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Development of a Systematic Research Method Towards the Evaluation of the Efficacy of Cosmetic Textiles

Kozmetik Tekstillerin Etkinliğinin Değerlendirilmesine Yönelik Sistematik Bir Araştırma Yönteminin Geliştirilmesi

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Abstract

This study aims to develop a systematic research method consisting of subjective and objective measurement methods to determine the effectiveness of cosmetic textiles on human skin. For this purpose, first of all, the expected properties of the cosmetic textile product were considered and the methods to be used for testing these properties were determined, and finally, a research method was created. Leggings, a cosmetic textile product, was selected to validate the method and a 28-day wear trial was carried out with female subjects to observe the effects of the product on human skin. During the wear trial, the subjects were provided to wear leggings that were designed from different knitting structures and applied cosmetic microcapsules to ensure the optimal slimming, moisturizing, and anti-cellulite properties. Dermatological and anthropometric measurements were carried out at specified periods of the study and the obtained data were statistically analyzed. According to the results, it was determined that the cosmetic textile product developed is skin-friendly and helps to increase skin moisture. Additionally, it was observed to provide a slimming effect to the wearer after a period of regular usage, however, it was suggested as a supportive product for women only with early-stage cellulite. A survey was also conducted to evaluate the cosmetic textiles by using subjective user opinions. The output of the survey has shown a high rate of satisfaction with the comfort, visual and sensory properties of the cosmetic textile product. By introducing the research method developed, it will be possible to accurately determine the effectiveness of cosmetic textiles on human skin and to design, develop and produce new cosmetic textile products with high cosmetic efficacy.

Keywords: *Cosmetic Textile, Wear Trial, Dermatological Clinical Evaluation, Anthropometric Measurement, Skin Moisture, Skin Topography*

Öz

Bu çalışma, kozmetik tekstillerin insan derisi üzerindeki etkinliğini belirlemek için subjektif ve objektif ölçüm yöntemlerini içeren sistematik bir araştırma metodunun geliştirilmesini amaçlamaktadır. Bu amaçla öncelikle dikkate alınan kozmetik tekstil ürününden beklenen özellikler ve bu özelliklerin test edilmesinde kullanılacak yöntemler belirlenerek araştırma metodu oluşturulmuştur. Sonrasında metodu doğrulamak için bir kozmetik tekstil ürünü olan tayt seçilmiş ve ürünün insan derisi üzerindeki etkilerini gözlemlemek için kadın deneklerle 28 günlük bir giyim denemesi gerçekleştirilmiştir. Giyim denemesi sırasında, deneklerin optimal incelme, nemlendirme ve selülit önleyici özelliklerin sağlanması için farklı örgü yapılarından tasarlanan ve kozmetik mikrokapsüller aplike edilmiş taytları giymeleri sağlanmıştır. Çalışmanın belirli periyotlarında dermatolojik ve antropometrik ölçümler yapılmış ve elde edilen veriler istatistiksel olarak analiz edilmiştir. Sonuçlara göre geliştirilen kozmetik tekstil ürününün deri dostu olduğu ve deri nemini arttırmaya yardımcı olduğu belirlenmiştir. Ek olarak, ürünün kullanıcıya belirli bir süre kullanım sonrasında incelme etkisi sağlandığı gözlemlenmiş, bununla birlikte sadece erken dönem selülit evresindeki kadınlar için destekleyici bir ürün olarak önerilmiştir. Kozmetik tekstilleri subjektif kullanıcı görüşlerinden yararlanarak değerlendirmek için bir anket de yapılmıştır. Anket çıktıları kozmetik tekstil ürününün konfor, görsel ve dokunsal özellikleri açısından yüksek oranda memnuniyet sağladığını göstermiştir. Geliştirilen araştırma yöntemi ile kozmetik tekstillerin insan derisi üzerindeki etkinliğini doğru bir şekilde belirlemek ve kozmetik etkinliği yüksek yeni kozmetik tekstil ürünleri tasarlamak, geliştirmek ve üretmek mümkün olacaktır.

Anahtar Kelimeler: *Kozmetik Tekstil, Giyim Denemesi, Dermatolojik Klinik Değerlendirme, Antropometrik Ölçüm, Deri Nemi, Deri Topografisi*

1. Introduction

It has become crucial to have functional properties for textiles apart from the expected ones such as durability, design, and fashion suitability. At this point, cosmetic textiles, which is a rapidly growing and developing link of functional textiles used in the health sector recently come into prominence. Cosmetic textiles are products that release a specific substance or solution to the human body, especially to the skin, at certain time intervals and are claimed to have properties such as slimming, cleansing, moisturizing, perfuming, changing appearance, revitalizing, anti-aging, and protection [1-4]. These products, which are also defined as "cosmetotextiles" in CEN/TC 248 Document N576, combine textile and cosmetics and provide consumers the benefits of both of them. Cosmetic textiles in which cosmetic or pharmaceutical raw materials or components are integrated into the fabric or garment by microencapsulation or different methods, act as a transport system. The principal condition to offer the desired benefits by releasing cosmetic ingredients due to body movements, body heat, and pressure is being in a contact with the skin [5-11].

Today, intense work tempo and exhausting city life do not allow people to spare extra time for their sports activities or personal care. All consumers, who are the target group of cosmetic textile products, especially women, tend to perform their neglected body care by using these products and feel younger, more attractive, fitter, and healthier. Especially in developed nations, people's desire to live longer and look younger increases this demand for beautifying and anti-aging products [12]. It is also true for consumers in countries with aging populations [13]. However, the fact the potential of cosmetic textiles offer superior benefits to the consumer in terms of body care by combining textiles and cosmetics has become one of the most popular trends of today's body care concept and has caused many cosmetic textiles are commercially put into the market. These products, which are claimed to have various cosmetic effects such as slimming, firming, and moisturizing can be perceived only as a marketing argument by consumers if they are not supported by scientific studies. In other words, consumers approach these products with suspicion, although they are interested in them. The increasing trend toward cosmetic textiles clearly shows the need for systematic methods to verify and prove their performance and effectiveness and certification them. Although there are many studies on cosmetic textiles in the literature, these studies generally focus on microencapsulation methods, microcapsule

formulations, washing strength, skin penetration rates, and stability degrees [14-20].

No sufficient studies were found in the literature about the performance properties of cosmetic textiles during product usage, and the effects of cosmetic ingredients on human skin, evaluated with standard methods. It can be said that there is a significant lack of information about the comprehensive evaluation of cosmetic textiles in terms of skin wellness and cosmetic efficacy on human skin. A few related studies carried out with human subjects found are as below.

Cheng et al. created an experimental qualification model to characterize cosmetic textiles and determined that cosmetic textiles did not have any cytotoxic effect [20]. Mosca and Rona investigated the effectiveness of the slimming and anti-cellulite effects of transpiring and hypoallergenic products made from Texenergy fabric and observed a slimming effect and a decrease in the appearance of cellulite[21]. Pugliese (1998) found that the socks he developed caused a slimming around the legs due to the transfer of the polyethyleneimine and theophylline applied on it to the skin with the effect of temperature, humidity, or pH [22].

According to the results of the literature review, it was determined that the studies on the evaluation of cosmetic textiles are limited, and these studies are not intended to test all the promised properties of the product, comprehensively.

For this purpose, in this study, experts in the field of textile engineering and cosmetic dermatology developed a systematic research method to evaluate cosmetic textiles comprehensively consisting of subjective and objective measurement methods that complete each other. In the scope of this aim, wear trials were carried out by the proposed systematic research method, scientific data obtained from the volunteers were analyzed and the effects of the cosmetic textile products on human skin were determined.

Through the newly developed research method, it will be possible to examine the claimed effects of cosmetic textiles with a standard research method based on scientific foundations in a wide range such as cosmetic efficacy, dermatological effects on human skin, wearing comfort, and customer satisfaction. On the other hand, this method can be adapted to special purpose functional textile products to test its suitability for different purposes.

2. Material and Method

In this study, a systematic research method was developed to evaluate the efficiency of cosmetic textiles comprehensively.

First of all, the expected properties of the cosmetic textile product to be tested were determined in the development phase of the research method, Secondly, the necessary test methods were determined to measure how much these properties were met by the product.

After the base of the research method was created, a product group was chosen to validate the developed method. Determining the cosmetic efficiency of the leggings that promises to the wearer a tight and slimmer body, moisturized and smooth skin, and decreased cellulite appearance was used for method validation in the work.

The expected features of the cosmetic leggings were determined, and objective and subjective evaluation steps were created accordingly to measure the expediency of the product (Table 1).

Table 1. Evaluation stages of the systematic method

Tablo 1. Sistematik metodun değerlendirme aşamaları

Expected Features	**Measurement Method for Testing the Feature**	
	Objective	**Subjective**
Skin-friendly	-	Dermatological treatment
Moisturizing the skin	Skin moisture analysis	-
Smoothing the skin surface and reducing the cellulite	Skin topography analyses	Dermatological clinical evaluations
Slimming and firming	Anthropometric and skinfold measurements	-
Customer satisfaction		Customer satisfaction survey

In this direction, the anthropometric measurement method, which is a classical method frequently used in the determination of garment measurements in ready-made clothing, was used to evaluate the efficiency of cosmetic textiles. Additionally, tewameter and visioscan devices, which are generally used for skin moisture and skin topography analyses in the scope of dermatological diagnosis and treatment, were used to evaluate the effectiveness of a cosmetic textile product, unlike their use in the literature.

2.1. Cosmetic textile product used in wear trial

"Leggings" is a sub-product of cosmetic textiles that was used in the wear trials. Because the cellulite mostly concentrates on the upper back leg and hip areas of a woman's body, and, the cellulite removal and slimming effect expected from the cosmetic textile product can be observed most accurately by using leggings.

The production of leggings was carried out on a Santoni knitting machine, and service was procured from a company that produces seamless products. Only a lock stitch was used at the crotch and the inner leg of the product. The fabric of the produced leggings was made of PA 85%- EA 15% and the fabric mass per unit area was 276 g/m^2. Table 2 presents the data of the produced leggings.

Table 2. The data of produced leggings

Tablo 2. Üretilen tayta ilişkin veriler

Product Group	**Leggings**
Garment Model	
Product Features	Anti-cellulite, slimming and moistening
Product Content	PA 85%, EA 15%
Sizes	S, M, L, L/XL

The fabric of leggings has different knitting structures such as rib, single jersey, and interlock that are combined with seamless technology that supports the desired regional shaping, firming, and slimming effects in the best way while providing wear comfort. The results of our previous studies were used to determine the fabric raw material and construction [23-24].

Table 3 presents the size chart and Figure 1 shows the technical drawing of the leggings.

Table 3. Size chart of produced leggings

Tablo 3. Üretilen taytın ölçü tablosu

Measurement (cm)	**Sizes**			
	S	**M**	**L**	**L/XL**
Waist (A)	26	28	30	32
Hip (B)	27	29	31	33
Waistband Height (C)	3	3	3	3
Front Crotch Length (Including Waistband) (D)	18	19	20	21
Crotch Patch Width (E)	11	11	11	11
Crotch Patch Length (F)	15	15	15	15
Near Length (G)	84	85	86	87
Inner Seam (Inner Lenght) (H)	63	64	65	66
Bottom Hem (I)	11	11.5	12	12.5
Bottom Height (J)	2.5	2.5	2.5	2.5

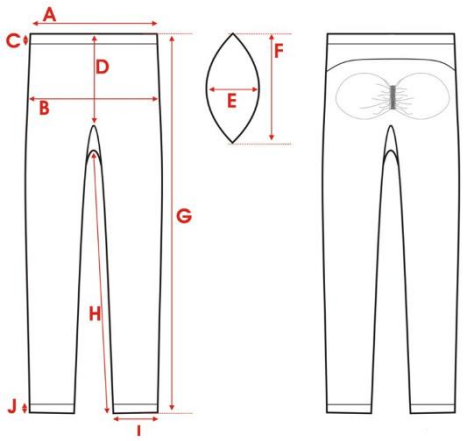

Figure 1. Technical drawing of the leggings

Şekil 1. Taytın teknik çizimi

After the production of leggings was completed, cosmetic microcapsules which were purchased from Robert Blondel SA and 5 microns in dia were applied to the leggings. Microcapsule formulation named slimming oil 20264 has slimming, moistening, and anti-cellulite properties thanks to the included herbal extracts such as caffeine, coleus forskohlii, brown seaweed extract, incha inchi oil, sandalwood extract, shea butter, and vitamin E. Microcapsules ensure a long term-controlled release of cosmetic ingredients onto the skin during usage when the microcapsule membranes break with the effects such as body heat, or pressure that caused by body movements, and friction between the garment and the skin [10]. The application of microcapsules onto the leggings was carried out with the exhaustion method under the proper temperature (~20-50 °C) and pH (5.5-6.4) range was used for the application of microcapsules onto the leggings [25-26]. After the application of cosmetic microcapsules, products were centrifuged till the moisture level in the structure was 35-40 %, and a drying process was carried out at 95° C for 45 minutes for the fixation of microcapsules. The final fabric mass per unit area was found 288 g/m^2 after microcapsule application. All the mentioned microcapsule applying processes were carried out in the project partner's company and the produced leggings as a cosmetic textile product conforms to Oeko-Tex Standard 100.

2.2. Equipment used in wear trial

Equipment such as microbalance, measuring tape, skinfold caliper, and anthropometer was used during the anthropometric measurements. On the other side, in clinical evaluation, Visioscan VC98 was used for scanning skin topography, and MPA 6 Tewameter for analyzing skin moisture.

2.3. Wear trial

Wear trial which was planned as a double-blind study was conducted in the Department of Dermatology and Venereology affiliates to the University Faculty of Medicine. The required ethics committee approval for the study was taken from the Clinical Research Ethics Committee affiliates to the same University Faculty of Medicine. Inclusion criteria for the study were as follows: (1) to be a female volunteer between the ages of 18-45 and have no health problems, (2) to be in S / M or L / XL sizes, (3) to wear underwear which will not interfere with the product effectiveness during the study, (4) not to be on any diet and only follow the typical daily eating routine to be able to compare each volunteer before and after the study, (5) not to take medication or thyroid hormone therapy. Exclusion criteria were specified and individuals: (1) who do not meet the inclusion criteria, (2) who have skin diseases such as atopic dermatitis, eczema, or psoriasis, (3) with a skin cancer history, (4) with asthma and/or known allergies, (5) with diabetes were not selected for the study. Volunteers who meet the inclusion criteria were given detailed information about the study, their questions were answered, and their verbal and written approval was taken. All of the subjects that took part in the study signed informed consent statement forms.

Objective and subjective evaluation methods were used in the wear trial to determine the effects of cosmetic microcapsules that are in the content of leggings on human skin and the cosmetic efficacy level of these products. Objective test methods, which are an essential part of cosmetic dermatology, are used to measure the effects of topical preparations on skin physiology and objectively evaluate the effectiveness of cosmetic applications [27]. Objective test methods consist of skin moisture and skin topography analyses.

Since emotions and feelings vary from person to person, and the effects of cosmetic textiles on each human skin differ, wearer satisfaction or allergic and irritant effects on human skin cannot be determined by objective test methods only. Therefore, it will be much better to use subjective test methods and to interpret the obtained objective data by combining them with subjective data. Dermatological treatment and dermatological clinical evaluation carried out in the scope of wear trial by the expert dermatologist are evaluated as subjective methods.

A wear trial was carried out for 40 women subjects who tried the product for 8 hours a day for 28 days. On the 0th day, subjects were invited and informed about the points to consider during the wear trial. The subjects were asked to take shower at least one day before the measurement days and not to use any moisturizing products or change the shower products they routinely use, during the study. Additionally, in the scope of the first subjective method called dermatological treatment, subjects were examined on the 0th day of the study by the dermatologist and checked for any dermatological findings on the human skin. The symptoms such as erythema, itching, contact dermatitis, rash, dryness, and tinea corporis were observed on the 7th and 28th days whether they are developed on the skin due to the use of the product.

During the second subjective method called dermatological clinical evaluations, cellulite formations and cellulite grades of the subjects were evaluated and scored between grades 1 to 4 by the dermatologist. The cross table regarding the changes in cellulite grades obtained from clinical evaluations performed by an expert dermatologist on the 0th and 28th day of the wear trial is given in Table 4. By the reason for the expert opinions that cosmetic textile products will be more effective on early-stage cellulite (grade 1-2) and will not be effective on late-stage cellulite, women with late-stage cellulite (grade 4) were excluded from the study. Dermatological clinical evaluation was carried out on the 0th, 7th, and 28th days of the study. Figure 2 shows the change in the cellulite appearance of a subject.

Table 4. Cellulite appearance 0th day *28th day

Tablo 4. Selülit görünümü 0. ve 28. günler

Cellulite appearance 0th day *28th day crosstable		**Cellulite 28th day**		
		Grade 1	Grade 2	Grade 3
Cellulite 0th day	Grade 1	6	0	0
	Grade 2	0	14	1
	Grade 3	0	2	16

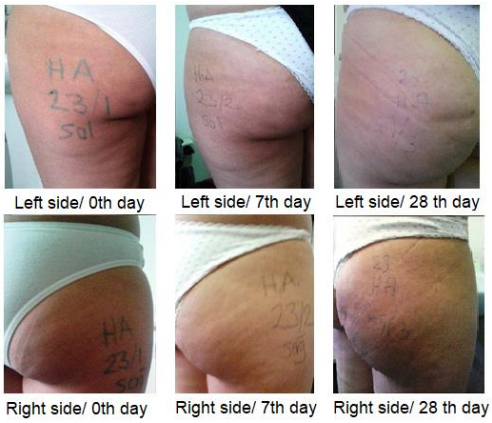

Figure 2. The change of the cellulite appearance of the subject code 23

Şekil 2. 23 kodlu deneğin selülit görünümünün değişimi

The transepidermal water loss (TEWL) of the skin was measured using MPA 6 Tewameter to evaluate the moisturizing effect of the leggings on the skin. According to the Courage Khazka Instruction Manual, the TEWL value of 0-10 g/h/m^2 indicates a very healthy condition of the skin, and the TEWL value of 25-30 g/h/m^2 demonstrates strained skin [28]. According to this manual, the TEWL values are expected to decrease. The skin topography of the subjects was scanned with Visioscan VC98 to evaluate the healing effect of the products on cellulite appearance. Both of the skin analyses were carried out by contacting the probe of the instrument directly to the skin. The subjects were measured objectively to observe whether the leggings provide the claimed cosmetic effects after usage for 28 days. Skin moisture and skin topography analyses were carried out, and the anthropometric measurements were taken on

the 0th, 7th, and 28th day of the study. During skin moisture and skin topography analyses, measurements were taken from specified points of the body such as 3 cm right from the belly button for the abdominal, back center of the upper leg, and the right side of the widest part of the calf. Measurement points were determined according to the expert dermatologist's opinion. Figure 3 shows the shots at some analysis and measurement moments.

After dermatological evaluations and skin analyses were completed, anthropometric measurements of the subjects were taken. Measurement points were determined according to the Anthropometric Standardization Reference Manual [29]. In the scope of anthropometric measurements, the skinfold thicknesses of the subjects were measured with a skinfold caliper according to the ISAK (The International Society for the Advancement of Kinanthropometry) [30]. Abdominal, supraspinale, front thigh, and calf skinfold thicknesses were defined as measurement points. Before measuring, these points were marked on the body, and measurements were repeated three times.

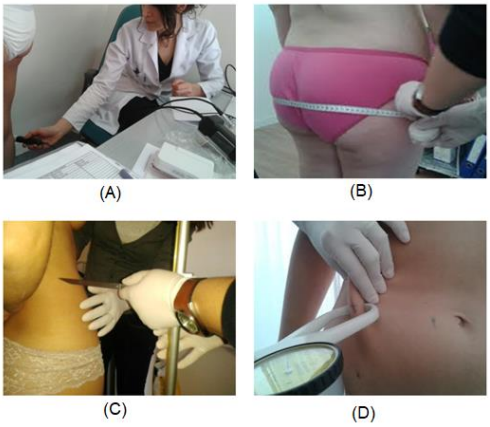

Figure 3. The skin moisture analysis (A), waist circumference measurement (B), anthropometric measurement of waist height (C), measuring supraspinale skinfold thickness with the skinfold caliper (D)

Şekil 3. Deri nemi analizi (A), bel çevresi ölçümü (B), bel yüksekliğinin antropometrik ölçümü (C), Skinfold kaliper ile supraspinal deri kıvrım kalınlıklarının ölçümü (D)

All data obtained from dermatological clinical evaluation, skin analyses, and anthropometric measurements were processed into registration forms for each subject. On the 28th day of the study, all subjects filled a Customer Satisfaction Survey out to complete the study. The opinions, expectations, and suggestions of the subjects about the leggings were questioned, and the results were used in product development.

Additionally, the data obtained from subjective and objective test methods were statistically analyzed with IBM-SPSS 21 software by using ANOVA and Bonferroni post-hoc tests at a 95 % confidence interval.

3. Results

The obtained results were evaluated under subtitles below.

3.1. Dermatological clinical evaluations

According to Table 4, there was no significant relationship found between the first and last cellulite appearances of the subjects ($x = 3.333$, $df = 1$, $p = 0.564$).

3.2. Skin moisture and skin topography analyses

According to the results on skin moisture (Table 5 (A)), a significant decrease was observed for the measurements taken from the abdomen, thigh, and calf. Especially, it can be said that skin moisture increases between the 7th and 28th days depending on product usage. Significance values of the Bonferroni test for the abdomen, thigh, and calf are $p23=0.002$, $p23=0.012$, and $p23=0.004$, respectively.

Data obtained from skin topography analysis are given in Table 5 (B). According to the results, relationships between the measurement values for the abdomen ($p1 = 0.978$) and calf ($p1 = 0.127$) were not significant. On the other hand, skin topography results of the thigh between the 0th and 7th days were found significant ($p12 = 0.015$). Nevertheless, the change in skin topography was not dermatologically meaningful and was related to cellulite appearance results determined by dermatological clinical evaluation.

Table 5. Data of skin moisture analysis (A) and skin topography analysis (B)

Tablo 5. Deri nemi analizi (A) ve deri topografisi analizi (B) verileri

	Values	0^{th} day (Mean.±St.Dev.)	7^{th} day (Mean.±St.Dev.)	28^{th} day (Mean.±St.Dev.)	Significance values
A **g/h/m²**	Abdomen	14.76±9.31	17.63±10.99	11.55±6.65	p1=0.005; p12=0.564; p13=0.175;p23=0.002
	Thigh	11.37±7.57	13.25±9.080	8.69±6.78	p1=0.014; p12=0.776; p13=0.213; p23=0.012
	Calf	10.27±6.29	12.54±7.27	8.45±3.49	p1=0.009; p12=0.408; p13=0.384; p23=0.004
B **%**	Abdomen	30.16±0.96	30.09±1.49	30.14±1.57	p1=0.978; p12=1.000; p13=1.000; p23=1.000
	Thigh	29.82±1.92	28.75±1.89	29.04±2.09	p1=0.010; p12=0.015; p13=0.107; p23=1.000
	Calf	30.33±2.06	30.03±1.56	30.70±1.50	p1=0.127; p12=1.000; p13=0.897; p23=0.039

p1= ANOVA

p12= Bonferroni 0^{th} day*7^{th} day

p13= Bonferroni 0^{th} day*28^{th} day

p23= Bonferroni 7^{th} day*28^{th} day

3.3. Anthropometric measurements

The statistical analysis results of the circumference measurements anthropometrically taken are given in Table 6. According to the results, a significant decrease was determined in waist circumference measurements taken during the study (p1 <0.001). When the average waist circumference values are examined, it was observed that the subjects become slimmer approximately 0.78 cm from their waist circumference after the usage of the product for 8 hours a day for 28 days. The results obtained from anthropometric measurements of the abdomen circumference show that there was a significant decrease in the values (p1=0.006). The average decrease around the abdomen after the usage of the product was 0.83 cm. Similarly, there were also found significant decreases in the upper leg (p1<0.001) and calf (p1=0.008) circumferences of subjects after 28 days.

The decrease measure was 0.75 cm for the upper leg and 0.28 cm for the calf. On the other hand, the results obtained from the data of the hip (p1=0.055), and the mid-upper leg (p1=0.072) circumference measurements were not found significant.

Additionally, data obtained with anthropometric measurement of subjects who tried products in different sizes, although they have the same circumference values were also evaluated separately. Table 7 shows the change of some circumference measurements on the last day of the study against the first day. When Table 7 is examined, it was seen that the garments with smaller sizes have better results. Considering these observations, it can be said that cosmetic textile garments, which cover the body more tightly provide better slimming effects.

It is a meaningful result because the pressure is one of the required factors in which the microcapsules that are on the leggings burst and the cosmetic ingredients release into the skin.

3.4. Skinfold measurements

Data obtained from skinfold measurements are given in Table 8. According to the statistical analysis results, there were significant changes in the abdominal, front thigh, and calf skinfold thicknesses. On the other hand, the change in supraspinale skinfold thickness was not found significant. The fact remains that according to the experimental measurement values, it was observed an insignificant increase in abdominal, supraspinale, front thigh, and calf skinfold thicknesses. Here, based on the skinfold measurement data, it can be said that the use of the product for 28 days does not affect the subcutaneous adipose tissue.

3.5. Relations between anthropometric and skinfold measurements

In the scope of the study, data obtained from anthropometric and skinfold measurements were evaluated together, and correlations between them were examined. Data related to the comparison between some circumference and skinfold thickness measurements are given in Table 9. According to the results, a significant linear correlation was found between all anthropometric and skinfold measurement data. Additionally, similar relation between measurement periods was observed.

Table 6. Data of anthropometric measurements

Table 6. Antropometrik ölçüm verileri

Values	0th day (Mean.±St.Dev.)	7th day (Mean.±St.Dev.)	28th day (Mean.±St.Dev.)	Significance values
Waist	79.09±8.26	78.38±8.20	78.31±8.16	p1<0.001; p12=0.001; p13=0.004; p23=1.000
Abdomen	91.14±9.46	90.60±9.23	90.31±9.19	p1=0.006; p12=0.015; p13=0.041; p23=0.668
Hip	102.99±7.68	102.63±7.71	102.65±7.65	p1=0.055; p12=0.020; p13=0.234; p23=1.000
Upper leg	60.81±5.35	60.26±5.49	60.06±5.44	p1<0.001; p12=0.003; p13<0.001; p23=0.753
Mid-upper leg	53.27±6.65	52.86±6.44	52.90±6.33	p1=0.072; p12=0.033; p13=0.334; p23=1.000
Calf	38.38±3.94	38.37±4.08	38.10±3.94	p1=0.008; p12=1.000; p13=0.0496; p23=0.014
p1= ANOVA			p13= Bonferroni 0th day*28th day	
p12= Bonferroni 0th day*7th day			p23= Bonferroni 7th day*28th day	

Table 7. The change of waist circumference (A), abdomen circumference (B), hip circumference (C), upper leg circumference (D), and calf circumference (E) of subjects with the same measures.

Tablo 7. Aynı ölçülere sahip deneklerin bel çevresi (A), karın çevresi (B), kalça çevresi (C), üst bacak çevresi (D) ve baldır çevresinin (E) değişimi.

	Subject no	Subject code	Body size	Circumference on the 0th day (cm)	Change in circumference on the 28th day (cm)	Change in circumference (%)
A	27	SP	S	69.5	-1.50	-2.16 %
	30	AO	M	69.5	-0.50	-0.72 %
B	35	KS	M	90	-2.50	-2.78 %
	32	DB	L	90	-1.00	-1.11 %
C	9	OA	S	96	0.00	0.00 %
	18	SC	S	96	-1.50	-1.56 %
	16	DA	M	96	-0.50	-0.52 %
	17	FB	M	96	-0.50	-0.52 %
D	37	YT	S	53	-2.00	-3.77 %
	30	AO	M	53	-1.00	-1.89 %
E	18	SC	S	40	-1.00	-2.50 %
	19	FK	S	40	-1.00	-2.50 %
	24	NDK	M	40	0.00	0.00 %

Table 8. Data of skinfold measurements

Tablo 8. Skinfold ölçüm verileri

Values	0th day (Mean.±St.Dev.)	7th day (Mean.±St.Dev.)	28th day (Mean.±St.Dev.)	Significance values
Abdominal	20.50±3.53	21.66±3.78	20.98±3.65	p1=0.001; p12=0.001; p13=0.427; p23=0.061
Supraspinale	17.33±5.91	16.92±6.00	16.50±5.64	p1=0.080; p12=0.948; p13=0.120; p23=0.449
Front thigh	27.85±5.17	28.72±5.11	28.50±5.22	p1=0.017; p12=0.021; p13=0.206; p23=1.000
Calf	20.15±5.35	21.32±5.81	20.60±5.62	p1=0.002; p12=0.002; p13=0.631; p23=0.060
p1= ANOVA			p13= Bonferroni 0th day*28th day	
p12= Bonferroni 0th day*7th day			p23= Bonferroni 7th day*28th day	

Table 9. Comparison between the abdomen circumference and abdominal skinfold thickness (A), the abdomen circumference and supraspinale skinfold thickness (B), the upper leg and mid-upper leg circumferences (C), the thigh skinfold thickness and mid-upper leg circumferences (D), the waist and hip circumferences (E).

Tablo 9. Karın çevresi ve karın deri kıvrım kalınlığı (A), karın çevresi ve supraspinal deri kıvrım kalınlığı (B), üst bacak ve orta-üst bacak çevreleri (C), uyluk deri kıvrım kalınlığı ve orta-üst bacak çevreleri (D), bel ve kalça çevreleri (E) arasındaki karşılaştırma.

	0th day	7th day	28th day
A	r=0.493; p=0.001	r=0.630; p<0.001	r=0.500; p=0.001
B	r=0.737; p<0.001	r=0.774; p<0.001	r=0.500; p<0.001
C	r=0.865; p<0.001	r=0.864; p<0.001	r=0.871; p<0.001
D	r=0.620; p<0.001	r=0.703; p<0.001	r=0.647; p<0.001
E	r=0.742; p<0.001	r=0.756; p<0.001	r=0.751; p<0.001

3.6. Customer satisfaction survey

Thirty-nine subjects filled the survey in after they completed the wear trial. According to the survey results, the age average of the subjects was 36.08±6.811; average height and weight were found as 161.74 cm ±7.165 and 66.24 kg ±11.285, respectively. It was determined that 84.2 % of the subjects have never tried a cosmetic textile product with similar properties, and 86.5 % of the subjects tried the product 8 hours a day for 28 days as recommended.

The opinions of the subjects about the wear comfort and pattern design of leggings and their satisfaction caused by the use of the product were also questioned through the survey. 84.6 % of the subjects gave a positive opinion on wear comfort, while 2.6 % of them had negative opinions and 12.8 % of them were indecisive. 89.5 % of the subjects reported high-level customer satisfaction. Additionally, 84.2 % of the subjects had positive thoughts on pattern design, while 10.5 % of them had negative comments and 5.3 % of them were indecisive.

On the other hand, the results of the survey were used in product development. The subjects' opinions were evaluated in terms of whether the use of the product causes any itching or irritation on the skin, whether the product's fabric causes any discomfort on the skin, and whether the softening and moistening effect of the product on

the skin after usage. According to the results, 97.4 % of the subjects did not state any itching or irritation on the skin due to usage, but 2.6 % of them reported that some itching or irritation occurs after usage of the product. All subjects (100 %) approved that the fabric of the product makes them feel comfortable. Finally, 86.9 % of the subjects reported that the product provides softening and moistening effects after usage. On the other side, 5.3 % of them had negative opinions, and 7.9 % of them were indecisive.

4. Discussion and Conclusion

The research and development of cosmetic textiles, that cover the body like a second skin and contact with the skin surface, is of great importance in terms of both protecting human health and providing wear comfort. Because a product that causes side effects on human skin, or does not have any real cosmetic effect, and does not provide a wear comfort cannot be expected to meet customer satisfaction. Consequently, the success of such a product cannot go beyond being a marketing argument. On the other hand, the product will not be accepted in any way if it harms the skin, even it has good cosmetic efficacy.

Since it is very important to evaluate the effectiveness of cosmetic textiles and their effects on the skin accurately and comprehensively, a research method has been developed in this study. The advantages of the developed method stem from its differences. The developed method is different from the others because it is interdisciplinary, comprehensive, and systematic. It consists of subjective and objective methods that complete each other according to the correlation between them. Additionally, the results of the study were evaluated by expert dermatologists and experts who carry out anthropometric measurement studies. In this way, the results obtained from the evaluation ensure the development of the accurate product, and it is thought that sharing these results as an expert opinion in the marketing strategy will increase the medical reliability of the product and customer satisfaction.

On the other hand, this method can be adapted to any type of cosmetic or functional textile product. In this direction, first, the expected features for a specified product are determined, then all of these features are tested comprehensively by using the proper objective and subjective methods. All of the mentioned advantages are considered as an innovative aspect of the study.

In this work, leggings, a sub-product of cosmetic textile was used for validation of the method. The results revealed that the products do not cause any undesirable symptoms on human skin, and maintain or even increase skin moisture. In this respect, it can be said that the products are dermatologically skin-friendly. Additionally, significant slimming effects were determined according to the anthropometric measurement results after 28 days of usage of the product. In other words, the product redeems its slimming function. On the other side, within the scope of the study, it was determined that seamless cosmetic textile products that cover the body tightly in exact body size perform better slimming effects. Because of this, it is suggested to design and develop cosmetic textile products compatible with the body size and body shape of the target customer to obtain high cosmetic efficacy.

The cellulite treatment effect, which is another claimed feature of cosmetic textile products, was also investigated within the scope of the study. According to the expert dermatologist, the problem of cellulite is a very difficult skin problem to heal with interventions with external influences such as clothing. In other words, it is very unlikely that interventions on the skin surface made with cosmetic ingredients break down the adipose tissue. Considering this situation, it can be said based on results supported by statistical analysis that the healing effect of the product is almost negligible for women with late-stage cellulite. On the other hand, it may be more effective to wear the product for more than 28 days with sport and diet, to burst of microcapsules that are on the product completely, and penetration of the cosmetic ingredients inside the microcapsules to the wearer's skin to provide the expected effects. Additionally, it is thought that the alleged cellulite treatment effect will be observed better for women with early-stage cellulite. Consequently, the leggings with cosmetic effects can be used as a supportive product in cellulite treatment, with diet, and sport.

As a result of the customer satisfaction survey carried out in the scope of the study, a high rate

of satisfaction with the comfort, visual and sensory properties of the cosmetic textile product was determined according to the opinions of the subjects who personally tried the leggings during wear trial.

In conclusion, through the developed systematic research method that is based on scientific foundations about cosmetic textiles, data were obtained using both objective and subjective methods and processed by using case report forms approved by the relevant ethics committee.

The developed research method will be a guiding basis for future studies on cosmetic textiles and can be used in the assessment and development of cosmetic textiles with comfortable, skin-friendly, and cosmetic efficacy properties, hence offering high customer satisfaction and broad market share by providing a comprehensive evaluation of these products.

4.Tartışma ve Sonuç

Vücudu ikinci bir deri gibi saran ve deri yüzeyi ile temas eden kozmetik tekstillerin araştırılması ve geliştirilmesi, hem insan sağlığının korunması hem de giyim konforunun sağlanması açısından büyük önem taşımaktadır. Çünkü insan derisinde yan etkilere neden olan veya gerçek bir kozmetik etkisi olmayan ve kullanım rahatlığı sağlamayan bir ürünün müşteri memnuniyetini karşılaması beklenemeyecektir. Dolayısıyla böyle bir ürünün başarısı bir pazarlama argümanı olmaktan öteye gidemeyecek, öte yandan, ürün kozmetik olarak iyi olsa bile derisine zarar veriyorsa hiçbir şekilde kabul edilmeyecektir.

Kozmetik tekstillerin etkinliğini ve deri üzerindeki etkilerini doğru ve kapsamlı bir şekilde değerlendirmek çok önemli olduğu için bu çalışmada bir araştırma yöntemi geliştirilmiştir. Geliştirilen yöntemin avantajları farklılıklarından kaynaklanmaktadır. Geliştirilen yöntem disiplinlerarası, kapsamlı ve sistematik olması nedeniyle diğerlerinden farklıdır. Aralarındaki korelasyona göre birbirini tamamlayan sübjektif ve objektif yöntemlerden oluşmaktadır. Ayrıca çalışmanın sonuçları uzman dermatologlar ve antropometrik ölçüm çalışmaları yapan uzmanlar tarafından değerlendirilmiştir. Bu sayede, değerlendirmeden elde edilen sonuçlar doğru ürünün geliştirilmesini sağlamakta, ve bu sonuçların pazarlama stratejisinde uzman görüşü olarak paylaşılmasının ürünün tıbbi güvenilirliğini ve müşteri memnuniyetini artıracağı düşünülmektedir.

Öte yandan, bu yöntem her türlü kozmetik veya fonksiyonel tekstil ürününe uyarlanabilir. Bu doğrultuda öncelikle belirli bir ürün için beklenen özellikler belirlenir, ardından bu özelliklerin tümü uygun objektif ve subjektif yöntemlerle kapsamlı bir şekilde test edilir. Bahsedilen avantajların tümü çalışmanın yenilikçi bir yönü olarak değerlendirilmektedir.

Bu çalışmada, yöntemi doğrulamak için kozmetik tekstilin bir alt ürünü olan tayt kullanılmıştır. Sonuçlar, ürünlerin insan derisinde istenmeyen herhangi bir belirtiye yol açmadığını, deri nemini koruduğunu ve hatta artırdığını ortaya koymuştur. Bu açıdan ürünlerin dermatolojik olarak deri dostu olduğu söylenebilir. Ayrıca antropometrik ölçüm sonuçlarına göre ürünün 28 günlük kullanım sonrasında belirgin inceltme etkileri saptanmıştır. Diğer bir deyişle, ürün inceltme fonksiyonunu yerine getirmektedir. Öte yandan çalışma kapsamında vücudu tam beden ölçüsünde sıkıca saran dikişsiz kozmetik tekstil ürünlerinin daha iyi inceltme etkisi gösterdiği belirlenmiştir. Bu nedenle, yüksek kozmetik etkinlik elde etmek için hedef müşterinin vücut ölçülerine ve vücut şekline uygun kozmetik tekstil ürünlerinin tasarlanması ve geliştirilmesi önerilmektedir.

Kozmetik tekstil ürünlerinin iddia edilen bir diğer özelliği olan selülit tedavisi etkisi de çalışma kapsamında araştırılmıştır. Uzman dermatologa göre selülit sorunu, giyim gibi dış etkenlerle yapılan müdahalelerle iyileşmesi oldukça zor bir deri sorunudur. Yani kozmetik içeriklerle deri yüzeyine yapılan müdahalelerin yağ dokusunu parçalaması çok düşük bir ihtimaldir. Bu durum göz önünde bulundurulduğunda, istatistiksel analizlerle desteklenen sonuçlar da baz alınarak ileri evre selülitli kadınlarda ürünün iyileştirici etkisinin yok denecek kadar az olarak söylenebilir. Öte yandan ürünün spor ve diyet ile 28 günden daha uzun bir süre giyilmesi, ürün üzerinde bulunan mikrokapsüllerin tamamen patlaması ve mikrokapsüllerin içindeki kozmetik bileşenlerin kullanıcının derisine nüfuz ederek beklenen etkilerin sağlaması için daha etkili olabilir. Ayrıca iddia edilen selülit iyileştirme etkisinin

erken evre selüliti olan kadınlarda daha iyi görüleceği düşünülmektedir. Sonuç olarak kozmetik etkisi olan taytlar selülit tedavisinde, diyet ve sporla birlikte destekleyici ürün olarak kullanılabilir.

Çalışma kapsamında gerçekleştirilen müşteri memnuniyet anketi sonucunda, giyim denemesinde taytı kişisel olarak deneyen deneklerin görüşlerine göre kozmetik tekstil ürününün rahatlık, görsel ve duyusal özelliklerinden yüksek memnuniyet oranı tespit edilmiştir.

Sonuç olarak, kozmetik tekstiller konusunda geliştirilen bilimsel temellere dayanan sistematik araştırma yöntemi ile hem objektif hem de subjektif yöntemler kullanılarak veriler elde edilmiş ve ilgili etik kurul tarafından onaylanan olgu rapor formları kullanılarak işlenmiştir.

Geliştirilen araştırma yöntemi, kozmetik tekstiller ile ilgili gelecekte yapılacak çalışmalara yol gösterici bir temel oluşturacak ve konforlu, deri dostu ve kozmetik etkinliğe sahip kozmetik tekstillerin değerlendirilmesi ve geliştirilmesinde kullanılabilecek, dolayısıyla bu ürünlerin kapsamlı bir değerlendirmesini sağlayarak yüksek müşteri memnuniyeti ve geniş pazar sunacaktır.

5. Ethics committee approval and conflict of interest statement

This study was carried out under the ethics committee approval that was taken from the Clinical Research Ethics Committee affiliated to the Ege University Faculty of Medicine.

The authors have no conflict of interest with any person or institution to declare.

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