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DETERMINING THE APPROPRIATE FABRIC TYPE FOR USE IN THE PRODUCTION OF COSMETIC TEXTILES BY PERFORMANCE TESTS

ABSTRACT

It was aimed to determine the appropriate fabric type for designing and developing cosmetic textiles with high comfort and cosmetic efficacy properties in this study. In this respect, 7 different types of knitted fabrics that are made of different raw materials, and have different fabric constructions and yarn numbers were planned to use in the production of cosmetic textile products. Firstly, trial productions of these fabrics were done and performance tests were carried out. After determination of the appropriate fabric type by performance tests, suggestions were given about proper end usage and final product according to the chosen fabric.

Keywords: Cosmetic Textiles, Performance Tests, Cosmetic Effects, Knitted Fabric, Garment

1. INTRODUCTION

The daily intense working routine in city life doesn’t allow people to spare time for sport and personal care. This situation leads people to be in a search of innovative products that could meet their various requirements. Additionally, it is thought to be the reason for the increasing demand for garments that are designed to transfer the active substances to the human skin for cosmetic purposes. These garments are named “cosmetic textiles” and claimed to ensure cosmetic benefits such as cleaning, perfuming, moistening, slimming, anti-aging, UV protection, energizing, refreshing, relaxing, and vitalizing [1, 2 and 3]. The importance of cosmetic textiles increases day by day due to their high potential caused by the integration of textile and cosmetics. These products are in large contact with the body and are claimed to ensure the aforementioned superior benefits to customers in terms of body care and wellness. Especially, women who are the main target customer of cosmetic textile products tend to perform the neglected body care using these products and feel younger, more attractive, and fit in this way. On the other hand, numerous initiatives on cosmetic textiles cause the questions that why textiles are used for cosmetic effects. Consequently, the lack of information on cosmetic textile is the main reason that the customers approach these products with suspicion. Namely, the claimed properties of cosmetic textiles are thought of as a marketing argument by customers, unless they are not supported with scientific basis studies. The existing situation about the increasing demand for cosmetic textiles demonstrates the need for systematic methods to verify, prove and document the performance and effectiveness of these products.

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2. RESEARCH SIGNIFICANCE

The former studies on cosmetic textiles are generally focused on microencapsulation methods, microcapsule formulas, their washing resistance, stability degree, and penetration rate to human skin [4, 5, 6, 7, 8, 9, and 10]. There are no studies on the evaluation of performance properties of these products with standard methods and the effects of cosmetic compounds in these products on the human skin. Additionally, it is thought the subject of wear comfort is very important for cosmetic textile products that cover the body like a second skin. As it is seen, even a cosmetic textile product has excellent cosmetic performance, it wouldn’t be put on regularly by the wearer if it is not comfortable. In other words, it can’t fulfill its cosmetic function properly without ensuring comfort to the wearer. On the other side, if a cosmetic textile product is comfortable, it will contact human skin for a long time, so the cosmetic effect could be observed much more. In this study, different types of knitted fabrics were produced, and by fabric performance tests they were examined in terms of suitability to use in cosmetic textile products and their physical properties were determined. According to the obtained results, the best fabric structure was revealed and suggestions were done according to the usage area.

3. MATERIALS AND METHODS

Yarns made of raw materials such as polyamide, cotton, elastane, cellulose, and regenerated cellulose were used as material for fabric production. Polyamide yarn numbers are in the range of 60-70 denier and the cotton yarn is 30/1 Ne. These yarns were knitted in different fabric constructions such as a rib, single jersey, and interlock. Fabrics were produced by using Santoni circular knitting machine given in Figure 1 and the produced fabrics are given in Table 1. After fabric production, the produced fabrics were evaluated with performance tests. By performance tests, the appropriate fabric construction and the appropriate model were determined in accordance with the desired feature of cosmetic textile garment which is planned to use in further wear trials. Test methods used in the measurement of physical comfort properties of fabrics are given below.

Figure 1. Santoni knitting machine production line

Table 1. Fabrics produced in the study

Fabric Code	Fabric Construction	Blend Ratio
FN-1	Interlock	Polyamide 85 %, Elastane 15 %
FN-2	Rib	Polyamide 85 %, Elastane 15 %
FN-3	Single Jersey	Polyamide 85 %, Elastane 15 %
FN-4	Single Jersey	Polyamide 83 %, Elastane 17 %
FN-5	3D Weft Knit	Polyamide 85 %, Elastane 15 %
FN-6	Single Jersey	Cotton 36%, Modal 36% and Elastane 28%
FN-7	Single Jersey	Cotton 95%, Elastan %5

3.1. Determination of Permanent Elongation and Stretching Properties

Stretching properties of fabrics were tested with Zwick/RoellZ010 testing machine according to ISO 14704-1:2005, M&S(P15A), and Next(TM21A) standards. Obtained parameters according to each standard are given in Table 2.

Table 2. Test standards and obtained parameters

ISO 14704-1: 2005	S (Elongation %)
	C (Unrecovered Elongation %)
	D (Recovered Elongation %)
	R (Elastic Recovery %)
M&S(P15A)	Extension % at 2 kgf
	Modulus at 40%
	Residual Extension
Next(TM21A)	Extension % at 2kg
	Recovery %

3.2. Measurement of Thermal Resistance

The thermal resistance (Rct) value of fabrics was measured by using a Sweating Guarded Hotplate instrument according to the EN ISO 31092, ISO 11092 ve ASTM F1868 standards. Standard test conditions were 20°C and 65% relative humidity.

3.3. Measurement of Air Permeability

The air permeability of fabrics has an important effect on wear comfort and was measured according to the TS 391 EN ISO 9237. During the air permeability test, test pressure was set to 100 Pa.

3.4. Measurement of Fabric Mass Per Unit Area

Fabric mass per unit area affects the properties of fabric such as strength, hydrophility, fabric density, knitting type, and softness. On the other hand, different fabric unit weight values are required according to the different usage areas and usage conditions. Mass per unit area of the produced fabrics was tested according to the TS EN 12127 standard.

3.5. Measurement of Pilling Property and Evaluation of Surface Change (Martindale Method)

Fabric samples were tested by using a Martindale tester to determine the pilling formation caused by fabric to fabric abrasion according to the TS EN ISO 12945-2. After the test, the fabric surface of each sample was evaluated subjectively and pilling levels were scored from 1 to 5. 1 refers to high surface hairiness and pilling formation, while 5 means there is no change on the surface [11].

4. FINDINGS

4.1. Permanent Elongation and Stretching Properties

Test results obtained for length and width elongation according to the ISO 14704-1:2005 standard are given in Table 3.

Table 3. Elongation and elastic recovery results (ISO 14704-1:2005:E)

Sample	Length Direction						
	S	C (1 min) %	D (1 min) %	R (1 min) %	C (30 min) %	D (30 min) %	R (30 min) %
FN-1	161.04	33.00	67.00	41.60	31.00	69.00	42.84
FN-2	136.25	20.00	80.00	58.71	18.00	82.00	60.18
FN-3	188.12	49.00	51.00	27.11	45.00	55.00	29.23
FN-4	214.70	33.50	66.50	30.97	29.00	71.00	33.06
FN-5	181.32	28.00	72.00	39.70	25.00	75.00	41.36
FN-6	106.31	4.00	96.00	90.29	3.50	96.50	90.76
FN-7	106.13	16.00	84.00	79.14	14.00	86.00	81.02
Sample	Width Direction						
	S	C (1 min) %	D (1 min) %	R (1 min) %	C (30 min) %	D (30 min) %	R (30 min) %
FN-1	146.40	20.00	80.00	54.64	19.00	81.00	55.32
FN-2	132.12	17.50	82.50	62.43	16.00	84.00	63.56
FN-3	160.86	30.00	70.00	43.52	27.00	73.00	45.38
FN-4	220.44	40.00	60.00	27.22	31.00	69.00	31.30
FN-5	163.83	18.00	82.00	50.05	16.00	84.00	51.27
FN-6	69.50	3.00	97.00	139.56	2.50	97.50	140.28
FN-7	123.24	23.00	77.00	62.48	20.00	80.00	64.91

In Table 3; S, C, D, and R indicate % elongation, unrecovered elongation, recovered elongation, and elastic recovery, respectively. % Elongation (S) was determined using Equation 1 where E (mm) is the extension at the maximum force on the 5th cycle and L is the initial length (mm):

$$S = \frac{(E-L)}{L} * 100 \quad (1)$$

Unrecovered elongation (C) was determined using Equation 2 where Q is the distance between applied reference marks after a specified recovery period (mm) and P is the initial distance between applied reference marks (mm).

$$C = \frac{Q-P}{P} * 100 \quad (2)$$

Recovered elongation (D) and elastic recovery were determined using Equation 3 and Equation 4, respectively.

$$D = 100 - C \quad (3)$$

$$R = D/S \quad (4)$$

Results obtained about permanent elongation and stretching properties of fabrics according to the M&S (P15A) standard are given in Table 4.

Table 4. Extension, modulus, and residual extension results (M&S P15A Standard)

Sample	Length Direction			Width Direction		
	Extension 1.5 kgf	Modulus 40 %	Residual Extension	Extension 1.5 kgf	Modulus 40 %	Residual Extension
FN-1	153.03	106.67	23.37	144.03	156.67	15.20
FN-2	131.27	170.00	16.30	134.10	160.00	14.80
FN-3	171.70	83.33	32.93	157.63	133.33	22.10
FN-4	214.63	46.67	26.70	217.67	46.67	27.10
FN-5	170.40	86.67	21.07	154.80	180.00	12.93
FN-6	103.57	363.33	3.80	66.40	663.33	3.33
FN-7	107.20	53.33	14.20	114.43	50.00	20.00

Test results obtained according to the standard of Next Method 21A are given in Table 5.

Table 5. Extension and recovery results (Next 21A)

Sample	Length Elongation		Width Elongation	
	Recov.	dL(2kgf) Fapply mm	Recov.	dL(2kgf) Fapply mm
FN-1	67.50	178.74	81.25	160.86
	70.00	168.41	81.25	158.54
	70.00	171.64	81.25	163.46
FN-2	80.00	149.84	82.50	146.54
	80.00	148.06	81.25	143.44
	80.00	148.59	82.50	149.11
FN-3	62.25	193.88	*	*
	62.25	194.43	*	*
	62.50	191.34	71.25	179.99
FN-4	71.25	219.79	68.75	233.39
	71.88	221.14	68.75	229.59
	71.25	220.41	68.75	231.79
FN-5	68.75	199.96	80.00	188.38
	70.00	194.96	80.00	186.08
	70.00	191.41	80.00	187.54
FN-6	93.75	122.48	95.00	80.93
	94.38	124.44	100.00	80.53
	93.75	121.08	100.00	80.53
FN-7	82.50	112.16	75.00	124.71
	81.88	112.96	75.00	127.67
	81.88	112.47	75.00	131.16
*Could not be measured				

Considering the results obtained from tests performed on 7 main fabric samples according to ISO 14704-1, M&S (P15A), and Next 21A standards, it was seen that the sample FN-6 has the best elastic recovery % value. This result was expectable because the elastane rate of FN-6 is 28% and higher than the other fabric samples. When the permanent elongation values of samples obtained according to ISO 14704-1 standard are compared, the sample FN-6 was found the best both in length and width directions. This result was followed by samples 7, 2, 5, 1, 4, and 3 in the length direction and by samples 2, 5, 1, 7, 3, and 4 in the width direction.

In the study, fabric samples FN-1, FN-2, and FN-3 that were made of the same raw materials in the same blend ratios were knitted together with seamless technology. Because of this, they were referred to as the new knitted fabric (NKF) and evaluated together in terms of permanent elongation and stretch properties. According to the results, sample FN-2 was planned to be used in the garment parts that are in contact with the moving parts of the body because of the high recovery ratio of the fabric both in width and length directions. Thus, it will provide comfort and ease of use for the wearer. Sample FN-1 which the value of length elongation is high was found suitable to use for garment parts that are in contact with the gluteal area of the body or similar areas that need more stretching property, although its elastic recovery is less than FN-2.

On the other hand, sample FN-3 was found to have the highest elongation but the lowest permanent elongation and lowest recovery value among the samples FN-1, FN-2, and FN-3. Because of this, FN-3 was planned to use in garment parts such as a leg.

When the results of the NKF were compared with the samples FN-4 and FN-5, it was determined that the sample FN5 has the lowest permanent elongation value. Similarly, elastic recovery values of the samples were evaluated and the NKF was found as the most elastic structure. This was followed by sample FN-5 and FN-4. It can be said that the permanent elongation and elastic recovery property of the sample FN-4 is not very bad, although it has a looser knit structure than the NKF.

4.2. Thermal Resistance

Test results obtained from the thermal resistance test are given in Table 6.

Table 6. Thermal resistance test results

Sample	Rct (m^2.K/W)
NKF (FN-1,FN-2, FN-3)	22.5×10^{-3}
FN-4	16.8×10^{-3}
FN-5	30.6×10^{-3}
FN-6	23.1×10^{-3}
FN-7	19.2×10^{-3}

According to the test results, sample FN-5 was seen to have the highest thermal resistance and was followed by FN-6, NKF, FN-7, and FN-4, respectively. The results are meaningful because the thickness of the fabric affects the thermal conductivity of the garment significantly. The thermal resistance of fabrics increases when the thickness and consequently the air inside the fabric increase [12]. When all the knitted fabric structures are evaluated, it can be seen that the thickest fabric is FN-5 due to its 3D weft knit structure and the loosest one is FN-4. After the determination of the thermal resistance property of fabrics, evaluations were done to determine the proper end uses of the produced fabrics in terms of wear comfort. Thermal resistance (Rct) is used to show the thermal isolation property of a material and high thermal resistance refers to high thermal isolation. So a garment that has high thermal resistance keeps the wearer warm [13]. In this direction to ensure wear comfort, fabrics with low thermal resistance values are preferred for garments used in hot weather conditions and fabrics with high thermal resistance values for cold weather conditions [14]. Accordingly, it is important to consider the weather conditions while the proper end use of garments that will be produced with high comfort properties is determined. For example, sample FN-5 which has the highest thermal resistance may be suggested for shapewear garments that are produced for the fall/winter season. In this way, the wearer will be warm and comfortable during a cold day. On the other side, sample FN-4 may be used for products of the spring/summer season due to its low thermal resistance. So the cosmetic shaping effect may be ensured during daily physical activities, with high wear comfort.

4.3. Air Permeability and Fabric Mass Per Unit Area

In the scope of the study, data of air permeability and fabric mass per unit area were evaluated together. Test results are given in Table 7 and Table 8, respectively.

Table 7. Air permeability test results

Sample	Average Air Permeability(l/m^2/s)
FN-1	131.00
FN-2	140.80
FN-3	121.00
FN-4	86.30
FN-5	91.60
FN-6	33.00
FN-7	540.00

Table 8. Fabric mass per unit area test results

Sample	Fabric Mass Per Unit Area(g/m²)
NKF (FN-1,FN-2, FN-3)	276
FN-4	239
FN-5	425
FN-6	300
FN-7	153

When the air permeability results were evaluated only for the samples FN-1, FN-2 and FN-3, values were found close to each other, however, the sample FN-2 was found to have the highest air permeability value among them. But in general, the sample FN-7 was found to have the highest air permeability (Table 7). This result is found meaningful when the fabric mass per unit area results (Table 8) are examined. Because the sample FN-7 has the lowest fabric mass per unit area among all fabric samples. This shows the inverse relationship between air permeability and fabric mass per unit area parameters [15]. Nevertheless, the air permeability of the sample FN-5 higher than the sample FN-6, although the fabric mass per unit area is the highest. This situation is predicted to originate because of the high elastane ratio of the fabric which makes it tighter. In line with the data obtained, it is determined that fabric knit structure and elastane ratio have important effects on the air permeability property of fabrics.

4.4. Pilling and Evaluation of Surface Change

Pilling degrees of fabric samples obtained after the number of revolutions 500 and 2000 are given in Table 9.

Table 9. Pilling degrees of fabrics

Sample	500 Revolutions	2000 Revolutions
NKF (FN-1,FN-2, FN-3)	4/5	4/5
FN-4	4/5	4/5
FN-5	4/5	4/5
FN-6	2	1/2
FN-7	3/4	2/3

The pilling results of the samples NKF, FN-4, and FN-5 were found the same both for 500 and 2000 revolutions. The value of 4/5 means that there is a negligibly little pilling occurred on the fabric surface. When the pilling resistance of knitted fabrics are compared, rib knitted fabrics are found to have the best pilling resistance, and interlock fabrics better than single jersey fabrics [16]. Because the NKF fabric is a combination of rib, interlock, and single jersey knit structures, the result could be associated with the knit structure. On the other hand, FN-4 is a single jersey, while FN-5 is a 3D weft knit, and polyamide and elastane yarns were used for both of them. The pilling degrees of FN-6 and FN-7 were found worse than NKF, FN-4, and FN-5, however, FN-7 is better than FN-6. This is related to two reasons. The first one is the effect of raw material. The pilling resistance of polyamide is better than cotton [17]. The second one is the elastane ratio of the fabric. It is known that the pilling degree decreases when the elastane ratio increases [18].

5. CONCLUSION AND RECOMMENDATIONS

The presence of the increasing demand for cosmetic textiles reveals the need for systematic methods and documentation of these products for verifying and proving their performance and effectiveness. As it is seen from the literature search, the subject of former studies wasn’t center on this need. In this study to design and produce cosmetic textile products with high-performance properties, knitted fabrics were produced and performance tests were carried out. According to the results, the best fabric structure that can meet the expectations of the desired shaping, slimming, moistening, and firming effects for the products planned to use in wear trials was found as the sample NKF which is a combination of FN-1, FN-2, and FN-3 by seamless technology. The content of the NKF fabric is polyamide %85 and elastane %15. Polyamide is a commonly preferred synthetic fiber that is used in similar cosmetic textile products in the market because of its lipophilic structure [19]. It is thought that this property is important and essential for the fabric that is used for a cosmetic textile product because of further processes like microencapsulation. On the other side, elastane fiber in the produced product ensures to produce a cosmetic textile product with high wear comfort due to its stretch property.

When study results are evaluated for the last time, FN-2 knit structure is suggested to use in the garment parts that are in contact with the moving parts of the body to provide comfort to the wearer due to its high recovery ratio. On the other side, FN-1 knit structure may be used for garment parts that are in contact with the gluteal area of the body or similar areas that need more stretching property. Finally, despite its high elongation both in length and width directions, FN-3 knit structure could be preferred in garment parts such as leg due to its low permanent elongation and low recovery.

This study constitutes an initial and a basis part of the further study on cosmetic textiles that investigate and determine the proper fabric type for designing a comfortable cosmetic textile product. Because it is thought that a garment which doesn’t ensure wear comfort can’t meet the customer satisfaction.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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DECLARATION OF ETHICAL STANDARDS

The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

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