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Development of the Composition of Foamy Washing Liquid with an Extract of Pollen for Use in Pediatrics

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Abstract

Introduction. The article presents material on the development of composition of foamy washing cosmetics with an extract of pollen for application in pediatric practice.

Materials and methods. In this study we used the pharmaco-technological, physico-chemical, rheological and statistical research methods, and the results of the study of antimicrobial activity of the samples.

Results and discussion. By results of the conducted comprehensive research we substantiated the composition of the foamy washing basics to the complex of detergent, humectant and a viscosity modifier with the recommended pH for children's skin at 5.5. With the help of microbiological research we proved antimicrobial activity of the active ingredient – extract of pollen and the need for additional introduction of the preservative "Rokonsal ND". The influence of existing and a number of auxiliary substances on foam formation ability and structural-mechanical properties of the basics and technological aspects of introduction of foamy washing means to improve the condition of the skin of the child.

Key words: foam washing liquid, extract of pollen, technology, rheological properties, antimicrobial activity.

Introduction

Skin care of the child involves the use of modern hygiene, which must meet more stringent requirements compared to the tools for adults. This is because a baby's skin has not fully formed a multi-tiered system of protection unlike an adult. Therefore, the development of modern children's foamy washing means to them impose more stringent requirements, such as: soft washing base; pH balanced; no odor or the presence of a sharp odor; no colors, hazardous preservatives; no irritating to the eye [1, 2, 3].

For the purpose of development of domestic foamy washing means for children that would meet modern requirements we have selected a number of modern detergents anionic, amphoteric and nonionic character.

The aim of this work was to develop composition of foamy washing means with an extract of pollen for application in pediatric practice.

Materials And Methods

In the first stage of the study it was necessary to carry out studies on the choice of the concentration of detergent. For this purpose we used a solution of the disodium laurilsulphate "Euranat LS 3", made by "EOS", Belgium), which is widely used in such cosmetic products, quickly dissolves in water at room temperature and is harmless for use in pediatric practice. We've created experimental samples of the solution of the disodium laurilsulphate of different concentrations of 5.0, 10.0 and 15.0 %, which was prepared at room temperature at low speed stirrers (20 rpm) to prevent the formation of air bubbles. Disodium laurilsulphate was dissolved in the required amount of water. As the result we obtained a transparent homogeneous liquid solutions without peculiar smell, the pH Value was in the range of 6.71-of 6.80. Since the recommended pH value for children washing foamy means is 5.5, it was necessary to spend its adjustment with lactic acid to the desired value [1, 5, 6, 8].

Justification of concentrations of surface-active substances (surfactants) was performed using the determination of foam formating ability and foam stability, the results of which are presented in table. 1.

Further, as the auxiliary SAS we have chosen Coco Amido Propyl Betaine ("Cocamidopropyl Betain", produced by "KAO", Japan), which is widely used with the aim of raising the level of foam, stabilization of formulated foamy washing means, enhances their cleaning properties and in combination with other surfactants contributes to thickening of the system. The maximum recommended concentration of Coco Amido Propyl Betaine is to 12.0 % [6, 8, 12].

Table 1 **Foam formation ability of disodium Laureth sulphate sodium**

The concentration of the disodium laurilsulphate, %	Foam production ability	
	Foam number, mm	The stability of the foam, conventional units
5,0	34,0	0,91
10,0	54,0	0,96
15,0	64,0	0,94

In the next phase of research on the above technology at room temperature we prepared 10.0 % solution of the disodium laurilsulphate and at the same speed stirrer was added the required amount of Coco Amido Propyl Betaine with the following concentrations of 4.0, 8.0 and 12.0 %. As a result, it formed liquid, transparent solutions, odourless with a much larger value of the foam number. It was found that with constantly working stirrer Coco Amido Propyl Betaine is completely dissolved within 5 min. The pH of these samples solutions were in the range of 6.82 to 6.88, therefore, to adjust the pH we added lactic acid to the desired value of 5.5. The results of the determination of the foam formation ability of the disodium laurilsulphate (10.0 %) and Coco Amido Propyl Betaine is presented in table. 2 [11, 13, 17].

Table 2 **Foam formation of the basics of the disodium laurilsulphate (10,0 %) and Coco Amido Propyl Betaine**

Concentration of Coco Amido Propyl Betaine, %	Foam production ability	
	Foam number, mm	The stability of the foam, conventional units
4,0	56,0	0,91
8,0	85,0	0,96
12,0	90,0	0,94

The next stage of work was devoted to the stabilization of the foam of the studied foamy washing means. As the foam stabilizer and superfatted agent we elected cocoglucoside oleate "Lamesoft PO 65", produced by BASF, Japan), the recommended concentration for children foamy washing means is in the range from 1.0 % to 5.0 %.

At first it was prepared with a 10.0 % solution of the disodium laurilsulphate, to which 8.0% of Coco Amido Propyl Betaine were added. The resulting solution was heated on a water bath to a temperature of 35 – 40, because SAS is a concentrated substance that it is difficultly soluble in cold water. At the specified speed agitator (40 rpm) to we added the solution the required amount of cocoglucoside oleate [7, 16]. When constantly working stirrer for 5-7 min SAS completely dissolved, resulting in the formed transparent liquid, odorless, light-yellow color. We have prepared five sample solutions with a concentration of cocoglucoside oleate in the following concentrations: 1,0, 2,0, 3,0 ,4,0 and 5.0 % for the above technologies [12]. The pH of these solutions was within 6.78-6,50, therefore, with the help of lactic acid it was necessary to adjust the pH value to 5.5. The results of the determination of foam formation ability of the disodium laurilsulphate (10,0 %), Coco Amido Propyl Betaine (8,0 %) and cocoglucoside oleate are given in tab. 3.

Table 3 **Foam formation the basics of the disodium laurenslivewebcam (10,0 %), Coco Amido Propyl Betaine (8,0 %) and oleate cocoglucoside**

Concentration of oleate cocoglucoside, %	Foam production ability	
	Foam number, mm	The stability of the foam, conventional units
1,0	143,0	0,94
2,0	124,0	0,95
3,0	106,0	0,93
4,0	92,0	0,90
5,0	66,0	0,90

Further, we prepared a 10.0 % solution of the disodium laurilsulphate, to which we added 8.0% of Coco Amido Propyl Betaine and cocoglucoside oleate - 1.0 %. The resulting solution was heated on a water bath to a temperature of 35-40, as this SAS is a concentrated substance that it is difficultly soluble in cold water. At the specified speed agitator (40 rpm) we added to the solution the required amount glycereth cocoate with constantly working stirrer for 15 min SAS was completely dissolved, and resulted in turbid colourless odourless liquid [13].

To determine the concentration we prepared 5 samples in various concentrations: 0,5, 1,0, 1,5, 2,0 %. The pH of these solutions was in the range 6,90-6,95, so we adjusted it to a value of 5.5 using lactic acid [12, 15]. The results of the determination of the foam formation ability of the disodium laurilsulphate (10,0 %), laurilsulphate (8,0 %), cocoglucoside oleate (1.0%) and glareola presented in table. 4.

Table 4 **Foam production ability of the disodium laurenslivewebcam (10,0 %), Coco Amido Propyl Betaine (8,0 %), cocoglucoside oleate (1.0%) and glareola**

Concentration glare Cocoate, %	Foam production ability	
	Foam number, mm	The stability of the foam, conventional units
0,5	142,0	0, 95
1,0	154,0	0,98
1,5	127,0	0,97
2,0	121,0	0,99

As a component, that thickens system, stabilizes the level of foam and softens the effect of anionic surfactants we have chosen a mixture of such SAS as: PEG-7 Glary Cocoate and PEG-200 palmitate Glary of the brand "Neopal Lis 80" manufactured by Industrial Chimica by Nazareno panzeri S. r.l, Italy) [11]. Recommended concentration "Neopal Lis 80" is 0.1% to 5.0 %. This component is added to the selected foamy washing basis at a temperature of 35-40 °C and at low rpm of the stirrer. The results are presented in table. 5.

Table 5 Foam production ability and structural viscosity of the samples

Foamy washing basis with «Neopal Lis 80» at a concentration ofi, %	Structural viscosity, MPa×s (20 rpm)	Foam number, mm	The stability of the foam, conventional units
3,0	240	152	0,95
4,0	3300	155	0,97
5,0	25000	157	0,96

For additional thickening and improving of the properties of the extrusion of foamy washing means we chose gelling agent (HPMC) ("Methocel 40-0100", "Dow" made in Germany). This component is recommended for use in the development of children's foamy washing means and it provides ongoing rheological properties during the storage period. It is known that HPMC contributes to the thickening of the system and enhances the foaming properties of such means. The recommended concentration of HPMC for children's means is between 0.1 to 0.5 % [4, 5, 9, 10].

We have manufactured experimental samples according to the following technology: separately prepares foamy washing based on technology that is shown above. For rapid dispersion of gel forming substance we mixed it with 3.0 % of glycerin, then added water (1/4 of the total concentration) at a temperature of 80-90 °C and stirred to obtain a basis of the desired viscosity. We introduced prepared gel base to foamy washing bases at room temperature and at a selected speed stirrer (35-40 rpm) [14, 15, 16]. The pH value was in the range of 6.74–6,95. The adjustment of the pH to 5.5 was performed using lactic acid. The results of study of physico-chemical and rheological characteristics of experimental samples of HPMC are shown in table. 6.

Table 6 **Physico-chemical and rheological properties of experimental samples with HPMC**

Concentration of «Neopal Lis 80», %	Concentration of HPMC, %	Structural viscosity, MPa×s (20 rpm)	Foam number, mm	The stability of the foam, conventional units
3,0	0,2	3300	151	0,95
3,0	0,3	4800	151	0,97
3,0	0,4	5500	149	0,97
4,0	0,1	6000	152	0,97
4,0	0,2	6200	152	0,97
4,0	0,3	3300	151	0,95
4,0	0,4	4800	151	0,97

The next step of our study was to investigate the antimicrobial activity of the foamy washing complex with a water-glycerine extract of pollen. To conduct this study we made the following samples: No. 1 – "pollen Extract", № 2 – the basis of foamy washing men, No. 3 – basis of “Extract of pollen" 0,1 %, № 4 – with a basis of Extract of pollen of 0.3%, No. 5 – the basis of the Extract of pollen" by 0.6%, No. 6 – the basis of the Extract of pollen" 0.9% Composition of the samples and the results of the determination of their antimicrobial activity are given in table. 7.

Table 7 **Antimicrobial activity of samples**

№ Of the sample	**Sample**	**Cultures of microorganisms**			
		S. aureus	***B. subtilis***	***E.coli***	***C.albicans***
		the diameters of zones of growth inhibition of microorganisms mm			
1	Extract of pollen	23,4±1,5	24,0±1,1	22,8±1,4	12,0±0,6
2	the basis of the foaming washing liquid	–	–	–	–
3	base with complex «JM Acti Care»0,1 %	18,6±2,4	21,2±1,9	18,8±1,6	–
4	the basis of extract of pollen of 0.3 %	24,6±0,8	26,8±1,4	25,0±1,8	–
5	the basis of the extract of pollen 0.6 %	27,2±1,6	27,6±1,6	26,2±1,0	–
6	the basis of extract of pollen of 0.9 %	28,2±1,3	27,8±1,3	26,2±1,6	–

Note. "–"zone of growth inhibition of microorganisms was not revealed n = 5.

The next step was to study the physico-technological properties of foamy washing means. It is known that active ingredients can significantly change the values of the rheological parameters and also affect other parameters (pH, colloidal stability, thermostability), which should be considered when developing foamy washing means. The study of structural-mechanical properties is one of the important stages which gives the opportunity to predict the reaction of foamy washing means during technological operations, extrusion from the container (bottle) and when applied to the skin surface [2, 13].

To study the type of flow and determination of the thixotropic properties we constructed a rheogram of studied foundations with operating and auxiliary substances: foamy washing means; basis with 0.9 % extract pollen extract pollen, bases with 0.5 % D-panthenol; 0.05% allantoin, the basis of 0.1% of a preservative "Rokonsal ND", the basis with 0.05 % gtoxycodone, as well as a sample of the finished promonova funds.

Data reogram of foamy washing means (Fig. 1) shows the dependence of the shear stress (τ, PA) from the velocity gradient (Dr, s-1). Received reo parameters were obtained by the method of continuous increasing destruction of the structure, as a function of shear stress. The assay was performed with increasing numbers of spindle speed from 20 to 100 rpm, achieving a constant shear stress at the maximum speed and further decrease the number of revolutions of the spindle. Rheogram of foamy washing means is shown in Fig. 1 and 2.

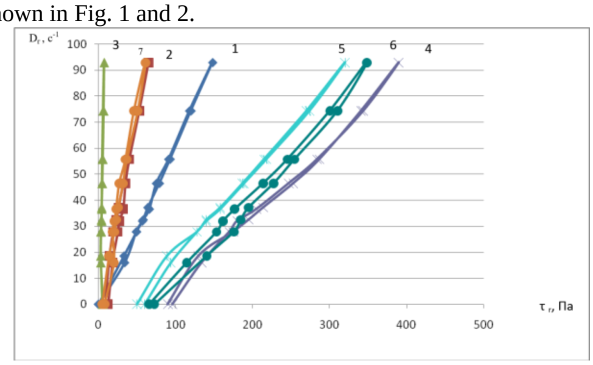

Fig. 1. Rheograms of foamy washing bases: 1 – 1 – foamy washing basis, 2 basis with an extract of pollen, a 3 –base with D-panthenol, 4 – base with allantoin, 5 – ready recipe, 6 – base gtoxycodone, 7 – based with preservative «Rokonsal ND»

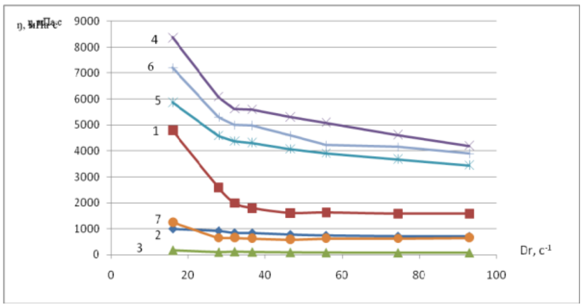

Fig. 2. The dependence of structural viscosity of foamy washing samples from shear rate: 1 – foamy washing basis, 2 basis with an extract of pollen, a 3 –base with D-panthenol, 4 – base with allantoin, 5 – ready recipe, 6 – base gtoxycodone, 7 – based with preservative «Rokonsal ND»

Results And Discussion

As it can be seen from the results of table 1 at a surfactant concentration of 5.0 %, a foam number was only 34.0 mm, the indicator of the stability of the foam had a high value of 0.91 conv. units At 10.0 % surfactant solution, there was a significant increase in both the foam number (up to 54 mm) and foam stability at the level of 0.96 conv. units by increasing the concentration to 15.0 % – foam number reaches its highest value and amounted to 64,0 mm and the foam stability decreased slightly and was at 0.94 conv. units. This gave the opportunity to conclude that this detergent must be used in a concentration of about 10.0 %, since the solutions in this concentration have the highest value of the foam, and an indicator of foam stability is not inferior to 15% solutions and is almost on the same level. However, these characteristics indicate that the use of this component without the addition of auxiliary substances is irrational and cannot fully provide the necessary prototypal ability.

The results of dissolution of the Coco Amido Propyl Betaine with a 10.0 % solution of the disodium laurilsulphate (table. 2) indicate that the stability of foam in the samples with a concentration Coco Amido Propyl Betaine 4,0 % (0,91 conv. units) and 12.0 % (0.94 conv. units) was slightly lower compared to the sample Coco Amido Propyl Betaine at a concentration of 8.0 % (0,96 conv. units). This gives you the opportunity to come to the conclusion that the most efficient concentration for Coco Amido Propyl Betaine is up 8.0 %, since this sample had a high value of foam stability and foam numbers.

The data obtained by definition of foam formation ability of the disodium laurilsulfata (10,0 %), Coco Amido Propyl Betaine (8,0 %) and cocoglucoside oleate (table. 3) indicate that the selected component contributes to the level of foam in the system, but it also significantly decreases the stability of foam. On the basis of obtained results it was established the necessity of introducing additional foam stabilizer and overstuffed agent, which was chosen a glareola of the brand "Levenol H&B" produced by "KAO", Japan. The selected stabilizer is recommended for use in combination with other SAS, since it stabilizes the foam and shows moisturizing and overstuffed actions, and also prevents the negative effects of surfactants on the skin.

As it can be seen from the results of the study of the foam formation ability of the disodium laurilsulphate (10,0 %), Coco Amido Propyl Betaine (8,0 %), cocoglucoside oleate (1.0%) and glycerol cocoat (table. 4), with the introduction of this SAS into the system increases the level of foam stability, but at concentrations of 1.5% to 2.0 %, the foam decreased (due to the fact that the foam was fine and it was losing its volume). On the basis of the experimental data it was revealed that the concentration of glycerol coconut in the system shall be of 1.0 %, because at this concentration the maximum observed value of the level of foam and its stability.

With the introduction of the mixture of PEG-7 of Glary Cocoate and PEG-200 palmitate Glary (table. 5) it was found that thickening of the system occurs only when the concentration of the "Neopal Lis 80" is rom 3.0 to 5.0 %. In this regard, we have fabricated samples of the non-ionic SAS at the concentrations of 3.0, 4.0 and 5.0 %. The pH of the samples was in the range of 6.74 to 6.83, therefore, we carried out the adjustment of the pH to 5.5. "Neopal Lis 80" was added to the selected foamy washing basis at a temperature of 45 °C and a low rpm stirrer. As can be seen from table 5, the structural viscosity of samples with a concentration of "Neopal Lis 80" between 3.0 and 4.0 % is insufficient, since the optimal value of structural viscosity should be in the range of 4000-5000 MPa×s).

It was found that at the concentration of the "Neopal Lis 80" 5.0% the value of structural viscosity goes beyond the recommended limits, the system formed a dense mass, which lost the ability to flow. The foam formation ability of all samples was satisfactory (table. 5). At the concentration of the "Neopal Lis 80" of 4.0 %, the structural viscosity was of utmost importance, so the increase in the concentration of this component is not rational.

As it can be seen from the data obtained in the study of physicochemical and rheological characteristics of experimental samples of HPMC (table. 6), in samples from 4.0 % "Neopal Lis 80" there was a significant thickening of the system, which required reducing the concentration of "Neopal Lis 80" up to 3.0 %. In the result, it was found that the sample with the concentration of the "Neopal Lis 80" of 3.0% and HPMC at a concentration of 0.2 % was too liquid, and the sample with the concentration of HPMC and 0.4 % – on the contrary, too thick. Therefore, we have chosen foamy washing basis of concentration of "Neopal Lis 80" 3.0% and HPMC 0.3% and which exhibits a satisfactory consumer, technological and physico-chemical properties.

On the basis of physical and chemical research the composition of foamy washing basics was justified: disodium laurilsulphate – 10,0 %, HPMC to 8.0 %, PEG-7 Glary Cocoate and PEG-200 palmitate Glary 3.0 %, of glycerin and 3.0 %, cocoglucoside the oleate and 1.0 %, glycerol cocoat of -1.0 %, the hydroxypropylmethyl cellulose is 0.3% lactic acid to pH 5.5, purified water to 100.0 %. With the help of the research conducted on the study of structural-mechanical properties it was found that developed foamy washing basis with a number of modern detergents is characterized by pseudoplastic types of flow, structural HPMC which is equal to 4800 MPa×s (at 20 rpm).

The results of tests to determine the antimicrobial activity of the studied samples are given in table. 7 indicate that the sample No. 2 (base of the foamy washing liquid) does not show antimicrobial activity against gram-positive, gram-negative microorganisms and yeast-like fungi (zone of growth inhibition of cultures was not observed). It is also established that samples with a complex of "pollen Extract" show any significant antimicrobial activity toward different cultures: gram-negative bacterial (E. coli) and gram positive (S. aureus, B. subtilis) cultures, and also exhibits weak antifungal activity against yeast-like fungi of the genus Candida.

Samples foamy washing means No. 3 (base of foamy washing liquid with 0.1% extract of pollen) and No. 4 (base of foamy washing liquid 0.3 % of an extract of pollen) show moderate activity against bacterial cultures (S. aureus, B. subtilis, E. coli).

It was found that the experimental samples № 5 (base of foamy washing liquid 0.6% extract of pollen) and No. 6 (b base of foamy washing liquid 0.9% of the pollen extract) showed high antimicrobial activity against gram-positive, gram-negative microorganisms and yeasts. Based on these data, we chose the sample No. 6 (concentration of the extract of pollen of 0.9 %). Further increase in concentration of extract of pollen did not lead to a significant increase in antimicrobial activity.

Also, based on the literary and patent search as active ingredients in the composition of the developing child base of foamy washing liquid allantoin was introduced (repairing, anti-inflammatory component), D-panthenol (a substance that reduces the irritating action of surfactants and moisturizes the skin), as well as hydroxyethyl urea (moisturizing ingredient).

The results of obtained rheograms, which are presented in Fig. 1 indicate that the samples No. 1 (foamy base), No. 2 (base with extracts of pollen – 0,9 %), No. 3 (base with D-panthenol – 0.5 %) and No. 7 (foamy base with preservative "Rokonsal ND" – 0,1 %) are characterized by a lower bound of the fluidity and pseudoplastic types of flow (within the studied range of gradients of shear rate).

The study of samples No. 4 (base with allantoin, and 0.05%), No. 5 (finished formulation) and No. 6 (base with hydroxyethyl urea – 0,05 %) have seen an increase in values reopener (structural viscosity and lower yield stress), the emergence of plastic properties and a slight thixotropic properties, which indicate the presence of a hysteresis loop on rheogram (Fig. 1).

The dependence of structural viscosity on the velocity gradient of the shear of the developed samples showed that the structural thickness of the sample No. 4 (base with allantoin, and 0.05%), No. 5 (finished formulation) No. 6 (base with hydroxyethyl urea – 0.05 %) and No. 1 (foamy washing base) gradually decreased with increasing gradient of shear rate (Fig 2), but particularly intense structural viscosity decreases in the range of increasing strain from 20 to 34 s-1, and then does not change as rapidly and with a strain rate of 60 s-1 describes a straightforward dependence.

In the study of this dependence of the samples No. 2 (base with extracts of pollen 0.9 %) and No. 3 (base with D-panthenol 0.5 %) (Fig. 2) it was found that their structural viscosity practically does not depend on the gradient of the shear rate. In the study of dependence of structural viscosity from the gradient of shear rate for sample No. 7 (base with the preservative "Rokonsal ND" 0,1 %) it was found its insignificant reduction, in particular in the range of increasing strain from 20 to 30 s-1, and further structural viscosity of foamy washing liquids as well as for samples No. 4 and 5 does not change so rapidly, and at a strain rate of 60 s^{-1} describes a straightforward dependence.

Dependences of the values of structural viscosity on the shear rate, indicating a more lightweight and uniform distribution of foamy washing liquids on the surface of the skin. The introduction of active agents has an impact on the value of structural viscosity, but the nature of the reduction of viscosity (the shape of the curves) from the gradient of shear rate is almost not affected.

Thus, according to the results of the performed technological, physical-chemical, microbiological, biological and toxico-GYN research, we developed the optimal composition of foamy washing liquids for use in pediatric patients (in%):

Disodium laurilsulphate	10,0
Coco amido propyl betaine	8,0
Peg-7 glary cocoate	3,0
PEG-200 palmitate Glary	3,0
Glycerin	3,0
Cocoglucoside oleate	1,0
Glareola	1,0
Extract of pollen	0,9
Gtoxycodone	0,5
D – panthenol	0,5
Of hydroxypropylmethyl cellulose	0,3
Preservative "Rokonsal ND"	0,1
Allantoin	0,05
Lactic acid	Up to pH 5,5
Purified water	Up to 100,0

CONCLUSIONS

1. The results of pharmaco-technological, physico-chemical, structural and mechanical studies substantiated the composition of the foamy washing base, which includes detergents (sulfosuccinate sodium – 10,0%, Coco Amido Propyl Betaine - 8.0 %, PEG-7 Glary of Cocoate and PEG-200 Glary palmat – 3,0 %, cocoglucoside oleate and 1.0 %, glareola – 1,0 %), humectant and a viscosity modifier (glycerol and 3.0 %, hydroxypropylmethyl cellulose and 0.3 %). This foamy washing base was developed at the recommended pH for baby skin (5,5) and adjusted with lactic acid.
2. Conducted microbiological studies proved the antimicrobial action of the extract of pollen and the need for additional introduction of the preservative "Rokonsal ND" (benzoic acid/degarcia acid/Phenoxyethanol, and 0.1 %).
3. The influence of current and the number of supporting active substances on prototypal ability (foam number not less than 150,0 mm, the resistance of foam – 0,95 mind. ed) and structural-mechanical properties of foundations and proved that adding D-panthenol, anti-microbial complex "JM Acti Care" observed decrease in the viscosity developed the foundations promonova funds, and when you add the allantoin and the preservative gtoxycodone "Rokonsal ND" on the contrary, there was an increase in the structural viscosity, which suggests the existence of its plastic properties.
4. Studied the technological aspects of the introduction of the active (D-panthenol, allantoin, gtoxycodone, extract of pollen) and auxiliary substances in the composition foamy washing liquids for use in pediatric practice with the goal of improving the condition of the skin of the child.

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