 15 cotton (raw)	L* 65.00	L* 37.04	L* 43.35
	30000 rpm Mass loss 5.02%	45000 rpm Mass loss 6.47 %	60000 rpm Mass loss 9.28 %		10000 rpm Mass loss 36.62%	15000 rpm Mass loss 38.52%	20000 rpm Mass loss 41.33%
Sample 8 polyester (raw)	L* 73.32	L* 6.62	L* 30.59	Sample 16 cotton (raw)	L* 67.28	L* 38.78	L* 47.69
	30000 rpm Mass loss 5.07%	45000 rpm Mass loss 8.31%	60000 rpm Mass loss 11.21%		10000 rpm Mass loss 3.93%	15000 rpm Mass loss 5.77 %	20000 rpm Mass loss 7.42 %

Digital weighing is a laboratory type precision scale of 210 g capacity, Ohaus pioneer type, with internal calibration, glass protection that can be opened from three sides, an LCD display, and a weighing 4.5 kg.

Spectrophotometer device, Konica Minolta CM-3600D is used for reflectance measurement. The device, which works in D/8° sphere geometry, works with quality control or prescription software connected to the computer.

Laboratory type dyeing machine, Thermal brand is a sample dyeing machine with 12x180 cc tube number, 380 V 50/60 Hz heat and time control, 5200 W power and a 26 lt internal volume.

Gloss meter, Konica Minolta MG 268A is an ultra compact and portable gloss meter that can measure all glossy surfaces from matte to high gloss with three angles of 20°, 60° and 85°. All features such as language settings, calibration, measurement and statistics can be performed with two operating keys.

2.2. Experimental

2.2.1. Abrasion process

The device was operated according to the determined number of rotations (10-15-20 thousand rotations for cotton and 30-45-60 thousand rotations for polyester), and the weight loss of the test samples was determined at the end of the rotation. (% Abrasion) Mass loss (%) = $(m_1-m_2) / m_1$ was determined as the m_1 sample weight before test (grams), the m_2 sample weight after the test (grams) [28, 29, 34].

2.2.2. Dyeing process

16 samples (8 cotton and 8 polyester) of cotton fabrics were dyed with reactive blue 221, yellow 145 and red 21, and polyester fabrics were dyed with disperse blue 56, yellow 211 and red 167 in a laboratory dyeing machine (Thermal).

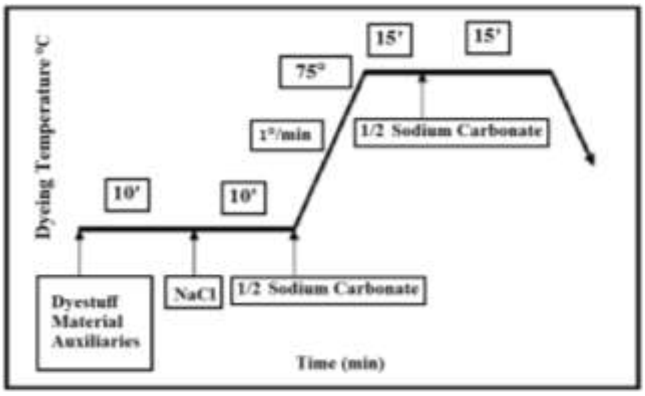

Figure 2. Reactive dyeing of cotton fabrics

2.2.2.1. Dyeing cotton velvet fabric

The dyeing process was carried out with 100% cotton fabric samples (10 g), with 1% dyeing in the sample dyeing machine (Thermal) at a flotte ratio of 1:10 according to the impregnation method. Dyeing was carried out in separate tubes of 25gr/lt soda and 60gr/lt salt reactive yellow 145, red 21 and blue 221 at 75°C for 60 minutes. The dyeing diagram is shown in Figure 2 [12, 13, 14].

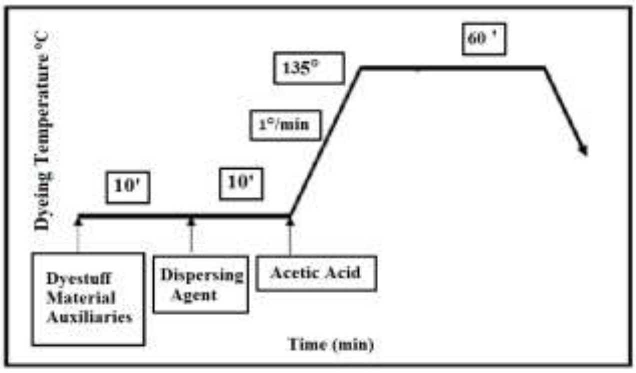

Figure 3. Disperse dyeing of polyester fabrics

2.2.2.2. Dyeing polyester velvet fabric

The dyeing process was carried out with 100% polyester fabric samples (10 g), with 1% dyeing in the sample dyeing machine (Thermal) at a flotte ratio of 1:10 according to the exhaustion method. Dyeing was carried out in disperse yellow 211, red 167 and blue 56 tubes in separate tubes at 135°C for 60 minutes. The dyeing diagram is shown in Figure 3 [9, 19, 20, 33].

2.2.3. Gloss measurement

The light emanating from the light source inside the device was reflected from the velvet fabric surface at a certain angle (such as 20, 60 and 85°) and reached the sensors on the other side of the glossmeter. Thus, the ratio of the amount of light reflected from the velvet fabric surface to the amount of light coming from the device source was measured. The resulting numerical value has been converted to a Gloss Unit (GU), which is a luminance unit. A flat black glass with a refractive index value of 1.567 was used for calibration purposes according to ASTM D523 standards. The measured value for this standard is 100 Gloss Units (GU). It is used for 85° low gloss (matt), 60° medium gloss and 20° high gloss in gloss angles.

2.2.4. SPSS 20 statistics program

Percent abrasion resistance values obtained with the Martindale test device were evaluated separately for 100% cotton velvets and polyester velvets. Density-number of rotation, pile height- number of rotation, weft yarn count-number of rotation and pile connection type- number of rotation relationships were evaluated with SPSS two-way anova analysis for 100% cotton and polyester fabrics using the percent abrasion results in Martindale. L (lightness) values obtained with spectrophotometer devices were evaluated separately for 100% cotton velvets and polyester velvets. Density-color, pile height-color, weft yarn count-color and pile connection type-color relationship were evaluated with SPSS two-way anova analysis for 100% cotton and polyester fabrics using L results in a spectrophotometer.

3. RESULTS AND DISCUSSION

3.1. Investigation of Parameters Affecting the Abrasion Resistance of 100% Cotton Velvet Fabrics

3.1.1. Effect of weft density on abrasion

In Figure 4, the increase in the weft density as 11, 13 and 15 picks/cm values increased the abrasion resistance of the velvet fabrics at 10, 15 and 20 thousand rotations and caused less mass loss. It is thought that the interaction of pile yarns with weft and warp yarns increases with increasing density. The closer the weft and warp yarns are to each other, the better the pile yarns will be attached to the fabric ground. In the literature [7,21] shirting fabrics were exposed to abrasion resistance and similar results were found when the density increased. The results showed that fabrics using 2 yarn sets (weft and warp) and velvets using 3 yarn sets (weft, warp and pile) overlapped with each other.

In the Post Hoc test, there were close values between 11 and 13 picks/cm for weft density in the subsets, there was no significant difference ($p=0.070>0.05$) but there was a significant difference between 11 and 15 picks/cm values and 13 and 15 picks/cm values in the subsets ($p=0.00<0.05$).

3.1.2. Effect of weft yarn count on abrasion

In Figure 5, the increase in the weft yarn count as 6, 12 and 20 Ne weft yarn count values decreased the abrasion resistance of the velvet fabrics in 10, 15 and 20 thousand rotations and caused more mass loss. It is thought that the connection of the pile yarns with the fabric ground decreases with the thinning of the weft yarns. For the same density value, increasing the weft yarn count (thinning the yarns) will create more gaps between the weft yarns. This gaps will reduce the pile-ground connection. The abrasion resistance increases as the yarn used for weft and warp in woven fabrics becomes thinner and the twist increases [22, 35, 36]. However, the thinning of the weft and warp yarns on the ground reduced the connection of the pile yarns and increased the amount of abrasion.

In the Post Hoc test, there was a significant difference in 6, 12 and 20 Ne values in the subsets ($p=0.00<0.05$).

3.1.3. Effect of pile height on abrasion

In Figure 6, with the increase pile height as 2, 3 and 4 mm values the abrasion resistance of velvet fabrics in 10, 15 and 20 thousand rotations decreased. As the pile height increases, the connection distance of the pile yarns with the fabric ground increases and these free ends abrade more. In literature, when pile heights increase by 0.5–1.0, 2.0–4.0 mm, the abrasion first increases and then decreases to reach the optimum value so it is thought that the abrasion may increase with the increase in pile height. With the available data, it is not known in which interval the optimum value is. However, it is thought to be between 1.0 and 2.0 mm. In order to determine the optimum pile height in abrasion, it will be more accurate to examine the abrasion by making studies with very repetitive, close to each other and wide range pile heights [23, 37].

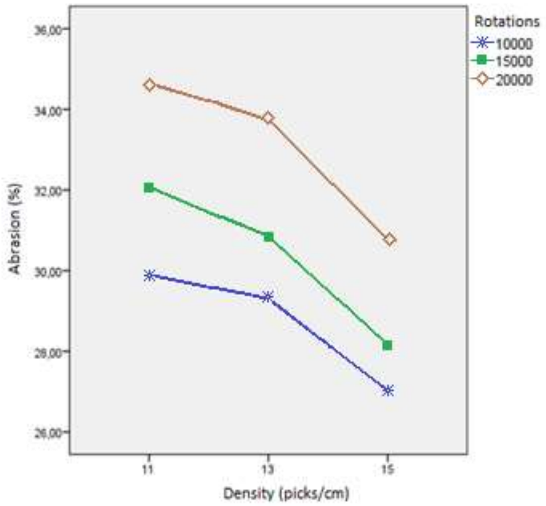

Figure 4. Weft density variation-(%) abrasion in cotton velvets. (comparison sample 9-10-13)

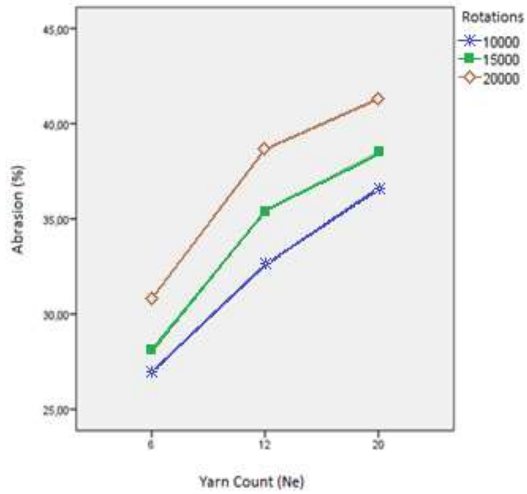

Figure 5. Weft yarn count variation-(%) abrasion in cotton velvets. (comparison sample 9-14-15)

There was a significant difference in the subsets of 2, 3 and 4 mm values used in the Post Hoc test ($p= 0.00<0.05$).

3.1.4. Effect of pile connection type on abrasion

In Figure 7, V and W connection types used in 100% cotton warp velvets, V connection pile velvets abraded more, while W connection pile fabrics abraded less. This result is thought to be that the W connection makes a better stronger connection to the velvet fabric ground compared to the V connection and therefore is abraded less. While pile connection type W is more difficult to move away from the fabric ground because it attaches to the fabric ground from two separate points,the pile connection type V connects to the fabric ground from a single point, it is easier to move away from the fabric ground. In literature, it was concluded that plain fabrics are less abraded than twill and satin fabrics [8,24,25]. As the reason for this, it was explained that the increase in the number of connections between the weft and warp yarns reduces the abrasion.

Before examining the effect of the parameters that make up polyester velvet fabrics on abrasion, when the effect of cotton fabrics on abrasion as raw material compared to polyester fabrics was examined, it was seen that cotton fabrics exposed more abrasion in literature [26,27].

3.2. Investigation of Parameters Affecting the Abrasion Resistance of 100% Polyester Velvet Fabrics

3.2.1. Effect of weft density on abrasion

In Figure 8, the increase in the density values as 20, 22 and 24 picks/cm increased the abrasion resistance of velvet fabrics at 30, 45 and 60 thousand rotations and caused less mass loss. As in cotton velvets, the interaction of pile yarns with ground yarns increases with the increase in density in polyester velvets, and accordingly, less abrasion is observed.

In the Post Hoc test, there was a significant difference in the subsets of 20, 22 and 24 picks/cm values ($p=0.00<0.05$).

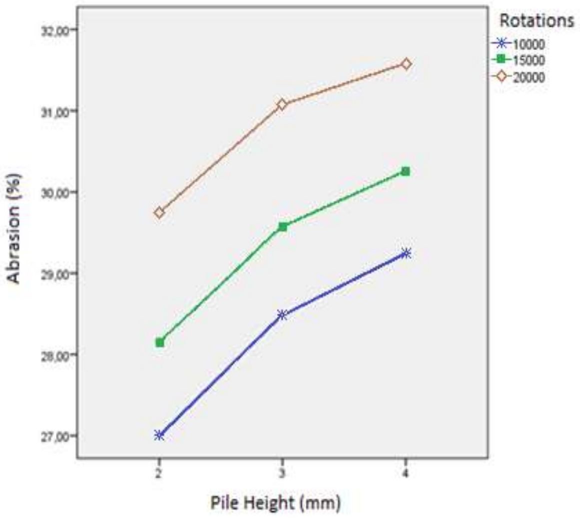

Figure 6. Pile height variation-(%) abrasion in cotton velvets (comparison sample 9-11-12)

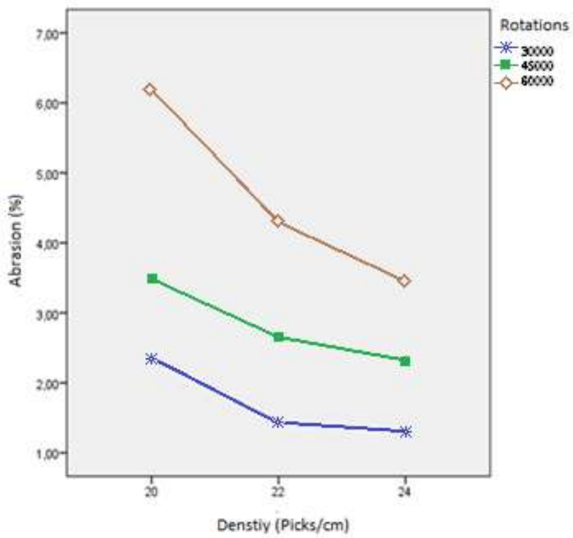

Figure 8. Variation of weft density-(%) abrasion in polyester velvets. (comparison sample 1-2-3)

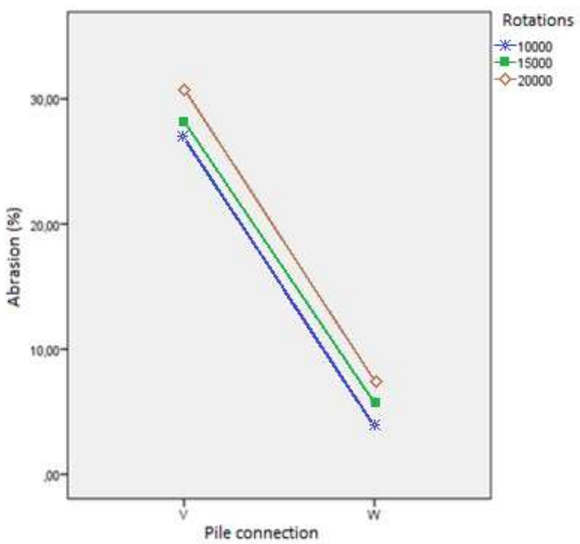

Figure 7. Pile connection variation-(%) abrasion in cotton velvets. (comparison sample 9-16)

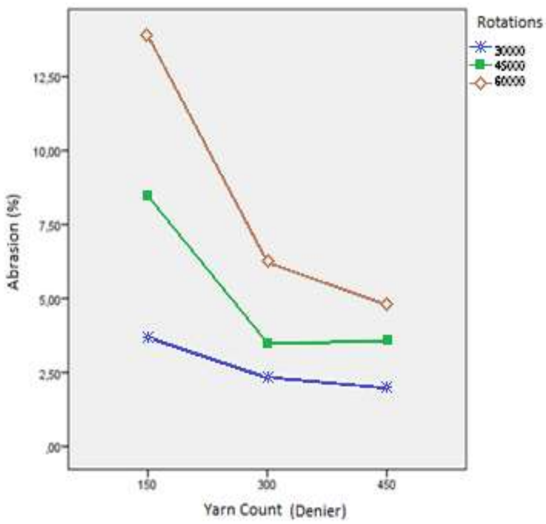

Figure 9. Weft yarn count change-(%) abrasion in polyester velvets. (comparison sample 1-4-5)

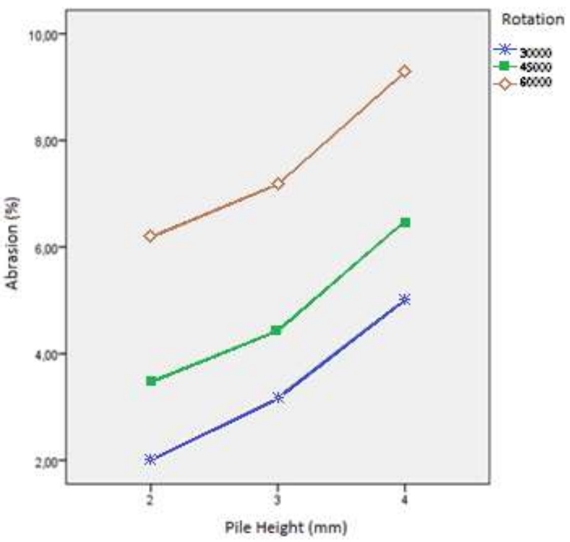

Figure 10. Pile height variation-(%) abrasion in polyester velvets (comparison sample 1-8)

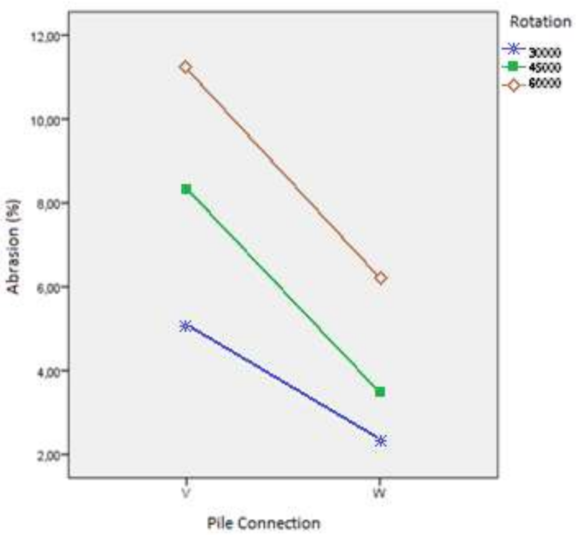

Figure 11. Pile connection variation-(%) abrasion in polyester velvets (comparison sample 1-6-7)

3.2.2. Effect of weft yarn count on abrasion

In Figure 9, the increasing weft yarn count values as 150, 300 and 450 denier increased the abrasion resistance of the velvet fabrics at 10, 15 and 20 thousand rotations and caused less mass loss. As in cotton velvets (decreasing Ne), the increasing yarn count (increasing denier) of the weft yarns in polyester velvets has led to an increase in the connection of the pile yarns with the ground and a decrease in abrasion. The change in raw material only changed the abrasion resistance values. While cotton velvets had a lot of abrasion at low rotations, polyester velvets had much less abrasion.

In the Post Hoc test, there was no significant difference between the subsets at 300 and 450 denier values ($p=0.130>0.05$). There was a significant difference between 150 and 300 and 300 and 450 denier weft yarn counts in the subsets ($p=0.00<0.05$).

3.2.3. Effect of pile height on abrasion

In Figure 10, the increasing pile height values as 2, 3 and 4 mm decreased the abrasion resistance of the velvet fabrics at 30, 45 and 60 thousand rotations and caused more mass loss. As the pile height increases, the connection distance of the pile yarns with the fabric ground increases and these free ends abrade more. The increase in pile height in cotton velvet fabrics decreased the abrasion resistance. A similar situation was observed in polyester fabrics.

In the Post Hoc test, there was a significant difference in the 2, 3 and 4 mm values used in the subsets ($p= 0.00<0.05$). As the pile height increased, a statistically significant increase was observed in the percentage abrasion resistance values.

3.2.4. Effect of pile connection type on abrasion

In Figure 11, V and W connection types used in 100% polyester warp velvets, V pile velvets abraded more, while W pile fabrics abraded less. It is similar to the result of W pile connection, which is one of the pile connection types made for cotton velvets, in the form of better connecting to the fabric and less abrasion compared to the V connection.

3.3. Investigation of Parameters Affecting the Color Properties of 100% Cotton Velvet Fabrics

The interaction test between the weft density, weft yarn count, pile height, pile connection type and color independent variables and the dependent variable L* (lightness) in cotton velvets are examined in the F value (ANOVA table) the color factor has a very large effect compared to other independent factors. Among the factors affecting the L* value, other factors besides the color factor are negligible. Color measurements were made by carding the piles in the same direction. The effect of pile connection type and pile height is slightly higher on the L* value compared to weft density and weft yarn count.

In the post hoc test, the color had a significant effect on the L* value (significance value $0.000<0.05$).

Table 5. Martindale (abraison percentage) test results of polyester and cotton velvet fabrics.

Codes		30,000 rotations	45,000 rotations	60,000 rotations	Codes		10,000 rotations	15,000 rotations	20,000 rotations
P/20 pck/300 d w/2 p h/W p c	Mean	2.34	3.48	6.19	C/15 pck/6-1 Ne w/2 p h/V p c	Mean	27.005	28.157	30.755
	SD	0.38	0.206	0.405		SD	0.157	0.799	1.186
	%CV	16.242	5.928	6.538		%CV	0.58	2.837	3.855
P/22 pck/300 d w/2 p h/W p c	Mean	1.426	2.663	4.289	C/13 pck/6-1 Ne w/2 p h/V p c	Mean	29.341	30.852	33.778
	SD	0.026	0.388	0.227		SD	0.236	1.04	0.747
	%CV	1.858	14.585	5.29		%CV	0.804	3.373	2.211
P/24 pck/300 d w/2 p h/W p c	Mean	1.304	2.321	3.445	C/15 pck/6-1 Ne w/3 p h/V p c	Mean	28.49	29.574	31.078
	SD	0.076	0.157	0.459		SD	0.235	0.304	0.198
	%CV	5.849	6.777	13.316		%CV	0.827	1.028	0.638
P/20 pck/150 d w/2 p h/W p c	Mean	3.701	8.467	13.879	C/15 pck/6-1 Ne w/4 p h/V p c	Mean	29.252	30.254	31.575
	SD	0.164	1.09	1.07		SD	0.124	0.208	0.596
	%CV	4.421	12.868	7.712		%CV	0.426	0.687	1.888
P/20 pck/450 d w/2 p h/W p c	Mean	1.982	3.594	4.778	C/11 pck/6-1 Ne w/2 p h/V p c	Mean	29.889	32.07	34.625
	SD	0.16	0.484	0.075		SD	0.517	0.334	1.142
	%CV	8.059	13.457	1.577		%CV	1.731	1.04	3.298
P/20 pck/300 d w/3 p h/W p c	Mean	3.164	4.438	7.179	C/15 pck/12-1 Ne w/2 p h/V p c	Mean	32.597	35.427	38.669
	SD	0.237	0.088	0.148		SD	0.272	0.611	0.658
	%CV	7.484	1.989	2.067		%CV	0.835	1.725	1.703
P/20 pck/300 d w/4 p h/W p c	Mean	5.024	6.474	9.288	C/15 pck/20-1 Ne w/2 p h/V p c	Mean	36.624	38.526	41.332
	SD	0.19	0.335	0.291		SD	0.74	1.162	0.195
	%CV	3.785	5.167	3.133		%CV	2.021	3.015	0.471
P/20 pck/300 d w/2 p h/V p c	Mean	5.07	8.317	11.214	C/15 pck/6-1 Ne w/2 p h/W p c	Mean	3.932	5.778	7.43
	SD	0.386	0.226	0.916		SD	0.14	0.073	0.276
	%CV	7.614	2.714	8.169		%CV	3.562	1.272	3.71

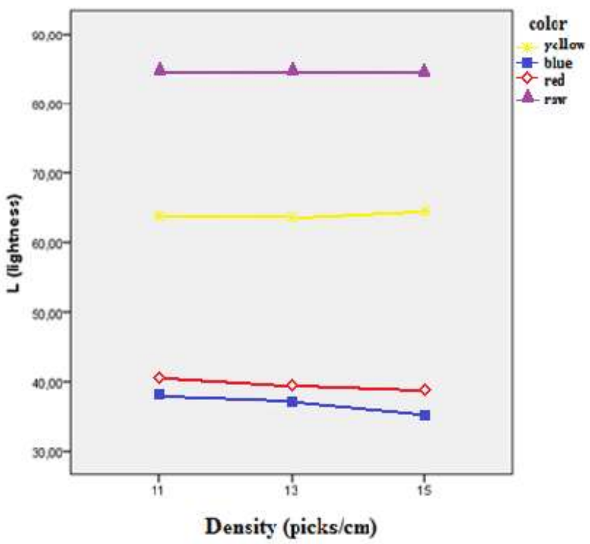

Figure 12. Weft density - L* in cotton velvets.9-10-13 (comparison sample 9-10-13)

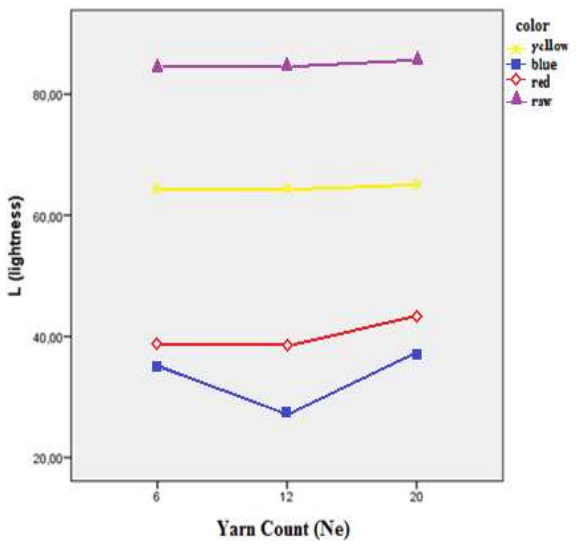

Figure 13. Weft yarn count - L* in cotton velvets. (comparison sample 9-14-15)

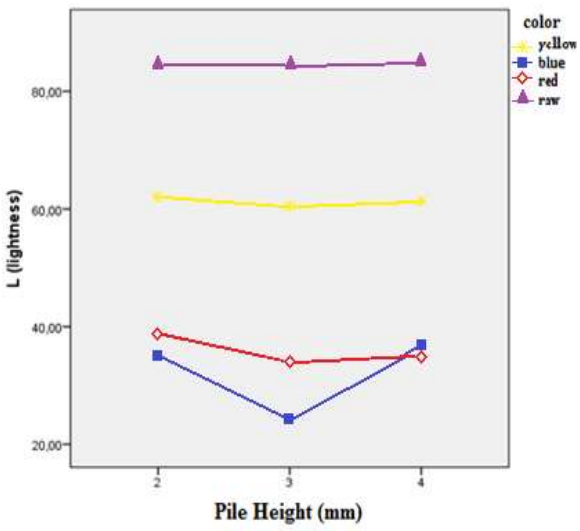

Figure 14. Pile height - L* in cotton velvets. (comparison sample 9-11-12)

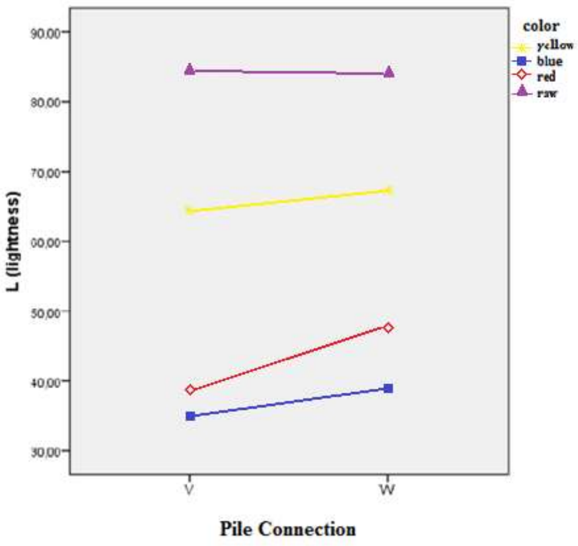

Figure 15. Pile connection - L* in cotton velvet. (comparison sample 9-16)

In Figures 12, 13, 14 and 15 the L* values of 100% cotton raw velvet fabrics are close to each other and vary between 83 and 84. Weft density, weft yarn count, pile height and pile connection type parameters have little effect on the L* value. A similar situation was observed in yellow cotton velvet fabrics. L* values were found to vary between 61 and 65. The effect of the production parameters on the L* value is more pronounced in red and blue cotton velvet fabrics. However, since this effect did not appear in a significant way in the graphics, no interpretation could be reached.

3.4. Investigation of Parameters Affecting the Color Properties of 100% Polyester Velvet Fabrics

In polyester velvets, as in cotton velvets, the relationship between weft density, weft yarn count, pile height, pile connection type and color was tried to be determined. While all other variables constitute the independent variables, L* was examined as the dependent variable. The F value (ANOVA table) of the interaction test between the variables show that the color factor has a great effect compared to other independent factors, as in cotton velvets. Among the factors affecting the L* value, besides the color factor, other factors are much less important. The same measurement method was used for cotton velvets and polyester velvets, and color measurements were made by carding the piles in the same direction. The effect of pile connection and pile height is slightly higher on the L* value than weft density and weft yarn count parameters.

In the post hoc test, the color had a significant effect on the L* value (significance value $p=0.000<0.05$).

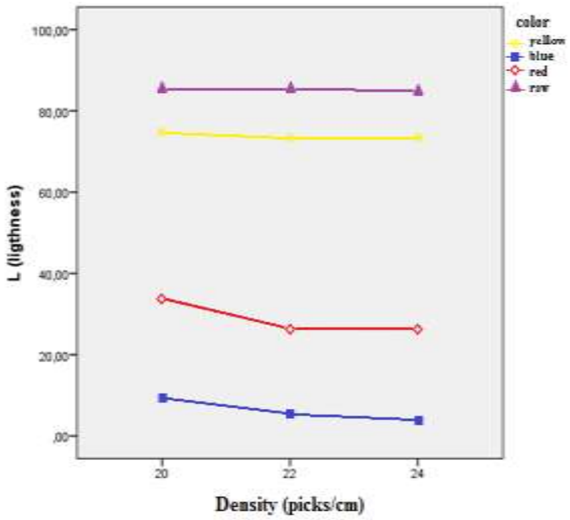

Figure 16. Weft density - L* in polyester velvet. (comparison sample 1-2-3)

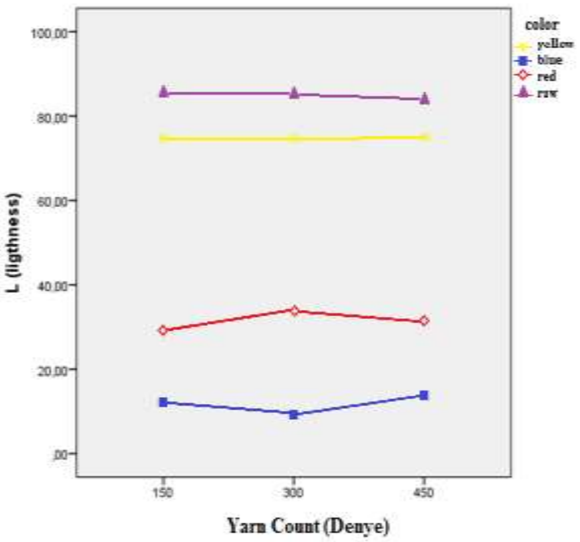

Figure 17. Weft yarn count - L* in polyester velvet. (comparison sample 1-4-5)

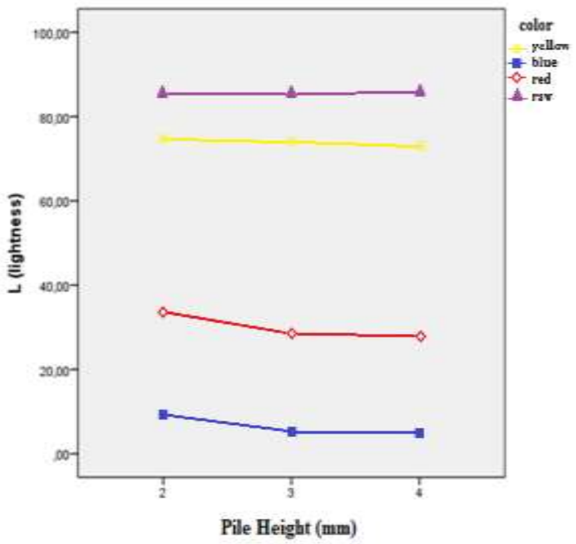

Figure 18. Pile height - L* in polyester velvet.
(comparison sample 1-6-7)

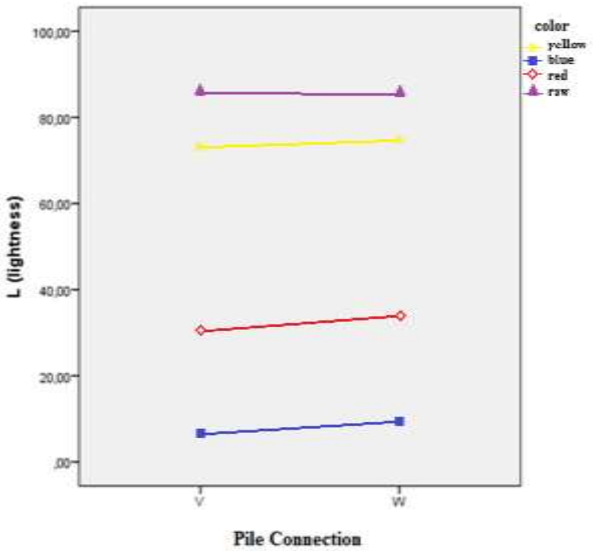

Figure 19. Pile connection - L* in polyester velvet.
(comparison sample 1-8)

In Figures 16, 17, 18 and 19 the L* values of 100% polyester raw velvet fabrics are close to each other and vary between 85 and 86. Since an undyed textile material reflects almost all of the incident light, it appears white under white light. In general, the structure of synthetic fibers is smoother than that of natural fibers and natural fibers often tend to curl. Because of this, more uniform reflection occurs on the surfaces of synthetic fibers and therefore they are more shiny [11]. Weft density, weft yarn count, pile height and pile connection type parameters have little effect on the L* value. A similar situation was observed in yellow polyester velvet fabrics and L* values varied between 73 and 74. The effect of the production parameters examined on the L* value is more pronounced in red and blue polyester velvet fabrics. However, this effect did not cause a change in the direction of decrease or increase as seen in the graphs.

Table 6. Spectrophotometer test results of cotton velvet fabrics.

		L*	a*	b*	C*	h			L*	a*	b*	C*	h
C/15 pck/6-1 Ne w /2 p h/V p c	yellow	64.38	28.05	69.51	74.96	68.03	C/11 pck/6-1 Ne w /2 p h/V p c	yellow	63.85	27.26	70.14	75.25	68.76
	blue	35.05	-0.61	-28.23	28.24	268.76		blue	38.09	-1.07	-28.81	28.83	267.89
	red	38.84	54.74	-3.35	54.84	356.49		red	40.69	54.42	-5.59	54.74	354.12
	raw	84.46	0.30	8.92	8.93	88.07		raw	84.38	0.15	7.92	7.92	88.93
C/13 pck/6-1 Ne w/2 p h/V p c	yellow	60.27	30.17	73.63	79.58	67.74	C/15 pck/12-1 Ne w /2 p h/V p c	yellow	64.30	26.68	68.13	73.17	68.62
	blue	37.10	-0.29	-28.30	28.30	269.41		blue	27.63	0.65	-26.44	26.45	271.42
	red	39.46	54.52	-3.99	54.69	355.81		red	38.42	54.60	-3.74	54.74	356.08
	raw	84.07	0.15	8.05	8.05	88.95		raw	84.58	0.05	7.91	7.91	89.67
C/15 pck/6-1 Ne w/3 p h /V p c	yellow	60.59	31.53	72.25	78.83	66.42	C/15 pck/20-1 Ne w /2 p h/V p c	yellow	65.00	28.28	70.58	76.04	68.18
	blue	24.25	2.49	-28.58	28.69	274.99		blue	37.04	-1.22	-28.62	28.65	267.58
	red	34.02	56.99	2.65	57.05	2.66		red	43.35	53.28	-7.04	53.76	352.47
	raw	84.39	0.23	8.80	8.80	88.52		raw	85.62	-0.56	6.03	6.05	95.36
C/15 pck/6-1 Ne w /4 p h/V p c	yellow	61.40	31.03	72.39	78.76	66.80	C/15 pck/6-1 Ne w /2 p h/W p c	yellow	67.28	22.74	63.26	67.23	70.23
	blue	36.36	-0.65	-28.92	28.93	268.70		blue	38.78	-0.20	-27.24	27.24	269.56
	red	35.12	56.55	0.31	56.56	240.32		red	47.69	50.69	-7.87	51.30	351.17
	raw	84.97	0.24	8.70	8.70	88.45		raw	84.03	0.50	9.01	9.02	86.82

Table 7. Spectrophotometer test results of polyester velvet fabrics.

		L*	a*	b*	C*	h			L*	a*	b*	C*	h
P/20 pck/300 D w /2 p h/W p c	yellow	74.65	2.97	105.60	105.65	88.39	P/20 pck/450 D w /2 p h/W p c	yellow	75.18	1.42	104.18	104.19	89.22
	blue	9.38	10.28	-29.96	31.68	288.95		blue	13.75	10.85	-32.96	34.70	288.22
	red	33.86	56.92	29.32	64.06	27.21		red	31.38	57.94	34.65	67.51	30.88
	raw	85.35	-0.33	0.16	0.38	154.04		raw	84.17	-0.42	0.54	0.69	127.75
P/22 pck/300 D w /2 p h/W p c	yellow	73.40	5.08	107.75	107.87	87.30	P/20 pck/300 D w /3 p h/W p c	yellow	74.15	3.54	106.96	107.02	88.11
	blue	5.49	10.77	-27.17	29.23	291.51		blue	5.29	11.48	-27.93	30.20	292.32
	red	26.41	57.23	38.32	68.87	33.81		red	28.45	57.93	37.90	69.23	33.19
	raw	85.43	-0.33	0.46	0.57	126.15		raw	85.34	-0.32	0.16	0.36	154.09
P/24 pck/300 D w /2 p h/W p c	yellow	73.29	5.41	108.79	108.92	87.15	P/20 pck/300 D w /4 p h/W p c	yellow	72.82	5.54	107.20	107.34	87.04
	blue	3.75	7.19	-21.11	22.30	288.80		blue	4.98	9.39	-27.26	28.84	289.02
	red	26.26	57.07	37.48	68.28	33.29		red	27.93	55.69	35.07	65.83	32.14
	raw	85.00	-0.37	0.24	0.44	147.68		raw	85.74	-0.36	0.14	0.39	158.44
P/20 pck/150 D w /2 p h/W p c	yellow	74.74	3.10	104.39	104.43	88.30	P/20 pck/300 D w /2 p h/V p c	yellow	73.32	3.78	104.95	105.02	87.95
	blue	12.12	10.85	-34.49	36.17	287.54		blue	6.62	10.38	-28.82	30.64	289.85
	red	29.19	58.14	37.39	69.13	32.75		red	30.59	56.41	30.82	64.28	28.66
	raw	85.38	-0.26	0.09	0.28	161.00		raw	85.88	-0.32	0.32	0.48	141.59

3.5. Investigation of Parameters Affecting Gloss Values of 100% Cotton Velvet Fabrics

3.5.1. Effect of fabric construction on gloss

Gloss values of cotton velvet fabrics are shown in Table 9. The increasing pile height (2, 3 and 4 mm) caused a decrease in gloss values in all three angles (20°, 60° and 85°) in both undyed and reactive yellow 145, red 21 and blue 221 dyed velvet fabrics. As the pile height decreases, a flatter pile surface is formed and it is thought that this pile surface reflects light better.

In addition, the gloss value of W pile fabrics in pile connection types was higher than the gloss value of V pile velvet fabrics in all three angles. The change in other production parameters (weft density, weft yarn count) did not have a significant effect on gloss values. In our opinion, since the ground is seen more clearly in W pile velvets, it reflects the light better and looks brighter than V pile velvets.

3.5.2. Effect of color change on gloss

Gloss values of cotton velvet fabrics in Table 9, gloss values of raw and reactive yellow 145 dyed velvet fabrics were found to be higher at all measurement angles (20°, 60° and 85°) than gloss values of velvet fabrics dyed with reactive red 21 and blue 221 colors.

3.6. Investigation of Parameters Affecting the Gloss Value of 100% Polyester Velvet Fabrics

3.6.1. Effect of fabric construction on gloss

Gloss values of polyester velvet fabrics in Table 10, the increase in pile height (2, 3 and 4 mm) caused a decrease in gloss values of raw and disperse dyed velvet fabrics in all three angles (20°, 60° and 85°). In addition, the gloss value of W pile fabrics in pile connection types is higher than gloss value of V pile velvet fabrics in all three angles. The change in other production parameters (weft density, weft yarn count) did not cause a significant change in gloss values. The same comment made for cotton fabrics in 3.7.1 is valid for polyester fabrics.

Table 9. Glossmeter test results of cotton velvet fabrics.

	Red			Blue			Yellow			Raw		
	20°	60°	85°	20°	60°	85°	20°	60°	85°	20°	60°	85°
C/15 pck/6-1 Ne w/2 p h/V p c	0.10	0.30	0.47	0.00	0.20	0.27	0.40	0.93	0.53	1.00	1.87	0.70
C/13 pck/6-1 Ne w/2 p h/V p c	0.10	0.30	0.47	0.00	0.23	0.33	0.40	0.93	0.63	1.00	1.67	0.50
C/15 pck/6-1 Ne w/3 p h/V p c	0.10	0.30	0.43	0.00	0.17	0.47	0.40	0.97	0.53	1.00	1.90	0.63
C/15 pck/6-1 Ne w/4 p h/V p c	0.10	0.30	0.50	0.00	0.27	0.47	0.40	0.87	0.50	1.00	1.73	0.50
C/11 pck/6-1 Ne w/2 p h/V p c	0.17	0.33	0.40	0.00	0.30	0.40	0.40	0.93	0.43	1.00	1.67	0.23
C/15 pck/12-1 Ne w/2 p h/V p c	0.10	0.37	0.53	0.00	0.23	0.50	0.40	0.90	0.50	1.00	1.67	0.53
C/15 pck/20-1 Ne w/2 p h/V p c	0.10	0.33	0.20	0.00	0.20	0.20	0.40	1.00	0.60	1.00	1.63	0.37
C/15 pck/6-1 Ne w/2 p h/W p c	0.20	0.40	0.33	0.10	0.30	0.47	0.50	1.00	0.57	1.00	1.77	0.50

Table 10. Glossmeter test results of polyester velvet fabrics.

	Red			Blue			Yellow			Raw		
	20º	**60º**	**85º**	**20º**	**60º**	**85º**	**20º**	**60º**	**85º**	**20º**	**60º**	**85º**
P/20 pck/300 D w /2 p h/W p c	0.10	0.20	0.20	0.00	0.00	0.13	0.70	1.00	0.20	1.20	1.63	0.20
P/22 pck/300 D w /2 p h/W p c	0.00	0.10	0.20	0.00	0.00	0.13	0.67	0.83	0.20	1.13	1.47	0.20
P/24 pck/300 D w /2 p h/W p c	0.03	0.10	0.10	0.00	0.00	0.13	0.70	0.93	0.23	1.20	1.47	0.23
P/20 pck/150 D w /2 p h/W p c	0.07	0.10	0.00	0.00	0.00	0.10	0.63	1.00	0.20	1.20	1.73	0.33
P/20 pck/450 D w /2 p h/W p c	0.10	0.10	0.10	0.00	0.00	0.20	0.80	1.23	0.33	1.17	1.70	0.33
P/20 pck/300 D w /3 p h/W p c	0.10	0.10	0.17	0.00	0.00	0.17	0.67	1.00	0.20	1.20	1.63	0.20
P/20 pck/300 D w /4 p h/W p c	0.00	0.10	0.20	0.00	0.00	0.03	0.60	0.87	0.10	1.10	1.57	0.20
P/20 pck/300 D w /2 p h/V p c	0.03	0.10	0.17	0.00	0.00	0.00	0.60	0.97	0.17	1.00	1.37	0.23

3.6.2. Effect of color change on gloss

Gloss values of polyester velvet fabrics in Table 10, the gloss values of undyed and disperse yellow 211 dyed velvet fabrics were found to be higher in all three angles (20°, 60° and 85°) compared to the gloss values of velvet fabrics dyed with disperse red 167 and blue 56 colors. It is stated in the literature that color change is not effective on gloss. In this study, both 100% cotton and 100% polyester velvet fabrics were glossier in light-colored velvet fabrics than in dark-colored fabrics.

4. CONCLUSION

According to the test results of 100% cotton and polyester face to face warp velvet fabrics, it was found that the increase in weft yarn count (increasing denier/decreasing Ne), increases the abrasion resistance, while the increase in pile height decreases the abrasion resistance. When the pile connection type was examined, W-connected fabrics were more difficult to abrade than V-connected fabrics. It has been determined that polyester velvet fabrics are more difficult to abrade than cotton velvet fabrics. As expected, the increase in the number of rotations increased the amount of abrasion on both cotton and polyester velvet fabrics. In the selection of velvet fabrics to be used as upholstery, it is recommended to choose high density fabrics with polyester mid-height pile instead of cotton, very high pile and loose density fabrics in terms of wear.

After dyeing, it was seen in the statistical tests that the production parameters for 100% cotton and polyester fabrics did not have a significant effect on the fabric color properties, L*. While the color properties of blue and red velvet fabrics had an effect on L*, it was found that the raw and yellow ones did not have a significant effect.

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Gloss values of 100% cotton and polyester fabrics, gloss decreases in the case of increasing the pile height and using V pile connected velvet, while gloss increases in W pile fabrics. The brightness value of light-colored cotton and polyester velvet fabrics was higher than the dark-colored ones. In the literature, it is stated that the brightness of the fabric depends on the surface appearance rather than the color of the fabric. In the study, the color had an effect on the brightness of the fabric. It is shown in Table 9 and Table 10.

In the selection of velvet fabrics to be used as upholstery, it is recommended to use light colors instead of dark colors in order to prevent the color from fading over time and to prefer light colors in terms of gloss.

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