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Production of mint whey drink at private and collective farms and agricultural holdings

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Abstract. This research aimed the development production of prophylactic whey drinks which allows enhancing the efficient use of resources of high-value dairy byproducts including cheese and curd whey. High level of safety and quality of milk supplied, soft, semi-hard cheeses and dry-curd cottage cheese, as well as curd whey were adapted. Pepper mint was added as a source of extra vitamins, mineral salts, macro- and micronutrients, dietary supplements. The first recipe for a whey drink with the addition of mint syrup includes curd whey 1 L, mint 1 g, sugar 30 g, water 25 mL, citric acid 4 g. The second recipe differs from the first in that peppermint contains 2 g, the third recipe for mint contains 3 g. The amount of whey, sugar and citric acid in the second and third recipes corresponds to the first recipe. Plant-based components of whey drink act as analeptics and expand the assortment. Also, the research aimed to develop zero waste and low waste technology for private and collective farms and agricultural holdings and as a result, provide the solution to whey disposal issue.

1. Introduction

Requirements for the quality of milk and dairy products are spelled out in national and international standards [1-2]. In the production of milk of high quality, activities aimed at improving the sanitary and hygienic conditions of production are of great importance [3-4]. In the EU requirements for the quality of raw milk are stricter than in Russia, but much more liberal than in the United States.

In the course of processing milk into cheeses, cheese whey is formed. In the Russian Federation (RF), a lot of curd is produced, which leads to the formation of a large amount of curd whey. Cheese and curd whey are milk whey. Whey is a valuable raw material for the production of various products for humans. Requirements for the quality of whey and products obtained from it are given in the regulatory documents in force within the country and on an interstate scale [5-6].

Scientific research and modern technologies are aimed at maximizing the use of the components of milk whey [7-8]. One of the promising areas for the use of whey is the production of beverages [9-10]. Herbal ingredients are used to increase the nutritional value of whey drinks. Peppermint is a valuable raw material for the production of mint-whey drink [11-12]. However, the use of additional raw materials in production requires preliminary study. Researches of many scientists of the world are aimed at studying the issues of the use of whey for the production of drinks [13-15]. The range and nutritional value of whey drinks increases with the use of additional raw materials [16-17]. The research results introduced in the conditions of large processing enterprises cannot always be effectively used in small enterprises. In Chuvash Republic, more than 50% of milk is produced in the conditions of personal



subsidiary farms. The villagers traditionally make a lot of cottage cheese from milk. As a result of this production, curd whey is formed. Questions on the use of curd whey remain unresolved not only for Chuvash Republic, but for the whole world [18-20].

The demand for drinks made from natural raw materials is increasing as the number of people on Earth grows. Milk whey contains whey proteins – albumin and globulin. The amount of albumin in milk is not more than 12%, and the amount of globulin is not more than 6%. Whey proteins are the carrier of immunoglobulins, which perform the protective function of the body. Among whey proteins, lactoferrin and lactoperoxidase have valuable properties.

Consequently, whey contains deficient proteins, serves as an additional source of essential amino acids, and whey drinks perform a prophylactic effect in improving health, have a high nutritional value, and are especially useful for people with active physical activity.

The novelty of the work is the use of peppermint syrup in the whey drink production technology. The purpose of the research is the production of whey drink in private households, collective farms and agricultural holdings using peppermint syrup.

2. Material and methods

The research was carried out in 2019-2020. Cow's milk, curd whey and whey drink. When accepting milk of morning and evening milking, point samples were taken from each batch. Curd whey and whey drink for research were taken from each batch and the average samples were made. For studies of the chemical composition of milk and milk whey, samples of 250 mL were taken from each batch.

In the educational and research laboratory for the technology of milk and dairy products of the Chuvash State Agricultural Academy (Cheboksary, Russia), cow's milk of the educational scientific production center 'Studentchesky' and whey obtained from the production of cottage cheese were examined.

The physicochemical properties of milk and whey were determined by the mass fraction of protein, fat, skim solids, milk solids, lactose, salts, added water, degree of homogenization, milk temperature in laboratory analysis and its freezing point, titratable and active acidity, oxidation-reduction potential (ORP). The physical and chemical properties of milk and milk whey were investigated on 'Klever-2M' milk analyzer (Biomer, Russia) and a 'Nitron-pH' pH-meter-thermometer (Biomer, Russia). The mass fraction of fat, protein, lactose, salts, dry milk residue, dry non-fat milk residue, and the freezing point were determined by the ultrasonic method on the milk analyzer. Active acidity, titratable acidity, oxidation-reduction potential and temperature were determined on the pH-meter-thermometer.

The test laboratory center conducted an organoleptic assessment of the whey drink in terms of taste, smell, texture and color. Taste and odor, texture, appearance and color were determined using visual and sensory analysis. The appearance and color of the products was determined as follows. From the pooled sample, a portion of the whey drink was transferred into a clean and dry Petri dish, filling it to about half of the container. The Petri dish was placed on a white sheet of paper and the contents of the dish were examined in reflected light. Organoleptic evaluation of smell and taste was carried out by smelling and tasting the product. The glass with the test sample of the product was brought to the nose at a distance of 1-2 cm. The smell was determined by short deep two-time inhalation. Then they drank at least 10 mL of the product, distributing it over the oral cavity to the base of the tongue, kept in the mouth for about 7 seconds. Then the sample was spit out into the spittoon. A swallowing movement was carried out with an exhalation into the nose and a final assessment of the smell and taste of the test sample was made. The oral cavity was thoroughly rinsed with weakly brewed tea at a temperature of $35 \pm 5^\circ\text{C}$. The consistency of whey and beverages was determined by pouring them from a transparent colorless flask with a capacity of 100 mL into another flask of the same size, while observing the homogeneity of the liquid being poured. Then they carefully examined the inner walls of the dishes from which the products were poured for the presence of protein flakes.

The microbiological safety of the drink was determined by the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), the content of bacteria of the *E. coli* group (CGB) and *S. aureus staphylococci*, pathogenic microorganisms, yeast and mold by conventional methods. The

method of determining QMAFAnM is based on the ability of mesophilic aerobic and facultatively anaerobic microorganisms to multiply on dense nutrient agar at $30\pm 1^\circ\text{C}$ for 72 h. The method for determining bacteria of the group of *E. coli* is based on the ability of coliform bacteria (non-spore gram-negative, aerobic and facultative anaerobic rods, mainly representatives of the genera *Escherichia*, *Citrobacter*, *Enterobacter*, *Klebsiella*, *seratia*) to ferment lactose in the nutrient medium with the formation of acid and the formation of acid and at $37\pm 1^\circ\text{C}$ for 24 h. The method for detecting the presence/absence of staphylococci in standardized dilutions of dairy products was used to determine *S. aureus staphylococci*.

From a mixture of morning and evening milk, which entered the laboratory, cottage cheese was obtained by the acid-rennet method. During the production of cottage cheese, secondary milk raw materials are formed – cheese whey. It has been found that whey can be used in the production of refreshing drinks. Developed a formula for a whey drink. Peppermint was used as flavoring filler in the whey drink.

Milk whey was obtained in the production of cottage cheese by the acid-rennet method including quality control and preparation of raw materials (whey, water, sugar, citric acid, peppermint), preparation of an aqueous tincture from mint, filtering a mint tincture, adding sugar and citric acid to the tincture, cooking mixtures, cooling mint syrup to room temperature, adding mint syrup to whey, filling the whey drink into consumer containers, cooling, and storing.

To prepare the syrup, peppermint 1, 2 and 3 g was presoaked in 25 mL of boiled water for 15 min. Then it was filtered through cheesecloth, added sugar and citric acid. The resulting mixture was brought to boiling and cooked for 3 min.

To obtain a drink with the best organoleptic characteristics, 3 versions of syrup with different amounts of mint were prepared. The first version of the whey drink recipe includes curd whey 1 L, mint (1 g), sugar (30 g), citric acid (4 g), and water (25 mL). Citric acid imparted a pleasant taste to the whey drink. The second and third versions of the recipe included 2 and 3 g of mint per 1 L of whey, respectively. The amount of sugar, water and citric acid was the same in all variants.

Whey drink production in the conditions of the educational and research laboratory for milk and dairy technology is organized into few basic processes as follows: whey filtering, whey separation, making of flavorings, adding flavorings to whey, pasteurization of the mix, cooling of the mix, whey drink bottling for retail, cooling and storage of whey drink at $4\pm 2^\circ\text{C}$.

The curd whey obtained in the laboratory was filtered through cheese cloth and a sieve. Cheese cloth was periodically cleaned of accumulated impurities. The separation was carried out on a separator Motor SICH SCM-100 (Motor SICH, Ukraine) at $35\text{--}40^\circ\text{C}$. Peppermint syrup was made to be used as flavor filler.

To decide the best milk whey drink formula, consumer attributes of drinks with varied doses of flavor fillers were studied. For our publication, to prepare peppermint syrup, peppermint was put in boiling water and soaked for 15 min. Water mint tincture was filtered through cheese cloth and added sugar and citric acid. The mix was brought to boiling and simmered for another 3 min. Mint syrup is ready. Mint syrup was added to milk whey and the mixture was heat treated at 72°C / 15-20 s. Whey drink was cooled to temperature of $20\text{--}25^\circ\text{C}$ and bottled in PET bottles. The ready drink from whey was cooled to $4\pm 2^\circ\text{C}$ and stored in the refrigerator for 12 days.

Thus, peppermint was added to the whey drink formula.

Organoleptic properties of whey drink were assessed by the following parameters: taste, odor, texture, appearance and color. According to the results of expert tasting, preference was given to the first and the second whey drink formulas. Whey drink formula 3 was not recommended for production by the taste-testers.

3. Research results

The physical and chemical properties of milk were determined many times. The article presents the results of studies of milk of the morning and evening milking. The mixture of this milk was sent to the production of curd by the acid-rennet method. The whey obtained from the production of curd was used to produce a whey drink. Table 1 shows the analysis of morning and evening milk.

Table 1. Physical and chemical parameters of morning and evening milk.

Parameter	Analysis of		Standard / range	Russia's average
	morning milk	evening milk		
Fat, %	4.6±0.004	4.6±0.016	≥ 2.8	3.5
Mass fraction of protein, %	3.1±0.007	3.2±0.021	≥ 2.8	3.2
Solids not fat, %	8.4±0.013	8.6±0.013	8-10	8.6
Total solids, %	13.1±0.017	13.3±0.013	10-15	12.5
Mass fraction of lactose, %	4.6±0.008	4.6±0.002	4.0-5.3	4.8
Ash, %	0.72±0.005	0.74±0.001	0.6-0.8	0.7
Temperature, °C	20.5±0.01	20.4±0.01	4-8	2-6
Freezing temperature, °C	-0.540±0.002	-0.544±0.001	≤ -0.520	-0.555
Density, kg/m ³	1027.9±0.043	1028.5±0.017	≥ 1027.0	1027-1032
Titrateable acidity, °T	16.3±0.166	17.9±0.076	16.0-21.0	16-18
Active acidity (pH)	6.7±0.007	6.6±0.004	6.3-6.9	6.5-6.7
Oxidation-reduction potential, mV	221.0±2.309	263.7±2.603	200-300	220-250

Milk quality was determined at temperature of 20°C. Morning and evening milk did not differ in content of fat and mass fraction of lactose. Mass fraction of protein in evening milk is 0.1% more than in morning milk. Solids not fat, total solids, ash is more by 0.2%. Consequently, this increased density. Density of evening milk increased by 0.6 kg/m³. Titrateable acidity of evening milk is 1.6°T higher than the acidity of morning milk. The pH of evening milk is less by 0.1 unit, the oxidation-reduction potential is higher by 42.7 mV.

It was found that the fat content of milk exceeds 1.6 times the requirements of regulatory documents and 1.3 times the average in Russia. Mass fraction of protein corresponds to the average. The rest of physical and chemical properties of milk correspond to the norms and average indicators in Russia. The quality of cow's milk meets the requirements for the production of cottage cheese.

Figure 1 shows the technology of milk processing in the laboratory. This technology provides for the production of cottage cheese. When processing 100 L of milk for cottage cheese, about 80 L of cheese whey are formed. The whey remains unclaimed. A small portion of the whey is used for feeding farm animals. Our scheme provides for the production of a drink from whey.

The next step was to measure physical and chemical properties of whey. Sustainable use of secondary raw dairy material as a high-value resource resulting from milk processing is reviewed at the top level by the community of professionals. Whey and technology for its processing hold great potential to open up new production and to the corporate success.

In Chuvashia, private and collective farms and agricultural holdings raise livestock and more than 50% of milk in the republic is procured by these farms. Using this milk, many families make unique recipe dry-curd cottage cheese, cheeses, butter and other dairy produce. After milk processing, farm have secondary dairy raw materials, curd and cheese whey, buttermilk, skim milk. Thus, the use of secondary dairy raw material is relevant not only for dairy plants, but also for private and collective farms and agricultural holdings. Educational and research laboratory of milk and dairy technology of Chuvash State Agricultural Academy researched scientifically sound, practical use of secondary dairy raw materials in small production facilities. Whey drink formulas and technology are currently being

developed. This will expand the assortment at small enterprises and enhance cost-effectiveness of milk processing due to resource saving.

Table 2 shows the results of studies of the chemical composition of filtered and separated whey obtained in the production of cottage cheese.



Figure 1. Technological scheme for the production of cottage cheese and whey drink.

Research results show that whey is inferior to whole milk for Fat and Mass fraction of protein. Mass fraction of lactose, Skim solids, Milk solids and Ash whey corresponds to the chemical composition of whole milk. It was established that the chemical composition of filtered and separated whey meets the requirements of regulatory documents [5-6].

Whey filtration and separation also affected physical and chemical parameters (table 3). Filtered whey has density 3.7 kg/m^3 higher than density of separated whey. This is because filtered whey contains more protein, salts, and skim solids. Filtered whey has freezing temperature 0.052°C higher than that of

the separated curd whey, which is also due to changed composition of whey after separation. Filtered whey has titratable acidity 12.8°T higher. In contrast to other parameters, whey active acidity dropped by 0.6 units. Thus, curd whey is consistent with the national and international standards, it is highly nutritional and is recommended for whey drink production. The whey drink was made according to the technological scheme shown in figure 1.

Table 2. Chemical composition of whey.

Whey	Parameter					
	Fat, %	Mass fraction of protein, %	Mass fraction of lactose, %	Skim solids, %	Milk solids, %	Ash, %
Filtered	0.08±0.02	0.85±0.01	4.21±0.02	7.71±0.02	7.75±0.03	0.68±0.02
Separated	0.02±0.01	0.47±0.02	3.69±0.04	6.68±0.04	6.69±0.03	0.59±0.02
Standard value as per GOST RF 53438-2009 for curd whey [6]	-	-	≥ 3.5	-	≥ 5.5	-
Standard value as per GOST 34352-2017 for curd whey [5]	-	≥ 0.4	≥ 3.5	-	≥ 5.0	-
Standard value as per GOST RF 52054-2003 for cow milk [1]	≥ 2.8	≥ 2.8	-	-	-	-
Limits for cow milk	2.7-6.0	2.8-3.6	4.0-5.3	8.0-10.0	10.0-15.0	0.6-0.8
Average value for cow milk	3.5	3.2	4.8	8.6	12.2	0.7

Table 3. Physical and chemical parameters of whey.

Whey	Parameter			
	Density, kg/m ³	Freezing temperature, °C	Titratable acidity, °T	Active acidity, pH
Filtered	1029.1±0.06	-0.474±0.01	59.9±0.24	4.5±0.02
Separated	1025.4±0.11	-0.422±0.01	47.1±0.11	5.1±0.02
Standard value as per GOST RF 53438-2009 for curd whey [6]	-	-	Max. 70	-
Standard value as per GOST 34352-2017 for curd whey [5]	-	-	Max. 70	-
Standard value as per GOST RF 52054-2003 for cow milk [1]	≥ 1027.0	≤ -0.52	Min. 16 Max. 21	-
Limits for cow milk	1027-1033	-0.51–-0.58	16-21	6.5-6.8
Average value for cow milk	1028.5	-0.55	17.0	6.69

The mint-whey drink was bottled in PET bottles (figures 2 and 3). It was found that an increase of amount of peppermint from 1 g to 3 g per 1 L of whey significantly affects the organoleptic properties of the drink (table 4). According to the results of organoleptic evaluation, a whey drink was selected using 1 g of peppermint. The drink was stored in the refrigerator at a temperature of 4±2°C for 12 days. After storage, changes in organoleptic parameters were not established (figure 3).

Microbiological safety of whey drinks was studied at the testing laboratory center of Chuvash State Agricultural Academy. Table 5 shows the findings and requirements of the study.

In whey drink sample 1, Quantity of Mesophilic Aerobic and Facultative Anaerobic Microorganisms (QMAFAnM) was found to be 1.0×10^1 CFU/mL, in sample 2 – less than 1.7×10^3 CFU/mL while the standard value for whey shall not exceed 1.0×10^5 CFU/mL (table 5). Coliform bacteria (CGB) and *Staph. aureus* in 0.1 g of the product, pathogens including *Salmonella* and *Listeria monocitogenes* in 25 g of product, yeast, molds, CFU/mL were not detected in whey drink.



Figure 2. Whey drink with mint syrup (from left to right: peppermint 1, 2 and 3 g per 1 L of whey).



Figure 3. Whey drink with mint syrup after 12 days of storage.

Table 4. Organoleptic properties of mint-whey drink.

Indicator	Characteristic
Consistency and appearance	Homogeneous opaque, slightly viscous liquid
Taste and smell	The taste is sweet and sour, refreshing, the smell is not pronounced (peppermint 1 g)
	The taste is sweet and sour, refreshing, slightly pronounced smell (peppermint 2 g)
	The taste is not pleasant, the smell is pronounced (peppermint 3 g)
Colour	Homogeneous, uniform throughout the mass, due to the color of the filler applied. Increasing the dose of peppermint from 1 to 3 g darkens the color of the drink (figure 2)

Table 5. Microbiological parameters of whey drink.

Parameter	Findings (for whey drink 1 for whey drink 2)	Standard value as per GOST 34352- 2017 [5]
QMAFAnM, CFU/mL	1.7×10^3 $< 1.0 \times 10^1$	not exceeding 1.0×10^5
CGB (coli-forms), mL / 0.1 g of product	<u>not detected</u> not detected	not allowed
Pathogens including salmonella, mL / 25 g of product	<u>not detected</u> not detected	not allowed
Staphylococci aureus, mL / 0.1 g of product	<u>not detected</u> not detected	not allowed
Listeria monocitogenes, mL / 25 g of product	<u>not detected</u> not detected	not allowed
Yeast, mold, CFU/mL	<u>not detected</u> not detected	-

4. Discussion

Solving the issue of using whey is relevant for the world's dairy industry [21-23]. In the production of cottage cheese and cheese vitamins, lactose, salts, and other milk substances are converted into whey. It was found that the composition of whey differs depending on the season and type of cheese in production [24]. The composition of cheese whey is influenced by heat treatment of milk [25]. The high mineral load of whey limits its use [26]. Research is underway to extend the shelf life of liquid cheese whey [27]. Various technologies for whey processing are being developed for large and medium-sized dairy processing enterprises. It is believed that the processing of whey in small enterprises is not profitable [28]. At the same time, a large amount of milk is processed in the conditions of personal and farm households. Our research is aimed at solving the problems of using whey in small enterprises.

Whey is a valuable raw material for the beverage industry. Today in the world there is a large assortment of whey drinks. There are three types of whey: cheese whey, cottage cheese and casein whey. The technology for the production of drinks from these kinds of whey is practically the same and does not have significant differences.

Below is a description of the main technological operations for the production of whey drinks.

Preparation of raw materials. For the production of the drink, whey is used with an acidity of not more than 70°T and must have a density of not more than 1030 kg/m³. To determine these data, an analysis is carried out, and if the serum meets these requirements, then it is taken for further production.

Filtration and separation of whey. After receiving the whey, it must be filtered and separated. At factories, whey is filtered using membranes. Polymeric membranes are mainly used. With this filtration, the whey is forced through a porous filter by pressure. Depending on the pore size, the filter can trap fat, protein, sugar and even salt. They form a layer on the membrane that is flushed away in a parallel flow and thus no blockage occurs on the filter.

Separation of whey is used to separate milk fat, casein dust (defatting) and to separate coagulated proteins (clarification). The serum is separated immediately after receipt or a short-term (no more than 2 h) backup is used. The whey must be separated at a temperature of 35-40°C. It is not advisable to heat whey before separation, as this increases costs. Most often, the centrifugal method is used for separation, since it is more efficient. Fat is more difficult to extract from whey than from milk, since the whey has a high dispersion of fat globules and the presence of casein dust. Only with a well-organized process can fat-free whey be obtained. Usually the fat content in whey after separation is not more than 0.1%.

Pasteurization. The pasteurization process is carried out to suppress the development of undesirable microflora. Seeding by extraneous microflora can occur at collecting or storing whey. Pasteurization is carried out in two ways: low-temperature (slow), at a temperature of 63-65°C with an exposure of 30 min, or fast at a temperature of 72 to 80°C with an exposure of 15-20 s.

Adding flavors. To improve the taste and increase the nutritional and biological value of whey, its biological processing (fermentation) and the addition of fillers – aromatic substances and stabilizers, carbohydrates, natural juices and syrups are used. They are usually added after the completion of all major processes.

5. Conclusion

Milk produced at 'Studenchesky' educational research and production center of Chuvash State Agricultural Academy meets the requirements for premium and first grade milk under national GOST RF 52054-2003 standard 'Cow's milk raw. Specifications' [1].

Organoleptic, physical and chemical, microbiological parameters of whey meet requirements to raw materials used to produce whey drinks under international GOST 34352-2017 standard 'Milk whey – raw material. Specifications' [5].

The technology of the production of mint whey drink consists of the following processes: acceptance of whey and additional raw materials; filtration and separation of whey; whey pasteurization, preparation and addition of flavors to whey; cooling the whey drink; bottling whey drink for retail; cooling and storage of whey drink.

It was found that the best result in terms of organoleptic indicators was obtained by a mint whey

drink with the addition of 1 g of peppermint per 1 L of whey. 80% of the tasters voted for the first option. The increase of the amount of mint to 2 g per 1 L of whey impairs the taste of the drink. 20% of the tasters voted for the second option. The variant using 3 g of mint greatly impairs the taste and smell of the drink. All tasters rejected the third option.

Recommendations. Whey drink technology is recommended for adoption by private and collective farms and small enterprises. To expand the assortment and enhance nutritional value, we recommend supplementing the drink formula with peppermint syrup dosed 1 g per 1 liter of whey.

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