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Physical-mechanical Properties of Aged Knitted Fabric for Swimsuits
Fizikalno-mehanske lastnosti staranih pletiv za kopalke

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Abstract

The physical and mechanical properties of knitted fabrics for sports swimsuits are analysed in this paper. The knitted fabrics were experimentally aged in seawater and exposed to the sun continuously for 100 hours. Data were processed for nine knitted fabrics with the same raw material composition, polyamide and elastane in different proportions. The physical-mechanical properties of all nine samples before and after aging, as well as the drying rate and water absorption capacity, were examined. The results show that the properties of the knitted fabric changed in all samples. The sample with a higher elastane content (59% PA and 41% EA) is less sensitive to changes in mass per unit area and thickness after aging (-0.89% and 0.40%). The results of maximum wetted radius absorption water on the top and bottom of the knitted fabric, spreading speed absorption and drying time are shown. The results show that the values of the maximum wetted radius of absorbed water and the spreading speed increase for all samples, while the drying time for the knitted fabrics show different results.
Keywords: fabric, knitwear, physical-mechanical properties, swimwear, mechanical functionalization

Izvleček

V članku so analizirane fizikalne in mehanske lastnosti pletiv za športne kopalke. Pletiva so bila poskusno starana v morski vodi in neprekinjeno 100 ur izpostavljena soncu. Meritve so bile izvedene za devet pletiv z enako surovinsko sestavo, poliamidom in elastanom v različnih razmerjih. Preučene so bile fizikalno-mehanske lastnosti vseh devetih vzorcev pred staranjem in po njem, hitrost sušenja in sposobnost vpijanja vode. Rezultati kažejo, da so se lastnosti pletiv pri vseh vzorcih spremenile. Vzorec z višjo vsebnostjo elastana (59 % PA in 41 % EA) je bil najmanj občutljiv na spremembe ploščinske mase in debeline po staranju (-0,89 % in 0,40 %). Prikazani so rezultati največjega omočenja na zgornjem in spodnjem delu pletiva (največji polmer kroga absorbirane vode), največje hitrosti vpijanja in časa sušenja. Vrednosti največjega omočenja in hitrosti vpijanja se povečajo za vse vzorce, čas sušenja za pletiva pa kaže različne rezultate.
Ključne besede: ploskovna tekstilija, pletenina, fizikalno-mehanske lastnosti, kopalke, mehanska funkcionalizacija

1 Introduction

The swimsuits used in sports today have undergone many transformations throughout history. From heavy woollen swimsuits to performance-enhanced sports swimsuits for competition. The first swimsuit manufacturers shifted their former underwear into the range of fashionable swimwear. The materials for swimsuits are knitted and, as such, are a relatively small, narrowly specialized manufacturing area in the textile industry. Thanks to technological innovations, swimwear manufacturing experienced revolutionary success in the 1980s and 1990s. In the late 1990s, new materials with a lower hydrodynamic resistance than shaved skin were developed. Reducing friction and hydrodynamic resistance has been a major issue recently. It is believed that the swimmer uses almost 90% of the energy to overcome hydrodynamic resistance during swimming. Swimsuit manufacturers invest a great deal of effort in developing new materials and cuts for swimsuits to reduce hydrodynamic resistance [1–4].

Flexibility, comfort, drying speed, high chlorine resistance and durability are desirable characteristics of knitwear for swimwear. Materials made from a mixture of polyamide and elastane, and often from 100% polyester fibres, are usually used to make swimsuits. Recently, swimsuits made of recycled materials have become popular, and sports swimsuits made of 100% recycled polyester can be found at well-known manufacturers. In sports swimwear, there is a classification of swimwear for competition, the so-called “fast suits” and training suits. Fashion swimsuits usually contain between 10% and 20% elastane, while in training swimsuits the most common blend is 68% PA and 32% EL. Competition swimsuits have an even higher percentage of elastane and have recently begun to contain carbon fibres, e.g. 65% PA/34% EL/1% carbon. Integrated carbon fibres, known for their strength and low density, work to apply compression before the fabric is fully stretched, giving the suit additional stretch capacity for excellent flexibility and mobility. Raw materials made from synthetic polymers are now an integral part of sportswear and equipment. Fast drying, lightness, perfect fit and resistance represent the characteristics and many advantages of these materials.

Polyamide 6 and polyamide 6.6 are most commonly used to make swimwear because they have higher resistance to wear, chemicals and oils, as well as good mechanical properties. However, polyamides have the ability to absorb moisture, which affects their overall properties. Polyester is a synthetic material that also offers numerous advantages and has similar properties to polyamide but has lower water absorption, which makes it more difficult for bacteria to grow. These fibres are characterized by the fact that they are resistant to deterioration and seawater compared to natural fibres. The maintenance of such synthetic fibres is easy, they dry quickly, can be mixed with other fibres and are susceptible to dying. Today, however, a great deal of research relates to the degradation of synthetic polymers such as PES and PA and their impacts on the environment. Under the influence of UV radiation, polyamide and polyester decompose at the molecular level, which consequently affects the properties of the material, durability and comfort [5–8].

As mentioned above, polymers are combined with elastane in different proportions in the manufacture of swimsuits. Elastane has a wide range of applications and is used for fashion or functional clothing, which is intended to adhere to the body and at the same time provide comfort and dimensional flexibility. Invented in Germany in 1937, spandex has exceptional elasticity, i.e. a temporary stretch of more than 200%, and also recovers quickly after exposure to stress. These fibres have a rubber-like behaviour with a high reversible elongation of between 400% and 800% [9].

The decomposition of swimwear knitted fabric is influenced by several factors. The most important factors in aging swimsuits are chlorinated water, sweat in an aqueous medium and on dry land, and swimsuit maintenance and care after each workout. In the summer months, UV radiation, high temperature and seawater are important factors for swimsuit aging. Swimsuit knitwear is expected to be resistant to UV rays, seawater, and chlorinated water. The durability of the colour in the sun is also an important requirement for the longevity and successful performance of swimsuit materials.

Previous studies have shown that the properties of materials made of polyamide, polyester and elastane change when exposed to aging conditions. The change in these properties also affects changes in the comfort and durability of the material. In the study by Salopek Čubrić et al [4], it was found that the aging of knitted fabrics made of a mixture of polyester or polyamide with elastane reduces resistance to tensile forces, and after prolonged exposure and the reduction of the mass per unit area of the knitted fabric.

Due to a number of influential research parameters related to the comfort and durability of knitwear, they represent a major challenge but have been the focus of much research for many years. The physical and mechanical properties of nine swimwear knitted fabrics from commercial manufacturers were investigated in this paper. The selected knitted fabrics were made from polyamide or polyester and elastane fibre blends in varying proportions and with different construction characteristics. The research presented in this paper is focused on the exposure of the knitted fabrics to external natural weather conditions during the summer. According to the manufacturer's description, all knitted fabrics are intended for fashion swimsuits, while six of them are for sports swimsuits. They are described as knitted fabric with maximum comfort, stretchable in both directions, easy to clean, with UV protection, and resistant to chlorine and pilling. The purpose of this study was to determine the physical and mechanical changes in the fabric after 100 hours of exposure to seawater and sun. A protocol was developed for the aging of knitwear for swimwear. The target group of the research was cadets for whom a training regimen of 120 minutes, six times a week was set, with athletes spending 10 hours training in the water. In this work, training sessions over 10 weeks were taken into account, for a total of 100 hours (June to August) spent in a water medium outdoors. The test results before and after exposure of the knitted fabric to aging conditions were compared.

2 Materials and methods

2.1 Material selection

Materials were selected to include knitted fabrics made from a blend of polyamide and elastane in varying proportions and mass per unit area, with one exception of PES and elastane. Selected materials are intended for use in the manufacture of swimsuits and are characterized by durability, resistance to chlorine, elasticity in both main directions that allows high comfort, and medium-strong compression to support the muscles. The selected sample with the highest elastane content of 41% was designated as S5. Of the nine samples, three have the same polyamide and 80/20 elastane content (Table 1.) All samples are marked with the letter S (swimming) and an ordinal number. Aged samples are marked with a letter "X".

2.2 Methods of measurement

In the experimental part, the following physical and mechanical properties of the fabric were studied: horizontal and vertical density of the fabric, mass per unit area, thickness of the fabric, breaking forces, resistance to bursting forces, maximum wetting radius during absorption, the water spreading speed of the knitted fabric and drying rate. All measurements were performed on samples before and after aging in seawater.

The horizontal and vertical densities of the knitted samples were measured using a Dino-Lite Pro AM7000 microscope at 200× magnification. The sample was placed on a flat surface and, after calibrating the microscope to the appropriate magnification, the loops in the measurement area were counted. The mass per unit area of the fabric was measured according to ISO 3801[10], method 5, where a circular sample for surfaces of 100 cm^2 was cut and measured on an analytical balance with an accuracy of +/− 0.001 g. The sample thickness was measured as the distance between the reference plate and the parallel circular feet. During the test, a pressure of 1 kPa was applied to the surface of the

Table 1: Materials for swimwear

Fabric sample	Fibre composition		Yarn linear density	
	PA (%)	EL (%)	PA (dtex)	EL (dtex)
S1	80	20	110/7	0.4/2
S2	80	20	62/7	0.6/2
S3	78	22	150/14	0.4/3
S4	78	22	150/14	0.4/3
S5	59	41	44/28	44/4
S6	73	27	33/28	33/3
S7	80	20	88/56	78/5
S8	72	28	44/28	44/4
S9	71	29	58/34	60/5

test sample. This test was performed in accordance with EN ISO 5084: 1996 [11].

Tensile force at break was measured according to ISO 13934-1 [12]. Test samples measuring 20 cm × 5 cm were prepared in the direction of the courses and in the direction of the wales. The test samples were placed between the clamps of the dynamometer and subjected to a tensile elongation at a constant speed of 100 mm/minute. The test procedure was repeated for all fabrics in both directions with five test samples. The knitted fabric was stretched to break, and the values of breaking force and breaking elongation were determined.

The resistance to bursting force was tested according to ISO 13938-2 [13]. Circular samples measuring 50 mm in diameter were secured to the bursting test ring with two circular stainless-steel rings. The samples were exposed to a steel ball with a diameter of 2.45 cm, which stretched the material in a spherical shape, and the angle of application of the force and the surface of the material on which the force acts changed continuously during the testing of the material [14]. The values obtained by this method are the force required to burst the knitted fabric.

The liquid moisture management of the fabric was measured according to the AATCC Test Method 195 [15]. This method evaluates and qualifies the moisture transfer properties of a particular knitted fabric. The instrument used for these measurements is the MMT (Moisture Management Tester) [16]. Samples measuring 8 cm × 8 cm were prepared for the test, and the test was repeated four times for each knitted sample. The values obtained and taken into account in this test were the maximum wetted radius for top and bottom surfaces, and the spreading speed for top and bottom surfaces of the knitted fabric [17].

Thermography was used as an additional method to observe liquid transport on the surface of s sample. It was used both to compare the values with the results obtained using the MMT and to describe this phenomenon in detail with regard to the parameters that were not observed using MMT, such as drying time and spreading in the x and y direction. This method has previously been used by investigators in different fields, including textiles, and authors have shown that this method is valuable in obtaining additional details that are used to observe the properties of materials [5,18]. An E6 infrared camera from Flir Systems Inc., USA was used for the measurements. The camera used has a measurement accuracy of ±2%, and thermal sensitivity of 0.06 °C. A square sample measuring 100 cm × 100 mm was prepared for the measurements. During the measurement, the sample was placed on a flat surface in a room with an air temperature of 20 °C ± 2 °C and relative humidity of 65% ± 3%. A solution of distilled water and artificial sweat (amount of 0.1 mL) was applied vertically with a pipette at a distance of 20 mm from the surface of the sample. A thermal imaging camera was placed vertically above the sample at a distance of 300 mm. It was used to detect the different phases of liquid transport and capture images, which were then used to measure the corresponding parameters. The experiment focused on the following parameters:

- wetting time (determined as the time required to absorb the solution),
- wetting area (the area of the wetted zone on the sample, determined from the image captured using the thermal camera),
- spreading speed in x- and y-direction (the spreading radii in x- and y- direction were determined from the thermal image, and those values were further used to calculate the spreading speed taking into account the wetting time), and
- drying time (after applying the solution to a sample, the temperature of the wetted zone changed, which can be seen as a colour change on a thermal image. Drying time was determined as the time taken from the moment of solution application until the moment when there was no longer a difference between the temperatures of the wetted and non-wetted zones).

FLIR Thermal Studio Suite software was used to analyse the thermograms. The liquid transport on the sample was determined by observing the histograms of the thermal images. More precisely, the histogram of the image at the beginning of the measurement was compared to the histogram of the image during the drying process of the material. At the point when it was determined that there were no differences between the two histograms (i.e., when these two histograms were equal), the material was deemed dry. The total time that elapsed from the application of the liquid to the point where the two histograms were equal was measured and noted as the drying time. The total number of repetitions was five.

2.3 Aging method

Aging conditions were defined by observing the training conditions of swimmers who trained for 120 minutes, six times a week, which means that they trained in the water for 10 hours a week, taking into account the washing of swimsuits after each training. The conditions of aging in seawater were taken into account in this work. The aging order of 100 hours of soaking in water in the sun was defined, followed by washing 10 times and air drying. All samples were immersed in seawater outdoors for a period of 100 hours during the summer in August 2021 in the Mediterranean climate zone in Dubrovnik. Maximum daily temperatures ranged from 32.2 °C to 33.5 °C, and the lowest from 27 °C to 28.3 °C, without precipitation with a mean daily relative humidity of 61% to 46%. Weather data was obtained from the Croatian Meteorological and Hydrological Service. After 100 hours of immersion in seawater, the samples were washed in a washing machine on a short program for 30 minutes at a temperature of 30 °C. ECE Formulation Non-Phosphate Reference Detergent (without optical brightener), manufactured by James Heal, was used to wash the samples, in a ratio of 5 g of detergent per 1 kg of textile. The samples were air dried in the shade and the washing procedure was repeated 10 times.

3 Results and discussion

The results of the measurements of physical and mechanical properties before and after aging are shown in the table for all samples. Table 2 shows the mean values of horizontal and vertical knitted fabric density, mass per unit area and thickness of the nine selected samples before the aging process. The results show that there are no significant differences in knitted fabric density for the first four samples (from S1 to S4), while the approximate values of mass per unit area range from 171 g/m^2 for sample S2 to 209 g/m^2 for sample S4. The thicknesses of these knitted samples are also very similar, ranging from 0.527 mm for sample S4 with the lowest knit density and the largest mass per unit area, to a thickness of 0.655 mm, which is the same for samples S1 and S2. Samples S1 and S2 are made with the same ratio of polyamide and elastane, 80%/20%, while S3 and S4 have a ratio of 78%/22%. Samples S5 to S9 have similar values for vertical and horizontal density, while the values for mass per unit area and thickness are very different. Sample S6 has a minimum thickness of 0.358 and a mass per unit area of 113 g/m^2, while the vertical and horizontal densities are 28%/26%. The sample with the largest mass per unit area is sample S5 with 226 g/m^2, while the maximum thickness of 0.655 mm was recorded for S1 and S2.

After the aging procedure, the same tests were performed on the samples under the same conditions. The results show that all samples changed to a greater or lesser extent. The change in density of knitted fabrics is shown graphically and numerically in Figure 1. The coefficient of loop density, which is the ratio between the horizontal and the vertical density, was calculated using the formula:

$$C = D_h/D_v \tag{1}$$

where D_h is horizontal knitting density and D_v is vertical knitting density.

Table 2: Results of measured density, mass per unit area and thickness of the knitted fabric samples before aging

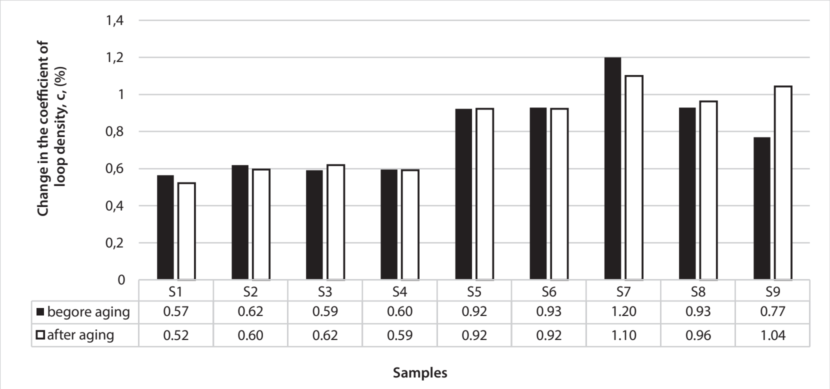
Fabric sample	Vertical/horizontal loop density (1/cm)	Mass per unit area (g/m^2)	Thickness (mm)
S1	46/26	187	0.655
S2	42/26	171	0.655
S3	44/26	198	0.561
S4	42/25	209	0.527
S5	26/24	226	0.495
S6	28/26	113	0.358
S7	20/24	216	0.502
S8	28/26	160	0.404
S9	26/20	184	0.450

The coefficient of loop density C was calculated for the values before and after the aging of the knitted fabric. It can be noted that no or insignificant change occurred in samples S4, S5 and S6. The change in the coefficient of loop density shows that the relationship between horizontal and vertical density changed, i.e. that the knitted fabric shrank more in the horizontal or vertical direction than in the other direction. This change can be observed in samples S1, S7 and S9, which leads to the dimensional instability of the knitted fabric after aging and ultimately to a change in the shape of the swimsuit.

The decrease in the coefficient of loop density in samples S1, S2 and S7 indicates that initial damage to the elastane occurred, which in other samples would occur after prolonged exposure to sun and sea. The change in mass per unit area and thickness is shown as a percentage in Table 3. Mass per unit area increased in most knitted fabrics, except in samples S4, S5 and S6, where the greatest mass loss occurred in sample S4 at 2.96%, while S5 and S6 recorded a smaller mass loss of 0.89%. The greatest change in mass per unit area was seen in sample S7, and the least in S5 and S6. A similar trend was observed for the change in thickness, with an increase in thickness for most samples except S4 and S6. The results show that the smallest change in thickness and mass per unit area occurred in sample S5 with the highest elastane content of 59% PA/41% EA, which gives it very good dimensional stability (Table 3).

Swimsuits, and particularly swimsuits for sports, are expected to fit the body very tightly, ensuring faster body movement in the water. In other words, the knitted fabrics are expected to be more resistant to multiple stresses. Since the aging process leads to changes in tensile properties, data on bursting strength were processed using the bursting test method. This method is recommended for testing the resistance of knitted fabrics to the increasing penetration load because the knitted structure stretches simultaneously in all directions.

The negative effect of UV rays and seawater on the resistance of knitted fabrics to breaking force is



	S1	S2	S3	S4	S5	S6	S7	S8	S9
■ begore aging	0.57	0.62	0.59	0.60	0.92	0.93	1.20	0.93	0.77
☐ after aging	0.52	0.60	0.62	0.59	0.92	0.92	1.10	0.96	1.04

Figure 1: Change in the coefficient of loop density before and after aging

Table 3: Changes in mass and thickness, expressed in %, compared to non-aged materials

Fabric sample	Changes in mass per unit area (%)	Change in thickness (%)
S1	2.09	3.68
S2	6.56	1.34
S3	4.35	1.41
S4	–2.96	–1.74
S5	–0.89	0.4
S6	–0.89	–1.99
S7	9.62	3.65
S8	7.51	1.7
S9	2.13	3.43

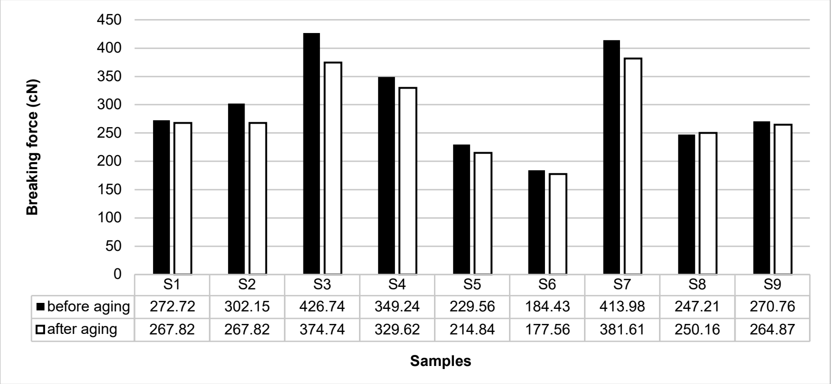
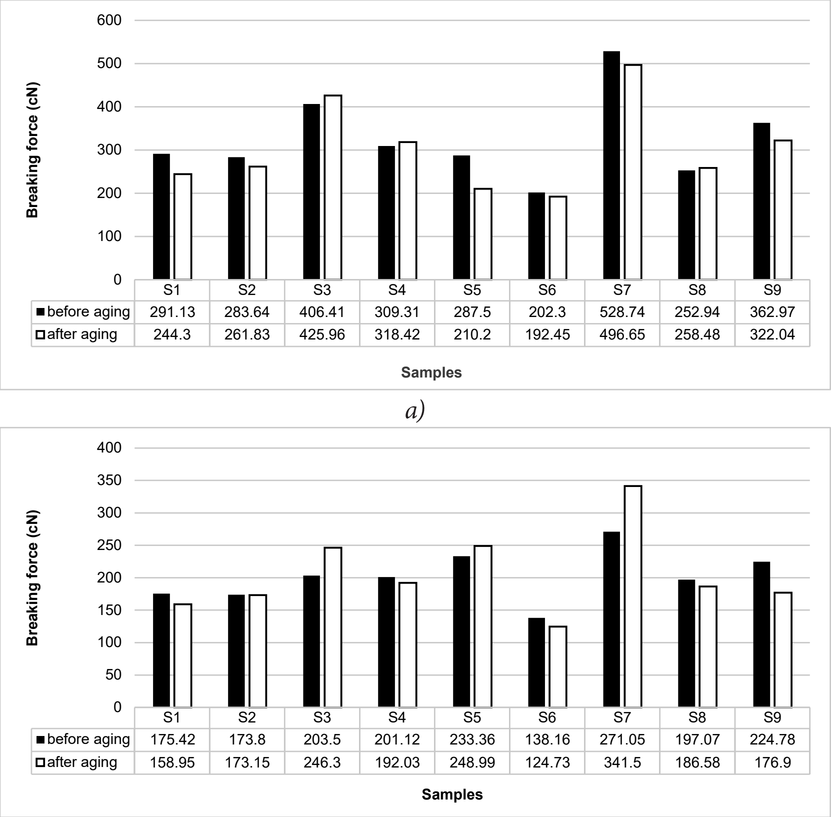


Figure 2: Change in the breaking force (bursting test) after aging

evident from the results shown in Figure 2. Eight of the nine samples showed a decrease in breaking force, while sample S8 showed a slight increase of 1.18%. This sample also showed one of the largest mass per unit area increases (because of shrinkage), which led to a small increase in the breaking force, although it can be assumed that this material was also damaged under the influence of UV radiation and seawater. The percentage decrease in resistance ranged from 1.83% to 13.88%, with S3 showing the greatest sensitivity to aging conditions.

The results of the knitted fabrics tensile strength test are shown in Figure 3a in the wale direction and 3b in the course direction. Eight samples showed a decrease in average breaking force in one of the directions, which is directly related to the lower stress tolerance. The highest percentage change was seen in S9-X with -27.07% in the wale direction and



a)

b)

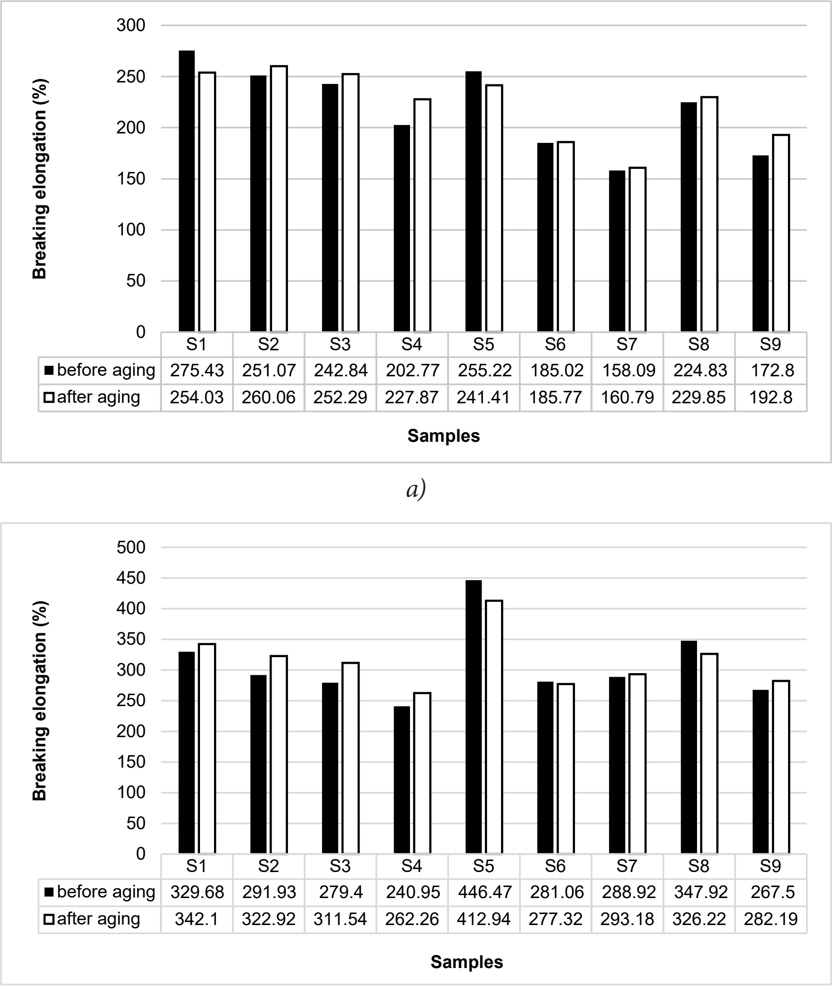
Figure 3: Change in the breaking force after aging (a) in the direction of wale (b) in the direction of course

-12.71% in the course direction. This sample recorded the largest change in the density coefficient of wales and courses from 0.77 to 1.04, i.e. the dimensional instability of the knitted fabric after aging. The next largest changes in the compaction coefficient were observed in S7 (from 1.20 to 1.10) and S3 (from 0.59 to 0.62), which was also reflected in the unexpected behaviour with increasing resistance to tensile forces in the row direction.

The influence of aging conditions was also reflected in the measured values of elongation at break, which gave the expected results of increasing elongation under the influence of aging. Of interest is sample S5, where the elongation at break was reduced in both observed directions. S5 is the sample with the highest mass per unit area and the highest percentage of elastane (Figure 4).

In order to better understand the influence of aging conditions on the changes in fabric strength, the changes of the individual measured values are given in Table 4.

Sports swimsuits are expected to absorb and retain less water, particularly in competitive swimsuits where water repellent finishes are used. The AATCC Test Method 195 and MMT tester test also evaluated the qualified moisture absorption capacity of aged and unaged samples. Figure 5 shows the results of the maximum wetted radius absorption on the top (a) and bottom (b) of the knitted fabric. These results suggest that the knitted fabric has a greater capacity to absorb water after aging, which is an undesirable characteristic for swimwear.

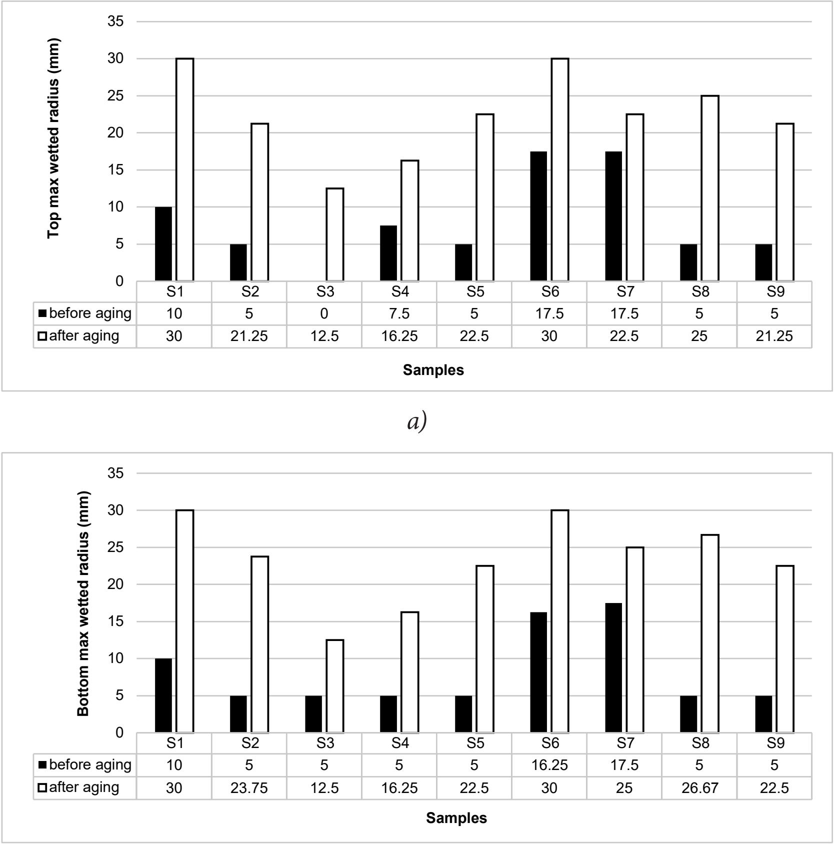


b)

Figure 4: Change in the breaking elongation after aging (a) in the direction of wale (b) in the direction of course

Table 4: Changes in breaking force and elongation, expressed in %, compared to non-aged materials

Fabric sample	Measured properties				
	Breaking force (N)			Breaking elongation (%)	
	Bursting test	Strip test/wale	Strip test/ course	Wale	Course
S1-X	−1.83	−19.17	−10.36	−8.42	3.63
S2-X	−12.82	−8.33	−0.38	3.46	9.6
S3-X	−13.88	4.59	17.38	3.75	10.32
S4 -X	−5.95	2.86	−4.73	11.02	8.13
S5 -X	−6.85	−36.77	6.28	−5.72	−8.12
S6 -X	−3.87	−5.12	−10.77	0.4	−1.35
S7-X	−8.48	−6.46	20.63	1.68	1.45
S8-X	1.18	2.14	−5.62	2.18	−6.65
S9-X	−2.22	−12.71	−27.07	10.37	5.21

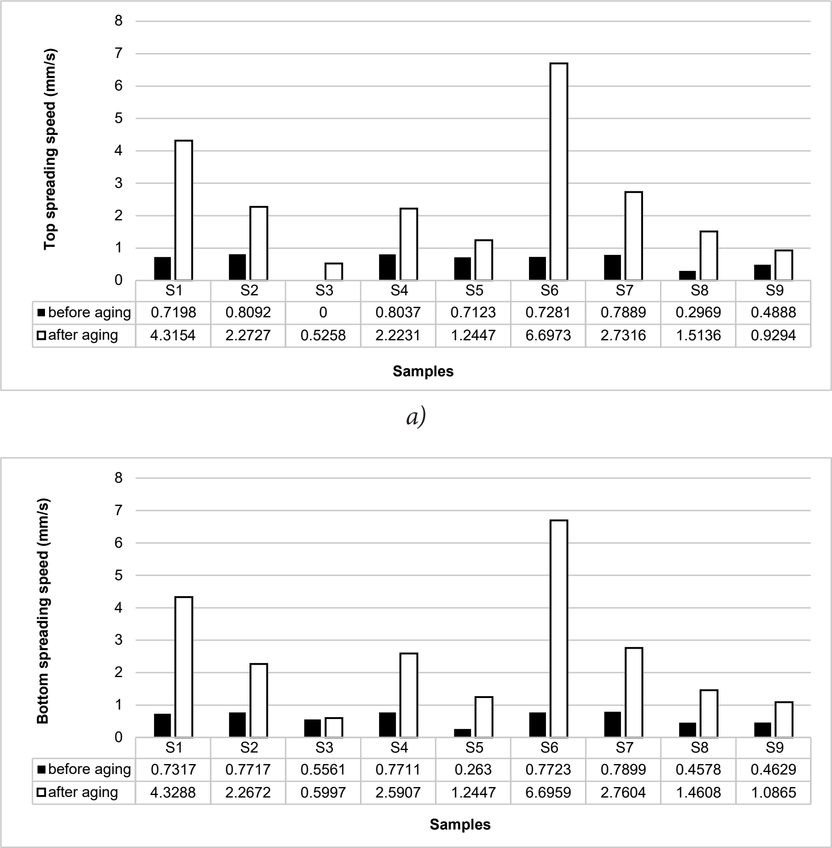


a)

b)

Figure 5. Change in the wetted radius on the top (a), and bottom (b) on the knitted fabric

As a result of the test, the spreading speed on the top and bottom side of the knitted fabric was also recorded. Figure 6 shows that the spreading speed increases after aging for all tested fabrics. The results show that the highest spreading speed after aging was recorded on S6 with the lowest mass per unit area and thickness.



	S1	S2	S3	S4	S5	S6	S7	S8	S9
■ before aging	0.7198	0.8092	0	0.8037	0.7123	0.7281	0.7889	0.2969	0.4888
☐ after aging	4.3154	2.2727	0.5258	2.2231	1.2447	6.6973	2.7316	1.5136	0.9294

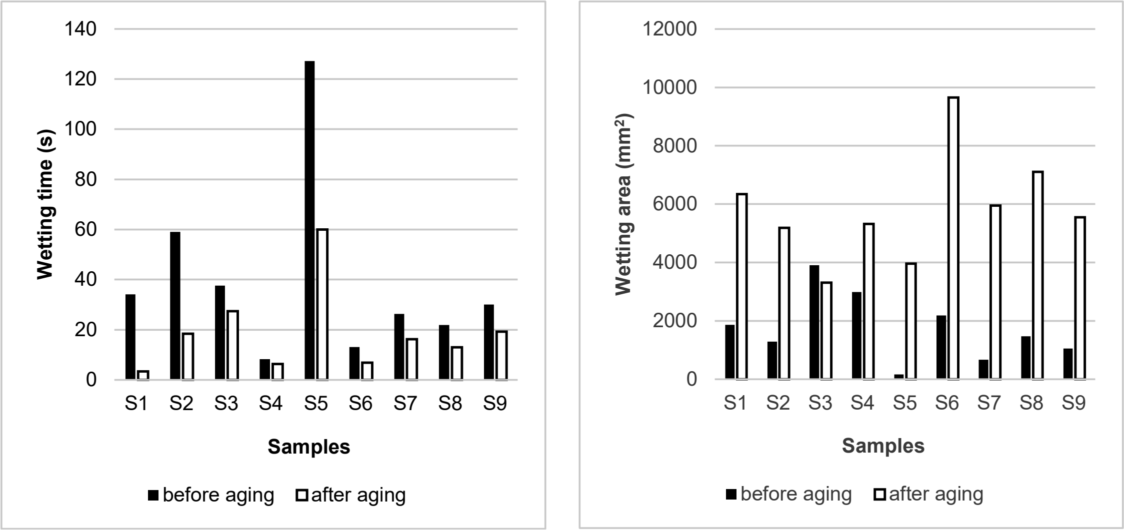
a)

	S1	S2	S3	S4	S5	S6	S7	S8	S9
■ before aging	0.7317	0.7717	0.5561	0.7711	0.263	0.7723	0.7899	0.4578	0.4629
☐ after aging	4.3288	2.2672	0.5997	2.5907	1.2447	6.6959	2.7604	1.4608	1.0865

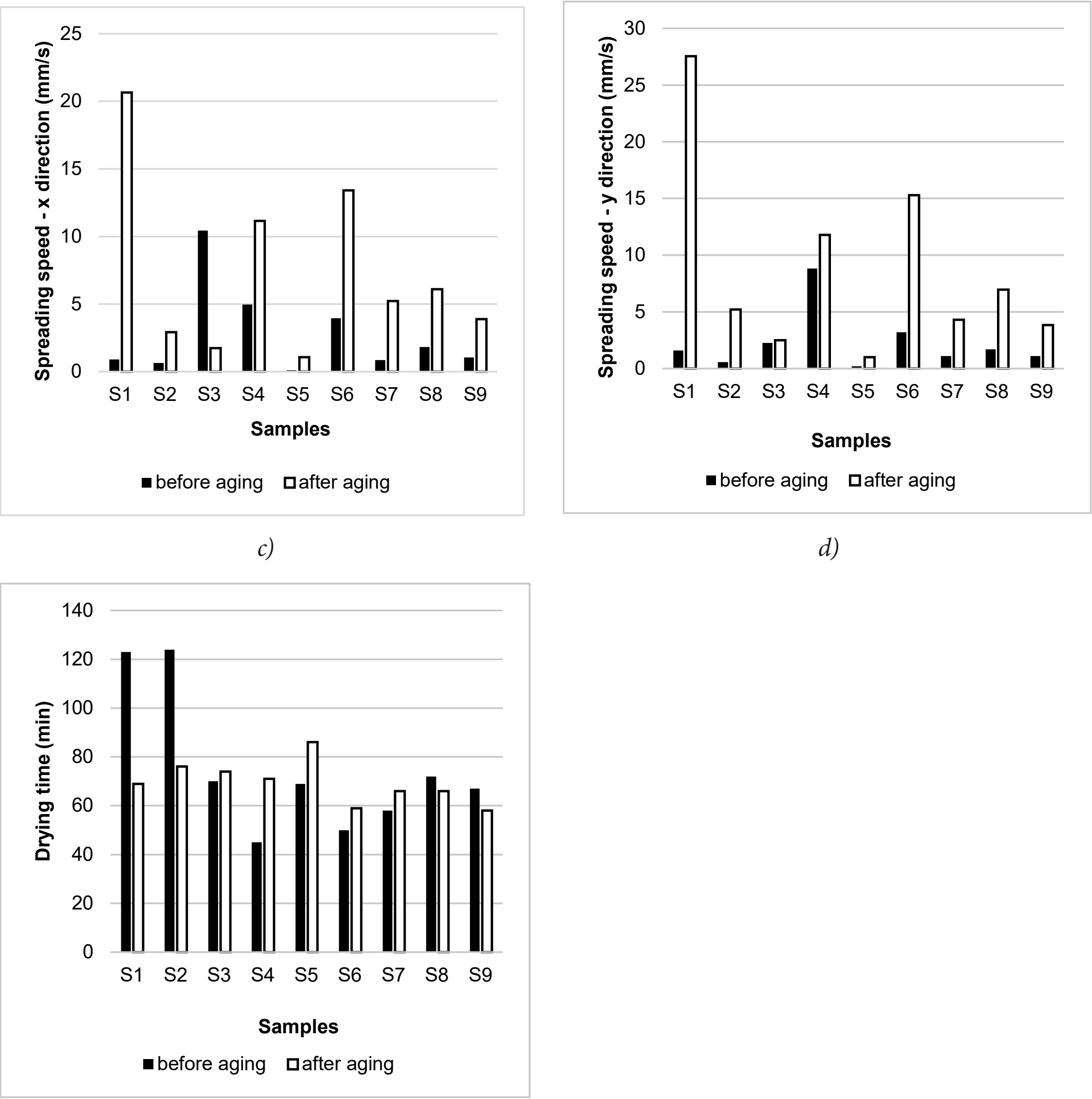
b)

Figure 6: Change in the water spreading speed on the top (a), and bottom side (b) of the knitted fabric

The results of measurements using the thermal camera are presented in Figure 7. Results relate to the wetting time, wetting area, spreading speed on the top of a sample (in both x and y direction) and drying time.



a) *b)*



c)

d)

e)

Figure 7: Results of measurement using the thermal camera: (a) wetting time, (b) wetting area, (c) spreading speed of the top of a sample in the x-direction, (d) spreading speed of the top of a sample in the y-direction and (e) drying time

The wetting time of observed materials was in the range of 3 to 60 seconds, and decreased for all samples studied. The longest wetting time of both unaged and aged samples was recorded for S5, which stands out for its highest mass per unit area (226 g/m^2, Table 2). The results of the measured wetting area were in accordance with the measured maximal wetted radius (measured using MMT, Figure 5). As can be seen from the presented graph (Figure 7 (b)), the wetting area also increases after aging for all samples studied. The increase is especially prominent for samples S1, S2, and S5-S9. The results of the spreading speed measured using the thermal camera correspond to the results of top/bottom spreading speed obtained using the MMT apparatus. For both spreading speeds (i.e. in x- and y- direction), the values increased due to aging. The most significant differences caused by aging were observed for S6 (the sample with the lowest mass per unit area and thickness among studied samples) and S1. It is interesting to note the results of the measured drying time. It can be observed from these results that the drying time was longer for the majority of samples after aging. A significant difference between the drying time of unaged and aged samples was clear for the samples with the highest initial thickness, i.e. samples S1 and S2 (both with a thickness of 0.655 g/m^2). For those two samples, the drying time decreased due to aging for up to 40% of the original drying time. As previously noted, a shorter drying time is preferable for the final purpose of the studied materials, but only if other properties are not negatively affected by aging.

4 Conclusion

All knitted fabrics had a similar raw material composition, but in different proportions and with different yarn constructions, and as expected they showed different resistance to the effects of aging conditions. However, it can be clearly seen that there were more or less significant changes in the performance of knitted fabrics in all samples. Knitted fabrics with the same content of PA and EL (S1, S2 and S7) of 80%/20% intended for fashionable swimwear showed similar behaviour after aging, in the form of a decrease in the density coefficient and an increase in the mass per unit area and thickness of the knitted fabrics. Resistance to breaking force decreasesd and elongation at maximum force increased. The wetted radius of water absorption and water spreading speed increased. Samples S3 and S4 had different raw material compositions (polyamide and polyester) in the same proportion with elastane of 72%/28%. From the results, as in the previous three samples, the sample with polyamide recorded an increase in the mass per unit area and thickness of the knitted fabric, while the sample with polyester recorded a decrease in the mass and thickness of the knitted fabric. However, their tensile properties under force were the same. The sample with the highest percentage of elastane of 41% showed slight changes in the mass per unit area and thickness of the knitted fabric, but the largest changes were observed under force, which is to be expected given the elastane content in the knitted fabric. The last three samples of polyamide and elastane with very similar proportions (73%/27%, 72%/28% and 71%/29%) showed similar changes in mass per unit area and thickness, although it can be observed that the sample with the higher elastane proportion was more sensitive to tensile and breaking forces and had higher elasticity.

The results show that the wetting time of observed materials decreased due to aging, while the wetting area and spreading speed increased. Fabrics showed different behaviours in terms if drying time. For the majority of fabrics, the aging process resulted in a slight increase in drying time, while that time decreased significantly for two out of nine fabrics.

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