

UDC 665.584.01:544.252.24

THE SAFE TRANSDERMAL COSMETIC PRODUCT WITH ANTITYROSINASE ACTIVITY

DOI: <http://dx.doi.org/10.15673/fst.v13i3.1481>

Article history

Received 25.04.2019
Reviewed 18.05.2019
Revised 20.06.2019
Approved 03.09.2019

Correspondence:

L. Pylypenko
E-mail: l.n.pylypenko@ukr.net

Cite as Vancouver Citation Style

Pylypenko L, Sevastyanova E, Novikova N, Makovska T, Kilimenchuk H. The safe transdermal cosmetic product with antityrosinase activity. Food science and technology. 2019;13(3):127-135. DOI: <http://dx.doi.org/10.15673/fst.v13i3.1481>

Cite as State Standard of Ukraine 8302:2015

The safe transdermal cosmetic product with antityrosinase activity / Pylypenko L. et al. // Food science and technology. 2019. Vol. 13, Issue 3. P. 127-135. DOI: <http://dx.doi.org/10.15673/fst.v13i3.1481>

Copyright © 2015 by author and the journal "Food Science and Technology".

This work is licensed under the Creative Commons Attribution International License (CC BY).
<http://creativecommons.org/licenses/by/4.0>



Introduction. Formulation of the problem

The development of a whitening cosmetic cream with an antipigmentation constituent and components that intensify the delivery of these biologically active compounds to skin layers is a topical scientific and practical problem. The modern rate of life, environment, ways of nutrition, cosmetics of poor quality result in the appearance of pigmentation on the face. The search for cosmetic ingredients, especially the natural ones, with antipigmentation properties is paid much attention to all over the world.

The strategic course in developing the technological base for creation of a cosmetic cream

L. Pylypenko, Doctor of Sciences in Engineering, Professor¹

E. Sevastyanova, Cand. of Chem. Sci., Assistant Professor²

N. Novikova, Cand. of Chem. Sci., Senior researcher³

T. Makovska, Assistant²

H. Kilimenchuk, Leading engineer³

¹Department of biochemistry, microbiology and nutrition physiology,

²Department of milk, fat and oil products and cosmetics
Odessa National Academy of Food Technologies,
112, Kanatnaya Str, Odessa, Ukraine, 65039

³Department of molecular structure and chemoinformatics
A.V. Bogatsky Physico-chemical institute NAS Ukraine,
86, Lustdorfskaya Dor. Str, Odessa, Ukraine, 65080,

Abstract. The possibility of developing a cosmetic product with antipigmentation properties has been considered. The cream is based on extracts, selected by monitoring, from plant components spread in Ukraine, able to inhibit tyrosinase and thus impart antipigmentation properties to the product. As active components expanding the range of the product's cosmetic properties, ingredients were selected that strengthen the skin matrix and saturate it with essential substances. To enhance the effectiveness of the biologically active constituents of the product, liquid crystals based on cholesterics as modern systems of transdermal delivery of active components (0.1%) were included in its composition. For the cosmetic product, it has been suggested to use the following thermotropic cholesteric composition: cholesteryl nonanoate – 45%, cholesteryl pentanoate – 25%, cholesteryl-4-nonylbutanedioate – 30%. According to the complex of the organoleptic, physico-chemical, biochemical, and microbiological quality parameters of the new product after its manufacture and storage during three months, it has been established that it complies with the general sanitary and hygienic requirements to perfumes and cosmetics of the 3rd group. Biotesting on the testing cultures *Allium cepa* L. and *Saccharomyces cerevisiae* has proved the complete integral safety and growth potentiation of both testing cultures by 9.6–19.3% to the control, even in the presence of a preservative. This is an evidence of the safety, biological activity, and advisability of the developed cosmetic product with antipigmentation properties, containing cholesteric liquid crystals. The cosmetic product, based on the formulation developed, has been tested on female volunteers. Its effectiveness has been established and a simultaneous increase in the face skin humidity has been proved instrumentally.

Key words: cosmetic cream, pigmentation, tyrosinase inhibitors, liquid-crystal cholesterics, biotesting.

with whitening and antipigmentation properties is selection of such components that would meet the requirements to natural ("organic," "green") cosmetics and that are safe both to the human skin and to the whole body [1].

While developing cosmetic creams of this type, it is necessary to take into account the contribution of each component, so that the cream, apart from its whitening and antipigmentation properties, could moisturize the skin, normalize the secretion of skin fat, improve the face skin matrix, and saturate the skin with vitamins, antioxidants, etc. [2].

Thus, monitoring and selecting such natural components, which, due to their chemical composition, can whiten and level the tone of face colour, gradually lessen the pigment spots, as well as monitoring systems of delivery of these components in the composition of safe, biologically active creams, are topical and prospective tasks of scientific and practical value.

Analysis of recent research and publications

Nowadays, there are a lot of cosmetic ingredients of different designation: also, different systems are used of delivering these components, such as liposomes, micro-/nanoparticles, β -cyclodextrin, emulsions [3].

According to estimations, about 15% of people buy skin whitening products, especially the Asian population [4]; analysts prognosticate that the world market of skin whiteners in 2020 will reach US \$ 23 billion [5]. According to *Sirona Biochem* report, in the Pacific region of Asia, US \$ 13 billion was spent on skin care products and cosmetics. In India, in 2010, US \$ 431 million was spent on skin whitening and skin care creams [5].

The factors that change the skin colour fall into exogenic, influencing mostly the epidermis, and endogenic, effecting on the derma. Relation of the factors effecting on the pigmentation is presented in Table 1 [3].

Table 1 – Factors influencing the skin pigmentation

| | |
|--|--|
| States connected with changes in the skin colour | <ul style="list-style-type: none"> • Hyper- and hypopigmentation • Vascular disorders • Oxidative stress |
| Cells and systems involved in the process | <ul style="list-style-type: none"> • Keratinocytes • Melanocytes • Immune system • Lipids peroxidation |
| Effective chemical substances | <ul style="list-style-type: none"> • Inhibitors of melanocyte stimulating hormone (HSH) • Inhibitors of L-dihydroxyphenylalanine (L-DOPA) • Inhibitors of melanosomes transport • Anti-inflammatory substances • Inhibitors of tyrosinase • Antioxidants |

The molecular mechanism of the action of skin whiteners consists in decreasing the amount of melanin, the main source of skin colouration. Melanin is formed in melanocytes of epidermis in a ratio of about 1/36 with basal keratinocytes [6]. In respond to ultraviolet irradiation, melanocytes synthesise melanin, and this process is called melanogenesis. Synthesised melanin is transformed by the neighbouring epidermal keratinocytes [7]. In normal physiological conditions, pigmentation has a positive effect on the skin photoprotection from hazardous ultraviolet damage, and also plays an important evolutionary role in the camouflage and mimicry of animals [8]. Excessive formation of melanin causes such dermatological problems as freckles, solar lentigo (age spots), melasma [9-12], cancer [13] and postinflammatory melanoderma [14]. Continuous UV-irradiation can result in DNA damage, genes mutation, immunity decrease, and photoaging [15]. The process of melanogenesis begins with L-tyrosine oxidation into dopaquinone (DQ), the key enzyme of which is tyrosinase. In this process, quinone is formed, which functions as a substrate for eumelanin and phaeomelanin synthesis [16,17].

Though numerous enzymes that catalyse biochemical reactions take part in melanogenesis, the main role in melanin synthesis is played by such enzymes as tyrosinase and its “relatives”: tyrosinase-related protein 1 (TRP-1) and tyrosinase-related

protein 2 (TRP-2). Tyrosinase, in particular, is an enzyme that catalyses the limiting stage of melanin synthesis, and thus, tyrosinase inhibition is an effective, prognosticated approach to developing melanogenesis inhibitors [18]. All over the world, compounds are actively looked for that can inhibit tyrosinase and thus, can be used, due to their physico-chemical properties, as components of cosmetic creams.

There are a lot of tyrosinase inhibitors developed, which directly take part in inhibiting the catalytic activity of tyrosinase from all sources, including laboratory methods of synthesis, natural products, virtual screening, and investigations of molecular docking based on the structure [18,19]. The concentration and cosmetic action of such compounds in cream depends on the delivering system. To ensure the appropriate percentage of whitening and inhibitory compounds getting to the skin layers, without loss of effectiveness, it is necessary to give reasons for the choice of the types and concentration of transdermal transporters. These compounds include cholesterol and its derivatives that are the components of the cornified layer and regulate some physiological functions of the epidermis, in particular, are responsible for permeability of the skin barrier.

The purpose of the work was developing a new, safe, biologically active whitening cosmetic cream with antipigmentation properties, using liquid crystal cholesterics.

To achieve the goal, the following **objectives** were formulated:

- to give reasons for the selection of the plant raw material common in Ukraine, and of the types of transdermal transporters that can be used in the cream composition;
- to determine the rational quantities of ingredients, and to develop the formulation of a cream with antipigmentation properties and high permeability;
- to determine the complex of sanitary-hygienic, physico-chemical, biochemical, sensory characteristics, and the biological activity of the cream developed after manufacture and storage.

Research materials and methods

The following raw materials were selected as plant ingredients: extracts of liquorice (*Glycyrrhiza glabra*, a genus of herbaceous plants of the *Fabaceae* family), dandelion (*Taraxacum officinale*, *Compositae* family), origanum (*Origanum vulgare*, *Labiatae* family), camomile (*Matricaria chamomilla* L., *Compositae* family), milfoil (*Achilea millefolium* L., *Compositae* family), parsley (*Petroselinum sativum* Hoffm., *Umbellifera* family); common plantain (*Plantago major* L., *Plantaginaceae* family); CO₂-extract of liquorice, and CO₂-extract of vanilla (manufactured in Ukraine); chia seed oil (manufactured in the EU); hydrolates of lemon and aloe (manufactured in Ukraine); standard mixture for creams *Cospem 704* (manufactured in France); preservative *Germall* (manufactured in the USA).

The aqueous-alcoholic (water:alcohol = 1:3) extracts of the plants were prepared to determine their antityrosinase activity. The extraction was carried out in a round-bottom flask equipped with an air cooler, in a bain-marie, during 60 min, at 60–70 °C, with the ratio between the solvent and the dry ground plant raw material 5:1. After the extraction, the extracts were kept at room temperature for 24 hours. After that, the alcohol was separated by a simple distillation method and filtered through a membrane filter *Millipore*, with the pore diameter 0.22 µm.

The tyrosinase activity was determined with L-tyrosine according to the method [20], with some modifications: 0.5 cm³ of enzyme solution was added into the test tube, containing 2.5 cm² of L-tyrosine solved (2.5 mmol/dm³) in sodium phosphate buffer solution (0.05mole/dm³, pH 6.5). After 10 min of incubation at 25°C, the mixture was measured by photometry at 475 nm, with the ray path length 1 cm, in a cuvette.

Inhibition of tyrosinase was studied by determining the enzyme activity in the presence of an inhibitor in the concentration range 0.3 to 5 cm³/dm³. The half-maximal inhibition concentration of tyrosinase, IC₅₀, was determined by the graph of the dependence of the enzyme activity on the concentration of the inhibitor, using the linear section

of the curve and extrapolating it to 50% of retaining of the enzyme activity.

Cholesterol esters were obtained by interaction of chlorides of respective acids with cholesterol in an anhydrous benzene medium, with addition of unhydrous pyridine for binding HCl [21]. The end products were crystallized from the ethanol-ether mixture. Nonanoic and pentanoic chlorides were obtained with thionyl chloride in anhydrous benzene by the method described in [22], and then, they were subjected to vacuum distillation.

The asymmetric diester of butan-1,4-dioic acid was synthesized according to the procedure described in [23]. A cholesterol reaction with succinic anhydride in a mixture of chloroform and DMSO, in the presence of pyridine and 4-N,N-dimethylaminopyridine, allowed obtaining cholesteryl hemisuccinate. Next, by interaction with thionyl chloride at room temperature during 48 hours, its chloride was synthesized, which, without isolation, was used for a subsequent reaction of obtaining nonyl alcohol ester.

The acid number was determined by the method of quantitative carbonic acid measurement. The method is based on the reaction of neutralizing free acids with an alkali solution. The ester number was determined by the colourimetric method. The saponification number is the sum of the acid and ester numbers [24]. Determination of the volatile components and water content in the cream was based on the cream mass decreasing after thermal treatment. For the precision of determination, pure sand calcinated to a constant mass was added to the cream, and then, the cream was dried in an air thermostat at 100–105°C to a constant mass [24]. The pH was determined with the help of a laboratory pH-meter supplied with glass and silver-chloride electrodes. The method of determining aggregative stability is based on measuring the amount of liquid or the oil phase that has been separated during centrifugation [25].

The integral safety of the cream developed was determined by biotesting on the subcellular and organism levels according to mitosis abnormalities, growth and survival of the testing cultures *Allium cepa* L. and *Saccharomyces cerevisiae* (bakery yeast *Saccharomyces cerevisiae*, from the collection of microorganisms at the department of biochemistry, microbiology and physiology of nutrition, Odessa Food Academy; race 14, isolated at Odessa yeast plant), according to recommendations [26]. The number of *Saccharomyces cerevisiae* cells was determined in dilutions either directly in Gorjaev's count chamber or by inoculation in Petri dishes of 1 cm³ of every dilution, with subsequent counting of colonies grown after thermostating at 26–28°C during 24–48 hours.

The sanitary and hygienic safety of the product developed was determined according to [24,25] by QMAFAnM. Mould and yeast-like fungi, yeast, bacteria of the *Enterobacteriaceae* family, *Staphylococcus aureus*, *Pseudomonas aeruginosa*

were determined by express methods using chromogenic microbiological media [26]. The microbiological medium *Compact Dry* was used: it is a sterile dry medium applied on a cloth substrate. 1 cm³ of the tested sample was added in the dish and then uniformly spread on the whole surface. After the incubation, the results (colonies of a certain colour that had grown on the medium surface) were counted. The inoculations were cultivated at a temperature optimum for every group of microorganisms, during 1–2 days. Colonies of a certain colour were counted: MAFAnM had red colonies, *E. coli* blue colonies. The total number of coliform group colonies is the sum of red and blue colonies. *Staphylococcus aureus* forms light-blue and blue colonies, *Pseudomonas aeruginosa*'s are red. The investigation of each sample was repeated three times.

The method of skin humidity determination is based on measuring conductivity with a standard electrode [25] using the laboratory instrument *User Manual Digital Moisture Oil Content Analyzer SK-8*.

The research procedure consisted in the following: volunteers taking part in the experiment, prior to the experiment, cleaned their skin with one and the same cosmetic product, then, after 20 minutes, with the help of the above mentioned instrument, the skin humidity was measured. On each volunteer's face, with light massaging movements, the cosmetic cream was applied, and after 10, 20, and 40 minutes, the skin humidity was measured again.

Results of the research and their discussion

At the first stage of the work, the presence of antityrosinase activity was determined in the extracts obtained from different plant species. Monitoring of plant extracts showed a sufficiently high antityrosinase activity in the samples from *Glycyrrhiza glabra* and *Origanum vulgare*.

The results of the experiment and the mathematical description of the antityrosinase activity in the extracts from raw materials common in Ukraine (liquorice and origanum) are presented in Fig. 1 and 2.

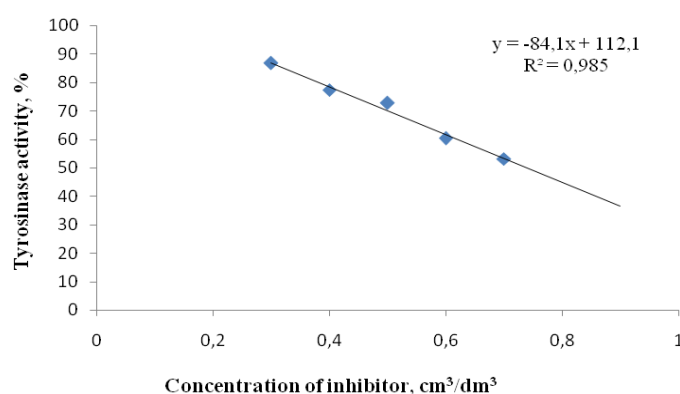


Fig. 1. Enzyme activity dependence on the inhibitor concentration in the liquorice extract

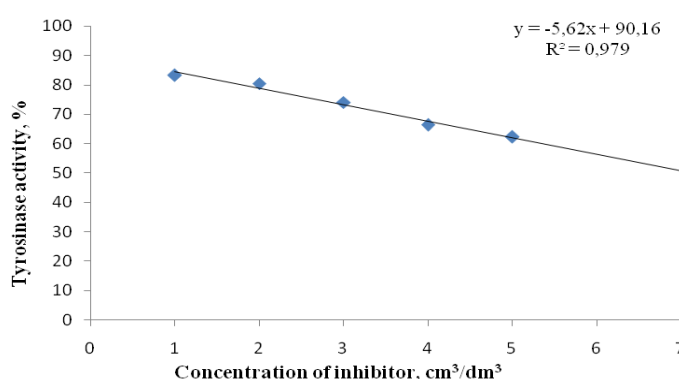


Fig. 2. Enzyme activity dependence on the inhibitor concentration in the origanum extract

Besides the experimentally obtained extracts with a high antityrosinase activity, the commercial CO₂-extracts of liquorice and vanilla were also used. A liquorice extract is used in cosmetic products as a powerful whitening component, and a vanilla extract as a tyrosinase inhibitor [28].

The next stage was the selection of active components, which expands the range of cosmetic cream properties, and the transdermal carrier able to transfer these substances.

One of the modern transdermal delivery systems of active components is the use of cholesterol-based

liquid crystals, which, due to their structure, resembles the structural matrix of the skin.

In cosmetology, in gels and emulsions, liotropic liquid crystals are widely used [29,30]. They are formed by dissolving, in certain solvents, some amphiphilic compounds that consist of molecules containing hydrophilic and hydrophobic groups (e. g. fatty acids).

In cosmetics, of thermotropic liquid crystals, only cholesteric are used. The Czech company RYOR offers creams containing the cholesteryl stearate-carbonate complex, which is introduced for direct nutrition of the liquid crystalline matrix, epidermal and dermal membranes [31].

Interaction of such liquid-crystalline systems with membrane structures reveals the thermal shifts of phase changes of the lipid matrix. When the temperature of a phase change of the lipid matrix is the same as the skin temperature, the permeability increases abruptly. Esters of polyatomic alcohols and saturated carbonic acids, as well as free unsaturated acids and cholesterol esters are easily penetrate through the skin lipid layers and contribute to their rarefaction and increase in permeability.

For our purpose, it was necessary to develop a thermotropic cholesteric composition, with the temperature range of the existence of the liquid-crystalline phase 27.5–36.5°C. As the main component, we chose cholesteryl nonanoate, for narrowing the mesophase interval, we took cholesteryl pentanoate, and to decrease the temperature, 1-cholesteryl-4-nonylbutanedioate. Finally, a cholesteric liquid-crystalline composition was developed, with the optimum properties of the following combination of the components (%): cholesteryl nonanoate – 45; cholesteryl pentanoate – 25; 1-cholesteryl-4-nonylbutanedioate.

For the effective action of any face cream, it is necessary to provide the skin matrix with polyunsaturated fatty acids (PUFA).

Chia seeds oil was selected due to its unique chemical composition, a high level of polyunsaturated fatty acids (PUFA) of the classes ω -3 and ω -6 (of them, 64 % is ω -3- α -linolenic acid, and 21 % is ω -6- α -linolic acid). The oily texture in combination with liquid crystals formed a homogenous consistency and was added to the cream as a biologically active ingredient.

Emulsions belong to the most widespread forms of cosmetic products [32]. Emulsion creams contain the aqueous and oily phases. As the aqueous phase, lemon and aloe hydrolates were chosen, which are obtained after distillation of lemons and of aloe leaves. The hydrolate content includes biologically active and other substances, vitally essential for our skin, in particular, vitamins, organic acids, pectic and mineral substances, etc.

The result of the research is the formulation of a cosmetic cream presented in Table 2.

Table 2 – Formulation of the cream developed

| Component | Quantity, % |
|---|-------------|
| Composition of the cream base (<i>Cospem 704</i>) – 50.1 | |
| Water | 22.1 |
| Glycerol | 5 |
| Cetyl alcohol (thickening agent) | 5 |
| Hydrogenated coconut oil | 5 |
| Isopropylpalmitate | 5 |
| Mineral oil | 5 |
| Meritage (active) | 1.5 |
| Aqualance (active) | 1.5 |
| Composition of recommended ingredients – 49.9 | |
| Chia seeds oil | 3.0 |
| Lemon hydrolate | 12.1 |
| Aloe hydrolate | 12.1 |
| Plant extract developed | 20.0 |
| CO ₂ -extract of liquorice | 1.0 |
| CO ₂ -extract of vanilla | 1.0 |
| Germall (preservative) | 0.6 |
| Liquid-crystalline phase | 0.1 |

At the next stage, the sensory characteristics of the cream were determined (physico-chemical and sanitary-hygienic). They were determined directly after the manufacture and after 3-month storage at a temperature of 3–5°C in a glass container with a tight-fitting lid. The results are presented in Table 3.

According to the results presented in Table 3, it can be concluded that the cream developed complies with the requirements to cosmetic products of the third group (it includes all cosmetics except for cosmetic ampoules, children's cosmetics, and eye cosmetics). The cream developed has high quality characteristics.

The biotesting was aimed at assessing preliminarily the integral safety of the cream obtained and establishing the absence of any effect on the genetic features of cells during their fission. Biotesting is an effective method that quickly gives an answer about the presence of toxins and other dangerous factors in perfume products.

The *Saccharomyces cerevisiae* yeast, the radicles and the apical meristem cells of *Allium cepa* L. are known as testing cultures for characterization of an integral effect on organisms. They manifest themselves in the form of mutagenic, toxicogenic, biomodifying, and other negative effects.

The results of the research are presented in Table 4. The results of the experimental research presented in Table 4 have shown that the components of the emulsion cosmetic cream developed have a stimulating effect on the *Saccharomyces cerevisiae* testing culture. The cells of the testing culture, by their size and shapes, corresponded to the initial culture. No abnormal cells have been detected. It has been determined that *Allium cepa* L. apical meristem cells have virtually no mitotic abnormalities compared with the research results (presented in the monograph [26]) obtained in the presence of toxic substances of different chemical nature.

Table 3 – The quality characteristics of the cosmetic cream after the manufacture and during storage

| Parameter | Parameters of the cosmetic cream | | |
|---|---|---|--|
| | Sensory characteristics | | |
| | After manufacture | After storage | Compliance with normative requirements |
| Appearance | Homogeneous mass without foreign impurities | Homogeneous mass without foreign impurities | State Standard 29188.0 |
| Colour | White cream with a scarcely visible beige tint | White cream with a scarcely visible beige tint | State Standard 29188.0 |
| Odour | Light odour, characteristic of this cosmetic cream, with a shadow of chia seeds oil | Light odour, characteristic of this cosmetic cream, with a shadow of chia seeds oil | State Standard 29188.0 |
| Physical and chemical characteristics | | | |
| Acid number, mg KOH/g | 2.44 | 2.45 | |
| Ester number | 129.97 | 129.97 | |
| Saponification number | 132.41 | 132.42 | |
| Moisture and volatile components content, % | 92.22 | 92.45 | State Standard 29188.4 |
| Hydrogen index (pH) | 5.7 | 5.7 | State Standard 29188.2 |
| Aggregative stability | Homogeneous mass without separation into layers | Homogeneous mass without separation into layers | State Standard 29188.3 |
| Microbiological characteristics | | | |
| QMAFAnM, CFU/cm ³ | 1.2·10 ² | 1.3·10 ² | not more than 10 ³ |
| Yeast, yeast-like, and mould fungi, CFU/cm ³ | 1.4·10 ¹ | 1.5·10 ¹ | not more than 10 ² |
| Bacteria of the <i>Enterobacteriaceae</i> family | not detected | not detected | absent |
| Pathogenic staphylococci (<i>Staphylococcus aureus</i>) | not detected | not detected | absent |
| <i>Pseudomonas aeruginosa</i> | not detected | not detected | absent |

Table 4 – Results of biotesting the cream samples

| Sample | <i>Saccharomyces cerevisiae</i> testing culture | | <i>Allium cepa</i> L. testing culture |
|--|--|--|--|
| | Number of colonies grown in the Petrie dishes, CFU/cm ³ | Biotesting results, % compared to the control sample | Abnormal cells, of the total amount of the inspected ones, % |
| Cream containing 50 % of plant extracts and cholesterol-based liquid crystals | 91 | 109.6 | 0.09 |
| Cream containing 100 % of plant extracts and cholesterol-based liquid crystals | 99 | 119.3 | 0.05 |
| Cream without addition of plant extracts and cholesterol-based liquid crystals (control) | 83 | 100.0 | 0.15 |

Thus, the ratio of all emulsion cream ingredients is characterized by its safety. The addition of the developed plant supplements and liquid-crystalline cholesterolies to the cream stimulates microbial growth even if the cream contains preservatives. This can be explained by the presence of transdermal components in the cream, based on cholesterol esters, which, as evidenced by the obtained results, increases the membranes' permeability in the testing culture cells.

One of the important stages of investigation was estimation of the humidity and the external testing of

the skin after using the cosmetic cream. The results of measuring the skin humidity have shown that 10 minutes after application of the cream developed, 6 volunteers out of 20 had an increase in the skin humidity (by 9.0% on average), after 20 min, 14 of 20 volunteers – by 25.5%, and 40 min after application – 14 of 20 volunteers – by 47.0%. The result of the work allows concluding that the cosmetic cream developed favourably acts on the humans skin, and the selected components moisten the skin and improve its appearance as for whitening the skin and elimination

pigment spots. After using the cream for one month two times a day, the humidity characteristics and the improvement of the appearance were stable.

Conclusions

1. Monitoring of plant raw materials widely spread in Ukraine has been carried out, and *Origanum vulgare* and *Glycyrrhiza glabra* have been selected, since they are characterized by antityrosinase activity, and their extracts have no hazardous effect on the human skin and noticeably decrease pigmentation.

2. Reasons have been given for using cholesterol-based liquid crystals as transdermal supports, because their composition makes them similar to the lipid barrier of the human skin, and they have the following composition (%): cholesteryl nonanoate – 45; cholesteryl pentanoate – 25; 1-cholesteryl-4-nonylbutanedioate.

3. The cream has been enriched with a plant biocorrector – chia seeds oil, a source of

polyunsaturated fatty acids (PUFA) of the classes ω -3 and ω -6, and with lemon and aloe hydrolates, sources of biologically active substances;

4. The formulation of a cosmetic cream has been developed, using plant ingredients that have thermotropic cholesteric composition and antipigmentation properties, and contain biologically active components to enrich with; a complex of sensory, physico-chemical, biochemical, and microbiological characteristics of the cream quality has been determined after the manufacture and during three months of storage;

5. Biotesting on the *Saccharomyces cerevisiae* and *Allium cepa* L. testing cultures has allowed proving the integral safety of the cosmetic product developed, and the instrumental method has made it possible to improve the skin state, which evidences about the advisability of using plant extracts with antipigmentation properties and their transdermal carriers in the cosmetic cream developed.

References:

- Margolina AA, Ernandes EI, Zaykina OE. Novaya kosmetologiya. M.: Izdat. dom «Kosmetika i Meditsina»; 2002.
- Kutts G. Kosmeticheskie kremy i emulsii: uchebnik. Kutts G. per. s nem. G. Kutts – Ausburg, 2001. ООО «Firma Klavel», Izdat. dom «Kosmetika i Meditsina». M.; 2004.
- Florens – Barret Hill. Zv'yazok mlzh stanom shkIri I kosmetichnim doglyadom. Kosmetichna hImlya dlya dermatologIv I kosmetologIv: pereklad z angl. Katerina Rahanska. M.; 2017.
- Seltenrich M. Programs Skin Lightening. Available from: <http://www.sironabiocem.com/products/>
- Available from: <http://www.cosmetics.spesialchem.com/news/industry-news/skin-lighting-products-market-to-reach-usd-23-bn-by-2020-global-industry-analysts> (Published on 2015-02-16).
- Francisco S et al. Hypopigmenting agents: an update review on biological, chemical and clinical aspects. Pigment Cell Res 2006;19: 550-557.
- Tsatmali M, Ancans J, Thody A.J. Melanocyte function and its control by melanocortin peptides. J. Histochem Cytochem 2002;50:125-133.
- Costin GE, Hearnig VJ. Human skin pigmentation: melanocytes modulate skin color in response to stress FASEB J. 2007;21:976-994.
- Ahn SJ, Koketsu M., Ishihara H., et al. Regulation of melanin synthesis by selenium-containing carbohydrates. Chem Pharm Bull 2006;54:281-286.
- Lozumi K, Hoganson GE, Pennella R et al. Role of tyrosinase as the determinant of pigmentation in cultured human melanocytes. J Invest Dermatol 1993;100:806-811.
- Li G, Lu HK, Chang HW et al. Melanin biosynthesis inhibitors from the bark of Machilus thunbergii. Biol Pharm Bull. 2003;26:1039-1067.
- Unver N, Freyschmidt-Paul P, Horser S et al. Alterations in the epidermal melanin axis and factor XIII amelanophages in senile lentigo and aged skin. Br J. Dermatol. 2006;155:119-147.
- Brener M, Hearnig VJ. The protective role of melanin against UV damage in human skin. Photochem Photobiol. 2008;84:539-549.
- Urabe K, Nakayama J, Hori Y et al. The pigmentary system: physiology and pathophysiology. New York, NY: Oxford University Press. 1998;909-913.
- Yang JY, Koo JH, Song YG et al. Stimulation of melanogenesis by scoparone in B16 melanoma cells. Acta Pharmacol Sin. 2006;27:1467-1473.
- Hearnig VJ. Mammalian tyrosinase-the critical regulatory control point melanocyte pigmentation. Int. J. Biochem. 1987;19:1141-1148.
- Haladan R, Patton RS, Cheng E et al. Abnormal acidification of melanoma cells induces tyrosinase retention in the early secretory pathway. J. Biol. Chem. 2002;277:14821-14829.
- Zoghadi S, Bahrami A, Khan MTH et al. A comprehensive review on tyrosinase inhibitors. Journal of Enzyme Inhibition and Medicinal Chemistry. 2019;34(1):279-309.
- Thanigaimalai Pillaiyar, Manoj Manickam, Vigneshwaran Namasivayam. Skin whitening agents: medicinal chemistry perspective of tyrosinase inhibitors, Journal of enzyme inhibition and medicinal chemistry. Taylor & Francis. 2017;32:403-425.
- Leeuwen JV, Wichers HJ. Tyrosinase activity and isoform composition in separate tissues during development of Agaricus bisporus fruit bodies. Mycological Research. 1999;103:413-418.
- Gray G. W. The Mesomorphic Behaviour of the Fatty Esters of Cholesterol. J. Chem. Soc.[London]. 1956;3733-3739.
- Veygand-Hilgetag. Metody eksperimenta v organicheskoy himii. M. Himiya;1968.
- Konstantinova TV, Klykov VN, Maslov MA et al. Synthesis of Cationic Cholesterol Derivatives with Succinyl Spacer Group. Russian Journal of Organic Chemistry. 2002;8(38):1189-1191.
- Natsionalniy standart Ukraini. Kremi kosmetichni. Zagalni tehnichni umovi DSTU 4765:2007.
- Kim VL, Zilberg LL, Puchkovaya TV. Analiz syrya i gotovoy produktsii. Mikrobiologicheskii kontrol. Praktikum po tehnologii kosmeticheskikh sredstv. M;2004.
- Pilipenko LN, Pilipenko IV. Biologicheskie metody v otsenke bezopasnosti rastitelnykh pi-schevykh produktov. Odessa: Izd-vo «Optimum»; 2014.
- Mikrobiologicheskie sredy Compact Dry pribori oy - Compact Dry instruksii. <http://www.pribori.com/pitatsreda/compact-dry/compact-dry-manual.html>

28. Asharaf Z, Rafiq M, Seo SY et.al. Synthesis, kinetic mechanism and docking studies of vanillin derivatives as inhibitors of mushroom tyrosinase. *Bioorg Med Chem.* 2015;23:5870-5880.
29. Iwai IH, Fukasawa J, Suzuki T A liquid crystal application in skin care cosmetics. *Int. J. of Cosmenic Science.* 1998; 20:87-102.
30. Laura Bonato Alves Oliveira, Rafaela Pereira de Oliveira I, Camila Oliveira, et al. Cosmetic Potential of a Liotropic Liquid Crystal Emulsion Containing Resveratrol. *Cosmetics.* 2017;4:54. doi:10.3390/cosmetics4040054.
31. Professionalnaya kosmetika. <http://global.ryor.com.ua>
32. Ernandens E.I., Margollna A.A. Nova kosmetologiya; 2005.

БЕЗПЕЧНИЙ ТРАНСДЕРМАЛЬНИЙ КОСМЕТИЧНИЙ ПРОДУКТ З АНТИТИРОЗИНАЗНОЮ АКТИВНІСТЮ

Л.Н. Пилипенко, доктор технічних наук, професор¹, E-mail: l.n.pylypenko@ukr.net

Е.В. Севастьянова, кандидат хімічних наук, доцент², E-mail: elena.vladimirovna.sevastyanova@gmail.com.

Н.С. Новікова, кандидат хімічних наук, старший науковий співробітник³, E-mail: nadyas.n73@gmail.com

Т.В. Маковська, асистент², E-mail: makov-t@ukr.net

О.Д. Килименчук, провідний інженер³, E-mail: lena_tvin@ukr.net

¹Кафедра біохімії, мікробіології та фізіології харчування,

²Кафедра технології молока, олійно-жирових продуктів і косметики

Одеська національна академія харчових технологій, вул. Канатна, 112, Одеса, 65039

³відділ молекулярної структури та хемоінформатики

Фізико-хімічний інститут НАН України ім. О.В. Богатського, Люстдорфська дорога, 86, Одеса, 65080

Анотація. Розглянуто можливість розроблення косметичного продукту з антипігментаційними властивостями. Основою крему стали підібрані шляхом моніторингу екстракти з поширених в Україні рослинних компонентів, які здатні інгібувати тирозиназу і завдяки цьому надають йому антипігментаційні властивості. Як активні компоненти, які розширюють спектр властивостей косметичного продукту, обрано інгредієнти, що зміцнюють матрикс шкіри і насичують його есенціальними речовинами. Для підвищення ефективності біологічно активних складових продукту до його складу були внесені рідкі кристали на основі холестериків (0,1%), як сучасних систем трансдермальної доставки активних компонентів. Запропоновано використання у складі косметичного продукту термотропної холестеричної композиції наступного складу: холестерилнонаноат – 45%, холестерилпентаноат – 25%, холестерил-4-нонілбутандіоат – 30%. За комплексом органолептичних, фізико-хімічних, біохімічних і мікробіологічних показників якості нового продукту після виготовлення і при зберіганні протягом трьох місяців встановлено його відповідність санітарно-гігієнічним та загальним вимогам, які висуваються до парфумерно-косметичної продукції III-ї групи. Шляхом біотестування на тест-культурах *Allium cepa* L. та *Saccharomyces cerevisiae* доведено повну інтегральну безпечність і потенціювання росту обох тест-культур на 9,6–19,3% до контролю навіть в присутності консерванта, що свідчить про безпечність, біологічну активність та доцільність використання розробленого косметичного продукту з антипігментаційними властивостями із застосуванням рідких кристалів-холестериків. Косметичний продукт на основі розробленої рецептури було протестовано на 20 волонтерах жіночої статі, встановлено його ефективність та інструментально доведено одночасне підвищення зволоженості шкіри обличчя.

Ключові слова: косметичний крем, пігментація, інгібітори тирозинази, рідкокристалічні холестерики, біотестування.

List of references:

1. Марголина А.А., Эрнандес Е.И., Зайкина О.Э. Новая косметология. М.: Издат. дом «Косметика и Медицина», 2002. 298 с.
2. Кутц Г. Косметические кремы и эмульсии: учебник. Кутц Г. пер. с нем. Г. Кутц. Аусбург, 2001. ООО «Фирма Клавель», Издат. дом «Косметика и Медицина». М.: 2004. 267 с.
3. Флоренс – Баррет Хілл. Зв'язок між станом шкіри і косметичним доглядом. Косметична хімія для дерматологів і косметологів: переклад з англ. Катерина Раханська. М. 2017. 140 с.
4. Seltenrich M. Programs Skin Lightening. Available from: <http://www.sironabiocem.com/products/>
5. Available from: <http://www.cosmetics.spesialchem.com/news/industry-news/skin-lighting-products-market-to-reach-usd-23-bn-by-2020-global-industry-analysts> (Published on 2015-02-16).
6. Francisco S., Stefania B., Mauro P., et al. Hypopigmenting agents: an update review on biological, chemical and clinical aspects // *Pigment Cell Res.* 2006. V. 19. P. 550-557.
7. Tsatmali M., Ancans J., Thody A.J. Melanocyte function and its control by melanocortin peptides. // *J. Histochem Cytochem.* 2002. V. 50. P. 125-133.
8. Costin G.E., Hearnings V.J. Human skin pigmentation: melanocytes modulate skin color in response to stress // *FASEB J.* 2007. V. 21. P. 976-994.
9. Ahn S.J., Koketsu M., Ishihara H., et al. Regulation of melanin synthesis by selenium-containing carbohydrates // *Chem Pharm Bull.* 2006. V. 54. P. 281-286.
10. Lozumi K., Hoganson G.E., Pennella R., et al. Role of tyrosinase as the determinant of pigmentation in cultured human melanocytes. *J. Invest Dermatol* 1993. V. 100. P. 806-811.
11. Li G., Lu H.K., Chang H.W., et al. Melanin biosynthesis inhibitors from the bark of *Machilus thunbergii* // *Biol Pharm Bull* 2003. V. 26. P. 1039-1067.
12. Unver N., Freyschmidt – Paul P., Horser S., et al. Alterations in the epidermal melanin axis and factor XIII amelanophages in senile lentigo and aged skin // *Br. J. Dermatol.* 2006. V. 155. P. 119-147.
13. Brenner M., Hearnings V.J. The protective role of melanin against UV damage in human skin // *Photochem Photobiol.* 2008. V. 84. P. 539-549.
14. Urabe K., Nakayama J., Hori Y. et al. eds. The pigmentary system: physiology and pathophysiology // New York, NY: Oxford University Press. 1998. P. 909-913.

15. Yang J.Y., Koo J.H., Song Y.G., et al. Stimulation of melanogenesis by scoparone in B16 melanoma cells // *Acta Pharmacol Sin.* 2006. V. 27. P. 1467-1473.
16. Hearing V.J. Mammalian tyrosinase-the critical regulatory control point melanocyte pigmentation // *Int J. Biochem.* 1987. V. 19. P. 1141-1148.
17. Haladan R., Patton R.S., Cheng E., et al. Abnormal acidification of melanoma cells induces tyrosinase retention in the early secretory pathway // *J. Biol. Chem.* 2002. V. 277. P. 14821-14829.
18. Zoghadi S., Bahrami A., Khan M.T.H., et al. A comprehensive review on tyrosinase inhibitors // *Journal of Enzyme Inhibition and Medicinal Chemistry.* 2019. n.34, V. 1. P.279-309.
19. Thanigaimalai Pillaiyar, Manoj Manickam, Vigneshwaran Namasivayam. Skin whitening agents: medicinal chemistry perspective of tyrosinase inhibitors, *Journal of enzyme inhibition and medicinal chemistry* // Taylor & Francis. 2017. No. 1. V. 32. P. 403-425.
20. Leeuwen J.V., Wichers H.J. Tyrosinase activity and isoform composition in separate tissues during development of *Agaricus bisporus* fruit bodies // *Mycological Research.* 1999. V. 103. P. 413-418.
21. Gray G.W. The Mesomorphic Behaviour of the Fatty Esters of Cholesterol // *J.Chem. Soc.[London].* 1956. P. 3733 – 3739.
22. Бейганд–Хильгетаг. Методы эксперимента в органической химии. М.: Химия. 1968. С. 234.
23. Konstantinova T.V., Klykov V. N., Maslov M. A., et al. Synthesis of Cationic Cholesterol Derivatives with Succinyl Spacer Group // *Russian Journal of Organic Chemistry.* 2002. No. 8. V. 38. P. 1189-1191.
24. Національний стандарт України. Креми косметичні. Загальні технічні умови ДСТУ 4765:2007.
25. Ким В.Л., Зильберг Л.Л., Пучковая Т.В. Анализ сырья и готовой продукции. Микробиологический контроль // *Практикум по технологии косметических средств.* М.: 2004. 89 с.
26. Пилипенко Л.Н., Пилипенко И.В. Биологические методы в оценке безопасности растительных пищевых продуктов. Одесса: Изд-во «Optimum», 2014. 264 с.
27. Микробиологические среды Compact Dry прибор ой - Compact Dry инструкции. <http://www.pribori.com/pitatsreda/compact-dry/compact-dry-manual.html>
28. Asharaf Z., Rafiq M., Seo S.Y., et.al. Synthesis, kinetic mechanism and docking studies of vanillin derivatives as inhibitors of mushroom tyrosinase // *Bioorg Med Chem.* 2015. V. 23. P. 5870-5880.
29. Iwai I.H., Fukasawa J., Suzuki T. A liquid crystal application in skin care cosmetics // *Int. J. of Cosmenic Science.* 1998. V. 20. P. 87-102.
30. Laura Bonato Alves Oliveira, Rafaela Pereira de Oliveira I, Camila Oliveira, et al. Cosmetic Potential of a Liotropic Liquid Crystal Emulsion Containing Resveratrol // *Cosmetics.* 2017, V. 4, P. 54; doi:10.3390/cosmetics4040054.
31. Профессиональная косметика. <http://global.ryor.com.ua>
32. Ернандес С.І., Марголіна А.А. Нова космологія. Том 1. – М.: 2005. с. 51.