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A Study of Different Types of Seersucker Fabric Design by Industrial Scale Production Line

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Seersucker Woven Fabrics, Fabric Mechanical Properties, Structural Design, Slow-Fashion, Sustainability.

ABSTRACT:
With the growing perception of sustainability and vintage fashion trend, the textile industry is taking steps toward change and innovation with the benefit of recent technological development. Using traditional fabrics to modernize from the past to today's technology is one of the most popular research and design topics. Fashion shows real proof that history repeats itself over and over again. Along with the modern developments increasing variety of fibers also helps to develop innovative product possibilities. Seersucker is not a common type of fabric. Seersucker actually refers to a style/pattern/texture that produces a puckering effect on the surface of the fabric with the textures smooth and coarse. In this study, first, a brief historical background of the seersucker fabrics is explained. The most used seersucker fabric types are determined to design and produce during this study. The selected patterns of seersucker fabrics with different fiber combinations were produced according to the common strip model, and their technical properties were tested and analyzed. 5 different types of fabrics are tested in terms of their structural properties, color fastness to water, color fastness to perspiration, etc.

1- Introduction

Introduction goes here introduction goes here In the historical past of seersucker, some of the earliest evidence shows that it was bought and sold by various companies in the East Indies in the 1600s. They were known as shirushakar, which means milk and sugar in Persian [1]. The first seersucker pattern got its name because of its light skin color, reminiscent of sugar cane, and white stripes, reminiscent of milk. It was introduced to the Western world 1 to 2 centuries later by Muslim traders from the Eastern region. When European men realized that seersucker fabric was an ideal fabric for summer, it was quickly used in this region as well. It was very popular in the British colonies because it is a comfortable and lighter fabric in hot climates and exudes elegance. Seersucker fabrics, crossing the ocean, began to gain acceptance in America as fabrics that could be used by the working class [2] . Jackets, shirts, overalls, and even hats made from seersucker fabrics began to emerge as stylish yet easy to use. From the 1800s to the early 20th century, seersucker fabric was used for mattresses, bedding, and evening wear during the summer, especially in England and the United States of America [3] .Being a cheaper and more durable fabric, it was also used during the Civil War in America to make sacks and pants that would last during the war [4]. In America, seersucker was considered the fabric of the poor as it was mainly used by American workers. The transformation of seersucker suits began in 1903 when a man named Joseph Guerney Canoon, the Speaker of the House of Representatives, wore a striped seersucker suit to a meeting with President Roosevelt [5]. In the 1920s, college students began wearing seersucker fabrics to make an ironic statement about the exclusivity that prevailed at the time. This event made the fabric very popular among the upper class [6] .Beginning in the 1940s, nurses and volunteers in American hospitals wore red and white uniforms made of seersucker fabric [7]. Joseph Haspel started his own company, Haspel, in New Orleans to supply comfortable men's clothing for the sweltering heat. The company, which initially manufactured work clothes, began producing suits in 1909. The company contributed to the fact that the fabric is still known in the industry today. It quickly gained popularity in the casual, style-conscious cultures that emerged after World War I. Today, with the post-pandemic increase in demand for comfortable and practical clothing, the effects of global warming on temperatures have renewed the orientation toward seersucker fabrics [8].

Figure 1: Haspel's seersucker product and advertisement [9]

Thanks to the shrunken texture of seersucker, the problem of creases is eliminated. The fact that it can be washed in household washing machines without the need for dry cleaning ensures ease of use. The most common form of seersucker fabric from the past to the present is the blue and white striped pattern. Today, seersucker fabrics can be made in different patterns and with different types of yarn. Seersucker fabrics can be used for a variety of garments, including sportswear. You can use it to make suits, shorts, shirts, and even bathrobes. It can be used for home textiles, curtains and bedding. The thermo-insulating properties of clothing are very important for the physiological structure of the skin as well as for the harmony of the human skin. The need for thermo physiological comfort of clothing is one of the needs that are made day after day. Given the temperature differences associated with global warming, in addition to the thermal insulation provided by clothing, the structural, mechanical and aesthetic properties are becoming more important day by day. Thermal resistance, water vapor permeability, and air permeability are considered the most important comfort characteristics of fabrics and clothing under expected climatic conditions. When the fabric is flat, it is closer to the skin, creates smaller air spaces, and can cause irritation due to increased skin contact. In addition, this smooth fabric easily reflects heat and moisture back to the body. Thanks to its corrugated surface, seersucker reduces skin contact and the fabric absorbs moisture in wet weather, reducing the "wet" feeling. At the same time, it also keeps hot air away from the body by increasing airflow and circulation between the surface and the skin.

Due to the slow weaving process, it is a low-yield and expensive fabric. This is well-known phenomena that increase in weaving parameters, the processing of structure time and speed slows down. But the fact that they are easy to use and have good properties in terms of comfort parameters, without being trapped in the perception of fashion in the concept of slow fashion, makes seersucker fabrics ideal for long-term use. With the rapid consumption in the industry, the deterioration, wrinkling and shrinkage caused by tangling in low strength products make it difficult for the fabric to participate in the next transformation cycle [10]. These problems can be avoided by using durable textile products with higher quality designs. When caring for seersucker fabrics, the fact that the fabric does not need to be ironed due to its wrinkled appearance again provides energy efficiency and promotes sustainability.

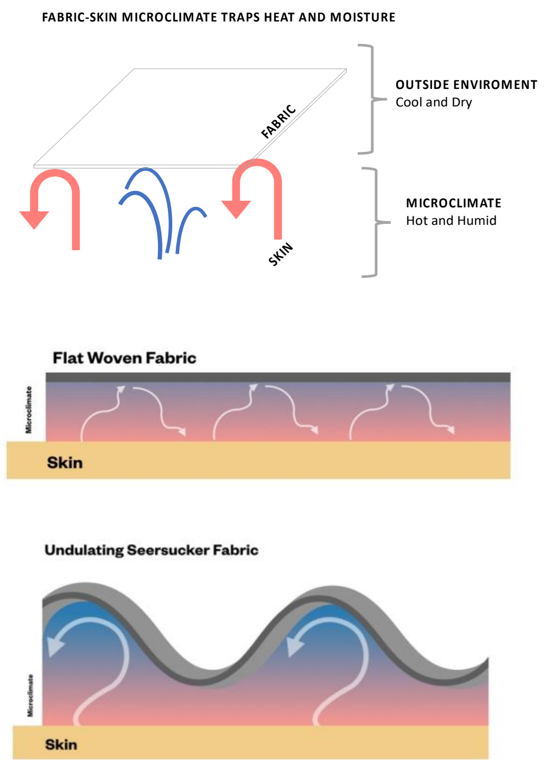


Figure 2: Visual modeling of thermal properties of plain and seersucker fabrics

2- Materials and Methods

Seersucker is a woven fabric with a regular shrinkage effect on the fabric surface. This effect can be created by various methods. Well-known seersucker image capture methods are single-beam, double-beam and calendar printing. The most commonly used method is the double beam method. In this method, two warp beams with different shrinkage rates are used and thanks to the shrinkage differences, a seersucker image is created. In the method with one warp beam, the image is created by weaving. Thanks to the use of elastane in the weft and the weaving connection, the desired seersucker image can be obtained. In calendar printing, a seersucker image is created by pressure and heat between two calendars, one of which is indented and one of which protrudes. In addition, there are several chemical treatment methods to achieve a shrinkage effect. Applying caustic soda and sodium hydroxide to selected areas of the fabric causes the fabric to shrink in the area where it is applied to produce a shrinkage effect. The disadvantage of this technique is that the fabric does not retain its shrinkage effect after washing and dry cleaning.

In this study, we made a seersucker image for the fabrics numbered 1-2-3 using the double bar method and for the fabrics numbered 8-11 using the single bar method. We used the same amount of raw material to study the effects of fabric construction on seersucker fabric properties in fabrics 1-2 and 8-11. For fabric number 3, we used 40% polyester to study the effects of polyester content on seersucker fabric properties. The raw materials and construction data used can be found in Table 1.A.

For fabrics 1-2-3, the warp threads of the serial warp were woven in a single weaving beam with different shrinkage rates. The warp threads were separated as two separate trees. Warp yarns with low shrinkage rate were used as the base warp. Yarns with high shrinkage, yarns with low yarn count or thick yarns were processed as the top beam. The tension was set on the bench for both warp beams. After the warp is pulled, the front warp is pulled and drawn in according to the total number of wires for the drawing-in process. In order to prevent the warps with high shrinkage rate from causing false warp breaks, suitable drop wires and strong wires were selected for weaving. After knotting the pre warp, the shrinkage (tension) was adjusted and weaving of the fabric was started. .

The warp shrinkage rates of the fabrics are as follows.

1- A: 40% B: 10%

2-A: 20% B: 6%

3-A: 10% B: 40%

For fabrics numbered 8-11, elastane weft threads were used to create a seersucker image. The image was achieved by the construction of woven joint and elastane weft. When weaving the fabric, 6 weft threads without elastane were combined into 2 weft threads with elastane. The weft threads without elastane were set to the adjusted tension and the mouthpiece was closed. The desired seersucker appearance was achieved on the fabric surface by re-shrinking the tensioned elastane weft threads. Information on the construction and pictures of the fabrics can be found in Table A and Table B.

The woven fabrics were dyed and finished. Fabrics dyed in equally different colors were subjected to the same finishing treatments.

Fabric Code	Fabric Content	Warp Yarn	Weft Yarn	Warp Thread Sequence	Weft Yarn Sequence	Fabric Structure
A	100% Cotton	A 40/2 B 60/2	A 60/2	8A 8B	16A	Plain
B	100% Cotton	A 20/1 B 40/1	A 40/1	6A 6B	12A	Plain
C	60% Cotton 40% Polyester	A 40/1 (CO) B 40/2 (%50 CO-%50 PE)	A 40/1 (%50 CO-%50 PE)	6A 6B	12A	Plain
D	99% Cotton 1% Elastane	A 30/1 B 30/1	A 30/1 B 30/1 (CO*EA)	8A 8B	6A 2B	Plain
E	99% Cotton 1% Elastane	A 30/1 B 30/1	A 30/1 B 30/1 (CO*EA)	6A 6B	6A 2B	Plain

Table 1. Structural properties of used fabrics

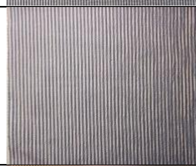
Fabric Code	Fabric Content		
A	100% Cotton		
B	100% Cotton		
C	60% Cotton 40% Polyester		
D	99% Cotton 1% Elastane		
E	99% Cotton 1% Elastane		

Table 2. Fabrics used in the study and their properties

3- Result And Discussions

3.1- Mechanical Properties of Fabrics- Tensile and Tearing Strength Properties of The Fabrics

Tensile properties of fabrics were determined using the strip method (ISO 13934-1:2013 Part 1: Determination of maximum force and elongation at maximum force using the strip method). Tear properties of fabrics - Part 1: Determination of tear force by ballistic pendulum method (Elmendorf) was performed on organic and conventional fabrics according to the standard ISO 13937-1:2000. In Table 3, it was found that depending on the numerical differences in the yarns used in the weft and warp directions, better values were obtained in the breaking and tearing strength of the fabric in the direction in which thick yarns were thrown. It was found that the use of elastane in samples B and D caused an increase in tensile strength in the weft direction of the fabric.

	Maximum Force (N)		Tearing Strength Max. Force (N)	
Samples	Warp	Weft	Warp	Weft
A	205.3	323,6	20.3	12.4
B	175.6	355.1	18.6	10.8
C	230.5	436.5	40.2	16.7
D	479.7	401.2	14.7	15.7
E	521.9	440.5	15.7	15.7

Table 3. Mechanical strength test comparison chart

3.2- Color Fastness to Water

Test for color fastness- Part E01: Color fastness to water test was carried out in accordance with ISO 105-E01:2013 standard. Since the content of A-B, B-E fabrics is mainly cotton, their dyeing properties and water absorption are the same. For this reason, the fastness values to water are also similar.

Sample Types	**Change in Color**	**Staining in Color**					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
A	4/5	4/5	4/5	4/5	4/5	4/5	4/5
B	4/5	5	5	5	5	5	5
C	4/5	5	5	5	5	5	5
D	4	5	5	5	5	5	5
E	4/5	5	5	5	5	5	5

Table 4. Color fastness to water comparison chart

3.3- Color Fastness to Perspiration (Acid)

Test for color fastness - Part E04: Color fastness test was carried out in accordance with the standard TS EN ISO 105-E04. Although the fabrics tested here have structural differences, they undergo the same chemical processes in the production phase. Although different raw materials are used for the fabrics numbered B-D-E, the fact that they are mainly cotton did not cause any significant difference in the test result. According to the results obtained from the test values, the factor that most affects the fastness to perspiration is the dyeing and chemical finishing of the fabric.

Sample Types	**Change in Color**	**Staining in Color**					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
A	4/5	4/5	4/5	4/5	4/5	4/5	4/5
B	4/5	4/5	4/5	4/5	4/5	4/5	4/5
C	4/5	5	5	5	5	5	5
D	4/5	4/5	4/5	4/5	5	5	5
E	4/5	5	5	5	5	5	5

Table 5. Color fastness to perspiration (Acid)

3.4- Color Fatness to Rubbing

Textiles - Tests for color fastness - Part X12: Color fastness to rubbing was performed in accordance with the standard TS EN ISO 105-X12. Due to the embossed surface of seersucker fabrics, the wear of the surface and its effects on the image are one of the most important parameters. Depending on usage, the finer threads in the elastane portion can break and cause both strength loss and visual deterioration. However, when the test results were examined, the same results were obtained as for the yarns with 100% cotton content. This shows that the elastane or polyester content has no negative influence on the rub fastness.

Samples	**Dry Rubbing**	**Wet Rubbing**
A	4/5	4/5
B	5	4/5
C	5	4/5
D	4/5	4/5
E	5	4/5

Table 6. Color fatness to dry and wet rubbing comparison chart

3.5- Fabric Shrinkage Test-Hofmann

The dimensional stability of a fabric is a measure of how long it retains its original dimensions after it is manufactured. Shrinkage is a problem that affects the dimensional stability of a fabric. Fabric shrinkage can cause problems in two main situations. These are the difficulties that can occur during the manufacture of the fabric, and the difficulties that the end customer may have in maintaining the fabric at home. The sample, cut in 500mm x 500mm, is marked with 3 sets of markers, with a distance of at least 350 mm in all directions and at least 50 mm on all sides. After measurement, the samples are washed in the appropriate washing solution in a washing machine that meets certain specifications. After the specified time has elapsed, the specimen is rinsed. After drying, the sample is conditioned in a standard test atmosphere and the distances between the marks are measured again. The results obtained are given in Table 7 in percentages. For samples D and E containing elastane, a high shrinkage was observed in the direction of the elastane blend yarns, which depends on the heat during washing.

Samples	Warp	Weft
A	-0.5	-0.5
B	-0.5	-0.5
C	-1	-0,.5
D	-1	-3
E	-1	-2

Table 7. Fabric Shrinkage Test Results

From the fabric conditioned under normal atmospheric conditions, more than two-gram pieces with different wefts and warps are taken from 3 different places. These pieces of cloth are divided into smaller pieces not exceeding 0.5 cm in size and placed in a flask. The KCl solution prepared with distilled water is also added to the flasks and mixed in a blender for 2 hours. The pH of the 3 stock solutions is measured using a pH meter and the average of the three solutions is obtained. The result thus obtained indicates the pH of the fabric. It is desirable that the result be in the pH range of 4.5-7.5.

Textile materials have a certain pH, both due to their structural characteristics and as a result of chemical processes. Especially in the garment industry, the pH of the fabric in contact with the skin is very important in order not to cause skin irritation. For human health, the pH of the fabric should be neutral or close to neutral. On the other hand, the pH test provides information about the chemical processes applied to the substances. All values in our test results, performed according to the Aatcc-81 standard, are in the range of 4.5-7.5, and the substances are safe for human health.

Sample	pH
A	5.5
B	5.7
C	7.0
D	6.7
E	6.2

Table 8. pH test results

3.6- Dimensional Change in Fabrics After Washing

In the dimensional change test, it has been observed that the dimensional change varies depending on the yarn number, since the knitting structure is plain even in different yarn throwing situations in the fabric samples. It has been observed that there are negative effects on the dimensional changes of the fabrics linearly with the amount of elastane in the content ratios of the yarns. In the weft direction 100% cotton fabrics are more rigid than elastane fabrics. The elastane yarn in fabrics D-E has suffered more shrinkage compared to other fabrics due to being exposed to heat during washing. When the relationship between warp directions A-C-D is examined, it has been observed that the amount of shrinkage in the fabric decreases as the fineness of the cotton yarns used in the fabrics increases.

Sample Code	Width	Warp Shrinkage	Weft Shrinkage	Drying Type
A	150.5	-2.5	-1.5	30HD
B	147.5	-3.5	-1.5	30 LD
C	148	-4	-1	30 LD
D	142	-4,5	-4,5	30 LD
E	142	-4	-4.5	30 LD

HD: Hang-Drying LD: Laying-Down Drying

Table 9. Dimensional change in fabrics after washing results

3.7- Seam Strength Test

ISO 13936-2 Textiles - Determination of the slip resistance of threads in a seam in woven fabrics - Part 2: Testing by the constant load method. As in other previous studies, it was found that the tensile properties of fabrics and sewing threads are very important factors for sewability. In terms of general quality assessment of garments for ready-to-wear collection, sewability in combination with seam stability can be considered as a comprehensive quality indicator. Both always depend on the raw materials and garment materials (fabrics, sewing threads), sewing machine, needle size, stitch type and quality characteristics of the materials. Many textile products such as suits, bedding and accessories are made of seersucker fabrics. Here, it is important that the sewing properties are good so that the products delivered to the end user are durable. The results obtained show that the embossed structural properties of seersucker fabrics have no negative impact on the final product.

Sample	(mm)	(Kg)	(Kg)
A	5	10.9	20
B	5	11.6	20
C	5	20	20
D	2,5	9.6	12.8
E	2,5	8.2	7.4

Table 10. Seam Strength Test Results

4- Conclusions

In accordance with the results of the study, it provides the opportunity to revise the settled substances according to our needs with today's developments. It was found that the seersucker fabrics examined in the study, with different contents and different production methods, provide the desired results in accordance with the desired design. It is possible to create efficient fabrics by updating the fabrics of the past with the technologies of today. By designing Coolmax combination seersucker fabrics based on polyester-containing fabrics, good results can be obtained in both stretch and comfort properties. In future studies, it is planned to investigate the surface structure properties with different fiber combinations. By acting within the concepts of sustainability in all processes, it will be possible to establish a better system in the textile industry, thanks to the production of durable, equipped fabrics.

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