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Research Article

THE INVESTIGATION OF THE DEVELOPMENT OF A CREAM COMPOSITION WITH THE SAPROPEL EXTRACT

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ABSTRACT

Objective: The objective of this research was the development of cream with sapropel extract on the emulsifying base and the investigation of the possibility for cream samples to be in future applied in medicine, cosmetics, and veterinary.

Methods: To carry out the research a set of methods (centrifugal, thermal, and potentiometric) to analyze colloidal and thermal stability and determine pH values of the tested samples were used. Organoleptic characteristics of the tested samples and possible signs of physical instability were studied. Rheological properties of the samples were determined on the rotating viscometer. The method of microscopic analysis was carried out to analyze the stability of the emulsion system.

Results: The research outcomes revealed that all the prototype samples have thermal and colloid stability, neutral pH value, and consistency that depends on the content of the oil phase and the emulsifying mixture. The samples, containing 15% of Vaseline oil and 4% and 6% of emulsifier no. 1, have low viscosity indexes, and the sample with 10% of emulsifier has a rather dense consistency. The samples containing 20% of oil phase possess unsatisfactory organoleptic properties. Since the sample with 4% of emulsifier possessed low rates of viscosity and phase separation occurred during its storage.

Microscopic studies have shown that the sample containing 6% of emulsifier no. 1 exhibits monodisperse and a uniform roundness of drops that indicates the stability of the system.

Conclusion: The outcome of the research is the development of the composition of the cream with sapropel extract with the emulsifying base containing 15% of corn oil, 6% of emulsifier no. 1, and 1% of Cetostearyl alcohol and purified water.

Keywords: Sapropel, Sapropel extract, Emulsifying base, Investigation of the cream.

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INTRODUCTION

A perspective tendency of modern pharmaceutical technology is the search for effective products based on natural biologically active substances, which due to multicomponent composition, have a wide range of pharmacological activity. They contain a number of natural antioxidants that are easily involved in the metabolic processes of the organism, are more affordable and characterized by low toxicity, mild influence, and the absence of side effects [1-3]. Such complex drugs are less toxic which is beneficial, and that distinguishes them from medicinal products of microbial and synthetic origin. The mentioned-above factors significantly predetermine the need for the search of new highly effective products of natural origin. It's known that in the current market conditions, the availability of raw materials determines the demand for a product. Sapropel is one of the substances, which satisfies these requirements, being a unique organic product, and its resources in Ukraine exceed 80 million tons.

The rational use of national natural resources might be provided as well by application of new resource-saving technologies to ensure its effective use and a decrease of all types of exes. Special attention should be paid to the complex non-waste recycling that allows the most completed application of raw materials and protects the environment from pollution. All these mentioned items are fully applicable to the investigation of sapropels, which are unique restored organic raw materials. Their deposits are characteristic for freshwater reservoirs. The processes of their accumulation still last in most of lakes [4].

The largest and most promising for processing sapropel locations in Ukraine occur in the northern part of Volyn region (Ratnivsky, Lubomlsky, Starovyzhevsky and Lubeshivsky districts). Sapropel, obtained in all these locations, is only used as a fertilizer, although it can also be applied for other purposes.

Cleaning of lakes from sapropel deposits simultaneously solves the problem of their storage. Some lakes, especially stagnant ones, are in critical conditions and require full or partial clearing from the deposits of sapropel. In these cases, the extraction of sapropel improves the environment due to the deepening of lake basins, and therefore, enhances the hydrological, hydrochemical, and biological regimen of lakes [5]. In sapropel, extracted from Prybych Lake, Volyn region, significant quantities of carboxylic acids [6], amino acids [7], micro- and macro-elements, and humic acids [8] were determined in our earlier investigations, that allows considering the natural raw material a perspective for the development of medicinal, cosmetic and veterinary products [5,9]. During the experimental studies, using cavitation method, we have improved the technology for preparation of the sapropel extract that provides a higher yield of humic and fulvic acids (above 20%) [8]. Anti-inflammatory, wound healing and antibacterial effects of the sapropel extract were shown [10,11].

The uses of native products and individual components of sapropels for many years have shown their effectiveness, accessibility, convenience, and safety. A diverse composition of sapropels allows to use them successfully in cosmetology. Sapropelic therapeutic muds exhibit anti-inflammatory

and desensitizing effect, protect the body from the damaging effects of free radicals, slow down the aging processes, give the skin freshness and elasticity, improve the cell regeneration by 10%, moisturize and increase elasticity, and thickness of the keratoid layer of the epidermis [5,12].

Cosmetics, based on sapropel, are represented within the market in various forms: Masks, tonics, creams, shampoos, balms - conditioners for hair, solutions, scrubs, peelings, soaps, bath salts, shower gels, and in the natural form.

Semi-solids constitute a significant proportion of pharmaceutical dosage forms. They serve as carriers for drugs that are topical delivered by way of the skin, rectal tissue, nasal mucosa, etc. Due to their peculiar rheological behavior, semi-solids can adhere to the application surface for sufficiently long periods before they are washed off. This property helps prolong drug delivery at the application site [13,14].

The objective of the current research was to develop the emulsifying base for the cream with the sapropel extract, to investigate its organoleptic characters, pH value, colloidal and thermal stability, structural and mechanical characteristics and to perform the microscopic analysis of the test samples with the prospect of medicinal, cosmetic, or veterinary applications for the investigated extract.

MATERIALS AND METHODS

Materials

The objects of the research comprised the sapropel extract from Prybych deposits (Volyn region, Ukraine), obtained by the method of cavitation [7], and excipients that were used during development of composition of the emulsifying base: Corn oil, emulsifier no. 1 (a mixture of fatty alcohols of the fraction C_{16}-C_{20} of the sodium salt of sulfoether of fatty alcohols), Cetearyl alcohol, and purified water [15-17].

Methods

Developing the composition of the cream with sapropel extract, there were considered basic requirements of the following applicable regulations: EP 8.0., 2013 (monograph 04/2010:0132) and the State Standard of Ukraine (SSU) No. 4765:2007 "cosmetic creams. General technical conditions," 2008.

Organoleptic characteristics and physical instability study

Organoleptic characteristics of the tested samples (appearance, odor, color, and consumer properties of the base) and possible signs of physical instability (coalescence, phase separation, aggregation of particles, and coagulation) were studied in accordance with the SSU No. 4765:2007 "Cosmetic creams. General technical conditions," 2008.

Determination of pH values

Determination of pH values of the tested samples of the cream with sapropel extract was conducted by the potentiometric method, using pH meter pH-150 MI ("Measurement Techniques Ltd," Russian Federation) in 10% aqueous solution of the cream, in accordance with the EP 8.0., 2013 (Monograph 2.2.3). 10.0 ml of purified water was added to 1.0 g of the tested sample, shaken during 10–15 min and filtered through a paper filter, the pH value of the filtrate was measured [18].

Colloidal and thermal stability

For determination of colloidal stability, the laboratory centrifuge ("Mechanìka precyzyjna," Poland) was applied. The test tubes were filled with 2/3 volume (approximately 9 g) by investigated test samples and weighed with an accuracy of 0.01 g. The samples then were centrifuged for 5 min at speed 5000 rpm (the relative centrifugal force was approximately 5,000 g) [19].

For determination of the thermal stability, 6 glass tubes with a diameter of 15 mm and a height of 150 mm were taken, and they were filled with 2/3 the volume of the subjected samples and placed in the thermostat TC-80M-2 at 40–42°C for 24 h. If the formation of an aqueous phase was not observed in any glass tube, the bases were considered as stable [19].

Rheological study

Rheological properties of the samples were determined on the rotating viscometer "Rheolab QC" ("Anton Paar," Austria) with coaxial cylinders CC27/SSN29766. The accurately weighted portion of the sample (about 17.0±0.5 g) was placed in a container of the external fixed cylinder; the required temperature of the experiment was set for 20 min of termostating period. Using the software with the equipped devices, the following experimental conditions were set: Shear rate from 0.1 to 350.0/s, the number of points (35) on the curve of the flow pattern, and the duration of measurement at each point of the curve (1 s). The device allows to measure the shear stress (τ) in the range of 0.5–3.0/10^4 Pa, shear rate (Dr) - from 0.1 to 4000/s, and viscosity (η) - from 1 to 10^6 Pas/s [18].

Microscopic analysis

Microscopic analysis of the samples was carried out using the laboratory microscope "Konus-Academy" with an eyepiece camera SpoTek DCM510. ScopePhoto Software™ was used for visualization of the images.

Preparation of the samples

To develop the cream with the sapropel extract, model samples of emulsifying bases were prepared: Corn oil in concentrations of 15 and 20% as oil phase and complex emulsifier no. 1, which included emulsifiers of 1 and 2 types in concentrations 4, 6, 8, and 10% have been used. To improve the viscosity of the bases composition, Cetostearyl alcohol (CSA), Type 2 emulsifier, in concentrations of 1% and 2% were incorporated into the composition.

The test samples were evaluated by organoleptic properties, indices of thermal and colloidal stability, pH values. Furthermore, dependence of structural and mechanical properties of the base from the concentration of oil phase and the emulsifying mixture was studied. The prototypes of emulsifying bases were prepared by the method of phase inversion. Emulsifiers with the oil were melted at 70–80°C. Water was heated (about 10%) separately to the same temperature and added into the oil phase.

The mixture was emulsified with the homogenizer Polytron PT 3100 D ("Kinematica AG," Switzerland) for 5 min at a speed of 3000 rev/min and the w/o type of emulsion received. The rest portion of an aqueous phase of the same temperature then was added at 55–65°C; a phase inversion occurred. Mixing was continued till the emulsion cooling to room temperature.

The composition and properties of model bases are listed in Tables 1 and 2.

RESULTS AND DISCUSSION

The results of the carried out investigation of the proposed creams with sapropel extract have showed that all the studied samples had the stability, adequate organoleptic indices, optimal pH values, and appropriate viscosity for cream (Table 2).

The research outcomes revealed that all the prototype samples have thermal and colloid stability, neutral pH value, consistency that depends on the content of the oil phase and emulsifying mixture. Hence, the samples, containing 15% of Vaseline oil and 4% and 6% of emulsifier no. 1, have low viscosity indexes (no. 1,2,4), and the sample with 10% emulsifier (no. 9) has a rather dense consistency. The samples containing 20% of the oil phase (no. 10-12) possess unsatisfactory organoleptic properties.

Rheograms

To study the dependence of structural and mechanical properties, including thixotropic ones, of the tested samples from the base composition (the concentration of the oil phase and emulsifying mixture), there were constructed full rheograms of the dependence of shear stress (τ_r) from shear rate (Dr) (Fig. 1).

According to the results of the determination of the viscosity, presented in the rheograms, an increase of concentrations of the oil phase,

Table 1: The structure of model emulsifying bases

Name of substances	Concentration of substances, %											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Corn oil	15	15	15	15	15	15	15	15	15	20	20	20
Emulsifier no. 1	4	4	4	6	6	6	8	8	10	6	6	8
CSA	-	1	2	-	1	2	-	1	-	-	1	-
Water purified	To 100,0											

CSA: Cetostearyl alcohol

Table 2: Properties of tested samples of emulsifying bases

The number of the sample	Organoleptic characteristics of samples	Thermal stability	Colloidal stability	pH value of 10% extract	Structural viscosity (η), mPas/20 rev/min
1	Liquid consistency, spread easily and absorbed, remains no greasy	Stable	Stable	6.10±0.1	1980±10
2	Liquid creamy consistency, spread easily and absorbed, remains no greasy	Stable	Stable	6.3±0.2	2880±10
3	Creamy consistency, spread easily and absorbed, remains no greasy, in the beginning of the application on the skin develops a white trace	Stable	Stable	6.32±0.1	3240±10
4	Liquid creamy consistency, spread easily on the skin, easily absorbed, remains no white film and greasy	Stable	Stable	6.3±0.2	5850±30
5	Creamy consistency, spread easily on the skin, easily absorbed, remains no white film and greasy	Stable	Stable	6.5±0.2	6900±20
6	Creamy consistency, spread easily and absorbed, remains no greasy, in the beginning of the application on the skin develops a white trace	Stable	Stable	6.6±0.1	7400±30
7	Creamy consistency, spread easily on the skin, easily absorbed, remains no white film and greasy	Stable	Stable	6.90±0.1	7120±20
8	Creamy consistency, spread easily on the skin, easily absorbed, remains no white trace after the application and has no oily film	Stable	Stable	6.9±0.2	7520±20
9	The consistency of thick cream spread easily on the skin, easily absorbed, remains no greasy, in the beginning of the application forms a white trace	Stable	Stable	7.0±0.1	8400±30
10	Creamy consistency, spread easily and absorbed, after the application a white trace and an oily film remain	Stable	Stable	7.02±0.2	6100±10
11	Creamy consistency, spread easily and absorbed, after the application a white trace and an oily film remain	Stable	Stable	7.05±0.1	6800±30
12	Creamy consistency, spread easily and absorbed, after the application a white trace and an oily film remain	Stable	Stable	7.06±0.2	7400±30

[a]mean±SD, n=5

complex emulsifier, and incorporation of CSA leads to an increase of viscosity indexes. The rheogram indicates that the investigated samples are non-Newtonian liquids with the plastic fluid type. The developed samples have enough thixotropy, as evidenced by the occurrence of hysteresis loops on flow rheograms (Fig. 1).

Considering the obtained results, for the further research, were selected samples no. 5 and no. 8, containing 15% of oil phase, 1% of CSA, and 6% (no. 2) and 8% (no. 3) of emulsifier no. 1. Since the sample with 4% of emulsifier possessed low rates of viscosity and phase separation occurred during its storage, the basis with 5% (no. 1) of emulsifier no. 1 was prepared. This sample had the viscosity of 2250 (η) mPas/20 rev/min.

Microscopic analysis of the three chosen samples

The sample with 5% of emulsifier no. 1 (no. 1) has different size of the drops from 0.001 to 0.02 μm, that indicates a decrease in the degree of dispersion of the emulsion and indirectly characterizes a low degree of the viscosity of the structure and displays aggregative instability of the system that can lead to phase separation of the emulsive system during the storage. The size and shape of the drops of samples no. 2 and no. 3 indicate the concentrated nature of the disperse phase. Sample no. 3 has a deformed shape of drops that suggests the high concentration of the disperse phase. Sample no. 2 exhibits monodisperse and a uniform roundness of drops, that indicates the stability of the system (Fig. 2).

Therefore, considering the outcomes of the performed research, for the development of composition of cream with sapropel extract was selected the sample, containing 15% of corn oil, 1% of CSA, and 6% of emulsifier no. 1. An increase of the emulsifier's content up to 8% is not appropriate since occurs the opportunity of development of skin-irritating effects and also the cost of the cream production increases.

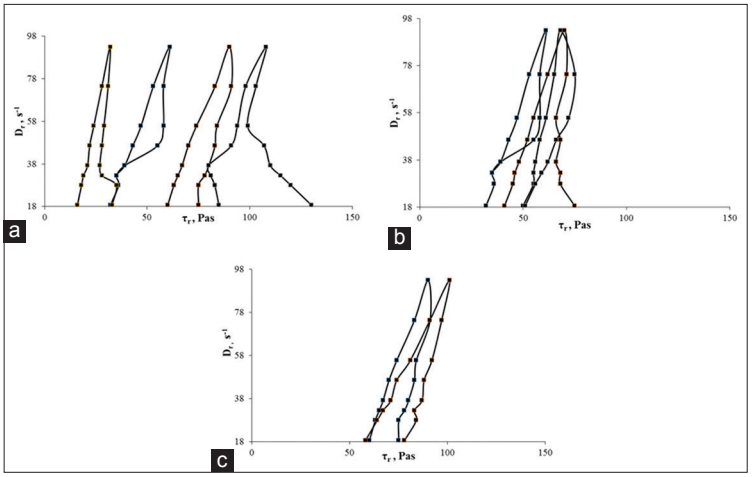

Fig. 1: The rheogram of the dependence of shear stress (τ_r) from shear rate (Dr) of the cream tested samples, the composition of which is given in Table 1. (a) 5%, (b) 6%, and (c) 8% of emulsifier no. 1

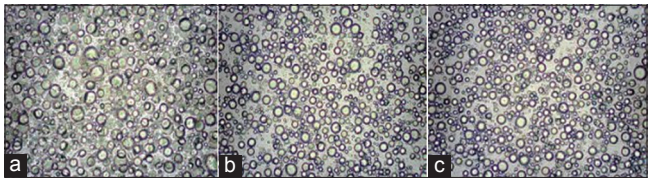

Fig. 2: Microscopic photos of the tested samples, containing 15% corn oil, 1% cetostearyl alcohol and: (a) 5%, (b) 6%, and (c) 8% of emulsifier no. 1

CONCLUSION

In accordance with investigated organoleptic and consumer properties, thermal and colloidal stability, pH values, structural and mechanical characters of prototype samples, for further experiments concerning the development of composition of cream with sapropel extract was selected the emulsifying base containing 15% of corn oil, 6% of emulsifier no. 1, and 1% of CSA and purified water.

Cream samples were investigated by the organoleptic parameters (appearance, odor, color, and consumer properties), and also assessed for physical stability (coalescence, separation, aggregation of particles, and coagulation).

Determination of acid-base balance (pH value), colloidal and thermal stability, structural and mechanical parameters, and microscopic analysis was carried out.

Rheological studies have shown the presence of appropriate characters of the developed compositions of emulsifying bases - thixotropic properties and the plastic fluid type.

Conducted microscopic studies of the proposed base pointed out its monodispersity and the equitability of the distribution of an oil phase in an aqueous dispersion medium.

CONFLICTS OF INTERESTS

All authors have none to declare

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