ORIGINAL ARTICLE

Optimization of physical and chemical characteristics of a modern intimate hygiene agent

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Abstract

Aim: The purpose of this research work was to study and compare the established physical and chemical characteristics of the developed foam-washing agent with ready-made gels for intimate hygiene produced by manufacturers presented in the Ukrainian market. **Materials and Methods:** The rheological parameters (structural viscosity, shear stress, and other rheological parameters) were measured using Brookfield DV-II+PRO (USA) viscosimeter, SC 4-21 spindle. Determination of the above parameters was performed using the Ross-Miles Foam Analyzer as a standard device for measuring the foaming ability of soaps and synthetic detergents. The level of the pH value of the foaming test samples was determined by potentiometry method. **Results and Discussion:** The main groups of components that form part of finished products for intimate hygiene are considered and analyzed. A comparative study of a number of ready-made agents for intimate hygiene and the developed prototype was conducted experimentally. To optimize the physical and chemical characteristics of a modern intimate hygiene product, the following characteristics such as pH value, foaming ability (foam number and foam stability), and structural viscosity were studied. **Conclusions:** It is proved that the developed agent has satisfactory organoleptic and physical and chemical characteristics. In particular, attention was paid to the structural and mechanical studies that affect the sequence of technological operations, the shelf life of the agent, and consumer characteristics, one of which is the extrusion from a container (flask).

Key words: Foaming ability, gel, intimate hygiene agents, pH (3.5–4.5), structural and mechanical properties

INTRODUCTION

The performed marketing researches allow to assert that at present the hygienic care of female body intimate areas plays a significant role in everyday life and is an essential factor for health support. It is well-known that dead cells, moisture, and body secretion remnants form a favorable environment for the uncontrolled reproduction of pathogenic microorganisms on the lingerie fabric, resulting in pH change (due to the excretion of ammonia and aliphatic amines by bacteria), emanation of odor, as well as the risk of skin irritation initiation. Therefore, personal hygiene of female genital organs requires meticulous and at the same time thorough cleansing, which would not disrupt the natural functions of sensitive areas of the mucous membranes and would not provoke appearance of unwanted reactions.[1-5]

The segment of intimate hygiene products is in a separate sector of the whole range of foam-washing agents. This is due to the fact that they are positioned as agents with the mildest effect thank to the use of amphoteric detergents in the first place. We conducted an analysis of the market for intimate hygiene products-the focus was on medium-priced agents (up to $ 10). It was stated that in the Ukrainian market the segment of agents for intimate hygiene is represented by products from both home producers and EU countries.[6]

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From this study, as a means of comparison, we selected a number of modern gels from different manufacturers, namely: "Nivea intimate" (Beiersdorf Manufacturing Waldheim GmbH, Am Eichberg, Germany), "Biona Forte" (Medical Scientific and Production Association "BIOKON," Ukraine), "Lactacyd" ("Soprodal NV," Belgium), "Femme Intime" (Private Firm "Pharmaceutical factory" SPA "Elfa," Ukraine), "Dove Intimo Neutral" (Unilever Poland SA, Home and Personal Care Factory, Poland), "Uriage Gyn Phy" (Laboratories Dermatological Uriage, France), "Miy Kapriz" ("Alliance of Beauty"), and Pharmaceutical Scientific Research Center, (Ukraine). In the first place, just the agents that could compete with the Ukrainian manufacturers were compared, that is why the samples of home production were taken in a greater number.[7]

To develop a home gel for intimate hygiene, we analyzed the composition of the above-mentioned agents, namely, detergents, which are most often used by manufacturers. Furthermore, to determine the basic physical and chemical characteristics, namely, the organoleptic properties, pH values, rheological indicators, we investigated these agents. This is due to the fact that the current normative document-Cosmetic products for the cleansing of skin and hair "cosmetic products for cleansing of skin and hair" regulates the general indexes for all foaming agents (shampoos, shower gels, liquid soap, etc.), which is not quite correct in relation to the agents for intimate hygiene. In our opinion, the study of structural and mechanical properties is one of the important stages of development because it makes it possible to predict the behavior of the agent during storage, technological stages, when extruding from a container (flask).[8]

To carry out the comparative study, it was important for us to incorporate the foaming agent developed by us into the experiment. On the basis of the performed experimental and literature-patent research, a number of modern detergents of anionic, amphoteric, and non-ionic nature, namely, disodium laureth sulfosuccinate 40% ("Euronaat LS 3," "EOS," Belgium), cocamidopropyl betain 35% ("KAO," Japan), glucoside/glyceryl oleate ("Lamesoft PO 65," Coco, producer "BASF," Japan), PEG-7 Glyceryl Cocoate ("Neopal HE," BASF, Germany), PEG-4 Rapeseedamide ("Amidet N," "BASF" Germany), PEG-150 Polyglyceryl-2 Stearateand/ Laureth-3 (Genapol LT, BASF, Germany), and Hydroxypropyl Methylcellulose ("Methocel 40-0100," "Dow," Germany) were used. To stabilize and increase the viscosity value (at the expense of electrolytic thickening), we introduced a solution of sodium chloride into the composition of the foam base.[9]

We used lactic acid as a pH regulator, which forms part of the acid mantle of the skin, as well as moisturizes, improves the condition and thickness of the epidermis. Lactic acid acts mainly against bacteria, especially anaerobic.[10]

On the basis of these substances, foam bases with different concentrations of detergents were prepared and the rational base was selected, which corresponded to physical and chemical parameters in accordance with the approved normative documentation of Ukraine and was stable.

As it is well-known, into the composition of agents for intimate hygiene, additional active substances are added which provide softening effect, increase blood circulation in the area of usage, they are capable of manifesting a soothing and anti-inflammatory effect, they correct and improve agent characteristics for consumers (smell and color). For this purpose, non-alcoholic herbal extracts (*Chamomilla recutita*, *Bidens tripartita*, *Calendula officinalis*, and *Salvia officinalis*) are often used, or their main active substances are bisabolol.

That is why we introduced an additional complex of active substances - D-pantenol, allantoin, hydroxyethyl urea, α-bisabolol, mandarin essential oil, and preservative "Nipaguard CMB" (benzyl alcohol/triethylene glycol/ chloromethylisothiazolinone/methylisoline, "Clariant," Switzerland). Based on microbiological, biological, and toxic-hygienic studies, their concentrations were substantiated.[11]

The purpose of this research work was to study and compare the established physical and chemical characteristics of the developed foam-washing agent with ready-made gels for intimate hygiene produced by manufacturers presented in the Ukrainian market.

Experimental Section

On analysis of home and foreign normative and technical documentation, we established optimal physical and chemical indicators that a modern gel for intimate hygiene should correspond to the following:

1. Appearance - homogeneous gel-like mass, which can have a pearly look;
2. Color - must match the colors of the product of a certain name;
3. Scent - must match the smell of the product of a certain name;
4. pH value should be in the range of 3.5–4.5;
5. Foaming capacity-foam number should be not <145.0 mm; foam resistance −0.8–1.0 Um;
6. Structural viscosity should be in the range 2000–12000 mPa • s.

To obtain optimal results, all studies were conducted at room temperature +15–+25°C.

The rheological parameters (structural viscosity, shear stress, and other rheological parameters) were measured using Brookfield DV-II + PRO (USA) viscosimeter, SC 4-21 spindle. The following technique was used: Approximately 8.0–8.5 g of specimen were placed into the chamber, and the spindle was lowered into it, which led to rotational movements

(20, 30, 35, 40, 50, 60, 80, and 100 r.p.m.), starting from small deformation rates and then in reverse order. At the same time, the indicators were fixed shear rates (Dr, c-1: 18.6, 27.9, 32.5, 37.2, 46.5, 55.8, 74.4, 93), shear stresses (τ, Pa), and structural viscosity (ï, milliPascals per second (mPa • s) on the viscometer display. This measurement was determined in triplicate.[12]

Determination of the above parameters was performed using the Ross-Miles Foam Analyzer as a standard device for measuring the foaming ability of soaps and synthetic detergents. The foaming ability of the test samples was determined by the method given in Cosmetic products for the cleansing of skin and hair ISO 696:2005 "Determination of the foaming ability by the modified method of Ross-Miles"[13] and GOST 22567.1-77 "synthetic detergents. The method for determining the foaming ability." To perform this test, the Ross-Miles foam analyzer, the ultrathermostat UT-15, a stopwatch timer, a rubber squeeze bulb, the analytical balance of the accuracy Class 3 for general purposes, pipettes: 1-2-50, pipettes: 1-2-1-2(10), flasks: 1-1000-2, and measuring glasses B-1-100(500)(1000) TC were used. The water jacket was connected to a thermostat, switched on, and the temperature of the liquid in the water jacket was adjusted to 37 ± 2°C. Simultaneously, 300 cm^3 of the solution of the surfactant studied was adjusted to the same temperature. Of this amount, 50 cm^3 of the solution was taken and poured down the sides of the graduated cylinder in order not to form the foam. In 10 min using a rubber squeeze bulb or a pump, the test solution of the surfactant in the volume of 200 cm^3 was introduced into the pipette in such a way that no foam could form. The pipette with the solution was fixed to the stand so that its outlet was at a distance of 900 mm from the level of the liquid in the cylinder, and the flow could get to the center of the liquid. Then, the tap of the pipette was opened. When there was no solution in the pipette, a stopwatch timer was switched on, and the height of the foam column formed (mm) was measured. The measurement was carried out in 30 s. In 5 min, the height of the foam column formed (mm) was measured. This parameter was measured in triplicate.

The level of the pH value of the foaming test samples was determined by potentiometry (SPhU 1.2, 2.2.3) using a "pH Meter Metrohm 744" device (Germany).[14] This measurement was determined in triplicate.

The present studies were carried out on the premises of the scientific laboratory of the Department of Commodity Science at the National University of Pharmacy.

RESULTS AND DISCUSSIONS

The comparative characteristic of the samples under the study is given in Table 1. In our opinion, it should be noted that all the gels for intimate hygiene under study, other than Biona-forte and the product developed by us, had a typical specific scent that was proper for aromatizers included in their composition. In our opinion, this is inappropriate, as it is known that this particular group of auxiliary substances can cause irritation of the skin and mucous membranes. It was noted that, unfortunately, not all specimens had the pH value interval recommended for the agents of this group.

Analyzing the obtained data related to the foaming ability, namely, foam number and foam stability, it was established that all investigated samples had the corresponding values of this characteristic in accordance with the established norms: The foam number was 0.8–1.0 conv. units, and foam stability was not <145.0 mm. It should be noted that boundary values were not found in any of the samples.

It is well known that the study of structural and mechanical characteristics is an indispensable step in the development of foam-washing agents comprising gelators. To study the flow type and the presence of thixotropic properties in the investigated gels, we made complete rheograms that show the dependence on the shear stress (τ, Pa) on the rate gradient (Dr, c-1) [Figure 1]. These reoparameters were obtained by the method of continuous ever-increasing structure destruction, as a function of the shear stress. The readings were made while increasing spindle speed from 20 to 100 r.p.m. reaching a constant shear stress at the maximum number of revolutions and further reducing the number of spindle revolutions.[15,16]

As it can be seen, all the samples had a pseudoplastic flow type and certain thixotropic properties, which confirm the correctness of the components selected for the composition, creating a colloidal system, due to different mechanisms of thickening. It should be noted that the samples containing gelators of semi-synthetic origin (Samples No. 1 and 7) had the most viscous characteristics, whereas the samples having a complex of detergents of different origin (Samples No. 2, 3 and 6) had the least viscous ones.

The second stage of the study of structural-mechanical properties was devoted to the study of the dependence of structural viscosity on the shear rate gradient of the investigated gel samples [Figure 2].

During the experiment, the following samples had the lowest viscosity indexes:

- Sample No. 2 ("Lactacyd") contains Magnesium Laureth Sulfate as the main detergent and a complex of several amphoteric detergents, which is known to exhibit the slightest irritant effect among anionic substances. Sodium chloride is used as an electrolyte thickener;
- Sample No. 3 ("Femme Intime") contains a mixture of amphoteric detergents (Cocamidopropyl Betaine) and anionic (Lauryl Glucoside and Sodium Lauryl Glucose Carboxylate). The peculiarity of this agent is the absence of any thickener, which in turn results in decrease of agent viscosity, i.e., thickening is performed by combining ingredients of anionic and amphoteric nature;

Table 1: Physical and chemical parameters of the investigated gel samples for intimate hygiene

Name of the investigated gel	Appearance	pH value	Foaming ability		Structural viscosity, mPa • s (20 r.p.m.)
			Foam number, mm	Foam stability, conv. units	
"Dove Intimo Neutral"	Homogeneous gel-like mass*	5.1±0.1	231±1	0.90±0.04	7100
"Lactacyd"	Homogeneous gel-like mass*	5.4±0.1	232±1	0.92±0.02	3300
"Femme Intime"	Homogeneous transparent gel-like mass*	5.8±0.1	232±1	0.90±0.03	2800
"Nivea intimate"	Homogeneous gel-like mass*	4.8±0.1	224±1	0.91±0.03	7851
"Biona-forte"	Homogeneous transparent gel-like mass*	4.1±0.1	253±1	0.90±0.04	4200
"Miy Kapriz"	Homogeneous transparent gel-like mass*	5.5±0.1	222±1	0.91±0.04	4500
Developed gel	Homogeneous transparent gel-like mass*	4.5±0.1	227±1	0.94±0.04	10200
"Uriage Gyn Phy"	Homogeneous gel-like mass*	4.8±0.1	256±1	0.90±0.05	4600

*The ingredients include pearl-forming additives (glycol distearate) - pearl-like color forming substances that add opal type to the additive in cosmetic and hygienic washing agents

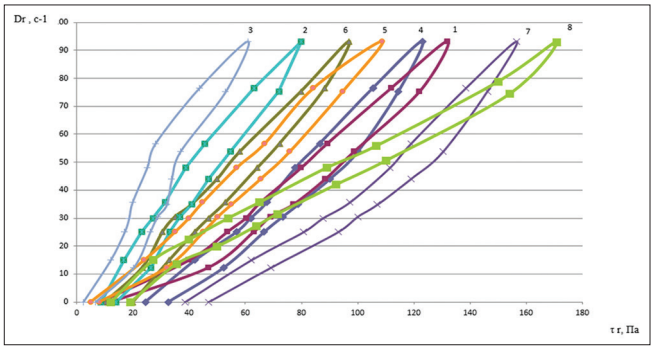

Figure 1: Rheograms of the investigated samples: (1)"Dove Intimo Neutral," (2) "Lactacyd," (3)"Femme Intime," (4) "Nivea intimate," (5) "Biona Forte," (6) "Miy Kapriz," (7) developed gel, (8) "Uriage Gyn Phy"

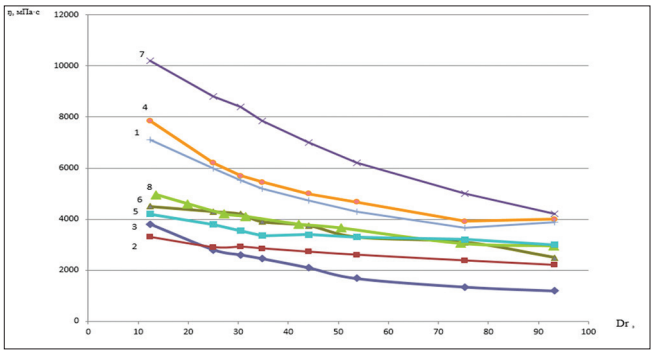

Figure 2: Dependence of structural viscosity on shear rate: (1) "Dove Intimo Neutral," (2) "Lactacyd," (3) "Femme Intime," (4) "Nivea intimate," (5) "Biona forte," (6) "Miy Kapriz," (7) developed gel, (8) "Uriage Gyn Phy"

- Sample No. 5 ("Biona-forte"), which contains in its composition a mixture of anionic and amphoteric detergents, which, when successfully combining, serve as a thickener. However, the detergent complex is not able to exhibit high fluidity of the gel.
- Sample No. 6 ("Miy Kapriz") is a classic representative of foam-washing agents that contains a complex of anionic, amphoteric, and nonionic detergents, while as a thickener, the manufacturer uses sodium chloride due to its electrolyte thickening. Thus, this agent has an average value of rheological indicators [Figure 2].
- Sample No. 8 ("Uriage Gyn Phy"), as well as Sample No. 6, has a traditional composition containing representatives of each group of detergents. It should be noted that due to the classical way of thickening of sodium chloride, this sample had roughly the same viscosity value as compared to Sample No. 6.

Analyzing the results of the dependence of the structural viscosity of the samples on the shear rate gradient [Figure 2], it was found that Samples Nos. 1, 4, and 7 had a higher value of dependence as compared to other samples.

It was found that Sample No. 1 ("Dove Intimo Neutral") contained, besides the standard mixture of detergents, a complex of thickeners of electrolytic (sodium chloride) and associative (acrylates copolymer) nature. Precisely by means of this combination, the additional stabilization of the foam-washing system was achieved.

Although Sample No. 4 ("Nivea intimate") also had a mixture of classical surfactants for a foam-washing system, and sodium chloride was used as a thickener, the sample had high viscosity and satisfactory fluidity. the manufacturer managed to achieve this by choosing a rational concentration of all substances to choose the best technologies and consumer packaging materials.

Analyzing the abovementioned, it can be concluded that the general manufacture tendency of such a specific agent as the gel for intimate hygiene is, it is to use, in most cases, the classical system of surfactants (a combination of anionic, amphoteric, and nonionogenic nature detergents) to provide sufficient foaming capacity. In addition to obtaining the necessary structural viscosity and consumer characteristics, manufacturers use two types of viscosity modifiers - electrolytic (sodium chloride) and associative (gelators of different origin and nature).

Our Sample No. 7 also contained a classical combination of primary and secondary detergents. However, it should be noted that our sample had a combination of co-surfactants of a non-ionic nature; first, to increase its viscosity and reduce further irritant effect. However, it was established that, unfortunately, the use of these detergents alone did not lead to the required above-mentioned range of viscosity (2000–12000 mPas • s). Therefore, we additionally introduced a complex of thickeners of electrolytic and associative thickening nature, namely, hydroxypropyl methylcellulose (semi-synthetic gel formulation) and sodium chloride, which led to an increase in the structural viscosity and extrusion properties of our product. Thus, the main difference of the agent developed by us consists in the use of a combination of non-ionic surfactants in combination with electrolytic and semi-synthetic thickeners.

One of the most important indicators of structural viscosity is mechanical stability (MS) as well. Therefore, the next step in our study was to calculate the value of MS for the developed gel and the means of comparison [Table 2].

It should be noted that the optimal MS value is equal to 1.0. Consequently, analyzing the obtained values of the MS of the gel developed by us and the investigated agents, we can assert that all samples are close to the optimal value of MS, which indicates a slight degree of destruction of the structure of gels in the process of their mixing under industrial conditions and satisfactory extrusion properties.

Table 2: Comparative MS value of experimental samples

Name of the gel for intimate hygiene	MC
"Dove Intimo Neutral"	1.2
"Lactacyd"	1.2
"Femme Intime"	2.0
"Nivea intimate"	1.6
"Biona-forte"	1.1
"Miy Kapriz"	1.5
Developed gel	1.3
"Uriage Gyn Phy"	1.8

MS: Mechanical stability

CONCLUSIONS

We carried out a comparative analysis of a number of gels for intimate hygiene and the agent we developed (by their merchandising and physical and chemical indicators), which are presented in the Ukrainian market in the average price range.

At this stage, the structural-mechanical properties of experimental samples were investigated, and it was proved that the agent developed by us had satisfactory characteristics in comparison with the ready-made agents for intimate hygiene. It was also established that the gel for intimate hygiene proposed by us had satisfactory consumer and physical and chemical parameters (the pH value is 3.5–4.5; the foaming capacity is foam number not <145.0 mm; and foam stability is 0.8–1.0 conv.units).

Thus, in our opinion, the developed gel can occupy its competitive position in the market among available consumer products in Ukraine.

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