In deep processing technologies whey is a more "valuable" product than cheese, cottage cheese. Even though whey has a low energy value among dairy products, it is at the same time very valuable biologically. Recently, the consumption of berries has increased markedly everywhere. This growth is explained by the growing attention of the population to health and the appearance on the market of many canned products "saturated with berries". In addition, there are many scientific studies concerning the composition of biologically active components in the composition of berries. Thus, scientific developments to produce new foods enriched with berries are of crucial importance for berry producers, food processors and consumers.

This study investigated the possibility of using wild plant raw materials of Northern Kazakhstan (chokeberry and saskatoon berry) in milk beverages' technology. This berries despite their rich chemical composition, are rarely used in the food industry. The study describes the nutritional value and chemical composition of whey drinks enriched with juice from saskatoon berries, black chokeberry.

In this study it is proposed thermosaltic coagulation as a primary treatment for whey. The comparative analyses of natural whey and treated one shows the expediency and benefit of using thermosaltic coagulation. At the same time, juices from wild berries increase the biological and nutritional value of whey drinks. Thus, the described advantages are confirmed with assays and confirm the expediency of using this combined technology in the production of drinks from whey with berry juices.

The obtained research results will be used to develop a new technology to produce juice drinks based on whey and will also be described in a patent for a utility model for the production of beverages from whey

Keywords: drinks from whey, processing of berries, saskatoon berry, chokeberry, sea buckthorn, berry juices, termosaltic coagulation, dairy industry

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EXPLORING THE IMPACT OF WILD NORTHERN KAZAKHSTAN RAW MATERIAL JUICES ON THE CHEMICAL COMPOSITION OF WHEY DRINKS

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1. Introduction

This article explores the possibility of processing wild berries and development of drinks from whey fortified by berry juices.

It is known that in the Nordic countries, such as the EU, Canada, USA, Russian Federation and Republic of Kazakhstan, berry consumption is part of the daily diet, and is also widely used in medicine [1, 2]. The widespread use of wild-growing raw materials in food industry constrains the lack of knowledge of certain plants. Wild-growing raw materials are valuable due to a specific combination of biologically and pharmacologically active components [3].

For instance, *Aronia melanocarpa* (black chokeberry) is known as a source of anthocyanins, phenolic acids, flavonoids and procyanidins [4]. Due to the high content of phenolic compounds, chokeberry berries have many preventive properties, such as antioxidant, antidiabetic and immunomodulatory effects [5]. Antioxidants are useful for fight oxidative stress, which plays a crucial role in the pathogenesis of many diseases, such as cancer, cardiovascular diseases, arthritis, or obesity [6]. In some exploration it was proved that saskatoon berries contain a large amount of biologically active substances, such as phenolic compounds and anthocyanins [7]. It can be indirectly proved by their bright and saturated color of juices [8]. This phenolic compound has ability to suppress free radicals, and so help our body to defeat diseases related to oxidative stress, such as atherosclerosis, diabetes and cancer [9]. Chokeberry berries and Saskatoon berries have many species and subspecies, growing in North America, Canada, Europe, Poland, Russian Federation and Republic of Kazakhstan. Due to their rich composition, they have become the object of research by many scientists everywhere [1, 10], but there is very little reliable data on the chemical composition of these berries growing in c.

Whey is used as the main component of beverages. The uniqueness of whey is that whey proteins do not contain toxic components, have a water-binding, emulsifying, foaming and gel-forming ability [11]. And, since it is a secondary product of dairy processing, its use will help not only expand the range of drinks, but also solve the problem with its disposal. As studies of recent years have shown, whey can serve as an effective extractant of biologically active substances of natural raw materials, thereby being a valuable basis for the production of beverages with fruit and berry juices. Wild plants are valuable due to specific combinations of biologically and pharmaceutically active components. Such substances are difficult to create artificially [12].

Black chokeberry and saskatoon berries are become wild-growing species in northern part of Republic of Kazakhstan since they are rarely used in the juice processing industry.

Therefore, research on the development of technology for the production of berry drinks using whey is relevant.

2. Literature review and problem statement

One of the important problem in the food industry is that wild fruit and berries has not fully used in the industrial due to the high cost and labor intensity in harvesting and its further processing. It is known that local products made from local raw materials have the greatest therapeutic effect, increase the body's resistance to extreme situations, normalize mental and physical ability, in addition, transportation costs are excluded [13]. In fact, in the food market of Republic of Kazakhstan, it is possible to find whey drinks, except imported ones. And there are no locally produced products enriched with berries of saskatoon berry and black chokeberry. Although these berries are widely known among the population and are used in the preparation of jams, compotes and preparations for the winter, no manufacturer has yet established the processes of growing, collecting and processing these types of berries in industrial conditions.

For the development of safe food products, many industrial entrepreneurs began to pay special attention to the environmental parameters of processing dairy product. With the increase in the volume of high-protein products, large volumes of whey are also formed. In the past, these streams were considered by-products, and they were often disposed of as waste [14].

Therefore, one of the urgent problems of the dairy products is rational use of valuable nutritional components of milk contained in whey. The emissions of whey into sewage systems causes serious environmental problems due to the high content of oxidizable organic compounds in the composition of whey. For example, the average biochemical oxygen demand (BOD) for some whey streams is about 40,000 mg/l, which is about 30 times higher than the runoff limit pree scribed for cultured dairy products and 130 times higher than the runoff limit for cheese products. Therefore, there is a growing demand in the industry for the full use of all milk components, especially whey [15].

The issues of processing whey as a valuable milk-protein raw material occupy one of the first places in the dairy industry in developed countries. In the USA, Canada, Germany, the dairy industry processes from 50–95 % of whey. In comparison in Republic of Kazakhstan it processed less than 10 %. To date, only "Amiran" LLP (Almaty) and "Agrofirma Rodina" LLP (Akmola region) produce whey for sale. However, this whey is not popular among mankind [16]. Due to the unpopularity of whey among the population, dairy plants are in no hurry to produce products based on it. Thus, the objects of this study were selected berries of black chokeberry, saskatoon berry, whey, since the processing of these berries and dairy products is a problem in the Republic of Kazakhstan. Using the experience of foreign manufacturers and researching work of scientists in this field, this work describes the chemical composition of the developed drink based on whey and enriched with wild local berries.

The following statements describes the beneficial properties of whey and saskatoon berry, chokeberry.

Last studies shows that whey proteins have potential as physiological dairy components for people with obesity and metabolic syndrome. High-protein dairy products, and in particular those containing whey proteins, can reduce fat deposition and increase insulin sensitivity [17, 18].

Also, whey proteins significantly reduce cholesterol levels in the blood and have protective functions, in particular, lactoferrin has an iron-binding ability. Lactoferrin is important for the development of newborns, as it prevents the growth of E. coli, staphylococci, Candida albicans in the body and transports the iron ions necessary for the child. Immunoglobulins have antibody activity against the corresponding antigens. Lysozyme has a direct lytic effect on bacteria, destroying their shell. In addition, lysozyme promotes the antibacterial action of antibodies [19]. Milk proteins and peptides also improve the bioavailability of minerals and trace elements such as calcium, magnesium, manganese, zinc, selenium and iron [13].

Wild fruit and berry raw materials are a full-fledged source of various biologically active substances, such as vitamins, polyphenolic substances, organic acids, sugars, macro- and microelements, dietary fibers and a number of others. These compounds required for daily synthesis and cell construction, as well as the implementation of normal metabolic processes and other functions in the human body. The chemical composition of fruit and vegetable raw materials determines the possibility of forming and changing taste, aroma and especially color of any products as a result of technological operations in the manufacture of food [20].

It is obvious use of whey offers tremendous opportunities to manufacturers. Whey proteins and its other components can be used to increase diverse food properties for nutritional, biological, and functional applications. It has been proven that whey has antimicrobial, anti-carcinogenic, immunostimulating and other health-stimulating effects [21]. Taking into account the beneficial biological properties of whey, scientists around the world began to develop new dairy products based on or with the addition of whey. But it cannot be totally implemented to commercial exploitation due to restricted applications base, a lack of viable industrial technologies for protein fractionation.

All this suggests that it is advisable to conduct a study on developing waste-free technologies in dairy industries by using whey as basis for drinks and complete it composition by adding juices of local berries.

3. The aim of the study

The aim of this study is identifying the impact of wild Northern Kazakhstan raw material juices on the chemical composition of whey drinks. Based on this study, it will be possible to develop regulatory and technical documents to produce beverages based on whey enriched with berries. This will expand the range of useful functional food products, subsequently increase the turnover of whey processing, and start processing black chokeberry and saskatoon berries in the northern region of the Republic of Kazakhstan.

To accomplish the aim, the following tasks have been set:

– to investigate effect of the primary treatment of thermosaltic coagulation on the composition and properties of whey by determining the active acidity and titratable acidity;

– to conduct microbiological analysis for determination the safety of the product;

– to determine nutritional value of samples;

– to determine energy value of samples;

– to determine vitamin and mineral composition in the studied samples.

4. Materials and methods

4. 1. Object and hypothesis of the study

In this study, wild berries of Northern Kazakhstan, namely saskatoon berry, chokeberry are used as a fortifier of whey drinks. Objectives of the study is to explore the undisclosed possibilities of wild berries of saskatoon berry, chokeberry and with the help of their use to develop a new product from whey. Thus, will cover two problems in the food industry of the Republic of Kazakhstan.

The main research hypothesis is in the assumption that use of berries will fortified the chemical composition of whey, give to the drink pleasant taste and attractive red color.

Simplification in this work is due to the assumption of a short shelf life of whey after its processing and before its further processing. Since in some cases the transportation of whey to the laboratory was a laborious process, an average amount of no more than 2 hours was taken for the average amount.

4. 2. Sample preparations

The studies was conducted on the basis of sanitary and hygienic requirements for dairy products in accordance with the following test methods. This study was carried out based on the laboratory and dairy shop at Saken Seifullin Kazakh Agrotechnical Research University, Astana, Republic of Kazakhstan and Scientific Research Institute of Food Safety at Almaty Technological University, Almaty, Republic of Kazakhstan.

The objective of the study is natural whey, whey treated with thermosaltic coagulation, drinks based on processed whey fortified by chokeberry, saskatoon berry juices.

Whey from the production of cottage cheese was obtained from Astana-Onim LLP (Akmola region, Republic of Kazakhstan). The natural whey were transported to laboratory within 2 hours since its get out from cottage cheese production. Its titratable acidity when it comes were 61±2 °T.

The berries of chokeberry and saskatoon berry were collected outside Astana city, in the Akmola region. Preparation of samples of chokeberry and saskatoon berries and their processing into juices took place in the laboratory of the Technical Faculty at Saken Seifullin Kazakh Agrotechnical Research University. Juices were get by using squeezer Moulinex. Then they were pasteurized at a temperature of 70±2 °C 10–15 minutes to prolong their shelf life. For the further study, samples of natural whey, whey treated with thermosaltic coagulation and drinks based on whey and berry juices were prepared in the laboratory:

– 1 sample – natural whey;

– 2 sample – whey treated with thermosaltic coagulation;

– 3 sample – drink based on processed whey with juice of saskatoon berry;

– 4 sample – drink based on processed whey with juice of black chokeberry.

The prepared pasteurized berry juices added to whey in next ratio:

– for sample 3–79.5 % of total weight processed whey, 20 % of total weight juice of saskatoon berry and 0.5 % of total weight rosemary infusion;

– for sample 4–79.4 % of total weight processed whey, 20 % of total weight juice of chokeberry and 0.5 % of total weight rosemary infusion and 0.15 of total weight of stevia infusion.

4. 3. Determination of active acidity (pH) and titratable acidity

The pH value was determined using calibrated measurements of the pH meter (Metller Toledo SevenCompact series) at 4 °C. The pH meter was calibrated in a refrigerator at 4 °C with pH 7.0 buffer solutions (KCl 3M), and the pH of the samples was measured at 4 °C.

Titrated acidity was measured by using AOAC standard methods of dairy products research, 2012.

4. 4. Conducting microbiological analysis

The method of detecting Salmonella bacteria (Horizontal method for the detection, enumeration and serotyping of Salmonella) in a certain mass or volume of the product consists of four stages: pre-enrichment in a non-selective liquid medium, enrichment in a selective liquid medium, transfer to cups for identification and identification of microorganisms. Colonies presumably belonging to bacteria of the genus Salmonella are identified using biochemical and serological tests.

The method of detecting L. monocytogenes bacteria in a certain mass or volume of the product consists of four consecutive stages. Primary enrichment of the analyzed sample in a liquid medium with a reduced concentration of selective components (semi-concentrated Frazer broth) at a temperature of 30 °C for 24 hours. Secondary enrichment of seed material obtained earlier in a liquid medium with a full concentration of selective components (Fraser broth) at a temperature of (37±1) °C for 48 hours. Replanting of the received seed material, in parallel on two dense selective media:

a) first environment (mandatory): ALOA;

b) second medium: one of the dense selective media, at the choice of the laboratory, in addition to agar, such as Oxford agar, Stick agar or PAL.

Crops on ALOA are cultivated at a temperature of (37±1) °C and viewed after (24±3) hours, and if necessary after (24±3) hours, monitoring the presence of growth of colonies characteristic of L. monocytogenes.

Crops on the second selective medium are cultivated at an appropriate temperature and scanned for the presence of growth of colonies with growth characteristic of bacteria of the genus Listeria after a certain time.

Replanting of the obtained colonies with characteristic growth for bacteria of the genus Listeria and the species Listeria monocytogenes on dense nutrient media and cultivation at a temperature of (37±1) °C for 24±3 hours and their identification by appropriate morphological, cultural and biochemical characteristics.

Standard methods were used to determine the amount of CMAFAnM and BGCP (coliforms). The essence of the method in determining CMAFAnM is based on the ability of mesophilic aerobic and facultatively anaerobic microorganisms to multiply on dense nutrient agar at (30±1) °C for 72 hours. When determining BGCP, the method is based on the ability of BGCP (indisputable gram-negative, aerobic and facultative anaerobic rods) to ferment lactose in Kessler's nutrient medium with the formation of acid and gas at (37±1) °C for 24 hours.

The method for determining the amount of S. Aureus with pre-enrichment is based on seeding the product and (or) its dilution into a liquid selective medium, incubating crops, taking into account positive vials (flasks), replanting the culture liquid onto the surface of the agarized selective diagnostic medium, confirming by biochemical signs that the isolated typical and (or) atypical colonies belong to coagulase-positive Staphylococcus and S. Aureus.

4. 5. Determination of the nutritional value of samples

Nutritional value is a complex of properties of food products that provide a person's physiological needs for energy and basic nutrients. The main source of energy for a person is proteins, fats and carbohydrates. The mass fraction of the protein was determined by the Kjeldahl method. This method is based on the mineralization of a milk sample with concentrated sulfuric acid in the presence of an oxidizer, an inert salt – potassium sulfate and a catalyst – copper sulfate. In this case, the amino groups of the protein are converted into ammonium sulfate dissolved in sulfuric acid [22].

The mass fraction of fat (in %) in yogurt was determined by the acid method (Gerber method). The method is based on the separation of fat from dairy products under the action of concentrated sulfuric acid and isoamyl alcohol, followed by centrifugation and measurement of the volume of released fat in the graduated part of the fat meter [23].

The mass fraction of carbohydrates was determined according to the Skurikhin method. Sugars are extracted from food products with 80 % vol. ethyl alcohol, taking into account natural moisture. Next, a triple extraction is used for 15 minutes at a temperature of 75–80 °C in a water bath. Alcohol extracts are combined, the alcohol is evaporated under vacuum at a temperature no higher than 40 °C, diluted with hot (80 °C) water and filtered. Further, reducing sugars are determined in the filtrate [23].

4. 6. Determination of the energy value of samples

The energy value of food products determined by using AOAC standard methods of dairy products research, 2012. It is usually expressed in kilocalories (kcal). If it is necessary to convert it to SI, a kilojoule (1 kcal=4.184 kJ) is used. To accelerate the determination of the energy value of products, a standard method was used to recalculate the obtained values of proteins, fats and carbohydrates, taking into account the energy value coefficient and summing the obtained figures.

4. 7. Determination of vitamin composition and mineral substances in the studied samples

The content of B vitamins and vitamin C in the studied products was determined by HPLC. Chromatographic analysis of calibration solutions and sample solution is carried out at the same injection volumes. The thiochrome peak on the chromatogram of the sample solution is identified by the coincidence of its retention time with the retention time of the thiochrome peak on the chromatogram of the calibration solution. Alternatively, the thiochrome peak on the chromatogram of the sample solution is identified by comparing it with the chromatogram of the sample solution with the addition of an analytical standard. Quantitative determination is carried out by the method of an external standard. The result of the determination is calculated using a calibration graph [24–26].

Atomic absorption spectrophotometry method was used to determine the mineral content in the samples under study. The method is based on spraying a solution of the mineralized sample in an air-acetylene flame. Metals in the solution of the mineralizate, falling into the flame, pass into the atomic state. The amount of adsorption of light with a wavelength corresponding to the resonance line is proportional to the value of the metal concentration in the test sample [27].

4. 8. Statistical analyses

Results of the physical-chemical analyses of the formulations was evaluate through the Analysis of Variance (ANOVA). All the results were expressed as means±standard error of triplicates.

5. Results of research of chemical composition of drinks based in whey fortified with sakatoon, chokeberry juices

5. 1. Investigation of effect of the primary treatment by thermosaltic coagulation on the composition and properties of whey by determining the active acidity and titratable acidity

The acidity of the whey at acceptance is 60 °*T*. This is a high indicator for drinks. Therefore, before preparing drinks, it is advisable to process whey by thermosaltic coagulation (Fig. 1). The content of active acidity (pH) and titratable acidity in the studied samples are shown in Table 1.

Fig. 1. Whey before and after thermosaltic coagulation

The method of thermosaltic coagulation of whey includes heating the whey to 92±2 °C, brought to a pH of 6.25 – by adding alkali, because of which the whey proteins become unstable and coagulate. It is last for 15–20 minutes, the whey proteins form agglomerates and settle to the bottom. The clarified whey is decanted (or the proteins are separated from the whey in a centrifuge).

As shown in Fig. 1 fresh whey were collected and used for primary processing by termosaltic coagulation. This treatment allows to decrease the titrable acidity of whey, get more transparent liquid.

Table 1

The content of active acidity (pH) and titratable acidity in the studied samples

Name of samples	Titratable acidity, °T	Active acidity, pH
Natural whey	60	4.2
Whey treated with thermosaltic coagulation	10	6.0
Chokeberry juice	14.8	3.6
Saskatoon berry juice	7.8	4.1
Drink based on processed whey with juice of saskatoon berry	46	4.1
Drink based on processed whey with juice of black chokeberry	47	4.0

Their lack delays the growth and development of the whole organism. Fats in the composition of food are consumed as an energy material, and are also a plastic material, part of cellular components. Carbohydrates are the main energy supplier in the body. Although their energy coefficient is less than that of fats, a person consumes more carbohydrates and gets 50–60 % of the required calories with them. Their complete exclusion from the diet causes the appearance of products of incomplete oxidation of fats (ketone bodies), which lead to disruption of the functions of the central nervous system and muscles [20]. Considering all the properties of these biologically active substances, it is worth noting that they show their most beneficial effect on the body with an optimal ratio with each other.

5. 2. Conduction of microbiological analysis for determination the safety of the product

To determine the purity and quality of the samples studied, a microbiological analysis was carried out for the presence of pathogenic microorganisms, bacteria of the Escherichia coli group (BGCP, coliforms), L.monocytogenes and Staphylococcus aureus, as well as for the number of mesophilic aerobic facultative anaerobic microorganisms (CMAFAnM) (Table 2).

All these assays were conducted by using standard methods that allowed to use in Republic of Kazakhstan.

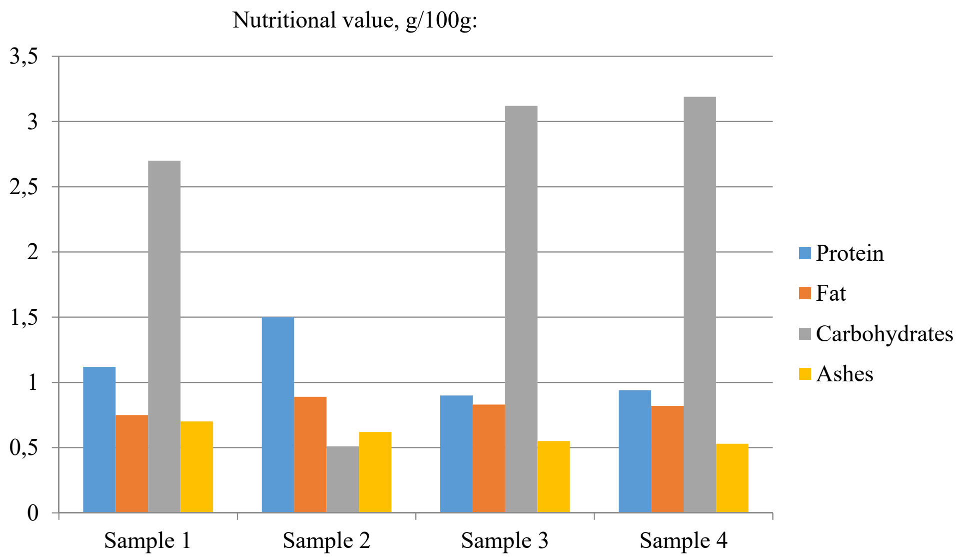

Fig. 2. Nutritional value content in samples, g/ 100 g

Table 2

Results of microbiological analysis

Name of samples	Pathogenic microorganisms, including salmonella, in 25 cm^3 (g)	Bacteria of the E. coli group (coliforms), in 0.01 cm^3 (g)	the number of mesophilic aerobic and facultative anaerobic microorganisms, colony-forming units/cm^3 (g), no more	L.monocytogenes, in 25 cm^3 (g)	Staphylococcus aureus, in 1 cm^3 (g)
Sample 1	Not detected	Not detected	$<1.5\times10^2$	Not detected	Not detected
Sample 2	Not detected	Not detected	$<1.5\times10^2$	Not detected	Not detected
Sample 3	Not detected	Not detected	$<1.5\times10^2$	Not detected	Not detected
Sample 4	Not detected	Not detected	2.6×10^2	Not detected	Not detected

5. 3. Determination of the nutritional value of samples

The nutritional value of food is determined by the content of proteins, fats, carbohydrates, ash (minerals, vitamins, biologically active compounds) in them. The main value of animal proteins is their irreplaceability by other food substances. They participate in the most important functions of the body, replenishing the structure of the body's cells. Fig. 2 illustrates the content of proteins, fats, carbohydrates and ash in the studied samples.

5. 4. The results of the amount of energy value in the studied samples

The energy value content (kcal/kJ/100 g) of the studied samples is indicated in Table 3.

The energy value of the products is determined by the quantitative chemical composition of the food and provides information about the amount of heat energy received when using this product.

Table 3

The content of energy value (kcal/kJ/100 g) in the studied samples

Name of samples	Sample 1	Sample 2	Sample 3	Sample 4
Energy value	22/92	13/54	24/100	24/100

5. 5. The content of vitamins and mineral substances in the studied samples

In this study, the quantitative content of B and C vitamins in the samples studied was determined. Vitamins cannot be synthesized in the human body, so their amount is replenished by eating food, mainly vegetables, fruits and berries.

The content of B vitamins and ascorbic acid in the studied samples is indicated in Fig. 3.

Ascorbic acid is involved in many important enzymatic redox reactions. The result of these reactions is stimulation of the actions of the endocrine glands, improvement of iron digestibility, increase of human resistance to adverse environmental influences.

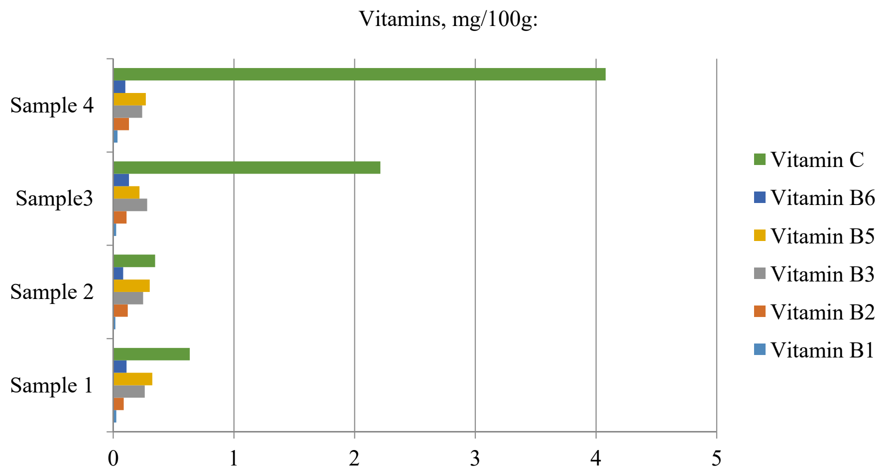

Fig. 3. Vitamin content in the test samples (mg/100 g)

B vitamins are part of a number of enzymes that regulate the metabolism of proteins, fats and carbohydrates, and also play an important role in oxidation reactions in all human tissues.

Mineral substances perform a plastic function in the processes of vital activity of the human body. The mineral content in the samples under study is shown in Fig. 4.

Mineral components are involved in the process of building bone tissue (phosphorus and calcium). Minerals are involved in water-salt, acid-base metabolic processes. Many enzymatic processes depend on the content of a mineral substance.

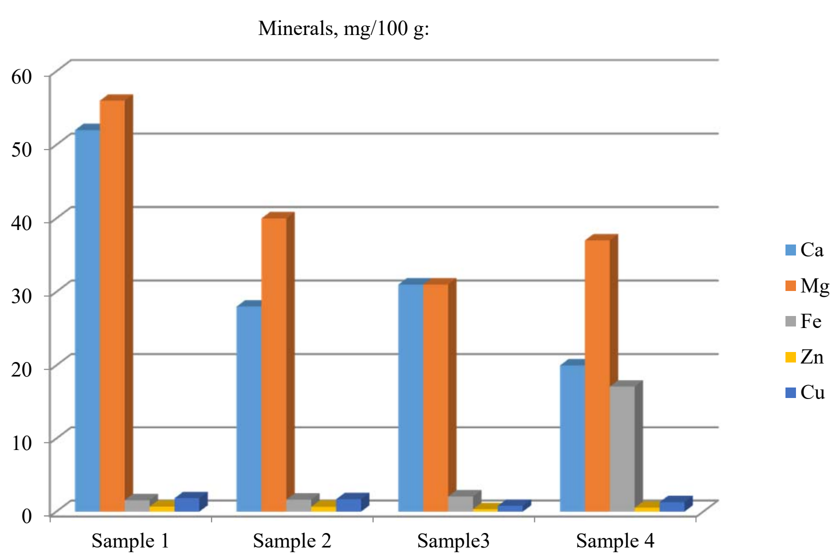

Fig. 4. Mineral content in the samples under study (mg per 100 g)

6. Discussion of the results of assays of chemical composition drinks from whey enriched by saskatoon berry, chokeberry juices

The composition of whey contains a certain amount of lactic acid, which by fermenting sugar increases its titrated acidity, while its shelf life is reducing. That is why a thermosaltic coagulation for primary processing was used. When receiving whey from the enterprise, the titrated acidity of the product was equal to 61±2°T. After thermosaltic coagulation, the titrated acidity of whey decreased to 10 °T (Table 1 and Fig. 1). In comparison with other drinks, some scientists in their research formulate a fortified drink with proteins based on goat milk whey got a lower acidity in it 0.21 %. [28]. In another research work in studied beverages used whey and pineapple (Ananas comosus) juice has higher acidity 1.3 % [29].

The active acidity of whey, on the contrary, increased after thermosaltic coagulation from 4.2 to 6.0. However, after receiving drinks with additives from fruit and berry juices, the active acidity decreased to 4.0. The active acidity of studied samples is almost the same as in whey drink with proteins based on goat milk whey [28] 4.36, and lower than in whey-carrot based functional beverage 6.54 [30].

According to the results of microbiological analysis (Table 2), it can be assumed that all the samples obtained are not seeded with pathogenic microorganisms, Bacteria of the E. coliform group, L. monocytogenes or Staphylococcus aureus, which is a sign of the purity and quality of the product. The number of mesophilic aerobic and facultative anaerobic microorganisms in all samples is contained within the normal range, no more than 1.0×105.

As can be seen from the diagram 2, the protein and fat content becomes lower after processing by thermosaltic coagulation. In drinks with fruit and berry juices, the content of proteins and fats is the same. The carbohydrate content in beverages is higher than in whey, especially after thermosaltic coagulation. The increase in the amount of carbohydrates in drinks depends on the amount of fruit and berry juices added to them. There is also a slight decrease in the ash content in beverages.

Thus, in comparison with beverages from whey with carrot juice drinks and whey-pineapple juice has higher content of protein (1.5 with comparison 0.021–1.06). However, ash content higher in beverages from carrot (7.83 %) than in drinks with berries (1 %).

The energy value of food is a quantitative indicator of the released energy of a food product when it is absorbed by the body. According to the data obtained in Table 3, the energy value of beverages is greater than in whey before and after thermosaltic coagulation due to presence of berry juices.

According to the results of Fig. 3, the largest amount of ascorbic acid is contained in a drink with chokeberry juice (4 mg/100 g). Almost two times less ascorbic acid content was obtained in drinks containing saskatoon berry. In some studies there refers that the daily intake of vitamin C is 62.5 mg per day [31].

The largest amount of vitamin B3 is contained in drinks with saskatoon berry juices (0.28±0.014 mg per 100 g). There is a very small amount of vitamin B1 in all samples (0.024 and 0.036 mg/100 g). Its largest amount is 0.036±0.001 mg per 100 g. The daily intake of vitamin B3 is 12 mg per day and vitamin B1 is 1 mg per day [31].

According to Fig. 4, the biggest amount of calcium and magnesium is contained in whey before thermosaltic coagulation (52 and 56 mg per 100 g, respectively). The magnesium content in drinks with chokeberry juices is higher than in drinks with saskatoon berry (37 and 31 mg per 100 g). The daily intake of magnesium is 420 mg per day [31]. However, the calcium content in drinks with saskatoon berry juices is higher than in drinks with chokeberry juices (31 and 20 mg per 100 g). The daily intake of calcium is 1200 mg per day [31]. The highest iron content is observed in drinks containing juices of chokeberry (17.11±3.42 mg per 100 g). The daily intake of iron is 18 mg per day [31]. The content of zinc and copper in all four samples is insignificant and their greatest amount is noted in the whey before thermosaltic coagulation – 0.68±0.07 mg per 100 g and 1.83±0.22 mg per 100 g.

The results of the study proved that adding fruit juices to whey supplements could be a viable alternative for creating nutritious beverages with the best sensory qualities and can be recommended for consumption.

The results obtained will be used in the field of the food industry and serve as a recommendation for manufacturers. Also, this study was carried out within the framework of a scientific project and the results of the research are used in the preparation of reports. Using these analysis results, it is expected to develop a project for the commercialization of food products in the Republic of Kazakhstan.

During the study, the parameters of the acceptance of whey were revealed. So, it should be noted that whey with a titratable acidity above 65 °T cannot be used. As well as the whey, which was delivered more than 3–4 hours after its production. Also, the whey of a cloudy white color is unacceptable for further processing.

Minor disadvantage of this study is the problem of primary processing of whey. In laboratory conditions, it was possible to use thermosaltic coagulation to achieve optimal values of the acidity of whey. However, on a production scale, the use of this method of processing whey may raise many questions. Therefore, as an alternative, the method of microfiltration and ultrafiltration of whey as a primary treatment will be studied in the future.

7. Conclusions

1. To achieve more stable and attractive for consumers product the thermosaltic coagulation as a primary treatment of whey were used (Fig. 1). As a result, the titrated acidity in the whey decreases from 60 °T to 10 °T, and the liquid itself becomes more transparent. Active acidity (pH) increased from 4.2 to 6.0.

2. To determine the safety of the studied product the microbiological assays were used. According to the results of microbiological analysis, no deviations from the normal were detected, namely Pathogenic microorganisms, Bacteria of the E. coli group (coliforms), L. monocytogenes, Staphylococcus aureus are not detected. That means the high safety of studied products. The number of mesophilic aerobic and facultative anaerobic microorganisms was $<1.5\times10^2$ colony-forming units/cm^3 for sample 1–3 and 2.6×10^2 colony-forming units/cm^3 for sample 4.

3. In terms of nutritional value, the resulting drinks are rich in carbohydrates (3.25/100 g) in comparison with whey (2.75/100 g). This dependence is due to the enrichment of drinks with berry juices, which are rich in carbohydrates, has small amount of protein and fats.

4. The energy value in drinks fortified with berries is greater than in processed whey – 24 kkal/100 g against 13–22 kkal/100 g. This can be attributed to the high carbohydrate composition of used berries.

5. According to vitamin content, among all the samples, drinks containing saskatoon berry, chokeberry juices are the richest in B vitamins (<0.5 mg/100 g) and ascorbic acid (<2.5 mg/100 g). Also, this drink is rich in iron and magnesium compared to other samples.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Data will be made available on reasonable request.

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Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the currrent work.

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