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INVESTIGATION OF THE EFFECT OF FUSIBLE INTERLINING ON STIFFNESS AND DRAPABILITY OF WOOLLEN FABRICS

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Abstract: Woollen fabric most popular tailored clothing material because of the fabric excellent and natural properties. In woollen garments, upper back, sleeve holes, collars, lapels, patch and welt pockets, and sleeve cuffs are the areas to apply interlining for more rigid appearance. Interlining is a layer fabric sticked on the fabrics of the garment to give form and to improve stiffness of garment.

In this study, the effect of fusible interlining on stiffness and drapability of woollen woven fabrics with different structural properties were investigated. For this purpose, eight woollen woven fabric samples having different structural properties were obtained. Same kind of fusible interlining applied all of these fabric samples. Therefore, woollen fabric samples without fusible interlining and with fusible interlining were obtained. The results showed that the fabric weigth, cover factor and weave structure of woollen woven fabrics effect fabric stiffness and drapability. All woollen fabrics with fusible interlining had significantly higher stiffness and drape coefficient values than woollen fabrics without fusible interlining.

Keywords: Fusible interlining, stiffness, drapability, woollen fabric

Yapışkan Telanın Yünlü Kumaşların Sertlik ve Dökümlülük Özellikleri Üzerine Etkisinin İncelenmesi

Öz : Yünlü kumaş, mükemmelliği ve doğal özellikleri ile en popüler giysi malzemesidir. Yünlü giysilerde, sırt kısmı, kol evleri, yakalar, takma ve peto cepler, klapalar ve kol manşetleri, daha sert bir görünüm için tela uygulanan bölümlerdir. Tela, giysiye form vermek ve onun rijitliğini arttırmak için giysinin kumaşına yapıştırılan bir kat kumaştır.

Bu çalışmada, yapışkan telanın farklı yapısal özelliklere sahip yünlü dokuma kumaşların sertliği ve dökümlülüğü üzerine etkisi araştırılmıştır. Bu amaçla, farklı yapısal özelliklere sahip sekiz yünlü dokuma kumaş numunesi seçilmiştir. Tüm bu kumaş numunelerine aynı yapışkan tela uygulanmıştır. Böylece yapışkan tela içermeyen ve içeren yünlü kumaş numuneleri elde edilmiştir. Sonuçlar, yünlü dokuma kumaşların gramajının, örtme faktörünün ve dokuma yapısının kumaş sertliğini ve dökümlülüğünü etkilediğini göstermiştir. Yapışkan tela içeren tüm yünlü kumaşlar, yapışkan tela içermeyen yünlü kumaşlara göre önemli ölçüde daha yüksek sertlik ve dökümlülük katsayısı değerlerine sahiptir.

Anahtar Kelimeler: Yapışkan tela, sertlik, dökümlülük, yünlü kumaş

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1.INTRODUCTION

Fusible interlining is a woven, knitted or non-woven thin fabric that is bonded between two layers of fabric in certain areas of the garment. Using fusible interlining on some parts of the garment can give durability to the garment and at the same time facilitate sewing.

Fusible interlinings give stiffness and fullness to the fabric to achieve a good appearance and performance in the garment. (Qian, Cheekooi and Wai, 2016). Fusible interlining should be applied to the fabric according to the structure and weight of the fabric.

More importantly, the interlinings are cut on the bias and sewn in so they move with the body and don't have the rigid, boardy look of fusibles. Interlining is a kind of fabric used in areas that need more stability than just the fabric weight.

In recent years, woollen fabrics are preferred in clothing industry. In woollen coat, suit or jacket tailoring, sleeve holes, upper back, collars, patch, lapels and pocket flaps are the areas to apply interlining. Fusible interlinings such as cotton, viscose or polyamide can be used for many areas such as belts, pocket flaps, collars and lapels of the garment (Kim, Inui and Takatera, 2011). The bending behavior of the fabric is generally determined by bending or flexural rigidity. The bending behaviour should be measured to determine the stiffness of the fabric and fusible interlinings (Yükselkaya, Howard and Adanur, 2008).

Fabric stiffness may not be so high for a good drape in apparel fabrics. Therefore there is necessity to optimize the seam parameters such as sewing thread type, stitch density and seam allowance in order to decrease the stiffness of the fabric on the garment (Gurarda, 2009; Hu, Chung and Lo, 1997). The longer the bending length, the stiffer is the fabric. Fabrics with very high stiffness values can cause sewing and handling problems as they are too stiff for formability (Cheng, How and Yick,1996).

Drape is a property that determines the appearance of the garment (Fan, Yu and Hunter, 2004). The bending and drapability properties of the fabrics are very important for the appearance of the garment. There are also important for determining the comfort and fit properties of the garment (Sharma, Behera, Roedel and Schenk, 2004; Seram and Rupasinghe, 2013). A lower drape coefficient mean the fabric is softer, and its drapability is better. (Hu, 2008).

Using interlinings in the garment effect the stiffness and drapability of the fabrics therefore garments. Although interlining is an invisible interior layer of a garment, the interlining construction and the fusion process of fusible interlining and fabric structure affect appearance, sewability, and mechanical properties of the garment (Amar and Al-Gamal, 2015). By bonding fusible interlining, the bending rigidity and stiffness can be controlled. The choice of a suitable fusible interlining is an important process in the production of garments for their formability and stiffness (Kim, Sonahara and Takatera, 2015).

In this study, the effect of fusible interlining on stiffness and drapability of woollen woven fabrics with different structural properties were investigated.

2.MATERIAL AND METHOD

2.1. Material

In this study, woollen fabrics with rib, 2/2 twill and derived twill structures, which are mostly used to produce men's suit were investigated. The structural properties of the fabrics used in this study are shown in Table 1. In this study, 105 g/m^2 100% polyester plain fusible interlining was used. The fusing temperature was 150-170 ºC and time was 10-15 sec. All fabric samples were fused with this fusible interlining. The weave structures of the fabrics are given in Figure 1.

Table 1.Structural properties of fabrics

No	Blend Ratio of Yarns		Yarn Count (Nm)		Thread Density (thread/cm)		Fabric Unit Weight (g/m^2)	Thickness (mm)	Fabric Cover Factor
	Warp	Weft	Warp	Weft	Warp	Weft			
A1	45%WO 55%PES	45% WO 55%PES	40/2	40/2	24	32	262	0.54	26.40
A2	45%WO 55%PES	43% WO 53%PES %4 EL	80/2	80/2	40	30	215	0.63	24.87
A3	45% WO 55%PES	43% WO 53%PES %4 EL	80/2	80/2	40	30	218	0.64	24.87
A4	45%WO 55%PES	43% WO 53%PES %4 EL	80/2	80/2	40	28	200	0.53	27.47
A5	100% WO	96% WO %4 EL	64/2	72/2	40	32	226	0.45	30.15
A6	100% WO	96% WO %4 EL	64/2	72/2	40	32	244	0.44	30.15
A7	45%WO 55%PES	44% WO 54%PES %2 EL	80/2	80/2	32	26	205	0.40	24.31
A8	45%WO 55%PES	44% WO 54%PES %2 EL	80/2	80/2	36	32	220	0.35	27.24

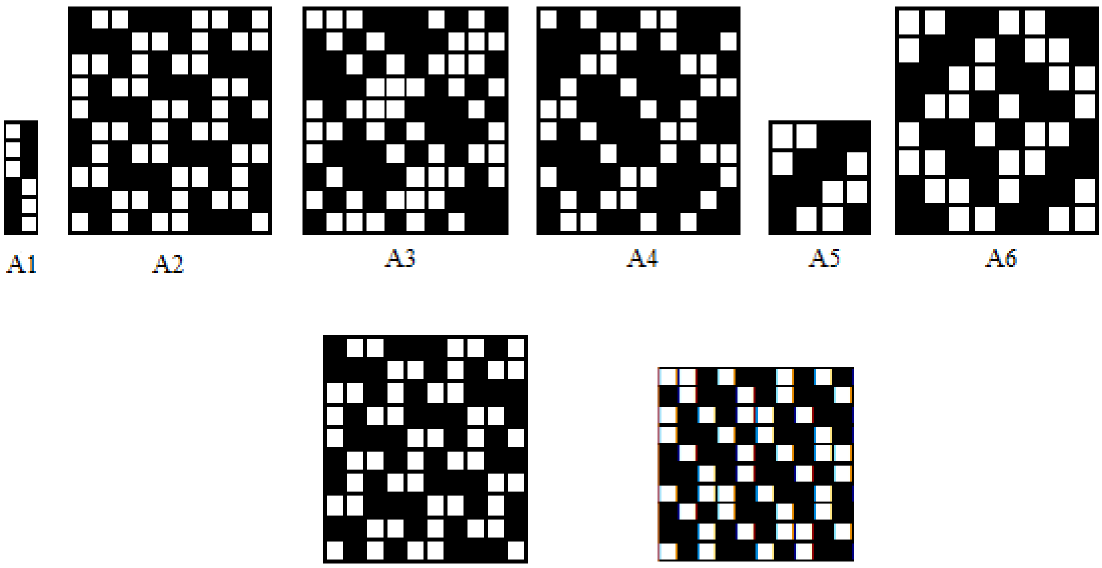

Figure 1:
Weave structure of fabric samples

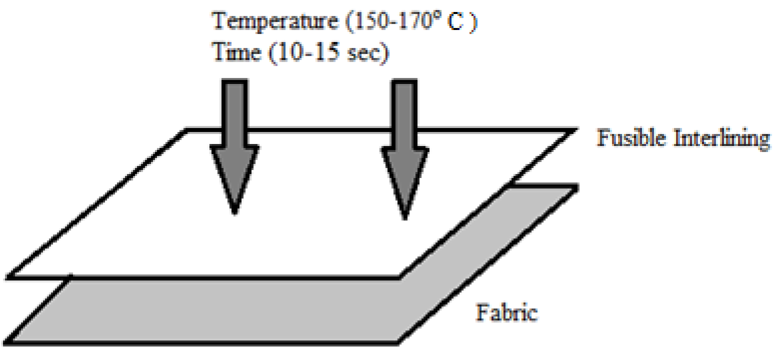

Figure 2:
Fabric with fusible interlining

2.2. Method

All woollen fabric samples fused with fusible interlining (Figure 2). It was obtained eight woollen fabric samples without fusible interlining and eight woollen fabric samples with fusible interlining. Therefore 16 different fabric samples were obtained. The ASTM D 3776-09a standard was used to measure the mass per unit area, and the ASTM D 3775-17 standard was used to measure the density of the fabrics (ASTM D 3776-09a; ASTM D 3775-17). Cover factor of the fabric samples were calculated according to the Peirce formulas (Peirce, 1937).

The warp and weft cover factor K_{wa} and K_{we} are defined at Equation (1) according to Peirce.

$$K_{wa} = (3.3 \times n_1) / \sqrt{N_1} \qquad K_{we} = (3.3 \times n_2) / \sqrt{N_2} \tag{1}$$

n_1 =Warp yarn density (thread/cm)
n_2 = Weft yarn density (thread/cm)
N_1 = Warp yarn count (Nm)
N_2 = Weft yarn count (Nm)

The fabric cover factor K_f is defined at Equation (2) according to Peirce.

$$K_f = K_{wa} + K_{we} - (K_{wa} \times K_{we} / 28) \tag{2}$$

The bending length and flexural rigidity should be measured to determine the stiffness of the fabric. The stiffness test was performed with the stiffness tester according to ASTM 1388-64 and TS 1409 standards. Equations (3), (4) and (5) were used to calculate the stiffness of fabrics (ASTM D 1388-64; TS 1409).

$$c = O / 2 \tag{3}$$

c = Bending length
O= The length of overhang, cm

$$G = W (O / 2) 3 = W x c3 \tag{4}$$

G = Flexural rigidity, mg cm
W = Weigth, mg/ cm^2

$$Go = (G w . G f)1/2 \tag{5}$$

G o = Overall flexural rigidity, mg cm
G w = Warp flexural rigidity
G f = Weft flexural rigidity

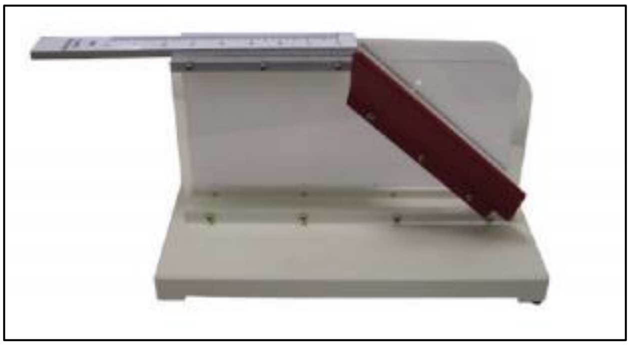

Figure 3:
Fabric stiffness tester (https://sdlatlas.com/products/fabric-stiffness-tester)

ISO 9073-9 standard was used for the drapability tests of the fabrics. The drape coefficient is indicated in the Equation (6).

$$DC (\%) = (W_2 / W_1) x 100 \tag{6}$$

DC = Drape coefficient (%)

W_1 = The weight of the paper ring

W_2 = The weight of the paper ring after the shadow was obtained (ISO 9073-9).

W_1 and W_2 were seen in Figure 4 (Kenkare and Plumlee-May, 2005). Figure 5 was shown the image of the device (Chung, 1999).

The results were evaluated with SPSS 14.0 statistical program. ANOVA and SNK tests were used to evaluate the influence of fabric type on stiffness properties of fabrics. The significance level value (α) selected for all statistical tests is 0.05.

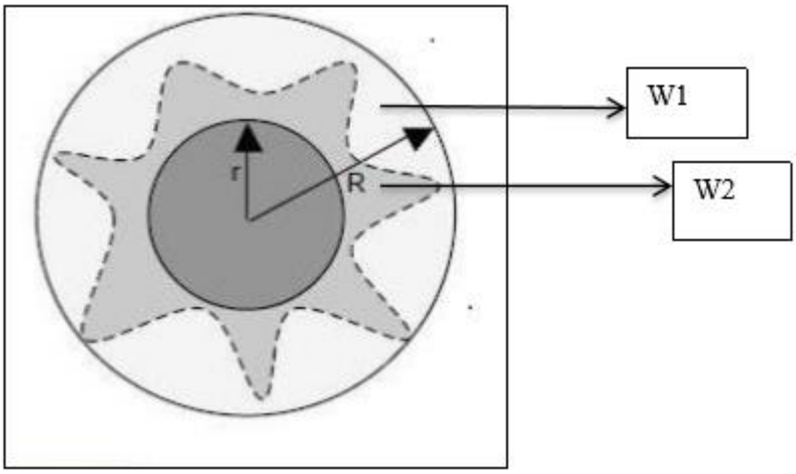

Figure 4:
Draped configuration of fabric (Kenkare, Plumlee-May, 2005)

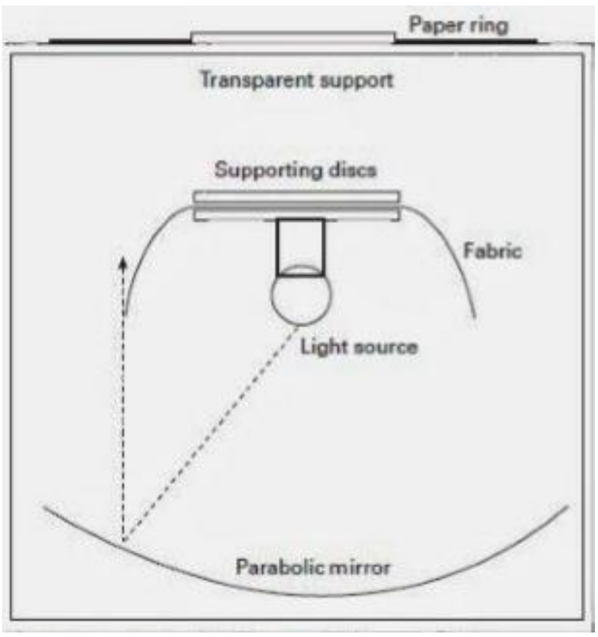

Figure 5:
Cusick's drapameter (Chung, 1999)

3. RESULTS AND DISCUSSION

3.1. Test Results of the Fabric Stiffness

Stiffness test results of fabrics without interlining and with interlining are given in Figure 4-8. Figure 4 shows that the lowest warp bending length was found for the rib fabric without interlining (A1) as 1.38 cm while the highest warp bending length was found for the 2/2 twill fabric without interlining (A5) as 1.72 cm. Derived twill fabric without interlining (A4 and A6) have 1.60 cm warp bending length as shown in Figure 4. Figure 5 shows that the lowest weft bending length was found for the derived twill fabric without interlining (A4) as 1.27 cm while the highest weft bending length was found for the rib fabric without interlining (A1) as 1.75 cm.

Figure 4 and 5 show that bending length values of fabrics with interlining were very high according to the fabric samples without interlining. Figure 4 shows that the highest warp bending length was found for the 2/2 twill fabric sample with interlining (A5) as 3.82 cm. Figure 5 shows that the highest weft bending length was found for the rib fabric sample with interlining (A1) as 4.30 cm.

The bending length is dependent on the fabric weight (Hu and Chan, 1998). The structural properties of the fabric such as density, weight and weave structure are the main factors affecting the stiffness of the fabric.

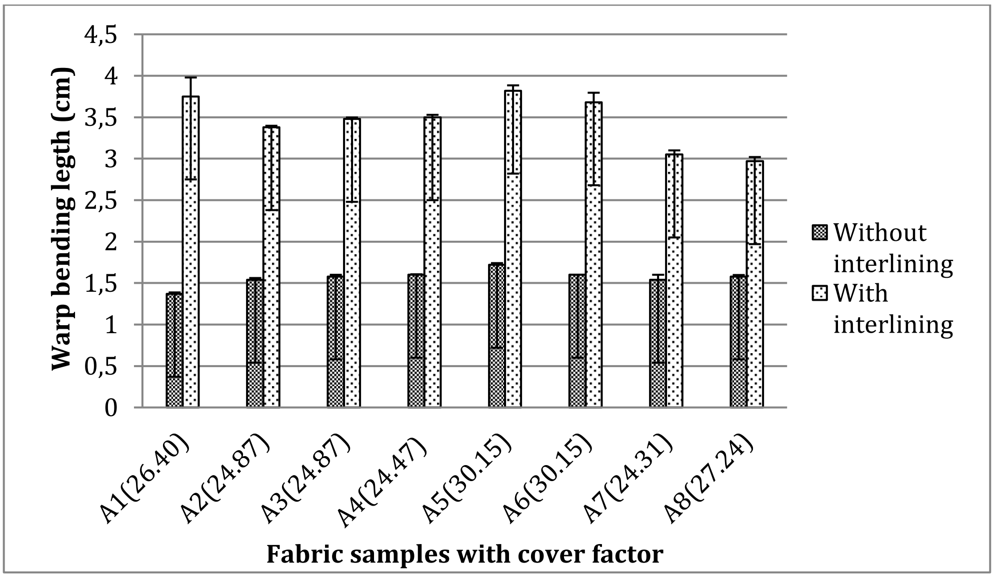

Figure 4:
Warp bending length results of fabrics without interlining and with interlining

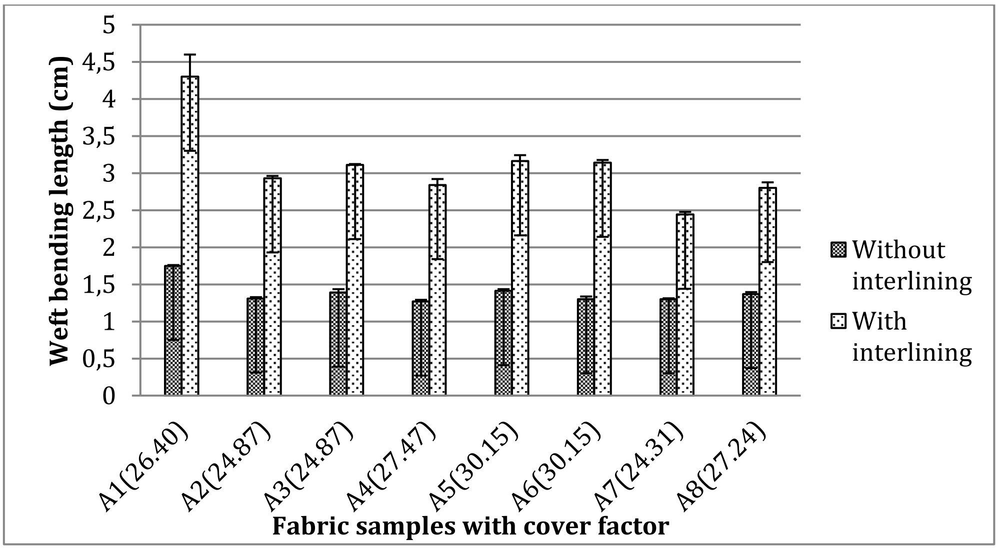

Figure 5:
Weft bending length results of fabrics without interlining and with interlining

Figure 6 shows that the highest warp flexural rigidity were found for the 2/2 twill fabric without interlining (A5) as 115 mg cm and lowest warp flexural rigidity were found for the rib fabric without interlining (A1) as 67.33 mg cm. Figure 7 shows that the highest weft flexural rigidity were found for the rib fabric without interlining (A1) as 140.17 mg cm and lowest weft flexural rigidity were found for the rib fabric without interlining (A4) as 43.63 mg cm.

Figure 6 and 7 show that flexural rigidity values of fabrics with interlining were very high according to the fabrics without interlining. Figure 6 shows that the highest warp flexural rigidity was measured for the rib fabric sample with interlining (A1) as 1924.8 mg cm. Figure 7 shows that the highest weft flexural rigidity was measured for the rib fabric with interlining (A1) as 2902 mg cm.

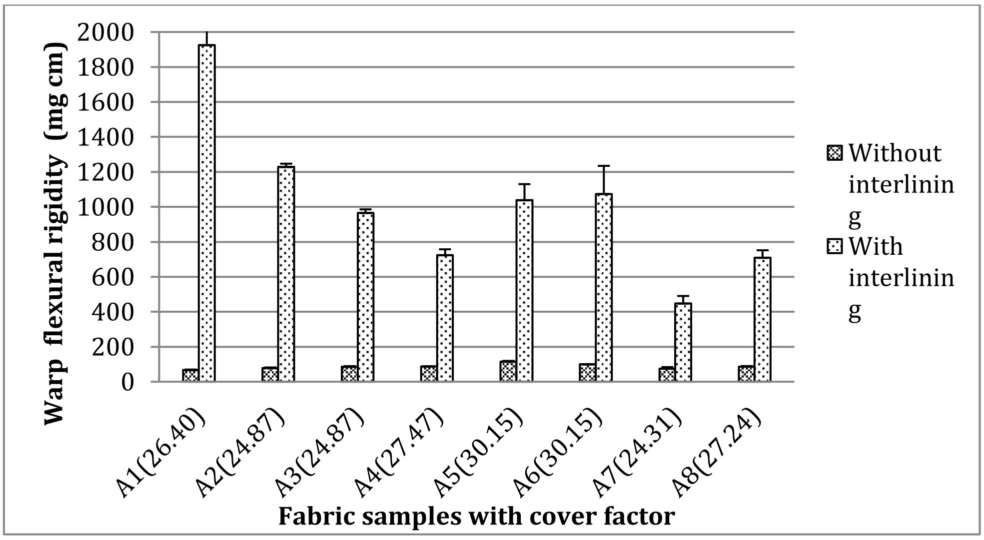

Figure 6:
Warp flexural rigidity results of fabrics without interlining and with interlining

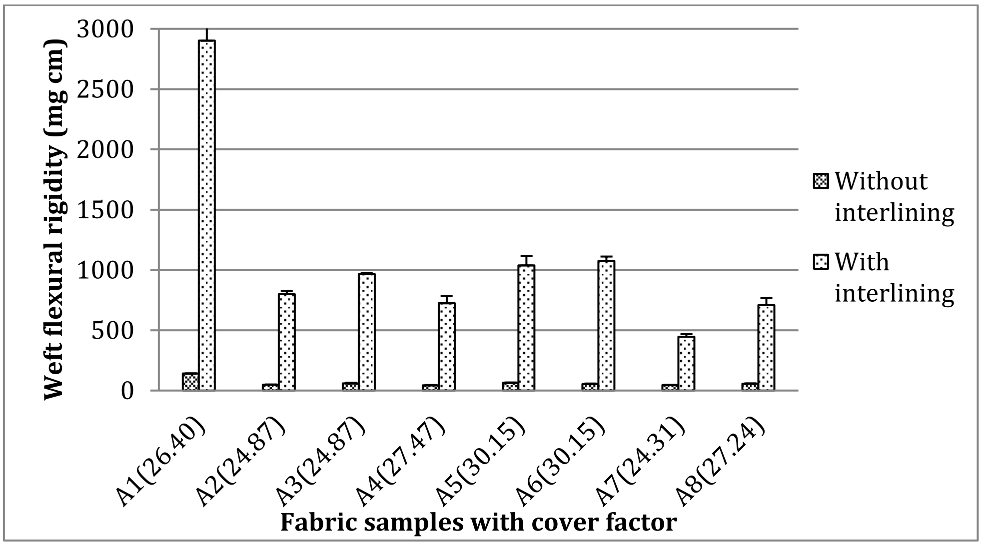

Figure 7:
Weft flexural rigidity results of fabrics without interlining and with interlining

Weight, thickness and cover factor are effective on the stiffness of the fabric. The stiffness of the thick fabric is always high. Figure 8 shows that the highest overall flexural rigidity was found for the rib fabric without interlining (A1) as 97 mg cm and lowest overall flexural rigidity was found for the derived twill fabric sample (A7) as 57.95 mg cm. Figure 6 and 7 show that flexural rigidity values of fabrics with interlining were very high according to the fabrics without interlining. Figure 8 shows that the highest overall flexural rigidity was found for the rib fabric with interlining (A1) as 2363.45 mg cm and lowest overall flexural rigidity was found for the derived twill fabric sample (A7) as 625.28 mg cm. The SNK results given in Table 2 showed that, warp and weft bending length, flexural rigidity and overall flexural rigidity of the fabrics both without interlining and with interlining (A1, A5 and A7) were significantly different from others. Table 5 shows that the overall rigidity has a strong positive correlation with weight and fabric cover factor.

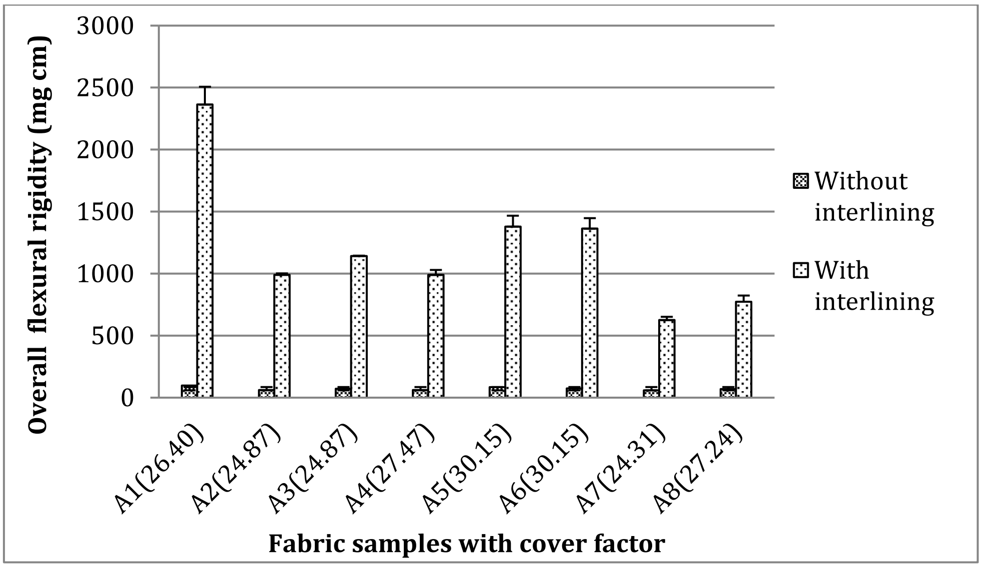

Figure 8:
Overall flexural rigidity results of fabrics without interlining and with interlining

Fabric cover factor is an important factor affecting stiffness. The highest stiffness values were obtained with fabric samples with highest cover factor (A1, A5 and A6) and lowest stiffness values were obtained with fabric samples with lowest cover factor (A2, A4 and A7). When the effect of cover factor on fabric stiffness was examined, it was seen that stiffness values increased as cover factor increased. Yarn count and density are important factors affecting fabric cover factor.

Table 2. Statistic analysis (ANOVA and SNK) results for stiffness test results of fabrics without interlining

Code	Bending Length (cm)				Flexural Rigidity (mg cm)				Over. Flexural Rigidity (mg cm)	
	Warp		Weft		Warp		Weft			
A1	.00*	1.37 a	.00*	1.75 c	.00*	67.38a	.00*	140.4e	.00*	97.28 d
A2		1.54 b		1.31 a		79.06b		48.34a		62.51 a
A3		1.58 b		1.39 b		86.01c		59.51c		70.63 b
A4		1.59 b		1.26 a		86.69c		43.30a		61.26 a
A5		1.71 c		1.41 b		114.3e		63.69d		85.29 c
A6		1.60 b		1.30 a		99.94d		53.68b		73.20 b
A7		1.54 b		1.30 a		75.58b		45.73a		58.72 a
A8		1.58 b		1.37 b		86.79c		57.01c		70.31 b

**:statistically significant (P < 0.05)*
(a),(b),(c),(d) and (e) represent the statistical difference ranges according to SNK test.

Table 3. Statistic analysis (ANOVA and SNK) results for stiffness results of fabrics with interlining

Code	Bending Length (cm)				Flexural Rigidity (mg cm)				Overall Flexural Rigidity (mg cm)	
	Warp		Weft		Warp		Weft			
A1	.00*	3.75 d	.00*	4.30 d	.00*	1939.2c	.00*	2943.7c	.00*	2362.0e
A2		3.38 b		2.93 b		1228.0 b		805.5 b		994.4 c
A3		3.48 b		3.11 c		1352.8 b		968.7 b		1144.8d
A4		3.50 b		2.84 b		1358.9b		724.9 b		991.8 c
A5		3.82 d		3.16 c		1839.7c		1042.8b		1385.0d
A6		3.68 c		3.14 c		1732.6c		1074.5b		1364.0e
A7		3.05 a		2.44 a		874.3 a		447.6 a		625.5 a
A8		2.97 a		2.80 b		846.6 a		715.1 a		777.9 b

**:statistically significant (P < 0.05)*
(a),(b),(c),(d) and (e) represent the statistical difference ranges according to SNK test.

3.2. Test Results of the Drape Coefficient (DC)

DC is a value used to determine the drapability of the fabric. A lower DC value means the fabric is softer, and its drapability is better and a higher DC value means the fabric is stiffer (Hu and Chan, 1998).

Drape coefficient (DC) test results of fabrics without interlining and with interlining are given in Figure 9. Figure 9 shows that the highest DC was found for the derived twill fabric without interlining (A5) as 62.72 % and lowest DC was found for the rib fabric without interlining (A1) as 48.92 %.

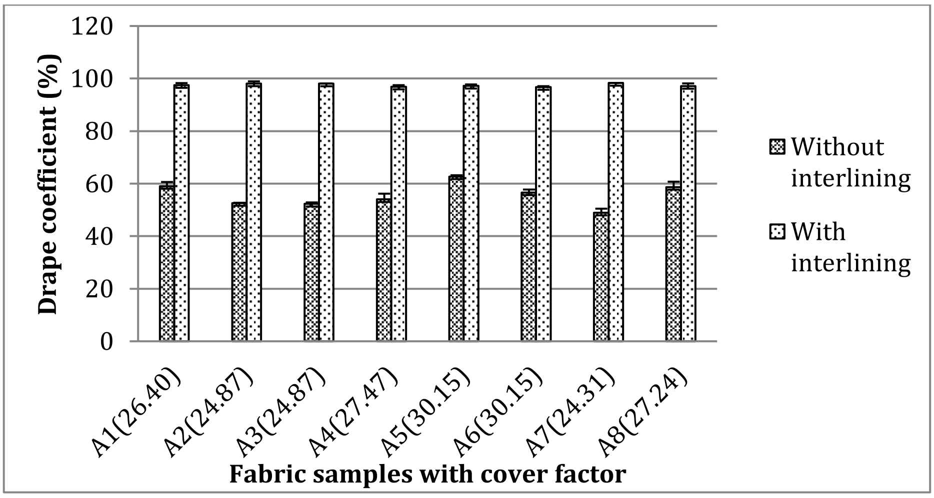

Figure 9:
Drape coefficient results of fabrics without interlining and with interlining

Figure 9 shows that drape coefficient values of fabrics with interlining were very high according to the fabrics without interlining. Figure 9 shows that the all the fabrics DC values up to 97 %. The interlining is making the fabric fuller and stiffer. The SNK results given in Table 4 showed that, DC of the rib fabric without interlining (A1) and 2/2 twill woven fabric without interlining (A5) were significantly different from others. The SNK test results given in Table 4 showed that, DC of the fabric sample with interlining doesn't statistically significant.

Increasing fabric drapability means decreasing fabric drape coefficient and overall rigidity. Table 5 shows that the DC has a strong positive correlation with weight and fabric cover factor. High fabric cover factor was found to decrease the drapability while increasing flexural rigidity and both correlations were strong. Increased cover factor increases the instability of fabric drape (Matusiak, 2017). All interlined fabrics had significantly higher drape coefficient than fabrics without interlining (Sanad and Caaidy, 2016).

Table 4. Statistic analysis (ANOVA and SNK) results for drapability results of fabrics without interlining and with interlining

Fabric Code	DC (%) of fabric without interlining		DC (%) of fabric with interlining	
A1	0.000*	59.08 c	0.059	97.47 a
A2		52.59 b		98.11 a
A3		52.30 b		96.60 a
A4		54.01 b		96.90 a
A5		62.72 d		97.19 a
A6		56.63 c		96.72 a
A7		48.92 a		98.46 a
A8		58.72 c		97.13 a

**:statistically significant (P < 0.05)*
(a),(b),(c) and (d) represent the statistical difference ranges according to SNK test.

Table 5. Correlation coefficient between structural properties and overall rigidity and drape coefficient results of fabrics without interlining and with interlining

	Fabric without interlining		Fabric with interlining	
	Overall Rigidity (mg cm)	Drape Coefficient (%)	Overall Rigidity (mg cm)	Drape Coefficient (%)
Weight	**0.863**	**0.572**	**0.884**	-0.296
Cover Factor	**0.414**	**0.764**	0.266	-0.875

Fabric cover factor is an important factor affecting drape coefficient. The highest drape coefficient values were obtained with fabric samples with highest cover factor (A1, A5 and A6) and lowest drape coefficient values were obtained with fabric samples with lowest cover factor (A2, A4 and A7). Yarn count and density are important factors affecting fabric cover factor.

4. CONCLUSION

Fusible interlining is a woven, knitted or non-woven thin fabric that is bonded between two layers of fabric in certain areas of the garment. Using fusible interlining on some parts of the garment can give durability to the garment and at the same time facilitate sewing.

In recent years, woollen woven fabrics are preferred in clothing industry. Men’s and women’s jacket, coat and trousers are usually made of woollen fabric due to their excellent comfort. Fabric structural properties like density, weight, weave structure and thickness are effective on stiffness and drapability properties of fabric. Fabric drapability and stiffness are effective on the aesthetic appearance of the apparel. Weight and cover factor are effective on the stiffness of the fabric.

Interlining is a support fabric used in areas where stability is required. Interlining is generally used in collars, cuffs, waistbands, closures, and sometimes hems. In woollen coat, suit or jacket tailoring, sleeve holes, upper back, collars, patch, lapels and pocket flaps are the areas to apply interlining.

In this study, the effect of fusible interlining on stiffness and drapability of woollen woven fabrics with different structural properties were investigated. Adding interlining some parts of the garments effect the drapability and stiffness of the garment. Increasing fabric drapability means decreasing DC and overall rigidity of fabric.

Statistical analysis was also conducted to identify relationships among the weight, thickness, cover factor and stiffness and drapability properties of fabrics without interlining and fabrics with interlining. It is observed that DC and overall rigidity have very strong correlation with weight and cover factor of wool fabrics without interlining and with interlining. It is also observed that the bonding fusible interlining to the fabric increased the stiffness and drapability of the fabric.

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REFERENCES

1. Amar, Z. and Al-Gamal, G. (2015) Effect of different types and orientations of fusible interlinings on men striped shirt cuffs, *Journal of American Science*, 11(3), 66-72.

2. ASTM D 3776-09a (2017) Standard Test Method for Mass per Unit Area of Fabrics, Annual Book of ASTM Standard, USA.

3. ASTM D 3775-17 (2017) Standard Test Method for End and Pick Count of Woven Fabrics, Annual Book of ASTM Standard, USA.

4. ASTM D 1388-64 (2002) Standard Test Methods for Stiffness of Fabrics, Annual Book of ASTM Standard, USA.

5. Cheng, K.P.S. How, Y.L. and Yick, K.L. (1996) The application of fabric objective measurement in shirt manufacture. *International of Clothing Science and Technology*, 8(4), 44-64. doi.org/10.1108/09556229610124008

6. Chung, J. (1999) The effect of assembly methods of a garment on fabric drape. PhD Thesis, Institute of Textiles and Clothing. The Hong Kong Polytechnic University.

7. Fan, J, Yu, W. and Hunter, L. (2004) *Clothing Appearance and Fit: Science and Technology*, Woodhead Publishing, England.

8. Gurarda, A. (2009) The effects of seam parameters on the stiffness of woven fabrics. *Journal of Textile & Clothing*, 19(3), 242-247.

9. Hu, J. (2008). Fabric Testing, *The Textile Institute*, England.

10. Hu J. Chung S. and Lo M.T. (1997) Effect of seams on fabric drape. *Int. Journal of Clothing Science and Technology,* 9(3), 220-227. doi: 10.1108/09556229710168351

11. Hu J. and Chan Y.F. (1998) Effect of fabric mechanical properties on drape, *Textile Research Journal*, 68 (1), 57- 64. doi.org/10.1177/004051759806800107

12. ISO 9073-9. (2008). Textiles-Test Methods for Nonwovens-Part 9: Determination of Drapability Including Drape Coefficient.

13. Kenkare, N. and Plumlee-May, T. (2005) Fabric drape measurement: a modified method using digital ımage processing, *Journal of Textile and Apparel Technology and Management*, 4(3), 1-8.

14. Kim, KO., Inui, S. and Takatera, M. (2011) Verification of prediction for bending rigidity of woven fabric laminated with interlining by adhesive bonding, *Textile Research Journal*, 81(6), 598-607. doi: 10.1177/0040517510387212

15. Kim, KO., Sonahara, S. and Takatera, M. (2015) Quantifying the appearance of jackets with adhesive interlinings, *International Journal of Clothing Science and Technology*, 28(1), 18-35.

16. Matusiak, M. (2017) Influence of the structural parameters of woven fabrics on their drapeability, *Fibres & Textiles in Eastern Europe*, 25,1(121), 56-64. doi: 10.5604/12303666.1227883

17. Peirce, F.T. (1937) Cloth Geometry, *Journal of the Textile Institute*, 28(3), 45-96.

18. Qian, Z., Cheekooi, C. and Wai, K.C. (2016) The coefficient analysis between interlining physical properties and low-stress mechanical properties in terms of fusible interlinings and woolen fabric bonded interlinings, *International Journal of Advances in Science and Technology*, 4 (4), 20-23.

19. Sanad, R.A. and Cassidy, T. (2016) *Fabric objective measurement and drape*, Textile Progress, 47(4), 317-406.

20. Sharma, K.R., Behera, B.K., Roedel, H. and Schenk, A. (2004). Fabric low-stress mechanical properties and drapability. *Indian Journal of Fibre & Textile Research*, 29, 57-61.

21. Seram, N. and Rupasinghe, W.(2013) The Influence of Bending Rigidity on Drape Coefficient of Selected Light Weight Woven Fabrics With Seams. *International Journal of General Engineering and Technology*, 2(1), 25-32.

22. https://sdlatlas.com/products/fabric-stiffness-tester (Accessed : 31.11.2019)

23. TS 1409, Turkish Standard (1973) Stiffness Determination of Woven Textiles.

24. Yükselkaya, M.E., Howard, T. and Adanur, S. (2008) Influence of the fabric properties on fabric stiffness for the ındustrial fabrics, *Textile and Apparel*, 18 (4), 263-267.