Çukurova Üniversitesi Mühendislik Fakültesi Dergisi, 37(3), ss. 803-812, Eylül 2022
Cukurova University Journal of the Faculty of Engineering, 37(3), pp. 803-812, September 2022

An Experimental Study on Comparison of Selected Performance Properties of Soybean and Cotton Knitted Fabrics

G. Banu GÖKGÖNÜL[*1] **ORCID** *0000-0002-5297-1592*
Emel Ceyhun SABIR[1] **ORCID** *0000-0002-2385-1524*

[1]*Çukurova University, Engeneering Faculty, Textile Engineering Department, Adana*

Geliş tarihi: 03.01.2022 Kabul tarihi: 23.09.2022

Atıf şekli/ How to cite: GÖKGÖNÜL, G.B., SABIR, E.C., (2022). An Experimental Study on Comparison of Selected Performance Properties of Soybean and Cotton Knitted Fabrics. Çukurova Üniversitesi, Mühendislik Fakültesi Dergisi, 37(3), 803-812.

Abstract

In this study, 100% soybean and 100% cotton suprem and pique knitted fabrics were produced. Quality performance parameters, color fastness and spectrophotometric color results of the knitted fabrics were compared. The aim of the study is to reveal the advantages and weaknesses of soybean knitted fabrics compared to cotton knitted fabrics. When the production and test results are examined, soybean fabrics are softer than cotton fabrics. Knitted pique 100% soybean protein fiber fabrics dimensional change is worse than 100% cotton. Air permeability of fabrics made from soybean fiber is better than cotton fabrics therefore it can be provided thermal comfort conditions. Bursting strength of soybean fabrics is as good as cotton fabrics. In the color fastness tests, the fastness values of the soybean fabrics were found to be high and wet rubbing fastness is good. As a result of this study, it was seen that the color fastness, softness, abrasion resistance, air permeability of the soybean knitted were better than cotton fabrics. Soybean fabrics were found to be more pilling than cotton fabrics. When the results of the research are examined, 100% soybean fabrics can be used instead of cotton fabrics.

Keywords: Soybean fiber, Cotton, Knitted fabric, Comfort, Quality tests, Colour measurements

Soya ve Pamuklu Örme Kumaşların Seçilen Performans Özelliklerinin Karşılaştırılması Üzerine Deneysel Bir Çalışma

Öz

Bu çalışmada %100 soya ve %100 pamuklu süprem ve pike örme kumaşlar üretilmiştir. Örme kumaşların kalite performans parametreleri, renk haslıkları ve spektrofotometrik renk sonuçları karşılaştırılmıştır. Çalışmanın amacı, soya fasulyesi örme kumaşların pamuklu örme kumaşlara göre avantaj ve dezavantajlarını ortaya koymaktır. Üretim ve test sonuçları incelendiğinde soya kumaşlarının pamuklu

[*]Corresponding author (Sorumlu yazar): G. Banu GÖKGÖNÜL, *bgokgonul@gmail.com*

kumaşlara göre daha yumuşak olduğu görülmektedir. Örme pike %100 soya proteini lifli kumaşlarda boyut değişimi %100 pamuktan daha kötüdür. Soya lifinden yapılan kumaşların hava geçirgenliği pamuklu kumaşlara göre daha iyidir, bu nedenle termal konfor koşulları sağlanabilir. Soya kumaşlarının patlama mukavemeti, pamuklu kumaşlar kadar iyidir. Renk haslığı testlerinde soya kumaşlarının haslık değerlerinin yüksek olduğu ve ıslak sürtme haslıklarının iyi olduğu tespit edilmiştir. Bu çalışma sonucunda, soya örme kumaşların renk haslığı, yumuşaklık, aşınma direnci, hava geçirgenliğinin pamuklu kumaşlara göre daha iyi olduğu görülmüştür. Soya fasulyesi kumaşlarda, pamuklu kumaşlara göre daha fazla boncuklanma olduğu tespit edilmiştir. Araştırmanın sonuçları incelendiğinde, pamuklu kumaşlar yerine %100 soya kumaşları kullanılabilir.

Anahtar Kelimeler: Soya lifi, Pamuk, Örme kumaş, Konfor, Kalite testleri, Renk ölçümleri

1. INTRODUCTION

Soybean fiber is a herbal protein fiber. Which has a protective property for human skin. Because of softness, comfort and brightness properties, Soybean protein fiber (SPF) is named for 'skin to skin'. The most important properties of SPF fabrics are as follows: excellent softness, luster, similarity of cashmere, air permeability (comfort), high resistance to acid, alkali and ultraviolet. This fiber resistant for bacteria e-coli, staphilococus, candida and albicana. For skin contact when comparison of herbal protein and animal protein, herbal protein havent any side effect and usefull for human body [1]. Some garments that obtained from SPF are used in underwear, towel, knitting and outdoor clothing.

Wool and silk are commonly used as protein fibers. Wool and silk have good phisical properties but their product process is expensive. There must be very mulberry tree efor requirement of silk production and also wool and silk performance features are limitted. Wool's surface is available for peeling and dieing wool is hard. Besides, regenerated protein fibers and soybean protein fibers can extruded which wanted theoric limitted. Production of SPF, competitive for textile industry. Oil prices increase 21 times in fifty years, soybean protein fibers increase 6.5 times. Another advantage is soybean protein have high protetein rate. Soybean have 40% protein, peanut have 25% protein and corn have 10% protein. Soybean protein is eco-friendly [2].

Li-Yi showed that soybean protein fibers are healty and comfotable, the fiber is new and popular in 21th Century, tecnolocically advanced in soybean fiber production in China. Most of its production provides from China [3]. Vynias showed SPF's morpholocig structure, all product stages and chemical [2]. Rijavec and Zuplin showed detail of soybean protein fibers chemicaly structure and fibers product stages [4]. Avcı has been compared the comfort properies of finished socks produced from new fibers and also applied comfort tests by producing socks of comfort tests by producing socks of different fibers such as modal, bamboo and soybean. The researcher has stated soybean water behavior similar to repellent fibers [5]. Ünal compared the performance and comfort properties of fabrics made from soybean and organic cotton yarns and showed that its airpermability of soybean protein fiber is better than cotton and its thermal condunctivity lower than cotton [6]. Pampal produced yarns in different blends from soybean fiber and bamboo, cotton, polyamide, acrilic and viscose and evaluated the performance caracteristics of knitted fabrics from this fibers. At the end of the this work, using %100 soybean yarn less using mixed soybean yarn. Mixed soybean yarn suitable than pure soybean yarn for yarn and fabric properties [7]. Perincek when new generation fibres prefinishing use ecofriendly method and while using different pre-finishing methods, chose most suitable method. Most suitable method detected for yellowness and brighteness for soybean [8]. Yıldırım et al. research SPF's general structure, product and enviremental factors. The researcers give

information about SPF'S biodegradable, renewable and sustinable properties advantages and using area [9]. Yılmaz compare SPF and other fibers and it have got superior fature similar natural fibers [10]. In their study, Öner and Okur examined the comfort properties such as air permeability, thermal resistance and water vapor permeability of fabrics knitted from soybean, 50%-50% cotton/coolmax, tencel, viscose and polyester. In the study, it was revealed that soybean fiber knitted fabrics have good breathability, high thermal resistance and good water vapor permeability, and will be effective in use in cold weather conditions, but are not suitable for sportswear in hot weather [11].

In the studies of Matusiak and Kamińska, comfort properties such as water vapor permeability and liquid moisture transport of SPF fabrics were investigated. In the research, it was found that the fabrics made of 100% SPFs have liquid moisture carrying ability significantly better than cotton, viscose and Dacron Coolmax fabrics [12]. Kavuşturan, Çeven and Özdemir tencel, bamboo, modal, soybean, 50/50% soybean-tencel, viscose and cotton They produced knitted fabric from core yarn with polyester and viscose and chenille yarns. They showed that 50% soybean 50% tencel can be used as chenille fabrics [13].

In their study, Ciukas et al. conducted experimental research on socks to determine the thermal properties of cotton, bamboo and soybean protein fibers. They emphasized in their studies that socks covered with (Lycra®) should be used for the cold season, since knitted fabrics made from pure cotton, soybean, bamboo yarns and covered with Lycra yarn have a lower thermal conductivity coefficient and feel more comfortable during clothing [14]. In their study in Abramaviciute et al., they conducted air permeability analysis on knitted fabrics produced from bamboo, soybean, cotton/seacell, bamboo/linen yarns to investigate the static water absorption comfort feature of knitted fabrics produced from natural and textured yarns. They concluded that an increase in the thickness and density of bamboo and soybean fabric worsened the water absorption feature [15].

Zhang et al.'s study examined the thermal-wet states of different hydrophilic fiber such as cotton, soybean, wool, modal, bamboo t-shirts in a heavy exercise environment. Cotton and wool are natural hydrophilic fibers, and regenerated fibers have been found to have better thermal and moisture comfort than the other fibers. Products made of bamboo, soybean and modal fibers gave a warmer and moist feel. Bamboo has a cooler feeling. The study revealed that different fibers should be used in different parts of knitted clothes worn during exercise [16].

Ekinci has designed eight different non-woven surface fabrics containing soybean and cotton fibers, and designed the fabrics to be ADL (Acquisition-Distribution Layer), the diaper/diaper used in hygiene textile [17]. On non-woven surfaces; Soybean and cotton were used as the carrier fibers, 6 denier thickness and 64 mm long bicomponent polyethylene)/polyester and bicomponent polyethylene/modified polyester fibers were used as binder fiber. Soybean and cotton were used separately with polyethylene/polyester in different proportions. The samples were applied performance tests for diapers/diapers, and it was observed that the samples containing soybean fiber were more resistant in wet form. The best values for the strength results in the width direction of the machine; obtained from dry /wet soybean /polyethylene/modified polyester samples. The best results in liquid transfer rate, wetting and dryness values were shown by soybean/ polyethylene/polyester samples. The results showed that the performance of the transfer of soybean fiber from the upper surface to the absorbent surface in the baby/ diaper in hygiene textile was at a high level [17].

In this study, dyeing of knitted fabrics produced from 24/1 soybean protein yarn was analyzed. Soybean kniitted fabric was compared with the knitted cotton fabric of the same structure. It is

aimed to contribute to the literature about dyeing and performance properties of fabrics made from soybean protein fibers by the study.

2. MATERIAL and METHOD

2.1. Material

Experimental study 24/1 Ne yarn number, twisting coefficient (α) 3.6 with 100% soybean protein fiber yarn made of (HAYTEKS AS/Turkey for soybean fiber) were used. Two different types of knitted fabrics were made with this yarn as pique and jersey. In order to determine the advantageous and disadvantageous aspects of soybean protein fiber, 100% cotton yarn of the same number and pique and jersey knitted fabric were also produced. The conditions of the knitting machine were kept the same for two separate materials. Knitted fabrics, pre-finishing, dyeing and finishing processes are applied. Figure 1 shows the finished knitted fabrics produced.

Table 1. The finished knitting fabric analize

Knitting analize	Soybean		Cotton	
	Suprem	Pique	Suprem	Pique
Number of stitches (piece/10 cm)	123	126	137	106
Verticle trick (piece/10 cm)	178	116	173	158
Stitch length (mm)	3	4	3	4

2.2. Method

Standard performance tests were carried out to determine the performance characteristics of sample knitted fabrics. Table 2 shows these tests.

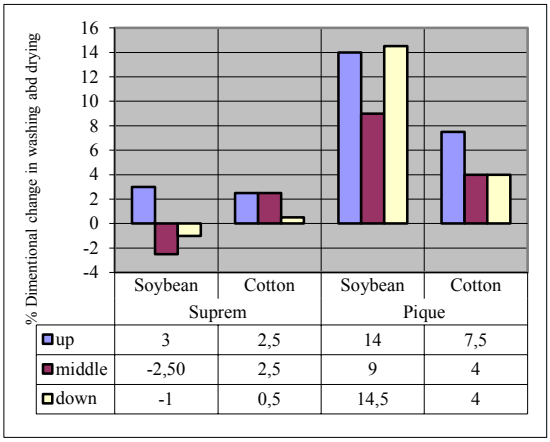
Table 2. Tests used in experimental study

No	Tests	Standards [18]
1	Knitted fabrics - Determination of number of stitches per unit length and unit area	TS EN 14971
2	Fabrics- Determination of mass per unit area using small samples	TS EN 12127
3	Determination of dimensional change in washing and drying	TS EN ISO 5077
4	Absorbency of Bleached Cotton Textile Materials	TS 866
5	Determination of permeability of fabrics to air	TS 391 EN ISO 9237
6	Tests for colour fastness - Part E04: Colour fastness to perspiration	TS EN ISO 105-E04
7	Tests for colour fastness - Part C09: Colour fastness to domestic and commercial laundering - Oxidative bleach response using a non-phosphate reference detergent incorporating a low temperature bleach activator	TS EN ISO 105-C09/A1
8	Tests for colour fastness - Part X12: Colour fastness to rubbing	TS EN ISO 105-X12
9	Tests for colour fastness - Part E01: Colour fastness to water	TS EN ISO 105-E01
10	Bursting properties of fabrics- Part 2: Pneumatic method for determination of bursting strength and bursting distension	TS EN ISO 13938:2
11	Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure	ASTM D 4032-94
12	Determination of the abrasion resistance of fabrics by the Martindale method - Part 3: Determination of mass loss	TS EN ISO 12947-3/AC
13	Determination of fabric propensity to surface fuzzing and to pilling- Part 2: Modified Martindale method	TS EN ISO 12945-2

3. RESULTS AND DISCUSSION

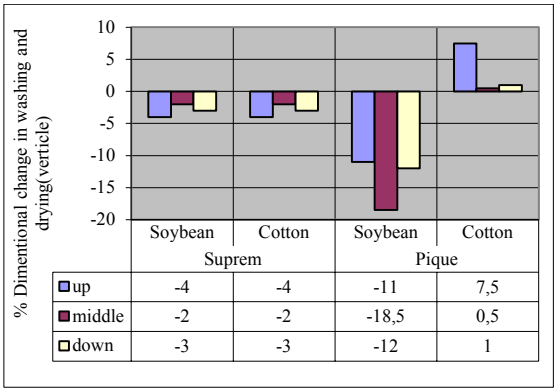
3.1. Dimensional Change in Washing and Drying

The results of the test results of the end-of-wash dimension change in the transverse direction of the knitted fabrics are given in Figure 1 and the results of the wash-end size change test in the longitudinal direction are given in Figure 2. In these tests, it is noteworthy that the size changes of the soybean pique samples in transverse and longitudinal directions are more than ± 3, which is the acceptable limit value.



	Soybean Suprem	Cotton Suprem	Soybean Pique	Cotton Pique
up	3	2,5	14	7,5
middle	-2,50	2,5	9	4
down	-1	0,5	14,5	4

Figure 1. Dimensional changes of the samples in washing and drying (direction of horizontal)



	Soybean Suprem	Cotton Suprem	Soybean Pique	Cotton Pique
up	-4	-4	-11	7,5
middle	-2	-2	-18,5	0,5
down	-3	-3	-12	1

Figure 2. Dimnsional changes of the samples in washing and drying(direction of verticle)

In the transverse direction, the soybean pique fabric showed elongation while the longitudinal direction was observed. Cotton samples of the same weave are observed to have a size change (creep) above the standard. Both soybean and cotton samples have changed size in acceptable porosity. With this experiment, it was concluded that soybean pique knitted fabric would exhibit non-standard dimensional change in house type washing.

3.2. Air Permeability

Figure 3 shows the air permeability test results considered as a comfort parameter. As a result of this test, it was observed that the air permeability of soybean fabrics was better (higher value) than cotton fabrics. It is seen that pique knitted fabrics have more air permability. Statistical analysis revealed that both the raw material and the porosity type affected the air permeability value (*significance value* = 0).

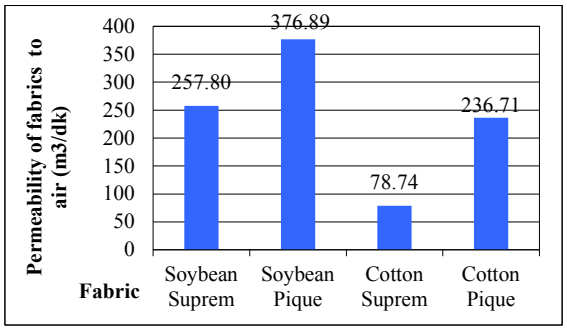


Figure 3. Air permeability of the fabrics

3.3. Bursting Strength

The bursting strength test results, which means that the fabric is drilled under air pressure, are given in Figure 4. High bursting strength values indicate high resistance. When the bursting strength of pique fabric is examined, it is seen that different results are obtained in soybean and cotton raw material use. Statistical analysis shows that the raw material variable efected bursting strecth (*significance coefficient* = 0.012). Again according to the statistical analysis, the cotton / cotton pique porosity structure also has a significant difference in bursting.

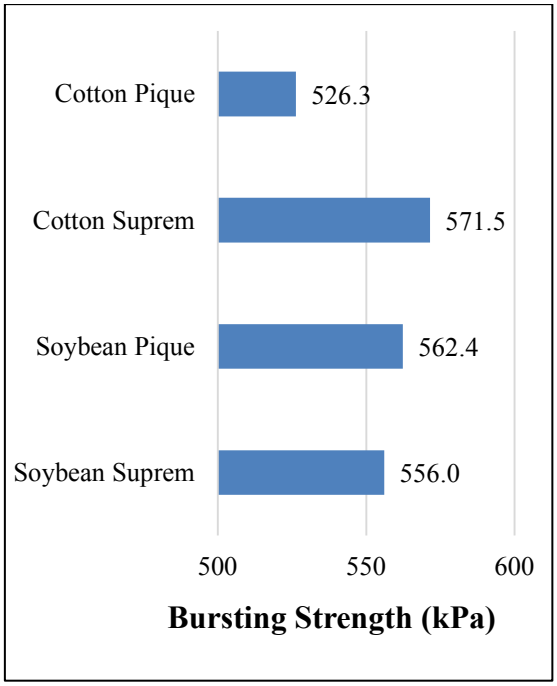


Figure 4. Bursting strength test results of the samples

3.4. Water Absorbency Performance

Figure 5 shows the water absorbency performance of fabrics. This value is high means that water absorption takes a long time. Soybean suprem and pique samples have a longer lasting water absorbency compared to cotton and pique samples. This test is not enough to evaluate this feature as good or bad. Further testing on dehumidification is required. In addition, this test is generally applied for cotton samples. The water absorbency performance of a new fiber, soybean fiber, was also measured by this test. It was also found that the difference in raw material effected the water absorption time with the statistical analysis (soybean suprem/cotton supreme sig. coeff = 0.002 and soybean pique/cotton pique sig. coeff.= 0). The study of Gretha et all. was investigated that three different counts of spun soybean yarn were utilized for knitted fabric production, such as 20 Ne,30SNe, and 40Ne.^{o} Gretha et all. show that the single pique structure with finer yarn count and higher loop length configuration showed higher moisture management properties [19].

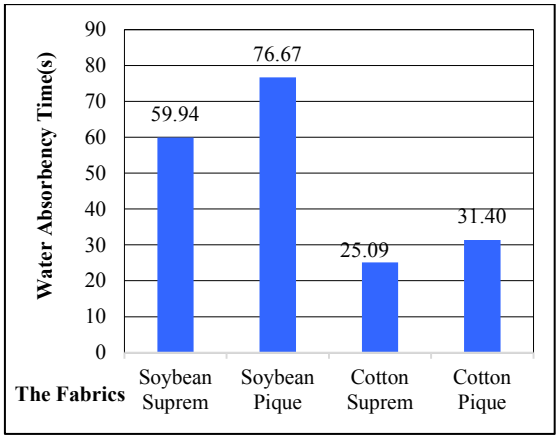


Figure 5. Water absorbency test results of the fabrics

3.5. Flexural Strength (Stiffness)

Flexural strength test is used to evaluate the softness or hardness of the fabrics. The high strength value is interpreted as the hardness of the fabric. Figure 6 shows the circular flexural strength test results. There is no difference in the fact that there is no difference in soybean or cotton in suprem knitting. However, soybean and cotton samples in pique knitting vary in terms of hardness (soybean pique/cotton pique *statistical significance coefficient* = 0.017). When we look at pique samples, it is seen that cotton has a harder fabric structure and soybean has a softer fabric structure than cotton.

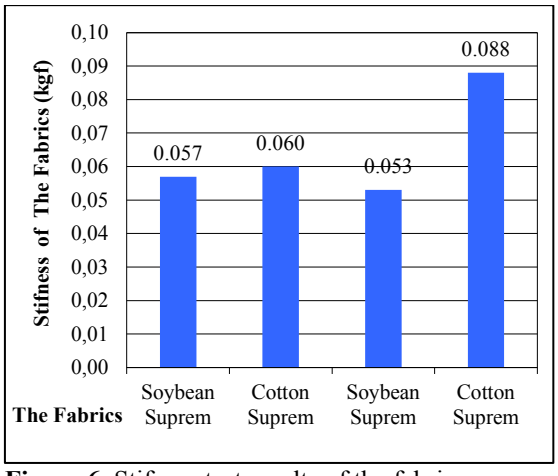


Figure 6. Stifness test results of the fabrics

Pilling

The pilling values of soybean and cotton knitted fabrics are graded with a gray scale at the end of 2500 cycles obtained by using of Martindale device. When the measurement results in Table 3 are examined, it has been determined that soybean knit fabric hair growth is higher than cotton.

Table 3. Pilling on surface of the fabrics (Martindale method)

Surfaze fuzzing and pilling (after 2500 period)			
Soybean suprem	Soybean pique	Cotton suprem	Cotton pique
1/2	1/2	2/3	3/4

3.6. Abrasion Resistance

Figure 7 shows proportionally the mass loss in the fabrics against abrasion. This high value means that the fabric has suffered a loss of mass under a force and impact. Soybeana suprema and pique samples lost less mass than abrasion and cotton samples. So soybean fabrics have better wear resistance than cotton. The difference in the raw material difference was also determined by the statistical analysis (*mass difference coefficient* = 0.019 and soybean pique/cotton pique = 0.02). According to the statistical analysis, the change in weave is a parameter that affects the mass loss (cotton supreme/cotton pique *significance coefficient*=0.004 and soybean supreme/soybean *pique significance coefficient*=0.043). This analysis showed that the abrasion resistance of soybean fabric was higher than that of cotton.

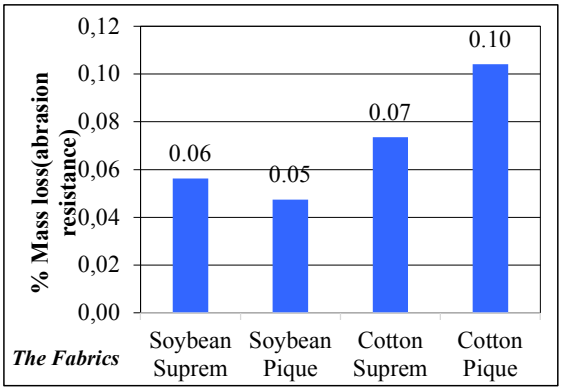


Figure 7. Abrasion resistance of the fabrics by Martindale method (after 15000 period)

3.7. Color Fastnesses

The results of color fastness tests are given in Table 4. For both cotton and soybean fabrics, the acidic and basic sweat fastness values were approximately the same and the fastness values were good. When washing fastness is examined; similar to the perspiration fastness for soybean and cotton, good fastness values were obtained. Similar results were found for soybean and cotton in water holding fastness.

Table 4. Color fastness test results of the fabrics (From A to E)

A) Colour fastness to alkaline perspiration

Fabrics	Wool	Acrylic	PES	Nylon	Cotton	Acetate	Fading
Soybean suprem	5	5	5	5	4/5	5	4/5
Soybean pique	5	5	5	5	4/5	5	4/5
Cotton suprem	5	5	5	5	4/5	5	4/5
Cotton pique	5	5	5	5	4/5	5	4/5

B) Colour fastness to acidic perspiration

Fabrics	Wool	Acrylic	PES	Nylon	Cotton	Acetate	Fading
Soybean suprem	5	5	5	5	4/5	5	5
Soybean pique	5	5	5	4/5	4/5	5	5
Cotton suprem	5	5	5	5	5	5	5
Cotton pique	5	5	5	5	5	5	5

C) Colour fastness to domestic and commercial laundering

Fabrics	Wool	Acrylic	PES	Nylon	Cotton	Acetate	Fading
Soybean suprem	5	5	5	5	4	5	5
Soybean pique	5	4/5	5	5	4	5	4/5
Cotton suprem	5	5	5	5	3/4	5	5
Cotton pique	5	5	5	5	3/4	5	5

D) Colour fastness to water

Fabrics	Wool	Acrylic	PES	Nylon	Cotton	Acetate	Fading
Soybean suprem	5	4/5	4/5	4/5	4	5	5
Soybean pique	5	4/5	5	4/5	3/4	5	5
Cotton suprem	5	4/5	5	4/5	3/4	5	5
Cotton pique	5	4/5	4/5	4/5	3/4	5	5

E) Colour fastness to rubbing

Fabrics	Dry	Wet
Soybean suprem	4/5	3/4
Soybean pique	4/5	3/4
Cotton suprem	4/5	4/5
Cotton pique	4/5	4/5

In the experiments, good fastness values were obtained except that the fabrics contaminated the cotton in the accompanying diaper. Cotton fabric has worse wet rubbing fastness than soybean fabric.

Colour analysis by spectrophotometer

Soybean and cotton knitted fabrics dyed in the same bath and with the same recipe were studied in the spectrophotometer and the measurement results in Table 5 were obtained (D65 in daylight). Cotton pique fabric was selected as the control sample and compared with Soybean pique fabric and ΔE:11.570 was obtained. By spectrophotometer; the sample was interpreted as lighter, greener, more blue. The smaller the ΔE value is interpreted as the lower the color difference.

Since the colors of the raw materials are different even after pretreatment, there is a color difference between the colored fabrics obtained in soybean and cotton. Soybean fiber has a unique yellow color and does not be bleached as much as desired. Thus, the color of soybean and cotton fabrics at the end of the dyeing resulted in a difference due to this yellowing on the ground. Due to the high ΔE value in spectrophotometric measurements, new measurements have been made about this difference and it has been tried to determine whether this difference is related to bleaching.

Table 5. Colour measurement results of spectrophotometer

The Fabrics							
Cotton suprem		**Cotton pique**		**Soybean suprem**		**Soybean pique**	
D65/10							
X	17.65	X	17.31	X	17.3	X	16.51
Y	9.99	Y	9.7	Y	10.51	Y	9.94
Z	3.36	Z	3.11	Z	5.44	Z	4.98
CIELab D65/10							
L*	37.82	L*	37.29	L*	38.75	L*	37.73
a*	53.5	a*	53.95	a*	47.61	a*	47.65
b*	29.74	b*	30.46	b*	20.38	b*	20.77
C*	61.21	C*	61.96	C*	51.79	C*	51.98
h	29.07	h	29.45	h	23.17	h	23.55

The color difference of the knitted fabrics before and after bleaching was measured and the results are given in Table 6. Here, the sample before the bleaching (raw) was taken as a control sample. It is observed that the schedule bleaching process is not effective in soybean fabric.

Table 6. Colour diference of soybean and cotton fabrics (compared before bleaching and after bleaching)

Bleached sample	The difference before bleaching and after bleaching, ΔE
Soybean pique	0,92
Cotton pique	9,14

The color differences of both soybean and cotton fabrics after bleaching were measured and compared. The aim of this measurement is to measure the color difference between the bleached cotton fabric and the bleacehed soybean fabric. Cotton bleached fabric was selected as the control sample. The color difference between cotton fabrics and soybean fabrics after dyeing was found as ΔE = 11.570. Before painting from Table 7, it was found that the color difference was large when it was still bleached (around ΔE = 15). This result shows that the bleaching process is not successful in soybean fabrics.

Table 7. Color difference of soybean sample from cotton sample (bleached both fibers)

Bleached sample	ΔE
Soybean suprem	15,01
Soybean pique	15,06

4. CONCLUSION

In this study, pure soybean knitted fabrics compare with pure cotton knitted fabrics. The findings are summarized below. These findings should be interpreted according to the raw material and production techniques mentioned in the material and method section.

- In the dimensional change, the values of 100% soybean protein fiber and knitted pique fabrics were above the standard.
- Air permeability of fabrics made from soybean fiber is better than cotton fabrics. Therefore, it can provide thermal comfort conditions.
- Bursting strength of soybean fabrics is as good as cotton fabrics.
- The water absorption rate of soybean fabrics is slower than cotton fabrics. Cotton fabric is aproximately better %60 then soybean fabric. (negative for comfort).
- Soybean fabrics are softer than cotton fabrics.
- Soybean fabrics are more pilling than cotton fabrics. Soft fabrics have a high tendency to pilling. Wear resistance of soybean fabrics was found to be better than cotton fabrics.
- In the color fastness tests, the fastness values of the soybean fabrics were found to be high and wet rubbing fastness is good.
- The color difference between soybean fabrics and cotton fabrics before and after the bleaching process is also high.

As a result of this study, it has been demonstrated that soybean protein fiber, a renewable, biodegradable fiber, can be used as an alternative to cotton fabrics. It can be preferred as a product in areas where cotton fabrics are used.

5. ACKNOWLEDGE

This study was supported by the Scientific Research Projects Unit of Çukurova University (Project code: FYL-2016-645).

Nomenclature;
L : colour darkness, lightness
a :axis of green,red
b : axis of blue,yellow
C :croma
h : hue angle X,Y,Z numerical value of color (redness, greens, yellowness)

6. REFERENCES

1. https://www.swicofil.com/commerce/products/soybean/152/introduction (Last Access: Sept. 2021).
2. Vynias, D., 2006. Soybean Fibre: A Novel Fibre in the Textile Industry, 12(2), 461-490, www.intechopen.com.
3. Li, Y.Y., 2004. The Soybean Protein Fibre – A Healthy & Comfortable Fibre for the 21st Century. Fibres & Textiles in Eastern Europe; 12(2), 8-9.

4. Rijavec, T., Zupin, Z., 2011. Soybean Protein Fibres (SPF), Researchgate [serial online]; Chapter 23th in book: 501-522. (DOI: 10.5772/19614).

5. Avcı, H., 2007. Yeni Liflerden Mamul Çorapların Konfor Özellikleri. İstanbul Technical University, Deptartment of Textile Engineering, Master Thesis (In Turkish). Turkey, 81.

6. Ünal, Z., 2010. Investigation of the Some Performance Properties of Knitted Fabrics which are Produced by Soybean and Organic Cotton Yarn. University of Gaziantep, Deptartment of Textile Engineering. Master Thesis.Turkey, 89.

7. Pampal, E.Ş., 2012. Soya İplik Özelliklerinde Etkili Faktörler Üzerine Bir Araştırma. University of Uludağ, Deptartment of Textile Engineering, Master Thesis (In Turkish). Turkey, 104.

8. Perinçek, S., 2014. Selülozik Liflerin ve Yeni Nesil Liflerin Ön Terbiye İşlemlerinde Çevre Dostu Yeni Yöntem ve Teknolojilerin Uygulanabilirliğinin Araştırılması. University of Ege, Deptartment of Textile Engineering, Ph.D. Thesis. (In Turkish). Turkey, 61.

9. Yıldırım, F., Avinç, O., Yavaş, A.. 2014. Soya Fasülyesi Protein Lifleri Bölüm 1: Soya Fasülyesi Protein Liflerinin Genel Yapısı, Üretimi ve Çevresel Etkileri. Uludağ Üniversitesi, Mühendislik Fakültesi Dergisi; 19(2), 29-50.

10. Yılmaz, D., Karaboyacı, M., Kılıç, H., Kitapçı, K., Yelkovan, S. 2015. Comparison of Selected Properties of Eco-friendly Soybean and Other Fibres. Fibres and Textiles in Eastern Europe; 23,(111), 14-24.

11. Öner, E., Okur, A., 2015. Thermophysiological Comfort Properties of Selected Knitted Fabrics and Design of T-shirts. The Journal of the Textile Institute; 106(12), 1403–1414.

12. Matusiak, M., Kamińska, D., 2019. Investigation of Selected Utility Properties of Woven Fabrics Made of Soybean Protein Fibres. FIBRES & TEXTILES in Eastern Europe; 27(6), 138.

13. Kavuşturan, Y., Çeven, E.K., Özdemir, Ö., 2010. Effect of Chenille Yarns Produced with Selected Comfort Fibres on the Abrasion and Bending Properties of Knitted Fabrics Fibres & Textiles in Eastern Europe; 18(1), 78.

14. Ciukas, R., Abramaviciute, J., Kerpauskas, P., 2010. Investigation of the Thermal Properties of Socks Knitted from Yarns with Peculiar Properties. Part I. Thermal Conductivity Coefficient of Socks Knitted from Natural and Synthetic Textured Yarns. Fibres and Textiles in Eastern Europe; 80(3), 89-93.

15. Abramaviciute, J., Mikucioniene, D., Ciukas, R. 2011. Static Water Absorption of Knits from Natural and Textured Yarns. Fibres and Textiles in Eastern Europe, 19(3), 86.

16. Wu, H.Y., Zhang, W.Y., Li, J. 2009. Study on Improving the Thermal-wet Comfort Clothing during Exercise with an Assembly of Fabrics. Fibres and Textiles in Eastern Europe, 17(4), 75.

17. Ekinci, D., 2018. Soya Lifi İçeren Dokusuz Yüzey Kumaşların Tekstillerinde Kullanılabilirliğinin Araştırılması. Msc Thesis, Çukurova University Institute of Natural and Applied Sciences Department of Textile Engineering, 73.

18. https://intweb.tse.org.tr/Standard/Standard/StandardAra.aspx, (Last Access: Sept. 2022)

19. Geetha, M.S., Kavitha, S., Senthilkumar, B., Vijay, D., Patchiyappan, K.M., 2022. Comparative Moisture Management Studies of Single Jersey Knitted Soya Bean Fabrics. Journal of Natural Fibers, DOI: 10.1080/15440478.2022.207294.