A SUSTAINABLE APPROACH TO SEERSUCKER WOVEN FABRIC PRODUCTION: ELIMINATING ELASTANE AND DOUBLE BEAMS FOR NATURAL MATERIAL-BASED DESIGN

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ABSTRACT

Nowadays, the increasing social consciousness on the protection of nature and, at the same time, the seeking for comfort and easiness caused by the pandemic, increase the interest in easy-to-use, comfortable textile products produced with natural raw materials. Seersucker woven fabrics are highly preferred in recent years due to their features such as providing wearing comfort and being user-friendly by not requiring ironing. However, in order to provide the three-dimensionality/wrinkle effect in woven seersucker fabrics in the currently used methods, it is necessary to use elastane in the weft/warp or to use double beams during production. At this point, it is not possible to produce completely natural fabric in the method using elastane, and in the other method, a special several warp and machine requirements are emerging. In this study, the literature on seersucker fabrics was reviewed and experimental seersucker weaving applications were carried out. Studies have been carried out in order to produce fabrics using completely natural raw materials (cotton), to improve production efficiency and to increase design possibilities. In this context, instead of the traditional methods used in seersucker fabric creation, seersucker fabric production was carried out with a single beam on the weaving machine by using different weaves in the dobby for fabric design. In this way, it has been provided that the seersucker weaving process can be performed with a single beam on any desired machine by using existing direct warps without the need for a special warp preparation.

KEYWORDS

Woven Fabrics; Seersucker Fabrics; Elastane Free Seersucker Fabrics.

INTRODUCTION

Woven fabrics are generally considered flat (2D - two-dimensional) textile materials. The reason is that their third dimension, thickness, is negligibly small compared to the other two dimensions, length and width. However, there are also woven or knitted fabrics that are considered 3D (three-dimensional) or 2D+. A basic common definition of 3D fabrics is having a third dimension – fabric thickness/ voluminosity [1,2].

Seersucker fabrics are thin, lightweight, comfortable fabrics with a striped appearance and a wrinkled, textured surface, usually produced by the combined use of cotton and synthetic yarns [3, 4]. Seersucker fabrics are the fabrics that have a three-dimensional appearance with their raised surface structures and some researchers qualify these fabrics as 3D fabrics [5].

It is possible to produce seersucker fabrics in both knitted and woven fabric production methods, but the subject of this study is woven seersucker fabrics. In Figure 1 and Figure 2, examples of woven and knitted seersucker fabric can be observed.

When their historical background is examined, it is seen that seersucker fabrics were traded by various companies in the East Indies in the 1600s [7]. However, it is understood from the written records of this period that "crimped" fabrics, which were woven with high twisted yarns and had a seersucker-like surface appearance, were traded in Anatolia in 1640 (Figure 3) [8, 9].

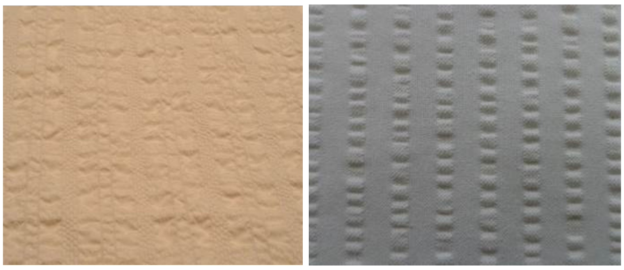

Figure 1. Woven seersucker fabric swatches [5,6].

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Figure 2. Knitted seersucker fabrics swatches [2].

(a) (b)

Figure 3. Examples of traditionally woven "crimped" fabrics in Anatolia [9] [10]. (Photograph (a): Servet Senem Uğurlu, 2006, Photograph (b): Dokuma Atlası, 2021).

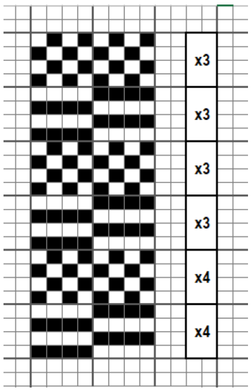
Seersucker fabrics developed in Eastern countries were introduced to the Western world by Muslim merchants. When European men realized that seersucker was an ideal fabric for summer, it was quickly adopted in this region. It was very popular in the British colonies as it was a comfortable and lightweight fabric in hot climates and exuded elegance. After crossing the oceans, seersucker fabrics began to be accepted in America as fabrics that could be used by the workers after a while [7]. These fabrics, which were initially used for workers' clothes, started to be worn/preferred by people belonging to the upper class since the 20th century. Seersucker fabrics have become popular again today because of their casualness and good comfort properties. Garments produced with seersucker fabrics are expected to keep the wearer dry and cool, especially in the summer months when the weather is hot and humid. By creating a more modern and wrinkle-free alternative to linen, one of the most popular fabrics of summer, the demand for suit models suitable for comfort after the pandemic is increasing day by day. Seersucker fabrics support air circulation thanks to the fact that the flat parts remain in the air on the wrinkled surface and only the shirred part touches the skin. This characteristic allows the fabric to breathe. Therefore, the fabric has good moisture transport and thermal conductivity, making the wearer feel dry and cool. Another feature that increases its attractiveness is that it does not require ironing due to its wrinkled structure [11].

Since these fabrics are lightweight, have a wrinkled appearance, and in terms of their surface, they are heterogeneous, meaning they contain locally loose and compact sections of weaving, they are generally used in the production of summer clothing. Seersucker fabrics are ideal fabrics for the production of skirts, summer dresses, blouses and shirts [3,12].

The characteristic shirred stripe effect in woven seersucker fabrics is created by controlled tension variations in the warp sections during weaving, the use of yarns with different shrinkage properties or chemical finishes [13].

Numerous academic studies have been conducted to enhance the surface and comfort properties of seersucker fabrics due to their growing demand. The article by Lukazs et al. introduces a method for measuring the surface geometry of seersucker woven fabrics using laser techniques [5]. Fracczak et al. investigate the friction properties of seersucker fabrics based on their structure [16]. Matusiak's studies explore the structural, mechanical, and moisture transport properties of seersucker fabrics, as well as their comfort - related characteristics [1, 12, 17, 18]. The research conducted by Matusiak and Bajzik focuses on surface characteristics and the effect of seersucker repetition on fabric parameters [14]. Furthermore, Matusiak utilizes non - contact optical methods to investigate the surface geometry of seersucker fabrics [15].

Currently, several different methods are used in seersucker fabric production. Typically, a wrinkled effect is achieved on the fabric's surface through the combined weaving of two warp yarns with different tensions or by using weft and warp yarns with varying tensions. This creates tension differences that result in the desired wrinkle effect. [3, 4]. In the method where two warp beams with different tension are used, one beam carries the warp yarns that will form the flat (basic) strip appearance and the other beams carry the warp yarns that will form the shirred strip appearance. During the weaving process, the warp yarns that will create the shirred appearance are adjusted so that they are fed faster than the other warp yarns. This discrepancy in tension among the warp threads leads to localized wrinkling in the fabric, particularly in areas where fast - feeding yarns are present. Consequently, the fabric surface exhibits both shrinked and flat strips running in the warp direction. This kind of shrinkage on the fabric surface



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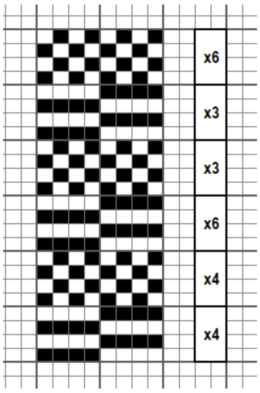

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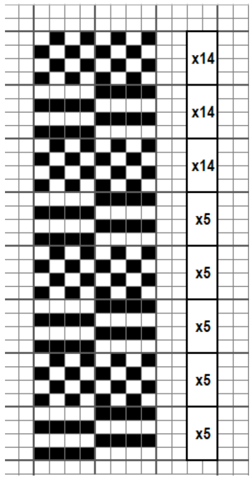


(c)

Figure 4. Design trials with different repeat regions: (a) D1, (b) D2 and (c) D3.

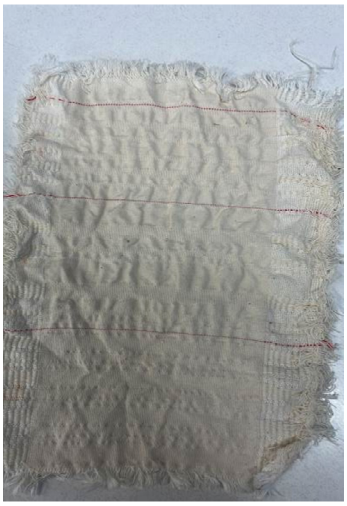


Figure 5. Fabric trials with different weave composition (Photograph: Ayçin Asma, 2022).

is called the seersucker effect. This type of fabric cannot be produced on conventional weaving looms with a single beam [4, 12]. For this method, a special weaving loom with two warp beams with separate tension control is required [3]. The use of elastane yarn in seersucker fabric production is also a method that has been widely used in recent years. Apart from these, seersucker effect can be created on fabrics with some finishing and printing processes after weaving [19].

In the study, it is aimed to produce fabrics with seersucker effect with completely natural raw materials without the necessity for double beam and without using elastane. In this context, fabrics using different weave values in dobby were designed, the trials of these designed fabrics on the template loom were carried out in the product design department of Akın Tekstil AŞ., and sample production was carried out for the model study in which the seersucker effect was obtained visually, and post-washing shrinkage, washing fastness, dry/wet rubbing and strength tests were applied.

EXPERIMENTAL STUDY

Design studies and hand loom texture trials

In the study, three different woven patterns were designed to give this effect on the fabric surface in order to create the seersucker effect. Various weaves were combined within the same design to achieve the desired waffle effect. Different repeat numbers were experimented within the design to determine the optimal weaving construction for a stronger puckering effect on the fabric surface. Figure 4 shows the weave plans of the prepared designs.

In the first design (D1), different weave regions have repeat numbers of x3 and x4, while in the second design (D2), the repeat numbers are x4, x6, x3, and x6. The third design (D3) exhibits higher repeat numbers compared to the first two examples, arranged as x5 and x14.

Trials of these three different patterns were produced on hand looms. Figure 5 illustrates the examples of fabric experimentations with different compositions.

As a result of the initial small-scale production, a puckering effect was observed on the fabric, leading to further production of larger samples (Figure 6). The fabrics produced with D1, D2, and D3 from the design trials (Figure 4) were coded as P1, P2, and P3, respectively.

Wrinkle effect was obtained on the fabric surface in all experiments. However, in one of them (P3), the weave pattern combination provided the most optimal waffle effect and a surface appearance having the surface appearance of the fabric produced by other conventional methods was obtained.

Industrial Development of Fabric

The fabric P3 (Fig. 6), which achieved the best result in terms of the desired seersucker effect, was industrially produced. It was woven using12x1 tex

(a) (b) (c)

Figure 6. Different proto trials on hand loom: (a) P1, (b) P2, (c) P3. (Photograph: Ayçin Asma, 2022).

and 20x1 tex combed cotton yarns as indicated in Table 1, on a 2022 model Picanol OptiMax weaving machine equipped with a single beam. The machine operated at a speed of 440 rpm during production. The warp density was 68 threads per cm, and the weft density was 37 threads per cm. Figure 7 shows the image of the machine during production.

The information regarding the yarns used in fabric production is provided in the following table (Table 1).

The raw fabrics were processed through various stages including singeing, cold mercerization, causticizing, ram drying, dye padding, dye washing, super touch drying, intermediate inspection, super touch finishing, steaming, and final inspection to transform them into finished fabrics. Figure 8 presents visual representations of both the raw fabric samples (a) and the finished fabric samples (b).

Tests were applied to the fabrics in order to measure the suitability and mass production of these seersucker-like fabrics.

Post-washing dimensional change, washing fastness, dry and wet rubbing fastness, rupture and tear strength tests were performed on the produced fabrics. Dimensional change measurements of the samples were made by washing under "delicate" conditions and “line drying” application in accordance with AATCC 135 standard [20]. Tensile strength test was performed on James Heal Tinius Olsen apparatus in accordance with ASTM D5034 [21]

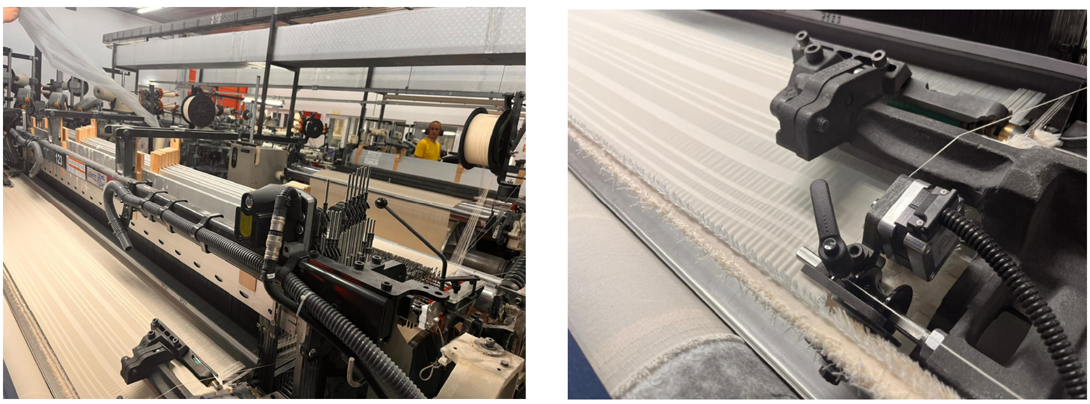


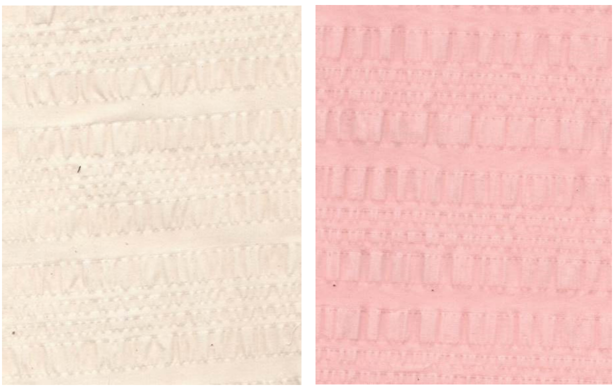
Figure 7. Seersucker fabric production on the machine. (Photograph: Ayçin Asma, 2023).

Table 1. Information on combed cotton yarns used in fabric production.

	Warp	Weft
Yarn Number [tex]	12x1	20x1
Yarn Twist [TPM]	1142	905
Yarn Twist Direction	Z	Z

Table 2. Declared values and test results.

Property	Direction	Declared Value	Test Results
Fabric Mass per Unit Area [g/m^2]		180 ± 5	185
Dimensional Stability (After Washing) [%]	Warp	-5.5	-4
	Weft	-3	-2.5
Washing Fastness Grade		4/5	5
Rubbing Fastness Dry Grade		5	4/5
Rubbing Fastness Wet Grade		5	4/5
Tensile Strength [N]	Warp	312.8	615.9
	Weft	560	603.1
Tear Strength [N]	Warp	19.43	16.43
	Weft	12.66	13.04
Extension [%]	Warp	4	4
	Weft	7.2	7
Growth [%]	Warp	0.4	0.8
	Weft	1.6	0.2
Air Permeability [mm/s]		73	30



(a) (b)

Figure 8. (a) Raw seersucker fabric swatch, (b) Finished seersucker fabric swatch. (Photograph: Ayçin Asma, 2022).

standard and tear strength test was performed on James Heal ElmaTear apparatus in accordance with ASTM D1424 [22] standard. The washing fastness was evaluated using the James Heal Gyrowash 1615 device following the AATCC 61 [23, 24] standard. The fabric stretch properties test was conducted according to the ASTM D3107 standard [25]. Additionally, the fabric air permeability test was performed on the SDL ATLAS air permeability tester device in accordance with the ISO 9237 standard [26].

RESULTS

In the study, three different fabric structure designs were made to obtain the seersucker surface appearance. Through the experiments conducted in line with the design studies, it was possible to achieve a wrinkled effect on the fabric surface by utilizing the tension differences created by the combination of various weaving structures in the fabrics. However, one of the fabric swatches (referred to as P3 in Figure 6) successfully exhibited the typical seersucker appearance. The focus of the study was specifically on this design, and the fabric was produced in its finished form. After dyeing and finishing processes, there were no alterations in the seersucker appearance of the fabric. The results of the washing, rubbing, and strength tests complied with the standards, and the fabric weight obtained fell within the desired values. The numerical values corresponding to the test results are provided in Table 2.

In a double warp beam loom, a traditionally woven 180±5 g/m^2, 100% cotton seersucker fabric exhibited dimensional change ratios (%) of -5.5 in the warp and -3 in the weft. Considering these values, it can be observed that the fabrics produced using the newly developed method within the scope of this study exhibit better dimensional stability.

In a commercially produced 180±5 g/m^2, 100% cotton seersucker fabric mentioned above, the washing fastness was rated 4/5, and the rubbing fastness averaged at 5. Upon examining the washing and rubbing fastness results of the fabrics produced using the new method, it is observed that they exhibit the same values as the fabrics produced using the traditional method.

When compared with fabrics produced using the traditional method, the tensile strength value of the fabric is significantly higher, while the tear strength result is slightly lower. However, the test results obtained for the fabric produced in this study are still within acceptable values.

When the results of fabric stretch properties are examined; in the warp direction, it is seen that the results are within the required value ranges as in the other tests. In the weft direction, it is seen that the growth value of the new fabric is better.

In addition to all this, when the air permeability properties are compared, it is observed that there is a difference between the traditional fabric and the new fabric. The reason for this is the difference between the production methods and fabric structures. However, this situation can be improved with further studies.

CONCLUSION

Seersucker fabrics have been in increasing demand in recent years due to their features such as being light, having good comfort properties, not requiring ironing thanks to their wrinkled surface appearance and thus being user-friendly. However, the increasing level of consciousness in the society about sustainability and the desire of consumers to return to natural lifestyles lead to the preference of products produced with natural raw materials in textile products. Seersucker fabric production is currently possible with different methods. However, in these methods, it is required either to use elastane yarns produced with synthetic raw materials or to have a special machine park that can work with double beam. In this study, it is aimed to produce seersucker fabrics without elastane and without the need for double beams. For this purpose, different fabric compositions were designed and sample productions of the designed fabrics were carried out. As a result of the experiments, it was seen that the seersucker effect was realized to the expected extent in the designed fabrics. The fabrics designed with the use of completely natural raw materials can be produced and commercialized. At the same time, seersucker production can be carried out on every machine when necessary with the method put forward in the study and the designed fabric weave compositions, and thus production efficiency can be increased. As such, the study offers an alternative method and design proposal to the methods currently used in seersucker fabric production. It is believed that the study will be a source for future academic and sectoral studies.

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