UDC 665.585.5:615.451.1–035.23:[579.864+579.873]:339.138
DOI: 10.15587/2312-8372.2019.180423

Tkachenko N.,
Vikul S.,
Pambuk S.

MODELING OF PROBIOTIC GEL SHAMPOO RECIPES WITH VEGETABLE EXTRACTS AND MARKETING ANALYSIS OF THEIR MARKET PROMOTION

Об'єктом дослідження є рецептури пробіотичних гель-шампунів, збагачених коротколанцюговими пептидами сироваткових білків та лізатами пробіотиків. Інтенсивне зростання попиту на нові види косметики, в тому числі косметику з пробіотиками, зумовлює прагнення виробників постійно вдосконалювати продукцію для задоволення вимог споживачів. З усього комплексу чинників, котрі формують кінцеву якість натуральних косметичних засобів, з точки зору споживача, одним з найважливіших є планування та розробка компонентного вмісту продукції. Тому перспективним завданням є вивчення можливостей створення пробіотичних гель-шампунів на основі доступних натуральних компонентів, що, завдяки математичному моделюванню рецептур та використанню перспективних технологій, дозволяє прогнозувати їх високу популярність та ефективність.

У роботі обґрунтовано доцільність застосування нанофільтрату молочної сироватки як екстрагента для вилучення біологічно активних речовин із лікарської сировини для виробництва пробіотичних гель-шампунів. Показано доцільність застосування екстрактів трави м'яти, листя кропиви та квітів чорнобривців у складі пробіотичних гель-шампунів, збагачених коротколанцюговими пептидами сироваткових білків та лізатами пробіотиків. Завдяки оптимізованому співвідношенню екстрактів лікарських рослин у складі, цільовий продукт має високі функціональні властивості. Співвідношення екстрактів листя кропиви, квітів чорнобривців та трави м'яти складає 2:1:1, при цьому суміш екстрактів має максимальну антиоксидантну активність – 1262,255 од. акт. В результаті досліджень розроблені рецептури пробіотичних гель-шампунів «Probio-beauty», призначених для щоденного використання та для укріплення й відновлення волосся. Показники якості розроблених за оптимізованими рецептурами пробіотичних гель-шампунів «Probio-beauty» відповідають вимогам нормативних документів.

Оскільки на сьогоднішній день на ринку відсутні косметичні продукти з пробіотиками українського виробництва, реалізація досліджень дозволить зайняти нішу «натуральної косметики». А правильно проведені маркетингові заходи, які пропонуються в даній роботі, дозволять закріпитись на ринку косметики, зробити бренд впізнаваним і розширювати асортимент продукції, ґрунтуючись на вподобаннях споживачів.

Ключові слова: *натуральна косметика, гель-шампунь, рецептурний склад, антиоксидантна активність, поверхня відклику, маркетинговий аналіз.*

Received date: 27.05.2019
Accepted date: 05.06.2019
Published date: 30.08.2019

1. Introduction

Cosmetic products are a daily necessity in a civilized life and remain one of the most promising among other non-food products. The world market of perfumes and cosmetics is quite saturated and has a certain development trend due to the development of new types of raw materials and modern production technologies.

Intensive growth in demand for new types of cosmetic products leads manufacturers to strive to constantly improve their products in order to meet consumer requirements. It is the consumer's free choice when buying and the variety of product ranges that create the competition that manufacturers seek to constantly improve and improve the quality that the consumer needs.

Of the whole complex of factors that form the final quality, from the point of view of the consumer, one of the most important is the planning and development of the component composition of products [1, 2].

One of the strategic directions for the effective development of leading states is the development and application of nanotechnology in various industries [3, 4]. Aware of the prospects of nanotechnology, most countries invest heavily in their development, introducing appropriate national programs, but it is interesting that cosmetology is the most open industry for their use [5, 6].

In this regard, it is of interest to study the possibilities of creating probiotic gel shampoos based on available natural components, which, thanks to the mathematical modeling of formulations and the use of promising tech-

nologies, makes it possible to predict their high popularity and effectiveness.

2. The object of research and its technological audit

The object of research is the formulation of probiotic gel shampoos enriched with short-chain peptides of whey proteins and probiotic lysate.

For the production of natural probiotic gel shampoos in the research process, the following medicinal plants were considered:

– nettle grass, tagetes flowers (Tagetes patula) and peppermint grass;

– four types of extractant for the extraction of biologically active substances (BAS) from medicinal plants (tap water, mineral water «Morshynska» and «Borjomi», nano-filtrate of milk cheese whey;

– a concentrate of whey proteins, low molecular weight peptides and free amino acids, enriched with probiotic cultures of lactobacilli and bifidobacteria;

– probiotic gel shampoos enriched with short chain peptides of whey proteins, probiotic lysates and extracts of a mixture of medicinal plants.

The choice of extractant for the extraction of biologically active substances from medicinal raw materials was carried out on the basis of the analysis of the antioxidant activity of the extracts obtained from the studied medicinal plants by each of the extractants according to the selected extraction mode.

The optimal ratio of medicinal plant extracts in the composition of probiotic gel shampoos enriched with short chain peptides of whey proteins and probiotic lysate was calculated in the medium of the Statistica 10 software package (StatSoft, Inc.) [7].

Basically, existing recipe optimization models come down to:

– linear programming problem in which the objective function is the requirements of the maximum value of the organoleptic evaluation;

– maximum output of any one component;

– need to maintain a component of at least the planned value or some additive criterion is a complex indicator that takes into account the combined effect of several criteria with different weighting factors [8, 9].

In the work, the objective function established the value of antioxidant activity (*AA*, act. units) of mixtures of extracts of medicinal plants.

3. The aim and objectives of research

The aim of research is optimization of the component composition of natural probiotic gel shampoos enriched with short-chain peptides of whey proteins, probiotic lysates and extracts of a mixture of medicinal plants.

To achieve this aim, let's solve the following objectives:

1. To optimize the ratio of extracts of medicinal plants (nettle leaves, marigold flowers and peppermint herbs) as part of natural probiotic gel shampoos.

2. To offer formulations of natural probiotic gel shampoos enriched with short-chain peptides of whey proteins, probiotic lysates and extracts of a mixture of medicinal plants, intended for daily use and for strengthening and restoration of hair.

4. Research of existing solutions of the problem

One of the most popular trends of the last decade is organic and natural products, next to the organic lifestyle, in which preference is given to natural clothing, food, furniture and cosmetics.

A special place among natural cosmetics is given to cosmetics with probiotics, the development of which continues in recent years in the leading countries of the world. Modern hygiene products deplete the natural balance of the skin microbiome, so the use of probiotic products is a promising innovative direction in cosmetology. The number of studies on the external use of probiotics is growing [10, 11]. The task of cosmetics with probiotics is to create favorable conditions for the development of bacteria characteristic of the human microbiome [12, 13]. In Ukraine, promising directions for the development of biotechnologies of «live» cosmetics using viable probiotic cells, as well as «probiotic» cosmetics using prebiotics and/or lysates of probiotic cultures of lactobacilli and bifidobacteria have been proposed [14]. Leading scientists point to the antimicrobial properties of cultures of lactobacilli and bifidobacteria, note their calming and anti-aging effects on the skin, hair, etc. [15, 16].

Dairy and whey proteins have long been widely used in cosmetic products. They have regenerative, anti-allergenic, moisturizing, softening, anti-inflammatory properties due to the fact that they contain all the essential amino acids and thus nourish the skin and hair [17]. Whey and milk proteins stimulate the growth and differentiation of young cells, thereby activating collagen synthesis and epidermal renewal. As part of whey proteins, a complete set of essential amino acids has been found; also present: cytokines (have high biological activity, are growth factors that stimulate cell division), enzymes and immunomodulators, as well as antimicrobial substances – lysozyme, lactoferrin and lactoperoxidase.

Milk proteins strengthen the hair shaft, nourish and restore the structure of both the internal tissues of the hair and its surface layer, making them smooth and shiny. Milk proteins perfectly soften and soothe even dry and sensitive skin, making it soft, smooth and silky. They also stimulate collagen synthesis [17].

Recently, hydrolysates of milk and whey proteins have been used in cosmetics as components that provide an effective, soft and caring effect on the skin and hair. Natural protein hydrolysates contain peptides of various sizes – high molecular weight and low molecular weight, which moisturize, nourish and condition, contribute to the restoration and rejuvenation of the skin. Low molecular weight peptides provide a delicate lifting effect due to penetration deep into the dermis and stimulate the development of fibroplasts that produce their own elastin and collagen. Today, many environmental factors act negatively on the skin and hair. Concentrates of whey proteins with low molecular weight peptides, enriched with probiotic lysate, are natural cosmetics ingredients that help create an invisible barrier with protective and restorative effects [17, 18].

Natural cosmetics incorporate biologically active substances, extracts of various plants, differs in their predetermined combination with other components so that the action of one of them is supplemented by the action of the other [17, 18].

ISSN 2226-3780

Medicinal plants are an integral component of natural cosmetics due to its healing properties and a set of chemical compounds in its composition. Herbs are one of the first remedies used to treat and improve hair and skin. They contain flavonoids, vitamins, essential oils, tannins and pectins. Each plant contains a unique combination of these substances [19].

To enrich the composition of the probiotic gel shampoo, nettle leaves, marigold flowers, and peppermint grass were selected [18, 19].

Nettle leaves contain:

– glycoside urticin, tannins (up to 2 %);
– carotenoids, volatile, chlorophyll (up to 5 %);
– vitamins C, B_2, B_3, organic acids, micro and macro elements (silicon, iron – 41 mg/100 g, copper – 1.3 mg/100 g, manganese – 8.2 mg/100 g, boron – 4.3 mg/100 g, titanium – 2.7 mg/100 g, nickel – 0.03 mg/100 g).

The healing properties of nettle help strengthen hair, improving its structure, enriching it with useful substances. Therefore, after just a few uses, the hair becomes lush, shiny, and has a healthy appearance [19].

The healing properties of marigolds are determined by the qualitative and quantitative composition of the chemical compounds identified in them, of which the following are of particular value:

– components of essential oil;
– carotenoids;
– flavonoids, alkaloids, volatile;
– minerals (Se, Fe, P, Mg, K, Au, Zn);
– vitamins (A, E, C, B_9, P);
– organic acids.

Marigold flowers carry out a cleansing, regenerating and moisturizing effect, eliminate acne, irritation, make the skin softer, soft and velvety, contribute to its rejuvenation. The essential oil of the plant is used in perfumes for aromatization.

Peppermint has a very wide range of properties – it cleanses the dermis of toxins, has an antiseptic effect, tones, stimulates blood circulation, and tightens. Mint contains up to 3 % of essential oil, it contains esters, flavonoids, tannins, menthol, which allow to use mint as a bactericidal plant [19]. The most popular peppermint ingredient for creating skin and hair care products is the essential oil, which is found in large quantities in leaves and flowers of the herb. Thanks to her and menthol, mint well refreshes and tones the dermis, as well as smoothes wrinkles [18].

Considering the listed beneficial properties of nettle leaves, marigold flowers and peppermint grass, they were chosen as a medicinal raw material for the production of natural probiotic gel shampoo.

5. Methods of research

5.1. The investigated materials used in the study and the methodology of the experiment. For conducting experimental studies as raw materials used:

– basis for the production of gel shampoos;
– a concentrate of whey proteins, low molecular weight peptides and free amino acids, enriched with probiotic cultures of lacto-and bifidobacteria, obtained at the Department of Technology of Dairy, Oil-Fat Products and Cosmetics of Odesa National Academy of Food Technologies (Ukraine);
– dry medicinal plant material (nettle leaves, peppermint grass and marigold flowers);
– tap water;
– mineral waters «Morshynska» and «Borjomi»;
– nano-filtrate of milk cheese whey;
– peppermint essential oil;
– mint flavoring;
– preservative for cosmetic products.

To select an extractant for the purpose of extracting biologically active substances from medicinal plant materials, the process of extraction of ground material (particle size up to 2 mm) was carried out at a temperature of 95±5 °C for 40 min. (the ratio of plant materials to extractant is 1:10) by each of the four types of extractants selected for research:

– tap water;
– mineral non-carbonated water «Morshynska»;
– mineral gas water «Borjomi»;
– nano-filtrate of milk cheese whey, provided for research «Bashtansky cheese factory» (Ukraine).

The extracts prepared in this way were determined by antioxidant activity (AA) [19]. Based on the results of determining the antioxidant activity of extracts of medicinal herbs, an extractant was selected – nano-filtrate of milk cheese whey.

To optimize the ratio of components in a mixture of extracts of selected medicinal plants in the formulations of probiotic shampoos, the response surface methodology was used [7]. The indicated method is a combination of mathematical and statistical techniques aimed at modeling processes and finding combinations of experimental series of predictors in order to optimize the response function $\hat{y}(x,b)$, which is generally described by the following polynomial:

$$\hat{y}(x,b) = b_0 + \sum_{l=1}^{n} b_l x_l + \sum_{k=1}^{n} b_k x_k^2 + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} b_{ij} x_i x_j, \qquad (1)$$

where $x \in R^n$ – the vector of variables; b – the vector of parameters.

Modeling and processing of experimental data was performed in the environment of the software package *Statistica 10 (StatSoft, Inc.)*.

In a mixture of medicinal plant extracts, the mass fractions of mint herb extracts (from 0 to 25 %) and marigold flowers (0 to 25 %) were varied; the mass fraction of the extract of nettle leaves was taken such that it provided the sum of the components of the mixture of extracts 100 %. All crushed medicinal plants were screened, magnetically cleaned and dosed. Cheese whey nano-filtrate, preheated to a temperature of 95±5 °C (the ratio of plant material to extractant was 1:10), was added to each prepared dried medicinal plant, and it was extracted for 40 min. without stirring at a temperature of 95±5 °C. The obtained extracts of medicinal plants were filtered, cooled to t=15...20 °C and mixed in predetermined proportions.

The result was a mixture of extracts of medicinal plants, which were determined by antioxidant activity (*AA*). The optimal ratio of components (extracts of medicinal plants) in the mixture was determined by the maximum value of antioxidant activity.

A mixture with an optimal ratio of medicinal plant extracts was used as a component of probiotic gel shampoos with prescribed prophylactic properties – gel shampoo to strengthen and restore hair and gel shampoo for daily use.

5.2. The experimental research methods used in the study. When performing studies on the antioxidant activity of extracts of medicinal plants and their mixtures was determined by monitoring the values of electron transport activity in the system: restored nicotine-dadenindinucleotide $NAD{\cdot}H_2$ – Potassium Ferrocyanide $K_3[Fe(CN)_6]$ in phosphate buffer. The criterion for evaluating the antioxidant activity of extracts of medicinal plants and their mixtures was the determination of the ratio of their optical density in the $NAD{\cdot}H_2$ – $K_3[Fe(CN)_6]$ optical density system over time [19].

6. Research results

The first stage of experimental research was the choice of extractant for the extraction of biologically active substances from plant materials. Selected extractants were used to obtain extracts of nettle leaves, marigold flowers, and peppermint grass, in which they were determined by antioxidant activity (Fig. 1).

When extracting BAS from peppermint grass (Fig. 1), their maximum amount contains the extract obtained on Borjomi mineral water, since it is it that is characterized by high antioxidant activity – 1233.3 act. units. (Fig. 1). The extracts obtained on mineral water «Morshynska» and tap water have low antioxidant activity – 333.3 and 566.7 act. units, accordingly, peppermint herb extract on nano-filtration whey has an antioxidant activity of 833.3 act. units.

When extracting BAS from marigold flowers, all the extracts obtained have very high antioxidant activity (3566.0–4000.0 act. units). But the extract obtained on whey nano-filtrate has the highest antioxidant activity – 4000.0 act. units.

The greatest amount of biologically active substances is removed from nettle leaves using Borjomi mineral water – this extract has the maximum antioxidant activity – 1766.7 act. units (Fig. 1). The extracts obtained on Morshynska mineral water, tap water and whey nano-filtrate have low values of 1233.0, 1400.0 and 900.0 act. units, respectively.

Despite the fact that extracts of medicinal plants obtained using Morshynska mineral water and tap water have high antioxidant activity only when BAS is extracted from marigold flowers, it is possible to conclude that it is advisable to use mineral water as an extractant for all three plant species Borjomi or whey nano-filtrate. The best extractant is Borjomi mineral water, but it has a high cost, and whey nano-filtrate is a secondary raw material that remains in large quantities at dairy plants, is free of charge and is not currently used for technological purposes. Therefore, it is advisable to choose whey nano-filtrate as an extractant for the extraction of biologically active substances from medicinal plant materials.

To optimize the composition of the mixture of herbs for the production of probiotic gel shampoos, extracts of nettle leaves, peppermint grass and marigold flowers obtained using whey nano-filtrate were used as raw materials. The quality indicators of extracts of plant materials – organoleptic, physico-chemical and biochemical (Table 1) – determine the possibility of using the obtained extracts of medicinal raw materials as components of natural probiotic gel shampoos.

Table 1

Quality indicators of plant extracts

Indicator	The value and characteristic of the indicator for the extract made of		
	nettle leaf	peppermint herbs	marigold flowers
Organoleptic indicators			
Smell	Nettle scent with light whey aroma	Peppermint scent with light whey aroma	Mild aroma of marigold flowers with a light aroma of whey
Appearance and consistency	Homogeneous translucent liquid	Homogeneous translucent liquid	Homogeneous translucent liquid
Color	Green with a touch of brown	Light green	Light brown
Physical and chemical indicators			
Active acidity, pH units	5.8	5.8	5.7
Biochemical indicators			
Antioxidant activity, act. units	900.0	833.3	4000.0

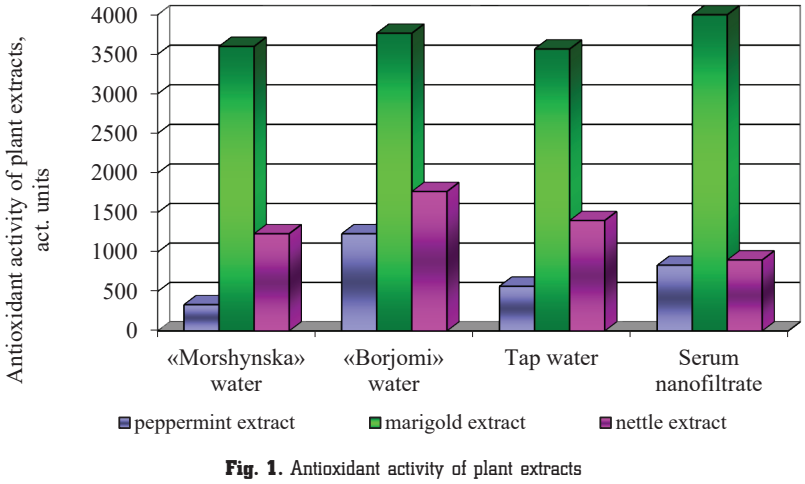

Fig. 1. Antioxidant activity of plant extracts

The criterion for optimizing the ratio of extracts of medicinal plants in their mixture was selected antioxidant activity (*AA*, act. units). Independent factors varied; in the experiment, the mass fraction of mint herb extract (C_{me}, %) and the mass fraction of marigold flower extract (C_{mf}, %) were selected. The content of the nettle leaf extract was set so that the mixture of all raw ingredients was 100 %.

To simulate antioxidant activity (*AA*, act. units) the response value was selected, which has the form of a polynomial of the second stage:

$$AA = b_0 + b_1 \cdot C_{me} + b_{11} \cdot C_{me}^2 + \\ + b_2 \cdot C_{mf} + b_{22} \cdot C_{mf}^2 + b_{12} \cdot C_{me} \cdot C_{mf}, \quad (2)$$

ISSN 2226-3780

where AA – the antioxidant activity of a mixture of extracts of medicinal plants (AA, act. units); C_{me} – the mass fraction of mint herb extract, %; C_{mf} – mass fraction of marigold flower extract, %; b_1, b_{11}, b_2, b_{22}, b_{12} – coefficients for the polynomial element.

In studies, a central composite rotatable abstract was used [7]. The choice of levels and ranges of variation of the factors was carried out according to the recommendations of the literature [17, 18]: the mass fraction of mint herb extract varied between 0–25 %; mass fraction of marigold flower extract – in the range of 0–25 %.

The planning matrix and experimental values of the response functions are presented in Table 2. To reduce the influence of systematic errors caused by external conditions, the sequence of experiments was randomized.

Table 2

Planning matrix and response functions

No. of experiment	Mass fraction of mint herb extract, C_{me}		Mass fraction of marigold flower extract, C_{mf}		Antioxidant activity, AA, act. units
	Coded level	%	Coded level	%	
1	–1	3.6	–1	3.6	560.0
2	–1	3.6	+1	21.4	833.0
3	+1	21.4	–1	21.4	1133.3
4	+1	21.4	+1	3.6	533.3
5	$-\sqrt{2}$	0.0	0	12.5	600.0
6	$+\sqrt{2}$	12.5	0	0.0	500.0
7	0	25.0	$-\sqrt{2}$	12.5	1000.0
8	0	12.5	$+\sqrt{2}$	25.0	970.0
9	0	12.5	0	12.5	833.0
10	0	12.5	0	12.5	870.0
11	0	12.5	0	12.5	833.0
12	0	12.5	0	12.5	870.0

To check the significance of the regression coefficients (2), let's construct the Pareto diagram shown in Fig. 2 (L – linear effect, K – quadratic effect).

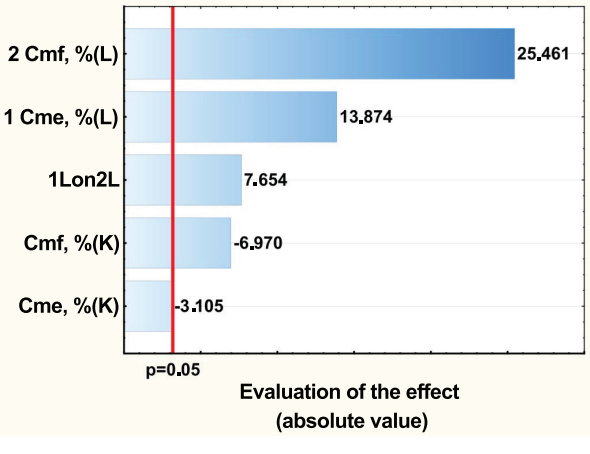

Fig. 2. Pareto diagram

The indicated Pareto diagram (Fig. 2) shows the standardized coefficients, sorted by absolute values. An analysis of the data shows that all the studied parameters and the effect of their interaction are significant, since the column for evaluating these effects crosses the vertical line, is a 95 % confidence probability.

The resulting equation with the calculated coefficients has the form:

$$AA = 424.630 + 7.269 \cdot C_{me} - 0.334 \cdot C_{me}^2 + \\ + 27.536 \cdot C_{mf} - 0.750 \cdot C_{mf}^2 + 1.032 \cdot C_{me} \cdot C_{mf}. \quad (3)$$

The adequacy of the developed model according to formula (3) was checked by analysis of variance. The data obtained, in particular, the value of the determination coefficient close to unity ($R^2 = 0.961$, $R^2_{adj} = 0.929$), as well as the value $p \geq 0.05$, allow to conclude that the resulting model (3) adequately describes the response.

The combined effect of the mass fraction of mint herb extract (C_{me}, %) and the mass fraction of marigold flower extract (C_{mf}, %) described by polynomial (3) on the antioxidant activity of a mixture of medicinal plant extracts are presented in graphical form in Fig. 3.

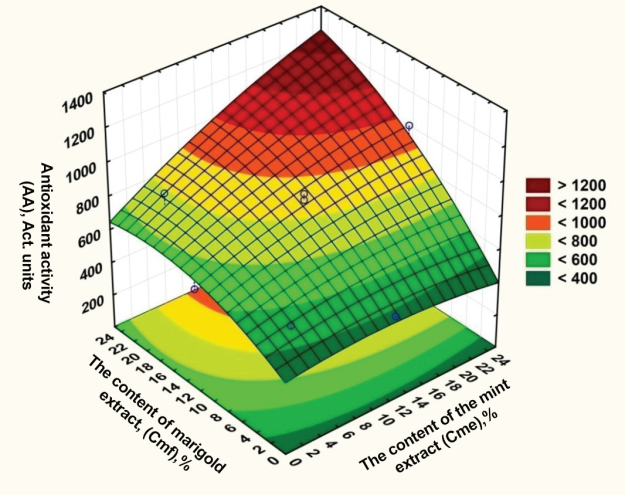

Fig. 3. Dependence of antioxidant activity (AA, act. units) of the mixtures of extracts of medicinal plants based on whey, from C_{me} and C_{mf}

With an increase in the content of marigold extract (Fig. 3), the antioxidant activity increases, since, with a minimum content of peppermint herb extract, the antioxidant activity increases from 200 to 600 act. units. And at the maximum content of mint herb extract increases from 200 to 1227 act. units. At the same time, the concentration of mint herb extract, with a low content of marigold extract, practically does not affect the increase in antioxidant activity. And at the maximum concentration of marigold extract, the antioxidant activity becomes higher due to the high concentrations of both extracts, this indicates that BAS extracts are in a state of synergism. With a concentration of both extracts of 25 %, and a nettle extract of 50 %, this mixture has the highest antioxidant activity of –1262.255 act. units. Therefore, it is recommended for the production of probiotic gel shampoo to use a mixture of extracts of marigold flowers, peppermint grass and nettle leaves in a ratio of 25:25:50 (1:1:2).

Based on the studies, formulations of probiotic gel shampoos enriched with short-chain peptides of whey proteins, probiotic lysates and extracts of a mixture of medicinal plants are developed, which are given in Table 3.

The above formulations differ in the content of lyophilized dried whey protein concentrate and low-peeling peptides, enriched with probiotic lysate: gel shampoo for hair restoration and strengthening contains 5 % concentrate, and gel shampoo for daily use is 10 times less. The introduction of whey proteins and low-peeling peptides into the composition of gel shampoo in an amount of 5 % contributes to reducing hair fragility, restoring its structure and strengthening.

Table 3

Formulations of probiotic gel shampoos enriched with short chain peptides of whey proteins, probiotic lysates and extracts of a mixture of medicinal plants

Raw materials	Mass of raw materials (kg) for the production of probiotic gel shampoo	
	for daily use	for strengthen and restore hair
The basis for gel shampoo	86.500	82.000
Whey nano-filtrate herbal peppermint extract	2.375	2.375
Whey nano-filtrate marigold flower extract	2.375	2.375
Nettle leaf extract based on whey nano-filtrate	4.750	4.750
Lyophilized-dried concentrate of whey proteins and low-peeling peptides, enriched with probiotic lysate	0.500	5.000
Peppermint essential oil	2.250	2.250
Flavor	1.000	1.000
Preservative	0.250	0.250
Total	100.000	100.000

«Probio-beauty» probiotic gel shampoos are prepared according to the developed formulations in the laboratory conditions of the Department of Dairy, Fat-and-Oil Products and Cosmetics Technology of Odesa National Academy of Food Technologies (Ukraine). In the manufactured gel shampoos, quality indicators are defined; it is shown that «Probio-beauty» probiotic beauty shampoos meet the requirements of regulatory documents in terms of quality indicators (Table 4). The difference in the composition of the developed gel shampoos consists in the content of short-chain peptides: the hair strengthening and restoration product contains 3.170 mg/cm^3, which is 10 times more than «Probio-beauty» gel shampoos for daily use.

SWOT analysis of the results of studies of «Probio-beauty» gel shampoos, enriched with short-chain peptides of whey proteins, probiotic lysates and extracts of a mixture of medicinal plants, is given in Table 5.

Based on the SWOT analysis, the following strategic solutions are proposed:

SO – strategic decisions. Using the fashion for a healthy lifestyle, it is supposed to promote and consolidate new gel shampoos by developing advertising campaigns, during which the emphasis will be on the strengths of products – the presence of natural components and probiotics, high functional properties and optimized component composition. Also, based on consumer interest in a new product, it is planned to pay attention to developing a product brand – to develop an attractive and unusual packaging design, a label that will attract the attention of the buyer and play the role of an advertising medium for the product. Also, an effective measure to popularize products is to participate in existing advertising events (for example, the So Green Fesst festival of healthy lifestyles and the Alternative festival), since it is cheaper than developing a new advertising event and such a strategy does not provide for a significant increase in the price of goods. In addition, it is planned to «introduce» the consumer to new probiotic cosmetics, namely, «Probio-beauty» gel shampoo tests, planned cooperation with specialized salons and stores that specialize in natural cosmetics, which will encourage consumers to buy these products, will be offered.

WO – strategic decisions. Let's propose to solve the first weakness, namely, the high price compared to similar products on the market, through the sale of products through a network of specialized stores of natural products, as well as beauty salons. Since the product has an optimal composition of healing components and high functional properties, a steady demand for these products is predicted.

Table 4

Quality indicators of the developed «Probio-beauty» probiotic gel shampoos

Indicator	The value and characteristic of the indicator	
	for daily use	for strengthen and restore hair
Organoleptic indicators		
Smell	Characteristic for gel shampoos with a pronounced aroma of mint	
Appearance and consistency	Homogeneous gel-like liquid	
Color	Light yellow, due to the addition of herbal extracts based on whey nano-filtrate	
Physical and chemical indicators		
Active acidity, pH units	5.3	5.2
Foaming ability: – foam resistance – foam number	 140 0.8	 138 0.8
The content of short chain peptides, mg/cm^3	0.317	3.170
Physical and chemical indicators		
Active acidity, pH units	26.08	26.12
Biochemical indicators		
Antioxidant activity, act. units	15.0	19.3

ISSN 2226-3780

Table 5

SWOT analysis matrix

Internal environment / External environment	*Strengths*	*Weaknesses*
	– presence of biologically active components of medicinal herbs, short-chain peptides, free amino acids and probiotics; – high functional properties; – optimized component composition with medicinal plants	– high price compared to traditional shampoos; – limited organoleptic properties; – narrow range of products
Opportunities – fashion for a healthy lifestyle; – interest in a new product; – growing popularity of products with probiotics; – lack of competition among Ukrainian manufacturers; – ability to sell products through specialized stores and salons	*SO* – strategic decisions	*WO* – strategic decisions
	– development of advertising campaigns and events in order to promote products; – product brand development (packaging, label); – participation in ongoing promotional events (festivals «Healthy Lifestyle» and «Alternative»); – providing the opportunity to test products (offer testers, cooperation with specialized salons and shops)	– implementation through special «organic» stores and salons; – use of organoleptic indicators as signs of naturalness and authenticity of the product; – development of assortment policy with a gradual expansion of the range
Threats – low prevalence of information about cosmetics with probiotics; – high competition with foreign manufacturers; – decrease in the purchasing power of the population; – unstable economic and political situation in the country	*ST* – strategic decisions	*WT* – strategic decisions
	– formation of demand for a new product by positioning the goods; – product promotion by various methods of marketing communications; – formation of a flexible pricing policy, the availability of regular customers cards, discount cards; – variation in value by selling products in large and small packaging	– conducting marketing activities to popularize products with probiotics, in particular; – creation and support of a site, a page on social networks with the location of advertising and explanatory information regarding the properties of the product; – discussion of the properties and advantages of the product in specialized forums; – maintaining price stability due to the lack of dependence on foreign producers and raw materials

Organoleptic properties are limited, namely, the presence of a natural color and the smell of mint can be positioned as a sign of the authenticity and naturalness of the product – the absence of artificial colors and flavors.

The narrow assortment is planned to be gradually expanded by using other medicinal components of directed action, using the fashion for a healthy lifestyle.

ST – strategic decisions. To reduce the threat of low prevalence of information about cosmetics with probiotics, the formation of demand for a new product by positioning the product and promoting the product using various marketing communication methods is proposed. It is necessary to carry out a set of measures that should begin at the initial stage of product development and continue at the entire stage of its creation and distribution. These measures should be aimed at informing potential consumers about the properties of a new product and the principles of a healthy lifestyle.

As regards the threats of «declining purchasing power» and «unstable economic and political situation in the country», the development of a flexible pricing policy, the availability of regular customers' cards, discount cards are envisaged. It is also proposed to envisage the release and sale of products in large and small capacity packages (including disposable travel packages).

WT – strategic decisions. Conducting marketing activities to popularize products with probiotics by creating and maintaining a website or page on social networks with the location of advertising and explanatory information regarding the properties of the product. Discussion of product features and benefits in specialized forums. Such measures allow, on the one hand, to conduct marketing activities, and on the other hand, to obtain feedback from the consumer – to identify preferences of customers for further expansion of the range, monitoring complaints and suggestions. It is also planned to maintain price stability due to the lack of dependence on foreign producers and raw materials.

7. SWOT analysis of research results

Strengths. The proposed formulations of probiotic gel shampoos with optimized component composition provide high functional properties of the product due to the selection and combination of components. So, probiotics in the composition of gel shampoos provide antimicrobial properties and have a calming effect on the scalp and hair. The introduction of whey proteins and low-peeling peptides into the composition of gel shampoo will help reduce hair fragility, restore its structure and strengthen. And the optimized composition of the mixture of extracts of medicinal plants provides a high antioxidant activity of –1262.255 act. units.

Weaknesses. Among the negative internal research factors, a narrow assortment is being developed. In the study, attention is paid to developing the formulation of gel shampoos only. The recipe composition of extracts of medicinal plants is also not wide enough so far – in the presented studies it is limited only to such plants as nettle leaves, marigold flowers and mint herbs. The use of only three plant extracts in shampoos limits the organoleptic characteristics of the finished product. In studies, such components of gel shampoos as short-chain peptides, free amino acids and probiotics are increase the cost of the product compared to Ukrainian counterparts.

Opportunities. When developing gel shampoo formulations, the popularity of cosmetics with probiotics and the fashion for a healthy lifestyle were taken into account. Since today there are no cosmetic products with probiotics produced in Ukraine on the market, the implementation

of research will allow to occupy the niche of «natural cosmetics». And correctly conducted marketing activities that are offered in this work will allow to gain a foothold in the cosmetics market, make the brand recognizable and expand the product range based on consumer preferences.

Threats. Among the threats can be noted the negative impact of foreign cosmetics manufacturers with probiotics. In the market, Asian cosmetics manufacturers can be very competitive. Korean natural cosmetics and cosmetic products with probiotics are very advanced in the world market. Among the threats, it is necessary to take into account the additional costs of developing and implementing a marketing product policy. It should be noted that the presented studies do not apply to essential goods, so the unstable economic situation can also have a negative impact and require additional costs for the competent promotion of research results.

8. Conclusions

1. The ratio of extracts of medicinal plants in the composition of probiotic gel shampoos has been optimized. The optimal ratio of extracts of nettle leaves, marigold flowers and peppermint grass is 2:1:1. Moreover, the resulting mixture of extracts has a maximum antioxidant activity of 1262.255 act. units.

2. The «Probio-beauty» probiotic gel shampoo formulations are enriched with short-chain whey protein peptides, probiotic lysates and extracts of a mixture of medicinal plants, intended for daily use and for strengthening and restoration of hair. Quality indicators developed with optimized formulations of «Probio-beauty» probiotic gel shampoos meet the requirements of regulatory documents.

References

1. Baitsar, R. I., Kordiyaka, Yu. M. (2013). Napriamky rozvytku vyrobnytstva shampuniv ta zabezpechennia yikh yakosti. *Formuvannia i otsiniuvannia asortymentu, vlastyvostei ta yakosti neprodovolchykh tovariv, 1,* 37–40.
2. Kordiyaka, Yu. M. (2017). *Vdoskonalennia normatyvno-tekhnichnoho zabezpechennia vyprobuvan ta yakosti kosmetychnykh zasobiv.* Lviv, 201.
3. Margolina, A. A., Ernandes, E. I., Zaykina, O. E. (2000). *Novaya kosmetologiya*. Moscow: ID «Kosmetika i meditsina», 206.
4. Balabanov, V. I. (2009). *Nanotehnologii. Nauka budushchego*. Moscow: Eksmo, 247.
5. Popova, Zh. M., Chekman, Ch. I. (2013). Vykorystannia nanotekhnolohiy u kosmetychnykh zasobakh – velykyi potentsial chy potentsiynyi ryzyk? *Voprosy farmatsii, 5,* 95–98.
6. Korzh, Yy. V. (2013). Assessment of the current market of parapharmaceutical products with photoprotector properties made on the nanotechnology basis. *Zaporozhskiy meditsinskiy zhurnal, 3,* 101–104.
7. Myers, R. H., Montgomery, D. C., Anderson-Cook, C. M. (2016). *Response surface methodology: process and product optimization using designed experiments*. New Jersey: John Wiley & Sons, 856.
8. Tkachenko, N., Nekrasov, P., Makovska, T., Lanzhenko, L. (2016). Optimization of formulation composition of the low-calorie emulsion fat systems. *Eastern-European Journal of Enterprise Technologies, 3 (11 (81))*, 20–27. doi: https://doi.org/10.15587/1729-4061.2016.70971
9. Tkachenko, N., Nekrasov, P., Vikul, S., Honcharuk, Y. (2017). Modelling formulae of strawberry whey drinks of prophylactic application. *Food Science and Technology, 11 (1)*. doi: https://doi.org/10.15673/fst.v11i1.303
10. Dréno, B., Araviiskaia, E., Berardesca, E., Gontijo, G., Sanchez Viera, M., Xiang, L. F. et. al. (2016). Microbiome in healthy skin, update for dermatologists. *Journal of the European Academy of Dermatology and Venereology, 30 (12),* 2038–2047. doi: https://doi.org/10.1111/jdv.13965
11. Ladizinski, B., McLean, R., Lee, K. C., Elpern, D. J., Eron, L. (2014). The human skin microbiome. *International Journal of Dermatology, 53 (9),* 1177–1179. doi: https://doi.org/10.1111/ijd.12609
12. Singh, P., Teal, T. K., Marsh, T. L., Tiedje, J. M., Mosci, R., Jernigan, K. et. al. (2015). Intestinal microbial communities associated with acute enteric infections and disease recovery. *Microbiome, 3 (1)*. doi: https://doi.org/10.1186/s40168-015-0109-2
13. Izawa, N., Sone, T. (2014). Cosmetic Ingredients Fermented by Lactic Acid Bacteria. *Microbial Production,* 233–242. doi: https://doi.org/10.1007/978-4-431-54607-8_20
14. Tkachenko, N., Chagarovskyi, O., Dets, N., Sevastyanova, E., Lanzhenko, L. (2017). «Lving» and «probiotic» cosmetics: modern view and defenitions. *Food Science and Technology, 11 (4),* 90–102. doi: https://doi.org/10.15673/fst.v11i4.735
15. Cinque, B., La Torre, C., Melchiorre, E., Marchesani, G., Zoccali, G., Palumbo, P. et. al. (2011). Use of Probiotics for Dermal Applications. *Microbiology Monographs,* 221–241. doi: https://doi.org/10.1007/978-3-642-20838-6_9
16. Zilber-Rosenberg, I., Rosenberg, E. (2008). Role of microorganisms in the evolution of animals and plants: the hologenome theory of evolution. *FEMS Microbiology Reviews, 32 (5),* 723–735. doi: https://doi.org/10.1111/j.1574-6976.2008.00123.x
17. Protein quality evaluation (1989). Report of the Joint FAO/WHO expert consultation. *Food and nutrition paper No. 51*. Rome: Food and Agriculture Organizations and the World Health Organization, 67.
18. Avramenko, G. N., Voytkevich, S. A., Gulyy, S. E., Kim, V. E., Koral'nik, S. I., Puchkova, T. V. (2004). *Tolkoviy slovar' po kosmetike i parfyumerii. Vol. 2. Syr'e i biologicheski aktivnye dobavki*. Moscow: «NAUKA, MEDITSINA, VETERINARIYA», 264.
19. Yaroshenko, N. (Ed.) (2006). *Vitaminy, mineraly i travy dlya Vashego zdorov'ya*. Moscow: Riderz Daydzhest, 415.

Tkachenko Nataliia, *Doctor of Technical Sciences, Professor, Head of Department of Dairy Technology and Technology of Fats and Perfume-Cosmetic Products, Odessa National Academy of Food Technologies, Ukraine, e-mail: nataliya.n2013@gmail.com, ORCID: http://orcid.org/0000-0002-2557-3927*

Vikul Svitlana, *PhD, Associate Professor, Department of Food Chemistry and Expertise, Odessa National Academy of Food Technologies, Ukraine, e-mail: vizaj_vik@ukr.net, ORCID: http://orcid.org/0000-0002-6753-5769*

Pambuk Svitlana, *PhD, Associate Professor, Department of Marketing, Business and Trade, Odessa National Academy of Food Technologies, Ukraine, e-mail: pambuk@ukr.net, ORCID: https://orcid.org/0000-0002-6651-5774*