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Cite / Sposób cytowania Madalińska A, Tomala O, Pytkowska K. Optimization of the antioxidant cream formulation in terms of sensory and organoleptic properties. *Aesth Cosmetol Med.* 2026;15(4):217-225. https://doi.org/10.52336/acm.2026.027

Optimization of the antioxidant cream formulation in terms of sensory and organoleptic properties

Optymalizacja receptury kremu antyoksydacyjnego pod kątem właściwości sensorycznych i organoleptycznych

ABSTRACT

Background: The market success of a cosmetic depends not only on its effectiveness but also on its sensory properties. The selection of ingredients influences both its application properties and the performance of the active substances.
Aim: The study aimed to optimize the formulation of an antioxidant cream containing wild strawberry leaf extract (*Fragaria vesca L.*) with respect to sensory and organoleptic properties, while preserving antioxidant activity.
Materials and methods: Nine formulations were developed, differing in extract content (60-70%), argan oil to shea butter ratio, and caprylic/capric triglyceride content. Sensory properties were assessed by a scaling and categorization method using a trained panel of 10 test subjects.
Results: All formulas demonstrated high antioxidant activity. Statistically significant differences were observed in sensory scores between the individual variants. The highest overall score was achieved by the formula containing 60% extract, 15% shea butter, 5% argan oil, and 10% caprylic/capric triglyceride.
Conclusions: Appropriate modification of the formula and a balanced lipid phase ratio allow the formulation of an effective and sensorially appealing cosmetic with high antioxidant potential.

Keywords: antioxidant cream, sensory evaluation, formulation optimization, organoleptic properties, skin.

STRESZCZENIE

Wstęp: Sukces rynkowy kosmetyku zależy nie tylko od jego skuteczności, ale i cech sensorycznych. Dobór składników wpływa na właściwości aplikacyjne, jak i na aktywność substancji czynnych.
Cel: Celem pracy była optymalizacja receptury kremu antyoksydacyjnego z ekstraktem z liści poziomki pospolitej (*Fragaria vesca L.*) pod kątem właściwości sensorycznych, przy jednoczesnym zachowaniu jego aktywności przeciwutleniającej.
Materiały i metody: Opracowano dziewięć wariantów recepturowych różniących się zawartością ekstraktu (60-70%), proporcją oleju arganowego do masła shea oraz udziałem trójglicerydu kaprylowo-kaprynowego. Ocenę cech sensorycznych przeprowadzono metodą skalowania i kategoryzacji z udziałem przeszkolonego panelu 10 probantów.
Wyniki: Wszystkie receptury wykazały wysoką aktywność antyoksydacyjną. Zaobserwowano przy tym istotne statystycznie różnice w ocenach sensorycznych pomiędzy poszczególnymi wariantami. Najwyższą ocenę ogólną uzyskała receptura zawierająca 60% ekstraktu, 15% masła shea, 5% oleju arganowego i 10% trójglicerydu kaprylowo-kaprynowego.
Wnioski: Odpowiednia modyfikacja receptury oraz zrównoważenie proporcji fazy lipidowej pozwalają na stworzenie skutecznego i atrakcyjnego sensorycznie kosmetyku o wysokim potencjale antyoksydacyjnym.

Słowa kluczowe: krem antyoksydacyjny, ocena sensoryczna, optymalizacja receptury, właściwości organoleptyczne, skóra.

INTRODUCTION

A cosmetic product's effectiveness is not the only factor determining its market success. Consumer loyalty, willingness to repurchase, and recommendations are primarily determined by the product's sensory properties. For this reason, optimizing the functional characteristics of the formulation is one of the key stages in product development [1]. This process requires the selection of appropriate cosmetic raw materials that improve application properties while maintaining the product's efficacy. The evaluation of antioxidant properties using the free radical scavenging method DPPH (2,2-diphenyl-1-picrylhydrazyl) and sensory analysis on a 5-point scale conducted by a trained panel of evaluators enable precise refinement of the formulation. Such an evaluation allows for the creation of a cosmetic product that combines high skincare efficacy with excellent user experience. The end result is the development of a cream formulation that achieves an optimal balance between efficacy and the pleasure of use, meeting the current needs of the market and the expectations of the modern consumer.

Determination of antioxidant properties using the DPPH radical scavenging assay

One of the most commonly used methods for assessing antioxidant activity is the DPPH radical assay. This is a stable nitrogen radical with an intense violet color, which, in the presence of antioxidants, undergoes reduction, changing color to yellow or becoming completely colorless. The change in color intensity is proportional to the antioxidant capacity of the sample being tested [2].

The change in absorbance is measured using a spectrophotometer at a wavelength of 517 nm, and the values can be expressed as a percentage change or converted to the equivalent of a known standard antioxidant, most commonly trolox (TEAC, trolox equivalent antioxidant capacity) [3]. However, this method has certain limitations - it does not fully reflect the mechanisms of action of antioxidants *in vivo*, since the reaction takes place in a methanol, ethanol, or acetone medium, which differs significantly from physiological conditions. Despite these the DPPH method is widely used in the evaluation of plant-based raw materials and cosmetics, characterized by high reproducibility and good correlation with other chemical assays [2].

In the context of cosmetic research, the DPPH method is widely used to evaluate the protective properties of products against oxidative stress, which is of significant importance in the prevention of skin aging and damage caused by free radicals [4].

Sensory analysis

Sensory analysis is a set of research methods used to objectify subjective sensory impressions. It is an integral and essential component of product quality analysis in many industrial sectors, including the cosmetics industry. Its purpose is to evaluate the perceptual characteristics of a product, as measured through sight, smell, touch, and sometimes taste. Such studies are conducted both at the initial stage of designing new formulations and as part of the final product inspection. Sensory testing provides information on consumer preferences and the level of product acceptance by the end user. It is an indispensable element of the cosmetics design process with optimal usage properties [5, 6].

Due to the subjective nature of sensory evaluation, research procedures must be strictly defined to ensure the repeatability and reproducibility of results. For this reason, these studies are typically conducted in specially equipped laboratories, under controlled environmental conditions that do not interfere with the measurements (appropriate temperature, lighting, and humidity) and by a qualified evaluation team, known as a sensory panel. Panelists may be experts with proven expertise or trained consumers [7]. Training of panelists plays an important role in sensory evaluation because it enables the standardization of perception and the identification of the evaluated characteristics, thereby ensuring the reproducibility of results and high-quality analysis [8]. The expert panel evaluates the intensity of a product's sensory parameters in accordance with established protocols. When the goal of the analysis is to assess product preferences and acceptance among potential customers, the same parameters as in sensory evaluation are analyzed, but the evaluation is conducted by untrained groups of testers. This type of study is referred to as an organoleptic evaluation. It is a hedonic evaluation and a form of consumer analysis. These studies typically involve larger groups of respondents, which allows for the collection of statistically significant data from the perspective of product development and market entry [6].

Cosmetics in the form of emulsions are subjected to sensory evaluation based on a set of quality criteria [9]. The parameters examined are: consistency, uniformity, spreadability, adhesion, cushion effect, stickiness, greasiness/oiliness, absorption, and smoothing.

- Consistency. This parameter is closely related to the product's density and viscosity. It is assessed by dipping a finger into the emulsion and analyzing the resistance the cosmetic offers when the finger is withdrawn.
- Uniformity. The degree of homogeneity of the formulation is assessed visually and by touch. Tthe evaluation includes the presence of separation, air bubbles, lumps, or other non-uniform fragments.

- Spreadability. Ease of applying the product to the skin and resistance to spreading.
- Adhesion. How easily the product is picked up by the fingertip and how it flows off. An emulsion with good adhesion forms a stable cone and does not tricle down after being picked up.
- Cushion effect. The sensation of the amount of emulsion felt between the index finger and thumb when rubbing. As the perceived volume of the applied product increases, so does the cushion effect.
- Stickiness. The sensation of stickiness remaining on the skin after product application is analyzed. The assessment is made by tapping the skin by the hand shortly after application.
- Oiliness/greasy feel. The presence of a greasy feeling immediately after application. The persistence of this effect after 30 and 60 minutes may also be assessed.
- Absorption. The time required for the emulsion to be completely „absorbed" through the stratum corneum. The shorter the time, the higher the rating for this parameter.
- Smoothing. The effect is assessed shortly after application of the product by comparing the degree of smoothness of the treated and untreated skin surfaces [10].

In addition to sensory testing and organoleptic evaluation, characteristics such as smell, color, and the overall impression the product makes on the consumer are also considered. This is a hedonic evaluation that pertains to individual preferences and the degree of consumer acceptance of the product (categories such as: "I like it/I don't like it"; "I would buy it/I wouldn't buy it"; "I like it/I don't like it"). Statistical analysis of such results is possible through the use of a rating scale (usually 7- or 9-point) [12].

AIM

The aim of the presented study was to optimize the formulation of an antioxidant face cream, with particular emphasis on its sensory and organoleptic properties.

MATERIALS AND METHODS

Raw materials used to create the formulations: distilled water, shea butter (*Butyrospermum Parkii Butter*), (Chmara Blend, Poland), a mixture of dehydroacetic acid and benzyl alcohol - the preservative Geogard 221 (Rumiano, Poland), caprylic/capric triglyceride (Rumiano, Poland), argan oil (Chmara Blend, Poland), wild strawberry leaf extract prepared in the laboratory from dried leaves (Aromatika, Poland). **Reagents used:** glycerol AR (Chempur, Poland), 2,2-diphenyl-1-picrylhydrazyl (DPPH; Sigma-Aldrich, USA), acetone AR (Chempur, Poland).

Laboratory equipment used: U-5100 spectrophotometer (Hitachi, Japan), analytical balance (Kern & Shon GmbH, Germany), WTB 2000 electronic balance (Radwag, Poland), ultrasonic bath (Polsonic, Poland), magnetic stirrer MS 11 (Wirgo, Poland), automatic piettes (Eppendorf, Germany), mechanical laboratory stirrer 10031050 (Steinberg Systems, Germany).

Plant material and extract preparation

The plant material used to prepare the extracts consisted of dried wild strawberry leaves purchased from herbal shop (Aromatika, Poland). The extract was prepared using ultrasonic extraction (40 Hz) for 60 minutes. The solvent used for this process was a 15% solution of glycerine in water. The content of leaves in the solvent was 5%. The concentration, extraction time, and type of solvent were selected based on previous studies.

Formulation optimization

As part of research on optimizing the formulation of an antioxidant cream containing wild strawberry leaf extract, an analysis of the factors influencing its sensory properties was conducted. The study aimed to determine how changes in the ratio of argan oil to shea butter and the extract content would affect the cream's sensory characteristics. In formulations where the extract content was reduced, an additional emollient - caprylic/capric triglyceride (CCTG) - was used. Nine formulation variants with different concentrations of these ingredients were developed. The formulations are presented in tab. 1.

Tab. 1. Qualitative andquantitative composition of the tested formulations of an antioxidant cream, with varying proportions of argan oil, shea butter, wild strawberry leaf extract, and CCTG. **Source**: Authors' own archives.

No.	Extract [wt. %]	Argan oil [wt. %]	Shea butter [wt. %]	Caprylic/capric triglyceride [wt. %]	Preservative [wt. %]	Emulsifier [wt. %]
1	70	10	10	0	2	8
2	70	15	5	0	2	8
3	70	5	15	0	2	8
4	60	10	10	10	2	8
5	60	15	5	10	2	8
6	60	5	15	10	2	8
7	65	10	10	5	2	8
8	65	15	5	5	2	8
9	65	5	15	5	2	8

Study of the antioxidant properties of emulsions using the DPPH radical scavenging assay

From each prepared solution, 1 g was taken and dissolved in 9 cm^3 of acetone, then placed in a magnetic stirrer for approximately 30 minutes (until completely dissolved). Using an automatic pipette, 2.5 cm^3 of the DPPH solution in acetone was dispensed into 1 mm - thick glass measuring cuvettes. Next, 0.132 cm^3 of each test sample was added to each cuvette at 30 - second intervals. The cuvettes were sealed with stoppers and thoroughly mixed by inversion. Three measurements were performed for each sample. The samples were incubated for 10 minutes at room temperature. After incubation, the absorbances of the samples were measured using a spectrophotometer at a wavelength of 517 nm. Based on the obtained measurements results and the calibration curve equation ($y = -0.7814x + 1.0153$; $R^2 = 0.9874$), the concentration of trolox equivalent (RT), expressed as a mass fraction of the preparation [mg trolox/emulsion], was determined using equations (1) and (2):

$$C_{trolox} = \frac{absorbance - b}{a} \quad (1)$$

where:

$C_{troloks}$ – trolox concentration [mmol/dm^3]
Absorbance – the absorbance of the sample
b – the value of b from the standard curve equation
a – the value of a from the standard curve equation

$$RT = C_{trolox} \times 5.01 \times dilution \quad (2)$$

where:

RT – trolox equivalent [mg trolox/g raw material]
C_{trolox} – trolox concentration [mmol/dm^3]
5.01 – calibration constant
dilution – dilution of the test sample

Sensory and organoleptic testing of formulations

A sensory evaluation of the developed formulations was conducted using a rating and categorization method on a panel of 10 test subjects. The panelists were employees of the Department of Cosmetic and Pharmaceutical Chemistry at the Pomeranian Medical University in Szczecin, who, in their daily work, professionally engage in the sensory and organoleptic evaluation of various cosmetic formulations, as well as members of the research club at the Department of Cosmetic and Pharmaceutical Chemistry of the Pomeranian Medical University in Szczecin, who frequently conduct sensory studies for scientific purposes. Perception was assessed using tests of surface sensation and deep sensation. The verification of the participants' sensitivity and sensory performance was based on standardized methods of sensory analysis in accordance with ISO standards (PN-EN ISO 8587, PN-EN ISO 8586, PN-EN ISO 4120).

To evaluate sensory sensitivity, test subjects were asked to use the triangle method to assess samples of scrubs containing various abrasives: sea salt, strawberry seeds and ground pumice. The evaluators received a set of three samples, two of which were identical, while one differed from the others. To qualify for the next phase of the study, a panelist had to correctly identify the differing sample in at least two out of three possible repetitions. All participants correctly identified all samples, thereby qualifying for the deep - sensation test.

In this stage, the evaluators were asked to assess three samples of simple cosmetic emulsions containing different concentrations of the emulsifier (lanolin). The concentrations in the samples were 3%, 6%, and 9%, respectively, which allowed for distinct differences in perceived density and viscosity. Once again, all panelists correctly ranked the test samples, thereby qualifying for the study.

All participants gave their informed, voluntary consent to participate in the study and agreed to the publication of the results of their surveys anonymously. The panelists were assigned numbers from 1 to 10.

Tab. 2. Descriptive explanation of the scoring scale for sensory andorganoleptic evaluation. **Source**: Authors' own archives.

Characteristic	Description of the scoring scale
Consistency	1–very light, 2–light, 3–medium, 4–heavy, 5–very heavy
Uniformity	1–separates, 2–noticeable lumps, 3–slight lumps, 4–air bubbles, 5–homogeneous
Cushion effect	1–almost none, 2–small, 3–medium, 4–large, 5–very large
Spreadability	1–spreads very easily, 2–spreads easily, 3–spreads moderately, 4–difficult to spread, 5–very difficult to spread
Adhesion	1–almost none, 2–low, 3–moderate, 4–high, 5–very high
Stickiness	1–almost none, 2–low, 3–moderate, 4–high, 5–very high
Oiliness/ Greasy film	1–no film, 2–slightly oily, 3–moderately oily, 4–quite oily, 5–leaves an oily film
Absorption	1–absorbs very quickly, 2–absorbs quickly, 3–absorbs at a moderate rate, 4–takes a long time to absorb, 5–takes a very long time to absorb
Smoothing	1–does not smooth, 2–does not smooth very well, 3–smooths moderately, 4–smooths, 5–smooths very well
Overall rating of the cosmetic	1–very poor, 2–poor, 3–neutral, 4–good, 5–very good

Organoleptic and hedonic analysis was included in the questionnaires as the final parameter and was conducted by the same panelists. The test subjects provided a subjective, personal evaluation of all formulations on a 1 to 5 point scale, where 1 indicated a very poor cosmetic and 5 indicated a very good cosmetic. Based on this, a formulation with optimal sensory properties and composition was selected.

The panelists did not know which formulations they were evaluating, and they made their assessments individually. The emulsion samples were labeled with numbers for identification purposes. The creams were submitted for testing in random order, with one sample used to determine all parameters, after which the samples were collected. The evaluation was conducted on a 5-point scale. A descriptive explanation of the scale points is presented in tab. 2, separately for each parameter tested.

The test subjects provided their evaluations in writing on paper questionnaires, in which specific formulations were identified by numbers, and they marked their rating on a point scale for each parameter with a check mark. Each formulation variant was evaluated once by each of the 10 trained panelists (N = 10).

Statistical analysis

The results of the sensory evaluations were presented as the arithmetic mean and standard deviation. A one - way analysis of variance (ANOVA) was used to assess the significance of differences between the individual reciformulation variants (1-9). Before proceeding with the analysis, its basic assumptions were verified: the normality of the distribution of scores within groups using the Shapiro-Wilk test and the homogeneity of variances. A significance level of $\alpha = 0.05$ was adopted (differences were considered statistically significant at $p < 0.05$). Statistical calculations were performed using Microsoft Excel. The choice of ANOVA analysis was dictated by the structure of the experiment, in which the only qualifying factor (independent variable) was the cream formulation variant (9 levels of analysis), and the measured dependent variable - the scores assigned to individual sensory attributes. The use of an ANOVA test allowed for a simultaneous comparison of the means comparisons among all 9 variants without the risk of committing a multiple-testing error.

RESULTS

Antioxidant properties of the formulations

An important aspect of the optimization was the preservation of antioxidant properties, which was tested for all formulations using the DPPH radical scavenging assay. The differences among all formulations were not statistically significant, as they fell within the margin of error. Each formulation was characterized by strong antioxidant properties ranging from 2.91 ± 0.07 mg to 3.5 ± 0.02 mg of trolox/g of emulsion, which allowed all emulsions to undergo sensory and organoleptic testing. A control sample was prepared using the modified formulation No. 1 of the cream, substituting distilled water for the extract. This sample was designated as No. 0. The antioxidant properties of sample 0 were 0.57 ± 0.02 mg of trolox/g of emulsion, which allowed to conclude that the antioxidant properties of the test samples were attributable to the content of wild strawberry leaf extract. The results are presented in fig. 1.

The results obtained regarding the antioxidant properties of all formulations made it possible to determine the extent to which variations in the formulations, in terms of extract concentration, the ratio of shea butter to argan oil, and the use of an additional emollient - CCTG, affected the antioxidant properties of the creams.

Formulations in which the shea butter content was increased to 15% performed the worst, while those with a 1:1 ratio of shea butter to argan oil performed the best for every extract concentration. However, formulations with the highest concentration of argan oil showed lower activity than those in which the oil-to-butter ratio was 1:1. This may be due to the fact that some antioxidants act synergistically with other compounds, thereby generating stronger antioxidant properties than when acting separately. An example of such synergy is gallic acid and other polyphenols that regenerate vitamin E (antioxidant cycle). Additionally, the secondary oxidation of argan oil may contribute to this result. Although it is rich in tocopherol, its high content of unsaturated fatty acids makes it more susceptible to oxidation if it is not properly balanced with other stabilizing components. Furthermore, a high concentration of vitamin E does not linearly increase antioxidant activity, which can lead to oversaturation of the reaction environment and pro-oxidative effects of tocopherols. A 1:1 ratio most likely falls within the optimal concentration range for tocopherols, which acts effectively but without side effects. Confirmation of this hypothesis requires further research.

Sensory analysis of formulation variants

Based on the survey results, average ratings were calculated for each parameter and summarized in tab. 3 and 4. The formulation that received the highest overall rating is highlighted in gray in the tables. Next, sensory evaluation profile graphs were plotted for each of the tested recipes.

The ANOVA test revealed statistically significant differences ($p < 0.05$) in the ratings of individual sensory attributes among the analyzed formulation variants.

Based on the evaluations in tab. 3 and 4, sensory profiles of individual formulations were created in the form of radial charts, which are shown in fig. 2. The chart for the overall formula is marked in navy blue.

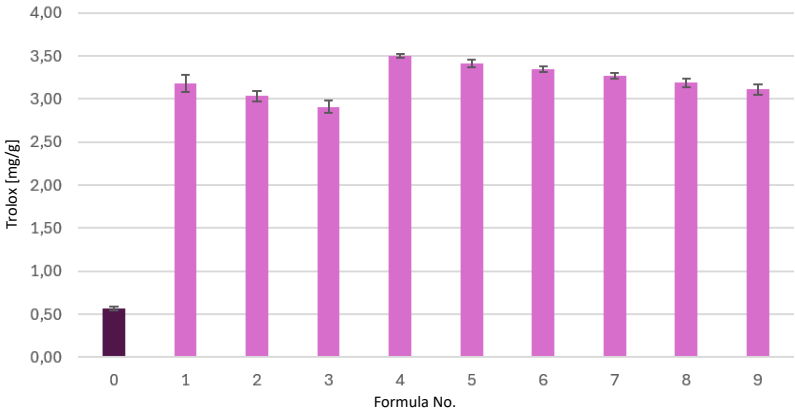

Fig. 1. Comparison of the DPPH radical scavenging capacity of all formulation variants of an antioxidant cream containing wild strawberry leaf extract. **Source**: Authors' own archives.

Tab. 3. Average ratings of sensory parameters by 10 panelists. Parameters evaluated: consistency, uniformity, cushioning effect, adhesion, and spreadability. **Source**: Authors' own archives.

No.	Consistency	Uniformity	Cushion effect	Adhesion	Spreadability
1	3.7 ± 0.5	5.0 ± 0.0	3.7 ± 0.5	4.0 ± 0.0	4.0 ± 0.0
2	3.2 ± 0.4	5.0 ± 0.0	2.9 ± 0.3	3.2 ± 0.4	3.2 ± 0.4
3	4.8 ± 0.4	5.0 ± 0.0	4 ± 0.0	4.5 ± 0.5	4.5 ± 0.5
4	2.7 ± 0.5	5.0 ± 0.0	4.3 ± 0.5	3.1 ± 0.3	3.1 ± 0.3
5	1.7 ± 0.5	5.0 ± 0.0	3.8 ± 0.4	2.3 ± 0.5	2.3 ±0.5
6	2.3 ± 0.5	5.0 ± 0.0	4.8 ± 0.4	3.5 ± 0.5	3.5 ± 0.5
7	2.9 ± 0.3	5.0 ± 0.0	3.5 ± 0.5	3.4 ± 0.5	3.4 ± 0.5
8	2.0 ± 0.0	5.0 ± 0.0	2.6 ± 0.5	3.1 ±0.3	3.1 ± 0.3
9	3.2 ± 0.4	5.0 ± 0.0	4.5 ± 0.5	4.2 ± 0.4	4.2 ± 0.4

Tab. 4. Average ratings of sensory parameters by 10 panelists. Parameters evaluated: stickiness, greasiness/oiliness, absorption, smoothness, overall rating. **Source**: Authors' own archives.

No.	Stickiness	Greasiness/ oiliness	Absorption	Smoothness	Overall rating
1	4.2 ± 0.4	3.6 ± 0.5	3.4 ± 0.5	4.5 ± 0.7	3.2 ± 0.4
2	3.7 ± 0.5	3.1 ± 0.3	2.6 ± 0.5	3.8 ± 0.5	3.6 ± 0.5
3	5.0 ± 0.0	4.8 ± 0.4	4.6 ± 0.5	4.7 ± 0.5	3.3 ± 0.8
4	3.1 ± 0.3	3.2 ± 0.5	3.0 ± 0.0	4.0 ± 0.0	4.3 ± 0.5
5	2.3 ± 0.5	2.3 ± 0.5	1.5 ± 0.5	3.5 ± 0.5	4.0 ± 0.0
6	3.5 ± 0.5	3.6 ± 0.5	3.8 ± 0.4	4.6 ± 0.5	4.6 ± 0.5
7	3.4 ± 0.5	3.6 ± 0.5	3.2 ± 0.4	4.0 ± 0.0	2.3 ± 0.5
8	2.8 ± 0.4	2.6 ± 0.5	1.8 ± 0.4	4.8 ± 0.5	3.6 ± 0.5
9	4.0 ± 0.0	3.9 ± 0.3	3.9 ± 0.3	4.6 ±0.5	3.2 ± 0.6

DISCUSSION

Based on the sensory analysis and formulation data, a clear influence of the type and amount of the ingredients used (emollient, shea butter, and argan oil) on individual sensory characteristics was evaluated by an expert panel.

Increasing the proportion of shea butter in the formulation significantly increased the consistency, resulting in a noticeable thickening of the product. Formulations with a higher shea butter content were rated as more tacky and sticky, which corresponds to the mechanism of increased viscosity and the occlusive properties (film formation) of the system as the proportion of the hydrophobic phase increases [12]. It was also noted that the use of an additional low-viscosity emollient in these formulations significantly alleviated this sensation. At the same time, when CCTG was used, a prolongation of the absorption time and an intensification of the greasy sensation after application was noticeable.

The presence of a higher concentration of emollient in some formulations had a beneficial effect on the product's spreadability. Creams with a higher emollient content were rated as lighter, less greasy, and faster-absorbing. At the same time, they exhibited lower viscosity and were easier to apply, which in many cases resulted in a higher overall rating for the cosmetic. This is consistent with the function of emollients, which form a layer by forming an occlusive barrier on the skin's surface, they reduce transepidermal water loss (TEWL). As a result, they directly improve the smoothness of the epidermis, affecting the perceived oiliness and ease of application of the formulation [13]. In the case of samples with a higher proportion of argan oil, higher average ratings were observed for greasiness and the cushion effect. This oil gave the formulations a more enveloping, slightly film-forming texture, which enhanced the sensation of skin smoothness. However, with its higher concentrations, the formulations were perceived as slightly more difficult to spread and more sticky.

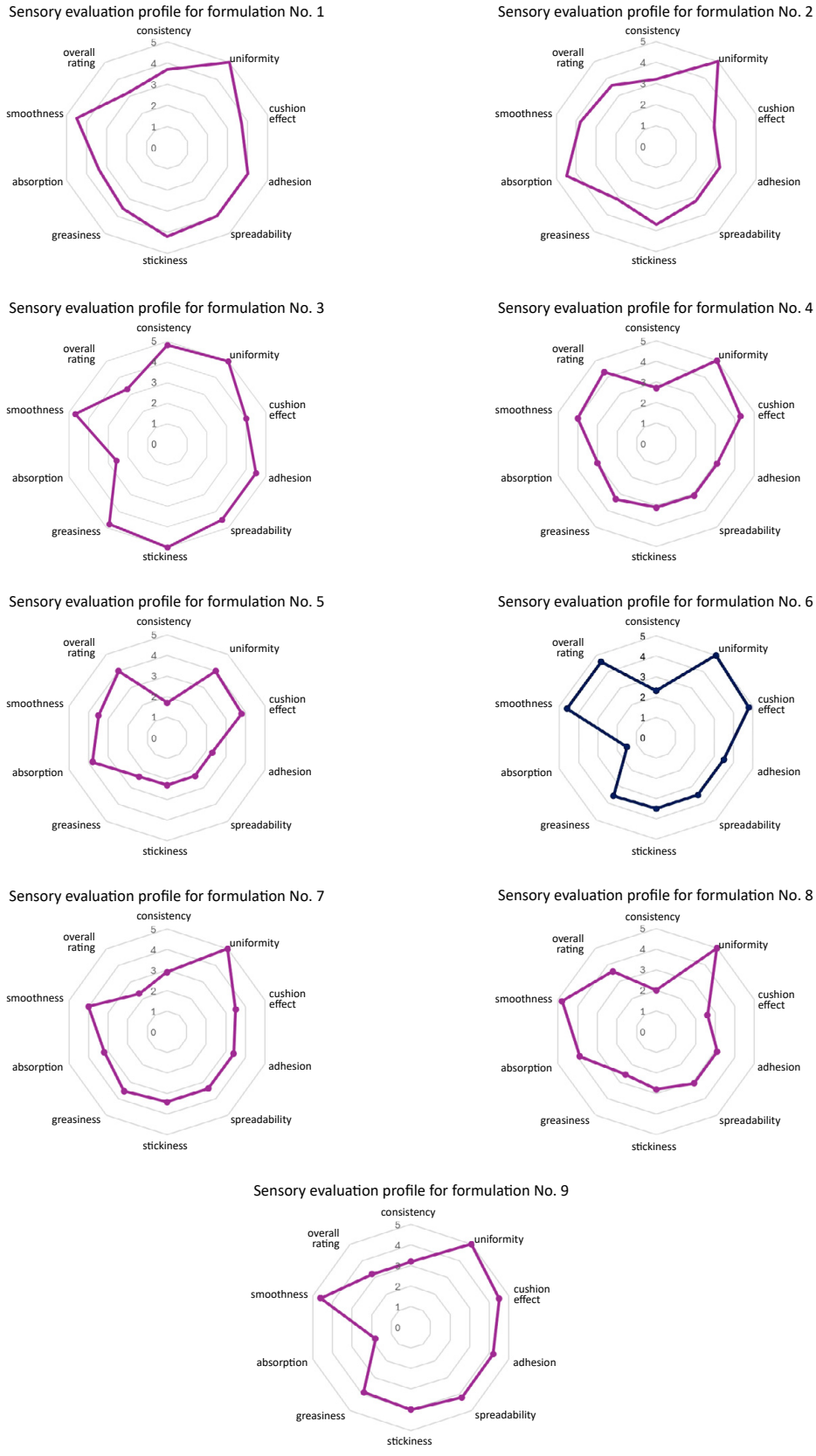

Fig. 2. Radial charts of the sensory evaluation of 9 formulation variants of a cream with antioxidant properties containing wild strawberry leaf extract. **Source**: Authors' own archives.

It should be emphasized that the consistency and uniformity of a preparation are determined not only by the phase ratio, but also by the presence and type of emulsifiers and rheology modifiers used [12]. Emulsifiers influence the consistency of a cosmetic product in various ways, both by altering the viscosity of the continuous phase and by determining the type of emulsion, and their effect is linked to the production technology, including the dispersion energy, which directly affects the uniformity and ease of application [14]. In addition to their physicochemical function, they often also improve sensory perceptions, imparting softness and sensory delicacy to the skin. In this study, the emulsifying system and production process parameters were kept constant across all formulations, which allowed the observed sensory differences to be attributed primarily to the varying composition of the lipid phase. At the same time, this means that the resulting sensory profile applied to the emulsifying system used and could be modified if that system was changed.

By comparing the results of the sensory evaluation with the content of key ingredients, it can be concluded that each component contributed a specific, consistent sensory profile. Synergistic or antagonistic interactions between the ingredients visibly influenced the perception of texture, application, absorption, and overall comfort after application.

Sample No. 6, containing 15% shea butter, 5% argan oil, and 10% triglyceride, received the highest overall ratings. The thick consistency caused by the high shea butter content was offset by the high CCTG content, while the low level of argan oil had a positive effect on the product's spreadability and viscosity. In their subjective assessment, the expert panel preferred light, fast-absorbing formulas that provided both a smoothing effect and a delicate richness, without any sticky feeling.

The expert panel rated the highest these formulations in which balanced proportions of all three lipid components were used. Similar observations were made by Lukić et al., who demonstrated that the composition of the oil phase determines all the tested textural and sensory characteristics of the preparation, and that replacing even a single emollient leads to a significant change in the sensory profile [10]. In turn, Semenzato et al. emphasized that the development of emulsions containing plant-based raw materials required finding the right balance between the system's stability, the sensory profile, and the product's biological efficacy [10].

The results indicated a complex interaction between the lipid component and active antioxidant compounds. What is crucial, it is not only the presence of individual components, but also their proportions and their ability to form a stable, synergistic lipid matrix that enables the antioxidants to work effectively.

It is interesting to note the phenomenon of a proportional decrease in antioxidant activity with an increased content of argan oil - despite the natural presence of tocopherols in this raw material. This points to the need to maintain a balance, both from the perspective of biological activity and chemical stability. The observed relationship requires further study; however, a likely reason for the decrease in antioxidant activity may be the high susceptibility of the polyunsaturated fatty acids contained in argan oil to oxidation processes.

An analysis of the effect of the extract concentration alone revealed a similar trend: samples with the highest extract content (70%, formulations 1-3) exhibited, in some measurements, a lower DPPH radical scavenging capacity than the system containing 60% extract (e.g., formulation 4). This phenomenon can be explained by the so-called pro-oxidative effect (antioxidant paradox). In systems with very high polyphenol concentrations, phenoxyl radicals may form or interactions may occur that promote the generation of new reactive species, which reduces the total antioxidant potential in the *in vitro* test.

In both cases, the composition of the lipid matrix plays a significant role. The addition of a saturated CCTG may have contributed to the relative decrease of concentration of the fraction of fatty acids susceptible to oxidation. Furthermore, CCTG, as a low-viscosity emollient, improves the dispersion of components in the system and facilitates the diffusion kinetics of antioxidant molecules in the measurement environment, which potentially stabilized the system under DPPH test conditions. However, it should be clearly emphasized that the mechanisms presented are merely interpretive hypotheses and, at the current stage of research, cannot be treated as definitive conclusions. A full explanation of these relationships requires verification through detailed studies of oxidative stability and reaction kinetics.

CONCLUSIONS

The effect of lipid components on sensory properties

- Shea butter increased the heaviness, density, viscosity, and tackiness of the formulation.
- Argan oil gave the formulations an enfolding, slightly film-forming texture and increased the sensation of greasiness and the so-called "cushion effect", but at higher concentrations it impaired spreadability.
- CCTG effectively counteracted the feeling of heaviness and stickiness caused by shea butter, improving the cream's ease of application and spreadability while prolonging the film's persistence on the skin.

Recommendations for the optimal formulation (application guidelines)

- The panel awarded the highest scores to formulations characterized by a balanced proportion of all three lipid components.
- In the test, formulation No. 6 (containing 15% shea butter, 5% argan oil, and 10% CCTG) was deemed to have optimal

sensory and performance properties. This variant provided a light texture that spread easily and absorbed quickly into the skin, delivering a smoothing effect without any undesirable stickiness.

Antioxidant properties and directions for further research

- A decrease in antioxidant activity (as measured by the DPPH test) was observed as the proportion of argan oil increased. The addition of saturated CCTG allowed for the maintenance of higher free radical scavenging potential values. The relationship presented requires confirmation through detailed studies of oxidative stability (including the determination of lipid oxidation indicators over time) and an assessment of the effect of the lipid matrix on the stability of the active substances contained in the wild strawberry leaf extract.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

FUNDING

The study received no external funding.

AUTHORS' CONTRIBUTIONS

Concept: A.M. and K.P.; methodology: A.M., K.P.; software and data processing: A.M.; formal analysis: A.M., O.T., K.P.; research: A.M., O.T.; resources: A.M., K.P.; data processing: A.M.; draft preparation: A.M. and O.T.; editing and proofreading: K.P.; visualization: A.M. and O.T.; supervision: K.P.; project management: K.P. All authors have reviewed and approved the published version of the manuscript.

ETHICS STATEMENT

The research conducted as part of this thesis does not meet the criteria for a medical experiment as defined by the Act of December 5, 1996, on the Professions of Physician and Dentist (Journal of Laws of 2023, Item 1516, as amended), and therefore, in accordance with Polish law and academic practice, did not require approval from the Bioethics Committee. All study participants were informed about the course of the study and the risks associated with it and gave their informed, voluntary consent to participate in the study.

USE OF ARTIFICIAL INTELLIGENCE-BASED TOOLS

While preparing this article, the authors used artificial intelligence (Generative AI) tools solely to improve the text's style, grammar, and editing (linguistic proofreading and standardization of terminology). AI tools were not used to generate data, perform statistical analysis, draw conclusions, or create the substantive content of the manuscript. The authors bear full responsibility for the final content and substantive accuracy of the publication.

REFERENCES / LITERATURA

1. Adamkiewicz K, Ulatowska-Szostak E, Marcinkowski JT. Najważniejsze czynniki skłaniające konsumentów do zakupu kosmetyków. *Hygiea Public Health*. 2011;46(4):467-470.
2. Sánchez-Moreno C. Methods used to evaluate the free radical scavenging activity in foods and biological systems. *Food Sci Technol Int*. 2002;8(3):121-137.
3. Apak R, Özyürek M, Güçlü K, Çapanoğlu E. Antioxidant activity/capacity measurement. 1. Classification, physicochemical principles, mechanisms, and electron transfer (ET)-based assays. *J Agric Food Chem*. 2016;64(5):997-1027.
4. Packer L, Valacchi G. Antioxidants and the response of skin to oxidative stress: vitamin E as a key indicator. *Skin Pharmacol Physiol*. 2002;15(5):282-290. https://doi.org/10.1159/000064531
5. Szymańska E, Sosnowska K, Zielińska A. Sensoryczna ocena kosmetyków i jej rola w przemyśle. *Przem Chem*. 2015;94(9):1579-1583.
6. Pensé-Lhéritier AM. Recent developments in the sensorial assessment of cosmetic products: a review. *Int J Cosmet Sci*. 2015;37(5):465-473. https://doi.org/10.1111/ics.12223
7. International Organization for Standardization. ISO 8589:2007. Sensory analysis - General guidance for the design of test rooms. Geneva: ISO; 2007.
8. International Organization for Standardization. ISO 8586:2023. Sensory analysis - General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors. Geneva: ISO; 2023.
9. Szakiel J, Turek W. Sensoryczna ocena jakości kosmetycznych produktów nawilżających przeznaczonych do pielęgnacji skóry rąk. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*. 2018;978(6):239-252.
10. Lukić M, Jaksic I, Krstonosic V, et al. A combined approach in characterisation of an effective w/o hand cream: the influence of emollient on textural, sensorial and in vivo skin performance. *Int J Cosmet Sci*. 2012;34(2):140-149. https://doi.org/10.1111/j.1468-2494.2011.00693.x
11. ISO 11136:2014. Sensory analysis – Methodology – General guidance for conducting hedonic tests with consumers in a controlled area. Geneva: International Organization for Standardization; 2014
12. Płocica J, Tal-Figiel B, Figiel W. Znaczenie analizy sensorycznej i pomiarów reologicznych w ocenie preparatów kosmetycznych. *Inżynieria i Aparatura Chemiczna*. 2015;54(2):54-56.
13. Lodén M. Role of topical emollients and moisturizers in the treatment of dry skin barrier disorders. *Am J Clin Dermatol*. 2003;4(11):771-788. https://doi.org/10.2165/00128071-200304110-00005
14. Savic S, Savic M, Tamburic S, Vuleta G. Surfactant-based liquid crystals as drug delivery systems. In: Fanun M, ed. *Microemulsions: Properties and Applications*. Boca Raton: CRC Press; 2008:411-448.

otrzymano / received: 25.06.2026 | zaakceptowano / accepted: 14.07.2026 | published / opublikowano: 17.08.2026