Innovative Technologies in Cosmetic Industry in Development of Biotechnology of Whey-Based Concentrates

M A Chikatueva¹, T V Voblikova², E A Abakumova¹ and A G Khramtsov¹

¹North Caucasus Federal University, ul. Pushkina, 1, Stavropol, Russian Federation
²Yaroslav-the-Wise Novgorod State University, ul. B. St. Petersburgskaya, 41
Veliky Novgorod, Russian Federation

E-mail: madina.chikatueva@mail.ru

Abstract. The article discusses the relevance of the development of an innovative cosmetic product for hair based on lactoserum with a prophylactic property, since it contains enzymes, vitamins and amino acids. The article describes the results of studies on the quality and safety of whey hair shampoo during its production and use. The results of the optimal concentration of milk whey as a basis for shampoo in the analysis of organoleptic parameters are presented, the content of vitamins is determined, the possibility of the combined use of milk whey and beer wort in order to obtain the highest quality concentrate for shampoo is studied, the quality and safety indicators of the finished product are studied.

1. Introduction

On the world and Russian markets there is a trend to create high quality whey-based cosmetic products for hair as whey is the main product of processing secondary milk raw materials.

In domestic [1] and foreign publications the main directions and ways of processing lactoserum as a valuable raw material [2] have been considered, as well as the effect of technological factors on the content of particular ingredients in it. The results of global studies indicate that at present, the problem of rational use of lactoserum has not been completely solved [3].

At searching for the ways of rational processing of lactoserum researchers take into account the volumes of milk supplies for industrial processing [4], the analysis of demands of various areas of the food industry [5], as well as economic and environmental factors [6]. The main problem of lactoserum processing is considered to be the lack of efficient high-performance equipment [7]. In Russia, both scientific communities [8, 9] and companies supplying equipment for processing secondary milk raw materials pay a special attention to solving this problem.

In this regard, the decision is relevant to resume the direction of lactoserum processing in the cosmetic industry, develop high-quality safe [10] hair shampoo based on milk whey. For this the task to develop a formulation and technology for a hair cosmetic product was set.

In 2021, based on the information about the energy value, chemical composition, content of particular whey components, the creative team of the Department of Applied Biotechnology proposed directions for using whey as the main ingredient, in order to produce a high-quality cosmetic product for hair (shampoo) additionally enriched with phyto-components and vitamins.

The aim of the work is to develop biotechnology of concentrates based on secondary milk raw materials for use in the composition of a hair shampoo with high quality characteristics, which serves
as a prophylactic agent for skin diseases of the scalp. For this, the optimal composition of the concentrate and the finished product was experimentally developed, the effect of the shampoo on the scalp was evaluated, the organoleptic, physicochemical and toxicological indicators of quality and safety were studied.

2. Materials and methods
The object of research is a cosmetic product for hair with vitamins and amino acids. The experiments were carried out at the Department of Applied Biotechnology of the Institute of Living Systems, research were carried out in the laboratories of the Center for Hygiene and Epidemiology in the Stavropol Territory FBUZ (Federal Budgetary Institution of Health care).

The analysis was carried out in several stages. At the first stage, the optimal concentration of whey as a basis for shampoo was determined in the analysis of organoleptic parameters, and the content of vitamins in the selected sample was determined. At the second stage, the possibility of the combined use of whey and beer wort was studied in order to obtain the highest quality shampoo concentrate. The next stage was a series of experiments to study the quality and safety indicators of the finished shampoo. Microbiological indicators, physical and chemical indicators, toxicological indicators, the content of toxic elements were determined. At the last stage, dermatoscopic studies of the skin were carried out after the application of shampoo with hydrolyzed milk serum by a volunteer-proband with signs of effluvium at the Doctor M Diagnostic Center LLC using a Heine Delta 20T dermatoscope at 10-fold magnification for 30 days.

3. Results and discussion
An innovative technology has been developed for the production of a cosmetic product for hair - shampoo with hydrolyzed milk serum, which has long served as one of the main components in cosmetic products due to its balanced composition. The developed method for the production of hair shampoo includes the following stages: preparation of a concentrate, which includes dry milk whey diluted with water, beer wort, brewer's yeast, subject to all technological stages (pasteurization, cooling, hydrolysis, cultivation, inactivation, filtration and centrifugation); cooking shampoo with the addition of a soap base, milk proteins, enzymes, additional ingredients, followed by stirring until the introduced substances are completely dissolved; unloading the finished shampoo; cooling; packing and packaging.

At the first stage, studies were carried out to determine the optimal concentration of milk whey as a basis for shampoo in the analysis of organoleptic indicators, and the content of vitamins in four samples was determined.

To determine the organoleptic characteristics of the obtained samples, an assessment of diluted milk whey (50 g/l, 60 g/l, 70 g/l) was carried out according to four organoleptic indicators: consistency, appearance, smell, color (table 1).

| Concentration | Organoleptic indicators                                      |
|---------------|-------------------------------------------------------------|
| 50%           | Consistency: liquid, no protein sediment                     |
|               | Appearance: no delamination                                  |
|               | Smell: clean, whey, pleasant, no foreign odors              |
|               | Color: light yellow                                          |
| 60%           | Consistency: liquid, with a small amount of protein sediment |
|               | Appearance: no delamination                                  |
|               | Smell: clean, whey, pleasant, no foreign odors              |
|               | Color: light yellow opaque                                   |
| 70%           | Consistency: viscous, sticky, with protein sediment          |
|               | Appearance: no delamination                                  |
|               | Smell: clean, pronounced whey                                |
|               | Color: light yellow opaque                                   |

Table 1. Organoleptic characteristics of fermented milk whey samples.
The sample with 60 g/l of diluted whey is the best in terms of the organoleptic indicator of quality, has a homogenous liquid consistency most suitable for shampoo, no delamination, excessive viscosity and stickiness, with a clean pleasant smell.

For a high-quality shampoo base the indicators of the content of group B vitamins are of principal significance. Therefore, at this experimental stage we decided to examine the content of vitamins in the obtained sample with 60 g/l, since it is this sample is adopted for all indicators for further research. Data on the quantitative content of vitamins are shown in table 2.

| Examined indicator | Vitamin | Content in 1 l of whey, mg | Content in 1 l of whey fermented with yeast, mg |
|--------------------|---------|----------------------------|-----------------------------------------------|
| Vitamins           | B1      | 0.32                       | 0.34                                          |
|                    | B2      | 1.6                        | 1.69                                          |
|                    | B6      | 1.27                       | 1.3                                           |
|                    | B12     | 2.4                        | 2.51                                          |

The amount of vitamins in this sample does not meet the content required for a high-quality product. Therefore, we decided to introduce beer wort into the base composition, in order to stimulate yeast development and, consequently, increase the concentration of B vitamins.

To obtain a product with the highest quality characteristics, beer wort is added to the shampoo concentrate. To create a concentrate for the shampoo containing whey diluted with purified water (60 g/l), the technological scheme should be followed. Namely, the hydrolysis with enzymes (β-galactosidase, pancreatin) is carried out, brewer’s yeast and beer wort are sown, which contributes to the active development of yeast and the enlargement of their biomass, and, as a result, the better fermentation of the liquid base for the shampoo. Brewer’s yeast and beer wort are introduced in different proportions (from 10 to 90 %), physical and chemical indicators of the obtained samples are determined, and the one with the best indicators is selected (table 3).

| Sample № | Wort amount, % | Lactose amount before cultivation, % | Lactose amount after cultivation, % | Protein amount before cultivation, g/l | Protein amount after cultivation, g/l | Dry matter before cultivation, % | Dry matter after cultivation, % | Titratable acidity before cultivation, °T | Titratable acidity after cultivation, °T |
|-----------|----------------|-------------------------------------|-------------------------------------|----------------------------------------|--------------------------------------|---------------------------------|---------------------------------|----------------------------------------|----------------------------------------|
| 1         | 10             | 7.64                                | 0.42                                | 0.6                                    | 5.1                                  | 5.5                             | 6.1                             | 19.3                                   | 22.5                                   |
| 2         | 20             | 10.57                               | 9.04                                | 0.41                                   | 0.65                                 | 6.1                             | 6.5                             | 8.7                                    | 22.5                                   |
| 3         | 30             | 11.43                               | 9.8                                 | 0.48                                   | 0.69                                 | 6.6                             | 7.0                             | 10.4                                   | 23.8                                   |
| 4         | 40             | 13.08                               | 11.56                               | 0.56                                   | 0.72                                 | 6.8                             | 7.1                             | 10.7                                   | 20.3                                   |
| 5         | 50             | 12.6                                | 10.45                               | 0.58                                   | 0.79                                 | 7.0                             | 7.3                             | 11.6                                   | 23.9                                   |
| 6         | 60             | 14.86                               | 13.79                               | 0.57                                   | 0.74                                 | 7.1                             | 7.5                             | 11.1                                   | 21.7                                   |
| 7         | 70             | 10.3                                | 9.62                                | 0.44                                   | 0.66                                 | 7.3                             | 7.6                             | 12.6                                   | 23.3                                   |
| 8         | 80             | 9.54                                | 8.33                                | 0.47                                   | 0.59                                 | 7.5                             | 7.8                             | 12.9                                   | 24.2                                   |
| 9         | 90             | 9.86                                | 8.41                                | 0.41                                   | 0.45                                 | 7.8                             | 8.1                             | 10.4                                   | 22.5                                   |
The best result was obtained for sample no. 5 with a lactose content (10.45 g/l) and the highest amount of protein (0.8 g/l). With an increase in the concentration of beer wort, the quality organoleptic indicators deteriorate, yeast growth and protein content increase, and the pH level also rises, while the amount of lactose decreases.

The shampoo with hydrolyzed milk whey was tested for safety indicators, regulated by the requirements of TR CU (Technical Regulations of the Customs Union) 009/2011, the results are shown in table 4.

### Table 4. Microbiological, physicochemical, toxicological indicators of safety of shampoo with hydrolyzed milk whey.

| first order no. | Determined indicators, units of measurement | Research results and permissible measurement error | Hygienic standard of PDK (Maximum Allowable Concentration) | ND (Regulatory Documents) on research methods | ND regulating the scope of research and its assessment |
|-----------------|---------------------------------------------|---------------------------------------------------|----------------------------------------------------------|---------------------------------------------|------------------------------------------------------|
| 1               | Microbiological safety indicators, ml        | less than $1,0 \times 10^2$ CFU in 1 g             | no more than $10^3$ CFU in 1 g                           | MG 4.2.801-99                              | TR CU 009/2011                                      |
| 2               | Candida albicans                             | not detected                                      | not allowed in 0.1 ml                                   | MG 4.2.801-99                              | TR CU 009/2011                                      |
| 3               | Escherichia coli                             | not detected                                      | not allowed in 0.1 ml                                   | MG 4.2.801-99                              | TR CU 009/2011                                      |
| 4               | Staphylococcus aureus                        | not detected                                      | not allowed in 0.1 ml                                   | MG 4.2.801-99                              | TR CU 009/2011                                      |
Table 5. Volunteer probant data.

| sex     | female |
|---------|--------|
| age     | 36 years |
| bad habits | absent |
| complaints | increased skin oiliness, itching, hair loss |
| diagnosis | seborrheic dermatitis of a fatty type |

Notes. On the surface of the scalp, redness and excessive hair oiliness are observed.

Hair loss is usually associated with a diagnosis of effluvium or visible baldness (alopecia). The probant has excessive oily hair and redness throughout the scalp. Seborrheic dermatitis of a fatty type was diagnosed.

The volunteer-probant was assigned the systemic use of shampoo with hydrolyzed milk whey, in the production of which special attention was paid to the amount of enzyme preparations, amino acids, promoting the utilization of fat.

The whey-based shampoo contains both enzymes (β galactosidase, pancreatin) and amino acids, as well as general strengthening components – B vitamins, vitamin A.
After 3 months of using the shampoo with hydrolyzed milk serum, the volunteer-proband noted a decrease in the amount of daily hair loss, an improvement in the structure and an increase in the density of the hair shaft. According to Figure 2, the surface of the scalp does not have redness and oily sheen. The tolerance of the shampoo in the probant volunteer was positive, there were no side-effects of skin rashes.

Thus, the comparative analysis showed a positive dynamics of dermatoscopy indicators in the volunteer-proband.
Figure 2. Dermatoscopy of scalp of probant volunteer after 3 months of application of whey-based shampoo.

After the use of the shampoo with hydrolyzed milk serum in the probant volunteer, the dermatoscopy indicators reached the norm, which allows us to state the high efficiency of this product as a prophylactic agent for seborrheic dermatitis of a fatty type. The shampoo has a high therapeutic efficiency.

4. Conclusion

The possibility of obtaining a concentrate for shampoo based on secondary milk raw materials was investigated, an innovative technology for the production of a concentrate that is part of a hair shampoo was developed, and the optimal concentration of whey as a base for shampoo was determined. The possibility of combined use of whey and beer wort in order to obtain a concentrate for shampoo was shown, safety indicators of the finished shampoo were determined for compliance with the TR CU 009/2011 requirements. Dermatoscopic examinations of the skin after applying the shampoo with milk serum were carried out.

After analyzing the data obtained, we can conclude that the appearance of an innovative cosmetic product on the consumer market will expand the range of cosmetics and will solve the problem of processing and further use of lactoserum. The unique composition of the shampoo is confirmed by the patent for invention no. 2739351 dated December 23, 2020: *Shampoo based on hydrolyzed milk whey and its production method* [1]. Correctly selected technological modes made it possible to obtain a high-quality product that eliminates skin defects in the form of redness and itching. It should also be noted that the shampoo does not cause skin irritation in persons with increased skin sensitivity.
References

[1] Khramtsov A G and Nesterenko P G 2004 *Whey production technology* (Moscow: Deli print) 578 p

[2] Babenyshev S P, Bratsikhin A A, Zhidkov V E, Mamay D S, Nurullo M and Khokha D S 2020 *Journal of Hygienic Engineering and Design* **Vol. 31** 63–68

[3] Baitukenova S B, Kulmagambetov A S and Rametullaeva A A 2016 *Conf.* (Shanghai) 78–81

[4] Kravchenko E F and Neznanov Y A 2006 *Journal Dairy industry* **Vol. 6** 13–17

[5] Kravchenko E F 2000 *Journal cheese making* **Vol. 2** 28–29

[6] Kravchenko E F 2006 *Journal Dairy industry* **Vol. 6** 20–21

[7] Lyublinsky S L and Sorokin V A 2003 *Milk processing magazine* **Vol. 5** 26

[8] Volkova T A and Kravchenko E F 2003 *Milk processing magazine* **Vol. 3** 29–30

[9] Horton B S 2003 *Milk processing magazine* **Vol. 10** 42–43

[10] Evdokimov I A, Khramtsov A G, Emelyanov S A, Lodygin A D and Volodin D N 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **677** 032075

[11] Patent no. 2739351 2020 *Shampoo based on hydrolyzed milk whey and a method for its production*