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THE IMPACT OF STORAGE TEMPERATURE ON THE QUALITY OF LIQUID BATH COSMETIC PRODUCTS[1]

Abstract: Currently, cosmetic companies compete in creating innovative, increasingly inventive formulas. Simultaneously, the need to ensure proper product safety is increasing. There are legal regulations pertaining to the control of the quality of products. However, there are cases where the given product is not exposed to standard storage conditions. Due to the fact there is a risk that after a prolonged period of storage (e.g. at an increased temperature) there will be changes in the physicochemical properties of the given product. One should note that the fluctuations of temperature during transport or storage may significantly affect the destabilization of the finished cosmetic product. The factors influencing stability during the storage and transport of liquid bath cosmetic products were characterized. Particular consideration was given to the effects of increased temperature. As the determinants of the quality of bath products were designated: stability, viscosity, foam-forming properties and dissolubility. Also a sensory evaluation of shower gels was performed. After 3 months of storage, all the properties of the evaluated cosmetic products were changed. Increased temperature and storage time contribute to increased dynamic viscosity, formation of more abundant foam, increased foam stability indicator and increased time of dissolubility of the tested cosmetic products. They also have an impact on the selected sensory characteristics.

Keywords: liquid bath cosmetics, physicochemical properties, higher temperature, storage.

JEL classification: L66.

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WPŁYW TEMPERATURY PRZECHOWYWANIA NA JAKOŚĆ PŁYNNYCH KOSMETYKÓW KĄPIELOWYCH

Streszczenie: Obecnie firmy kosmetyczne prześcigają się w tworzeniu nowatorskich, coraz bardziej innowacyjnych receptur. Jednocześnie rośnie potrzeba zapewnienia odpowiedniego bezpieczeństwa produktu. Istnieją uregulowania prawne odnoszące się do kontroli jakości produktów. Jednak zdarzają się sytuacje, gdy dany produkt nie jest poddawany standardowym warunkom przechowywania. Z tego względu istnieje ryzyko, że po dłuższym okresie przechowywania (np. w podwyższonej temperaturze) nastąpią zmiany właściwości fizykochemicznych danego produktu. Należy zaznaczyć, że wahania temperatury podczas transportu lub składowania mogą znacznie wpływać na destabilizację gotowego produktu kosmetycznego. Scharakteryzowano czynniki wpływające na stabilność podczas przechowywania i transportu płynnych kosmetyków kąpielowych. Szczególną uwagę zwrócono na działanie podwyższonej temperatury. Jako determinanty jakości produktów kąpielowych wytypowano: stabilność, lepkość, właściwości pianotwórcze oraz roztwarzalność. Dokonano także oceny sensorycznej żeli pod prysznic. Z przeprowadzonych badań wynika, że po trzech miesiącach przechowywania zmianom uległy wszystkie właściwości ocenianych kosmetyków. Podwyższona temperatura i czas przechowywania przyczyniają się do wzrostu lepkości dynamicznej, tworzenia obfitszej piany, zwiększenia wskaźnika trwałości piany oraz podwyższenia czasu roztwarzania badanych kosmetyków. Wywierają także wpływ na wybrane cechy sensoryczne.

Słowa kluczowe: płynne kosmetyki kąpielowe, właściwości fizykochemiczne, wysoka temperatura, magazynowanie.

Introduction

The adverse changes in the quality of the goods lead to the deterioration of their quality. Various changes may occur and may be systematized in various manners, e.g. according to the place that creates the potential for the occurrence, type of goods affected, according to the factors that cause it, type of process, etc. The factors triggering qualitative changes in goods are divided into those that have a continuous effect and those that have a temporary one. The factors having continuous effect include, e.g. long-term static load or ambient conditions. Whereas temporary factors may include impact during the handling of goods, shocks and vibrations during transportation, etc. Another division classifies the factors as exogenous, having an effect on the outside of the product or the packaging, and endogenous, which penetrate the inside of the product or packaging. The protection against exogenous factors may be ensured to a large extent by the proper packaging. Some of the most important factors that may have a destructive impact on goods are: improper temperature, moisture, air, dust, biotic factors, improper storage and exposure during transportation, etc [Szakiel 2010, p. 89; Chochół and Depa 2002, p. 5; Karpiel and Skrzypek 1997; Barell, Paye, and Maiback 2001].

Temperature determines the number of the multiplied micro-organisms, maintenance of physical characteristics of stored goods and the rate of chemical transformations taking place. Too high a temperature may be the cause of rapid drying, changed consistency of the goods, loss of fragrance, and the accelerated biochemical or microbiological processes in products. Sunlight increases the temperature and causes the fading of some products or packaging. It also accelerates the photochemical processes that may result in decreased product quality or their complete damage. In contrast, a low temperature has detrimental effect on the products containing water since it leads to freezing and packaging cracking and damages the products causing, e.g. demulsification of emulsion products [Szakiel 2010, p. 89; Chochół and Depa 2002, p. 5; Karpiel and Skrzypek 1997].

One of the most important qualitative determinants that characterize liquid washing cosmetics is their stability. In accordance with the Regulation of the European Parliament and of the Council (EC) no 1223/2009 of 30 November 2009 on cosmetic products, a cosmetic product without a stated expiry date should be fit for use for a period of 30 months from the purchase date. In order to determine the stability of a cosmetic product, it undergoes resistance testing at various temperatures, most frequently 3–5°C, 40°C and at room temperature (approx. 20–25°C). We also perform a variable test that recreates extreme conditions. It guarantees storage stability in various conditions. The daily temperature ranges between 20–40°C, therefore in order to determine the 30-month stability, essential indicators are the results of the tests obtained after several months of storing the preparation at the temperature of 40°C. Within the period, undesirable changes in the physicochemical properties of the products may occur, e.g. dispersion, changes in colour, fragrance, consistency, which may have a significant impact on the quality of the finished cosmetic product [Starzyk and Zachwieja 2010, p. 12].

The paper presents the results of studies regarding the selected physicochemical properties for shower gels (commercial and the one developed according to the authors own formula) before (initial results) and after exposure to increased temperature for a period of 3 months (final results). The original cosmetic product included the following raw materials: Sodium Laureth Sulfate, Cocamide DEA, Cocamidopropyl Betaine, PEG/PPG 14/0 Dimethicone, Lactic Acid, Preservative, Perfume, Sodium Chloride and Aqua. The following were designated as the determinants of the quality of bath products: stability, viscosity, foam-forming properties and solubility. Also the sensory evaluation of shower gels was performed.

1. Materials and methods

1.1. Raw materials

As ingredients of shower gel detergents the following materials were used:
- *Sodium Laureth Sulfate*, Texapon NSO from Cognis Polska,
- *Cocamide DEA*, Rokamid KAD from Rokita S.A.,
- *Cocamidopropyl Betaine*, Dehyton K from Cognis Polska,
- *PEG/PPG – 14/0 Dimethicone*, Abil 8843 from Evonik Industries,
- *Lactic Acid* from P.O.Ch,
- *Methylparabene Ethylparabene Propylparabene* from Synteza Polska,
- *Perfume* from Brackmoills Ind Estate,
- *Sodium Chloride* from Brenntag Poland,
- *Aqua (distilled water).*

1.2. Methods

Stability

In order to assess the stability of preparations, temperature tests were conducted. The tests allowed the visual evaluation of the preparations stored alternately at increased (40°C, 1 day) and lowered temperatures (5°C, 1 day) for a period of 7 days. The tests were performed in the incubator type ELKON CL-65 and an Amica cooler. The testing of the sample after 7 alternating cycles was visually assessed.

Viscosity

The measurements of dynamic viscosity were conducted using the viscometer Brookfield type RVDV III Ultra. The measurements were made at the temperature of 20°C at the speed of 50 rpm. The average from 5 independent measurements was assumed as the final result.

Foam-forming properties

The foam-forming properties of the preparations made with the use of the Ross-Miles method based on the PN-ISO 696:1994 standard. 1% aqueous solutions of the tested shower gel compositions were prepared and the volume of foam, formed during their free flow from the separating funnel to the cylinder, was measured.

The volume of foam was read after 10 s from the moment of its formation (foam-forming capability) and after 1 and 10 min. The sustainability ratio was calculated according to the following formula:

$$X = (V_2/V_1) \cdot 100\%,$$

where:
V_1 – foam volume measured after 1 min [ml],
V_2 – foam volume measured after 10 min [ml].

The arithmetic mean from three independent measurements was accepted as the end result.

Solubility in water

The test is performed in order to determine the time of rinsing the preparation from the surface of the body. It is an important factor, because a part of the product remaining on the skin may have an irritating effect. It is desirable that the cosmetic products are rinsed as quickly as possible from the skin. The solubility of the product in water also determines the rate of the solubility of the preparation in a bath.

The test consists in determining the time required for the complete visual solubility of the shower gel in water, during mixing at the specified rotation speed (100 rpm).

The measurement procedure consisted in: placing 100 g of distilled water in a 150 ml beaker, adding 2 cm^3 of the shower gel onto the moving magnetic stirrer. Subsequently, the complete solubility of the preparation in water was measured. The measurement was made at the temperature of 22°C. The end result was the arithmetic mean of the three conducted measurements.

Sensory evaluation

The sensory method consists in determining by the respondents their sensations after applying the preparation on the skin. The test was performed on a ten-person group. The group of respondents evaluated such parameters as: adhesion, consistency, uniformity, pillow effect, distribution, smoothing, adsorption, glutinosity, and greasiness. The definitions of the sensory parameters

were presented in the literature [Sułek, Zięba and Mazurek 2011, p. 87]. The sensory evaluation of shower gels was carried out using a five-point scale:
- 5 – very good/very high,
- 4 good/high,
- 3 satisfactory/average,
- 2 unsatisfactory/low,
- 1 bad/very low.

As the end result the arithmetic mean from 10 evaluations was obtained for each of the parameters.

2. Results and discussion

Based on the literature data [Williams and Schmitt 1992; Mitsui 1998; Wasilewski and Klimaszewska 2007, p. 62; Sułek, Wasilewski, and Klimaszewska 2008, p. 325; Sułek and Małysa 2013; Sułek, Zięba, and Żyła 2006, p. 81] and initial own studies, the formula for an original shower gel was developed (Table 1).

Table 1. Original shower gel formula (OG)

Ingredient name	INCI name	[% w/w]
Texapon NSO	Sodium Laureth Sulphate	30
Rokamid KAD	Cocamide DEA	3.0
Dehyton K	Cocamidopropyl Betaine	6.0
Abil 8843	PEG/PPG 14/0 Dimethicone	0.2
Lactic acid	Lactic Acid	up to pH = 6.0
Preservative	Methylparabene, Ethylparabene, Propylparabene	q.s.
Fragrance composition	Perfume	q.s.
Sodium Chloride	Sodium Chloride	3
Woda	Aqua	up to 100

The execution of the preparation in accordance with the formulas (Table 1) required the development of the technologies used. Sodium Laureth Sulphate, Cocamide DEA also Cocamidopropyl Betaine, PEG/PPG 14/0 Dimethicone were added to the water. At the end the preservative, Lactic Acid, Perfume and Sodium Chloride were added.

Two commercial preparations were used, marked with the symbols: CG1, CG2.

Shower gel CG1 – creamy shower gel with a delicate aroma of summer flowers. Delicate foam with silk extract which cleanses and nourishes the body, leaving the skin soft and delicate throughout the day.

INCI composition: Aqua, Sodium Laureth Sulphate, Cocamidopropyl Betaine, PEG – 4 Rapeseedamide, Sodium Chloride, Lauryl Glucoside, Perfume, Styrene Acrylates Copolimer DMDM Hydantion, Citric Acid, Hydrolysed Silk, Propylene Glicol, Butylphenyl Methylpropional, Benzyl Benzoate, Methyl 2-octynoate, Benzyl Salicylate, Cl 16035.

Shower gel CG2 – creamy shower gel containing mild cleaning and nourishing substances. Enriched with sweet almond extract provides the skin with the proper level of hydration, soothes irritation and smooth's the skin. Pleasant smell of sweet almonds ensures an exceptional feeling of relaxation in the bath.

INCI composition: Aqua, Sodium Laureth Sulphate, Cocamide DEA, Cocamidopropyl Betaine, Sodium Chloride, Cocamidopropylamine Oxide, Styrene/Acrylates Copolimer, PEG-7 Gryceryl Cocate, Prunus Amyqdalus Dulcis, Fruit Extract, Perfume, Propylene Glicol, Tetreasodium EDTA, Methylchloroisothiazolinone, Imidazolidinyl Urea, Citric Acid, Hexyl cinnam-aldehyde, Hydroxylethylpentyl-cyclohexenecarboxaldehyde, Cl 14720.

The examination of physicochemical and functional properties and the sensory analysis at room temperature (22°C) were conducted on the first day of testing (initial results) and after 3 months (90 days) of the preparation storage in an incubator (temp. 40°C) at the temperature of 22°C (final results).

2.1. Stability

An important aspect of shower gel manufacturing is ensuring stability during storage and use. The stability criterion is the first stage of the evaluation of washing preparations. The preparations may undergo numerous adverse phenomena, such as: dispersion, colorant separation, turbidity, and change in consistency, etc. Therefore, ensuring the proper product stability starts already at the stage of developing formulas and selecting raw materials. The critical issue is maintaining the form stability throughout its useful life.

All of the tested shower gels, both on the first day of the testing (initial results) as well as on the 90th day of the testing (final results), were resistant to the exposure to increased and decreased temperature.

2.2. Viscosity

The viscosity and proper consistency are among the essential determinants attesting the quality of washing preparations. High viscosity is often associated by consumers with a high content of active ingredients in the formula. The view is often erroneous since the high viscosity of the preparation may be obtained due to the use of the proper viscosity modifier, whereas the decrease in viscosity may be caused by increased solvent concentrations.

The dynamic viscosity may be a very important indicator of adverse changes in shower gels as a result of product aging processes depending on storage conditions.

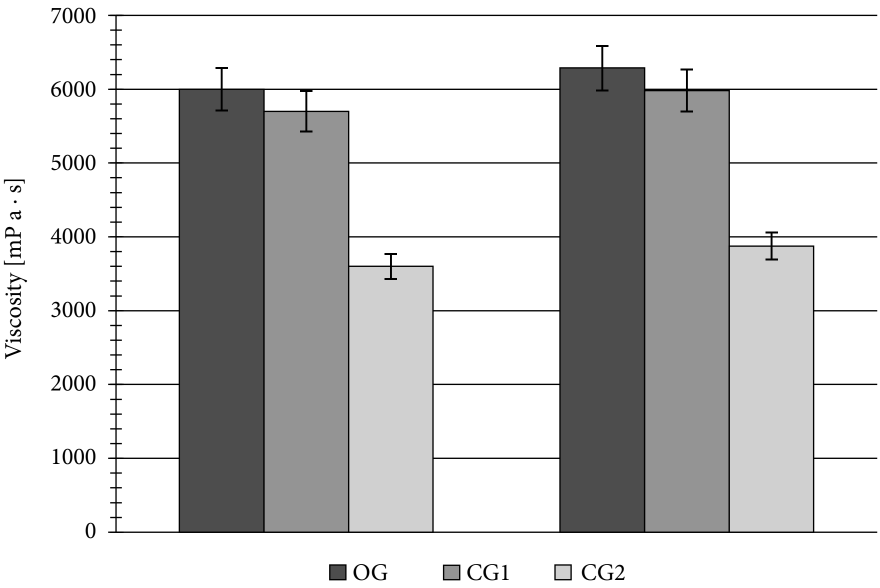

Figure 1. Dynamic viscosity of the original shower gel (OG) and commercial gels (CG1, CG2) on the first day of testing (initial value) and on the 90th day of testing (final value)

The initial values (baseline) of dynamic viscosity of the original shower gel and commercial gels range between 3,600 to 6,000 mPa·s. The dynamic viscosity of all the tested gels stored at the temperature of 40°C for a period of 3 months (value after 3 months) is higher by approximately 5% compared to the viscosity obtained at the beginning of the preparations before they were subjected to increased temperature. A slight increase in the viscosity of shower gels was most probably caused by the evaporation of water from the product due to increased temperatures.

2.3. Foaming abilities

The volume of the created foam (foaming ability) and its stability are very important criteria in the evaluation of the quality of washing preparations. Consumers often associate heavy and persistent foam with a good washing effect.

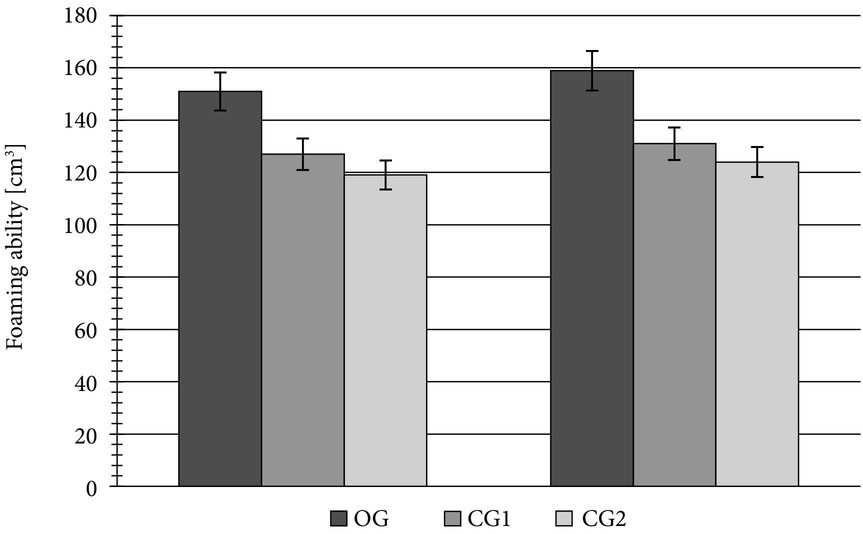

Figure 2. The foaming ability of the original shower gel (OG) and commercial gels (CG1, CG2) on the first day of testing (initial value) and on the 90th day of testing (final value)

The foaming ability of the tested shower gels on the first day of testing was within the range of 119 to 151 cm^3, whereas the proprietary gel (OG) was characterized by the highest foaming ability. On the 90th day of testing (value after 3 months) an increased foam-forming ability was observed in the case of all the tested preparations by approximately 5% in reference to the results obtained on the first day of the testing (initial value).

Also, the foam stability index for the tested cosmetic products was determined (Figure 3).

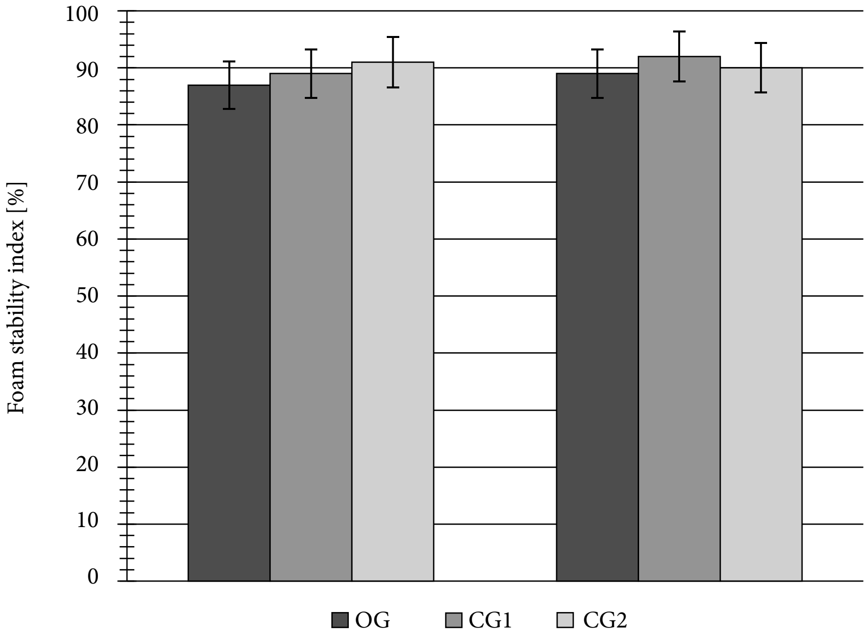

Figure 3. The foam stability index (FSI) of the original shower gel (OG) and commercial gels (CG1, CG2) on the first day of testing (initial value) and on the 90th day of testing (final value)

The increased temperature and storage time do not have a significant effect on the values of the foam stability index in the case of all the tested gels. The results range within between 87–92%.

It is expected that the slight FSI increase vs. time is an effect of the increased concentration of active foaming substances in the formulation. The increase in the concentration of active foam-forming substances is the result of water evaporation from the cosmetics stored at an increased temperature.

2.4. Solubility

The last stage of the process of washing is rinsing with water. That is why it is important that shower gels have good water solubility.

For the gel developed according to own formula OG) and the commercial gel CG1 an increase in the time of water solubility was observed by approximately 18–25% after 3 months of storing in an incubator at 40°C (final value) compared to the results obtained on the first day of testing (initial value). However, in the case of the commercial gel marked CG2 an increase in the time of water solubility by approximately 10% in reference to the initial value was observed.

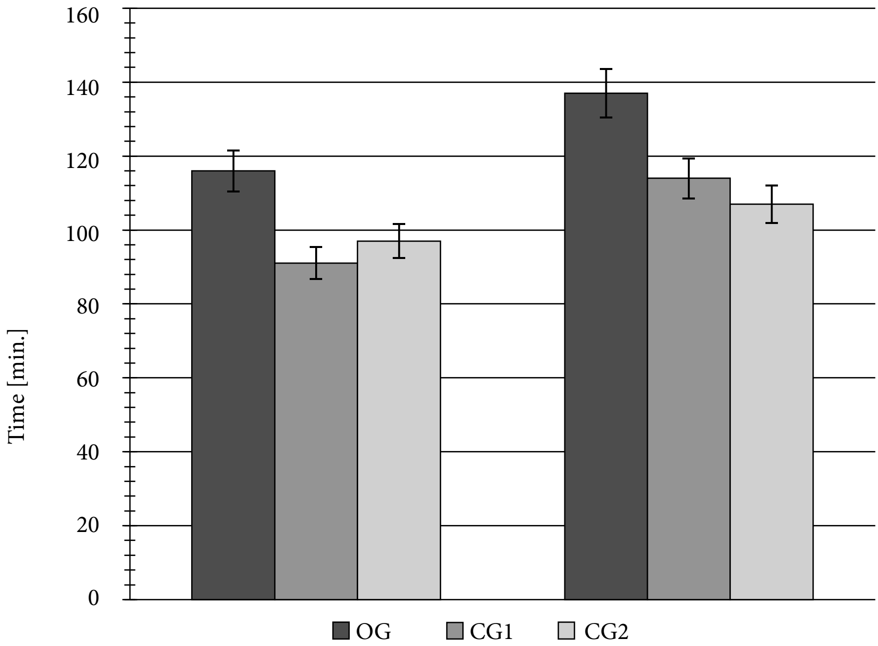

Figure 4. The solubility time of the original shower gel (OG) and commercial gels (CG1, CG2) on the first day of testing (initial value) and on the 90th day of testing (final value)

These results correspond with the results obtained for the viscosity values. With the passage of time a longer time of solubility of the formulations can be observed. It is associated with the higher viscosity of cosmetics. The higher viscosity of cosmetics the worse is solubility in water.

2.5. Sensory evaluation

The sensory evaluation is the decisive criteria of product development, quality control and consumer acceptance. In Figure 5 the sensory evaluation of the original gel and commercial gels on the first day and on the ninetieth day of the testing can be seen below.

The storage at increased temperature had the greatest impact on consistency, uniformity, adhesion and distribution of the commercial gels CG1 and CG2. The sensory evaluation of these characteristics after 3 months decreased,

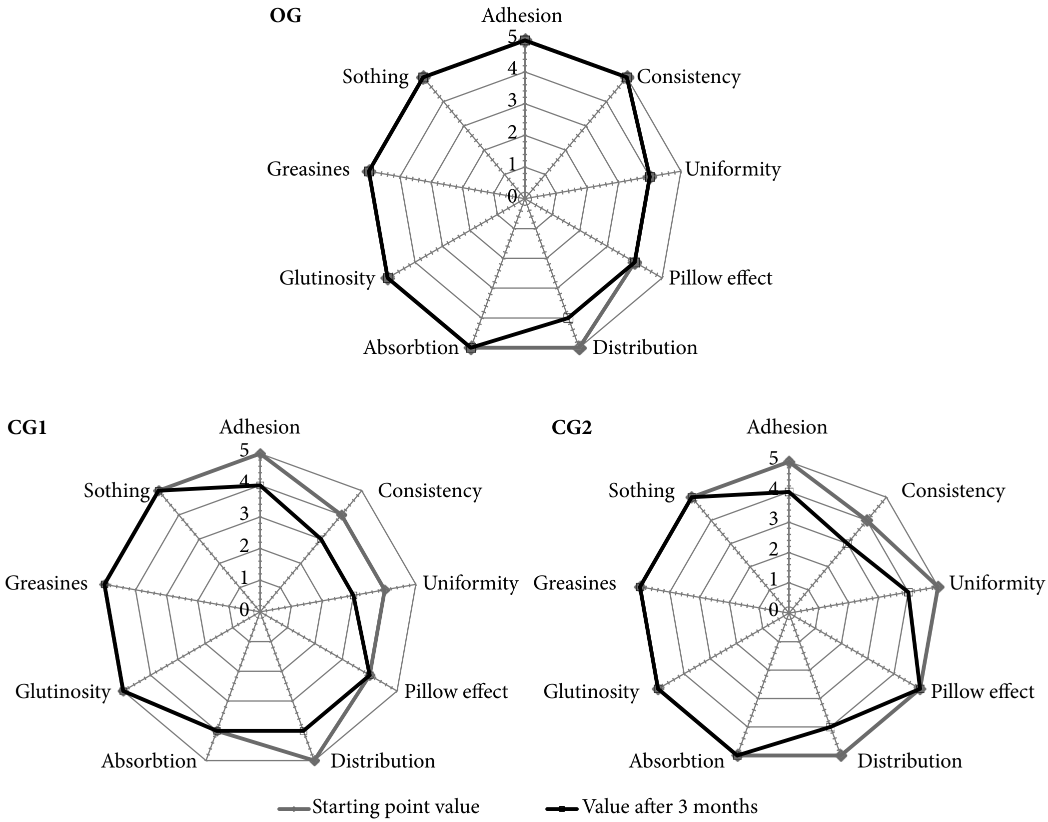

Figure 5. The sensory evaluation of the original shower gel (OG) and commercial gels (CG1, CG2) on the first day of testing (initial value) and on the 90th day of testing (final value)

the products changed their consistency and uniformity. In the case of the original gel, distribution over the skin deteriorated, which may be the result of the increased dynamic viscosity of the product. The remaining characteristics in the individual measurements after the time elapsed changed insignificantly.

Conclusions

The paper examines the impact of storage temperature and time on the physicochemical and functional properties of shower gels. Based upon the results, the following conclusions were reached:

- Storage and increased temperature contribute to the increased dynamic viscosity of the original gel and commercial shower gels. Viscosity increases over time.
- Foam-forming increases together with the lapse of time spent in the incubator. Increased storage temperature and time contribute to the formation of more abundant foam. However, the obtained results oscillate at the verge of significance.
- From the point of view of customers, of crucial importance is the time of solubility in water. In the case of the original gel and the commercial CG1, leaving the preparations for 3 months reduces the product's water solubility values, increasing the time of their solubility. Only in the case of the commercial gel CG2 the value after 2 months is lower than the initial value. This means that the product after storage dissolves quicker in water.
- The sensory evaluation allows for the determination of individual characteristics of the cosmetic product in such a manner as it is evaluated by customers. In the case of the tested gels, only some of the values changed to a certain extent. This means that the increased temperature and time do not have a significant effect on the selected sensory characteristics.

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