

# Development of a Technology for Producing an Alcohol-free Beverage Based on Whey

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**Abstract** The possibility of using curd whey and cheese whey to produce alcohol-free beverage has been researched. The study aims to develop a refreshing functional beverage based on whey with the addition of natural flavoring additives, as well as to study its chemical composition and consumer properties. Whey was examined for organoleptic indicators (colour, visible purity, presence of impurities, spots of mold; smell, taste; density, viscosity, and homogeneity), the mass fraction of fat, protein, active and titratable acidity, and the content of nitrogen, carbon, and hydrogen were determined. The content of macroelements in whey and beverage samples was determined by elemental analysis. Honey was researched for organoleptic parameters: the surface of the product, its colour, visible purity, presence of impurities, spots of mold; smell, taste; density, viscosity, and homogeneity. The microbial count of the product was determined for *Staphylococcus aureus*, *Salmonella* spp., and *E. coli* group bacteria. Based on the research results, formulas for two beverages were developed: curd whey, honey, and lemon juice; cheese whey, grated lemon, and sugar syrup. Based on the data of the elemental analysis conducted within the framework of the research, in the developed beverages compared to whey, the content of the studied organogenic elements increases, which, in the authors' opinion, may contribute to the activation of metabolism, specifically the synthesis of proteins and carbohydrates. It was experimentally established that the shelf life of the produced beverage is five days.

**Keywords:** whey, beverage, organoleptic indicators, microbiological indicators, acidity, macroelements.

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## 1. Introduction

Increasing the average lifespan of the population is one of the most important tasks in the field of sustainable development of a country. It is planned to achieve this by implementing mechanisms to ensure the nation's health. These mechanisms primarily include healthy nutrition.

According to the World Health Organization, a person's health depends only 10% on the healthcare system and 50% on lifestyle, shaped by the person's environment, quality of life, and the availability of opportunities for health improvement. Quality nutrition is the basis for healthy development. [1,2]

For several years, work has been underway at the Abylkas Saginov Karaganda Technical University as part of the "Biotechnology" educational program to create alcohol-free beverages based on whey. [3,4]

There is growing interest in beverages based on whey, as its use positively affects not only consumer health but also company revenues, reducing raw material costs and, therefore, the cost of production. [5,6,7] Whey is a dairy

industry waste product left over from the production of curd and cheese. Often it is not used further and is dumped. However, it contains a complex of biologically active substances that positively affect human health. [8] Using whey as a raw material for beverage preparation addresses its disposal issues.

Therefore, obtaining beverages, which include whey containing a complex of biologically active substances as one of the main ingredients, is very promising.

It is known that the impact of whey on the body is significant. [8] It helps with stress, relieves neuroses, and improves the stability of a person's emotional state. Whey is recommended for consumption with gastritis with low acidity and to stimulate the secretion of digestive glands. It normalizes intestinal microflora, eliminates putrefactive processes caused by low-quality products, and helps to remove excess cholesterol and toxic substances from the blood.

Also, whey assists in the following diseases: atherosclerosis, diabetes, chronic constipation, cardiosclerosis, dysbiosis, angina, ischemia, secondary hypertension, chronic respiratory organ problems, and skin lesions. Moreover, whey may have a beneficial effect on diseases of the female reproductive

system (herpes, disruption of microflora, cystitis).

Whey is especially beneficial for the elderly and children. In children's nutrition, whey partially replaces breast milk. Thanks to the high content of antioxidants, this product slows down the body's aging. Whey is also beneficial for physical training. [9]

Whey is applied in several areas. It is widely used in three related branches:

1. In medicine. [10] Many valuable drugs are created based on it;
2. In nutrition. [7] Dietary and children's nutrition is only possible with this product. Whey provides growth, normal development, and functioning of the human body at any age;
3. In cosmetology. [11] Whey is particularly beneficial for hair and facial skin. Many creams, shampoos, facial masks, and balms are made on this basis. Shampoos based on whey gives volume to the hair and strengthen its structure. Quite often, this product is used to treat psoriasis. Recent studies have shown that whey contains particular low-molecular-weight proteins responsible for regenerating human body cells. [8,9].

This study aims to develop a refreshing functional beverage based on whey with natural flavoring additives and research its chemical composition and consumer properties.

Following the set objective of the study, the following tasks were solved in the work:

- develop technology for producing a beverage based on whey;
- research the composition, physicochemical, biochemical, microbiological, and organoleptic indicators of the new product;
- develop technical documentation for the functional whey beverage.

## 2. Materials and methods

### 2.1. Materials

The following products were used in the production of the beverage:

- curd whey of “‘Natige’ Sut Fabrikasy” LLP, corresponding to State Standard 53438-2009 “Dairy whey. Specifications”;
- cheese whey of “‘Natige’ Sut Fabrikasy” LLP, corresponding to State Standard 34352-2017 [13];
- natural honey, corresponding to State Standard “Natural honey. Specifications”;
- lemons, corresponding to State Standard 4429-82 “Lemons. Specifications”;
- vanillin, corresponding to State Standard 16599-71 “Vanillin. Specifications”;
- white sugar, corresponding to State Standard 33222-2015 “White sugar. Specifications”;
- water corresponding to State Standard 51232-98 “Drinking water. General requirements”.

State Standards are generally accepted in the territory of Kazakhstan. Standard methods for determining physicochemical, biochemical, and microbiological indicators were used in the work.

## 2.2. Methods

### 2.2.1. Characteristics of the Used Equipment

The production of the beverage was carried out on the following equipment — automatic CIP (clean-in-place) stations, a curd vat, a reservoir for the removal of excess air, a centrifugal pump for whey, a vertical paired filter, a pasteurizer, a cooler, homogenizer, an automatic bottling line with an ultra-clean filling system. The equipment supplier for the enterprise is the Swedish company “Tetra Pak”.

Automatic CIP stations. Performance is 10,000 liters/hour. The automatic CIP cleaning system uses a PLC microprocessor with electronic programming of washing phases. The system includes a device for the restoration of solutions. The line includes a cylindrical tank made of stainless steel; pneumatic valves; electronic automatic temperature control; centrifugal pumps; and devices for restoring solutions.

Pasteurizing-cooling units allow for the pasteurization of milk and other food products at temperatures of 62-95°C (a range of temperatures which, according to the technical specifications indicated in the operation manual, can be used on this unit) with the possibility of adjusting the temperature of the product at the outlet. When working to improve the technology of producing an alcohol-free beverage based on whey, pasteurization was carried out at temperatures of 62-65°C. The “Tetra Pak” pasteurizing-cooling unit configuration includes a separator-cream separator; flow normalizer; homogenizer; microfuge. Control of all line elements was performed from a single panel.

The automatic bottling line with an ultra-clean filling system is designed to fill plastic bottles with dairy and other liquid food products. It can handle different types of bottles, including those made from PET or XDPE.

At the entrance to the monoblock, the stream of bottles is split into two. Six bottles are simultaneously placed under the dispensers. The bottlenecks are secured in a fixed position, ensuring the filling stage's accuracy. Dispenser nozzles are lowered into the bottles, and filling begins. As the bottles are filled, the dispensers rise at a specified speed, ensuring a minimum gap between the nozzles and the product, thus preventing splashing and foaming. After filling, the bottles are immediately passed to the capping station. This station has three screwing cartridges, which receive the cap from a horizontal table and then precisely place it on the bottle. This Pick-and-Place technology ensures virtually perfect cap screwing without skewing or under-screwing and can handle caps of various models with different types of material. The line configuration in the ultra-clean system version includes a bottle orienter; aseptic bottle rinser; bottling monoblock; labeler; date coder; conveyor group for supplying filled bottles with a label; an automatic group packaging machine. [12]

To prepare the beverage in laboratory conditions, a Japanese autoclave SANYO Labo Autoclave MLS-2420U was used. The whey was autoclaved at a temperature of 105°C for 15 minutes. The automatic autoclave of the Japanese company Sanyo has a built-in safety system, which is maintained by microprocessor control. The safety system blocks the autoclave from turning on in case of insufficient water or an open chamber door. The

temperature inside is maintained with an accuracy of up to 1 °C.

In addition to the equipment listed above, a shaker from the company EKROS model PE-6500 without heating was used in laboratory conditions. The shaker is designed for the simultaneous mixing of liquids in several vessels with volumes from 100 to 1000 ml by reciprocating the movement of the platform.

### 2.2.2. Scheme of the Experiment

At the study's initial stage, the experiment's objectives were set. In accordance with these objectives, tasks were identified, and research methods were chosen.

In the second stage of the study, the use of ground (homogenized) lemons or lemon juice to produce a functional beverage was justified. The composition and properties of cheese whey and unsalted curd whey

(hereinafter referred to as “whey”) and ground lemons were studied. Additionally, it was decided to conduct studies using natural honey, sugar syrup, mint extract, and flavorings.

The third stage of the research was dedicated to working out the parameters for obtaining products based on curd whey, natural honey, and lemon juice. For this, experiments were carried out to study the influence of different mass fractions of ground lemons (within 2 to 6%) and the mass fraction of honey or sugar syrup (within 1 to 10%) on the scoring assessment of taste and aroma, and the scoring assessment of consistency. Additionally, separate experiments were conducted using cheese whey (unsalted) and sugar syrup.

The final stage of the research involved analyzing the conducted studies.

The basic scheme of production is presented in [Figure 1](#).

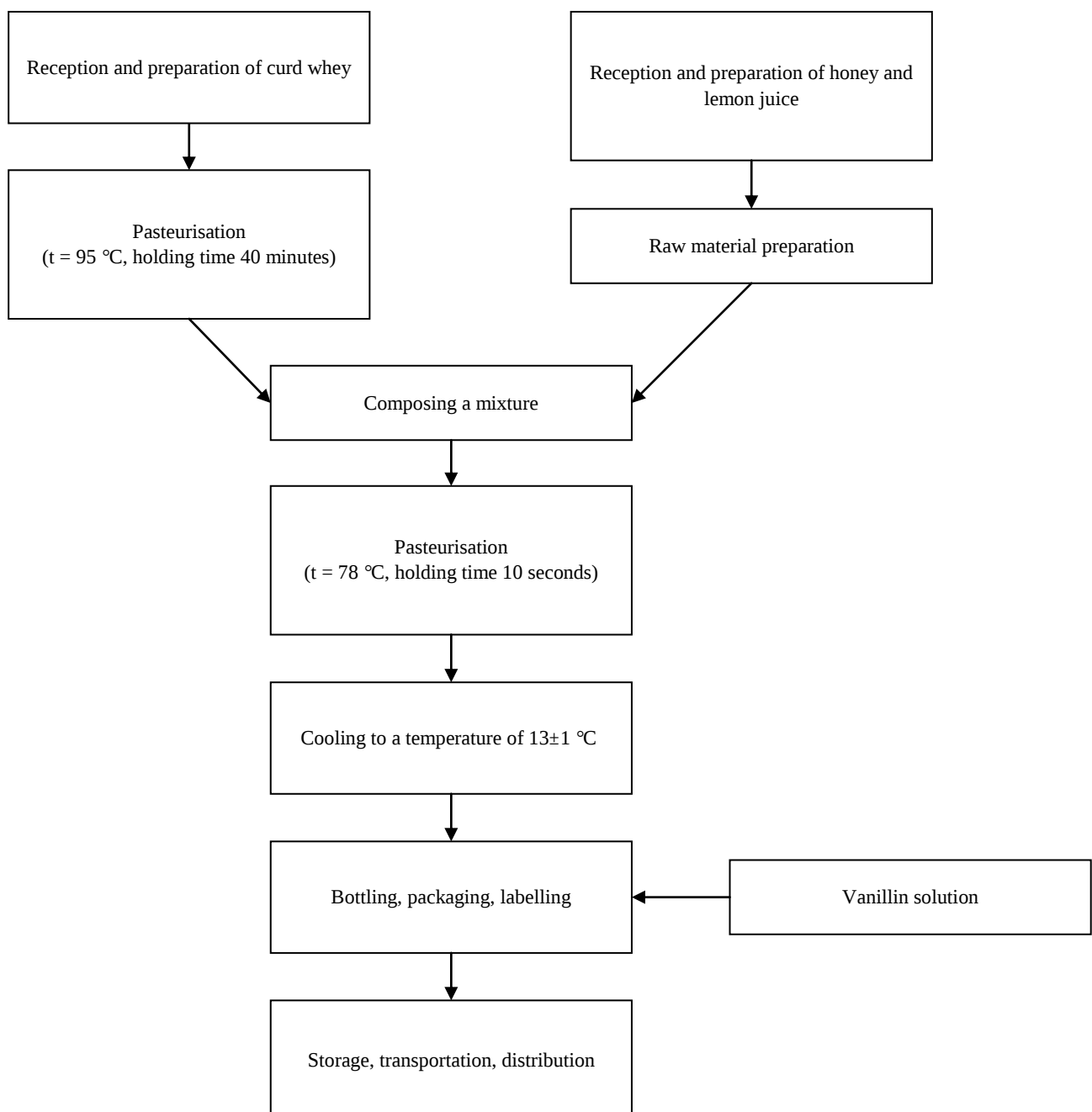


Figure 1. Beverage production scheme

### 2.3.3. Techniques Used in the Experiment

Organoleptic evaluation of whey. The product's surface, colour, cleanliness, impurities, and mold spots were examined; smell and taste were identified; thickness, viscosity, and homogeneity were evaluated by rubbing a sample in the mouth by the tongue. [14]

Determination of the fat mass fraction by the acid method. The method is based on the extraction of fat from milk and dairy products under the action of concentrated sulfuric acid and isoamyl alcohol, followed by centrifugation and measurement of the fat volume in the calibrated part of the butyrometer. [15]

Determination of the protein mass fraction by the Kjeldahl method. The method is based on burning organic components of a milk sample in a Kjeldahl flask in the presence of sulfuric acid; the nitrogen released is determined by titration, and the protein content is calculated based on its quantity. [16]

Determination of the fat mass fraction by the acid method. The method is based on the extraction of fat from milk and dairy products under the action of concentrated sulfuric acid and isoamyl alcohol, followed by centrifugation and measurement of the fat volume in the calibrated part of the butyrometer. [15]

Determination of active and titratable acidity. The method is based on neutralizing acids in the product with a sodium hydroxide solution in the presence of a phenolphthalein indicator. [17]

The nitrogen, carbon, and hydrogen content in the whey was determined using an EA3100 Elemental Analyzer (made in Italy).

Organoleptic evaluation of honey. The product's surface, colour, cleanliness, impurities, and mold spots were examined; smell and taste were identified; thickness, viscosity, and homogeneity were evaluated by rubbing a sample in the mouth. [18]

Lemons with zest were mechanically ground to obtain a crushed mass, and natural honey was placed in a thermostat at a temperature of 40°C for 40 minutes to bring it to a liquid consistency.

Detection and determination of *Staphylococcus aureus*. The method for determining the amount of *Staphylococcus aureus* without prior enrichment by seeding on agarized selective media is based on sowing the product or diluting it on the surface of a solid medium, incubating, counting typical *Staphylococcus aureus* colonies and subsequently confirming the grown colonies as *Staphylococcus aureus* based on their plasma coagulation ability. [19]

Detection and determination of *Salmonella* spp. The method for detecting *Salmonella* spp. is based on seeding a certain amount of the product into a liquid non-selective medium, incubating the cultures, subsequently identifying in these cultures bacteria capable of developing in liquid selective media, forming typical colonies on agarized differential-diagnostic media, having biochemical and serological characteristics typical for *Salmonella* spp. [20]

Detection and determination of *E. coli*. The method for detecting and determining the most probable number of *E. coli* is based on seeding a certain amount of the product and dilutions of the product suspension into a liquid selective medium with lactose, incubating the cultures, counting positive test tubes, reseeded, if necessary, the culture liquid onto the surface of agarized selective-

diagnostic medium for confirmation by biochemical and cultural characteristics of the growth of the isolated colonies belonging to coliform bacteria. [21]

The methodologies are taken from State Standards, ensuring a product is safe for public health. State Standards help ensure safety by setting standards for contamination levels, ingredients permissible for use, and storage conditions. For a whey-based beverage, following these standards can help prevent foodborne illness and other health risks. State Standards for products describe their approved quantitative and qualitative composition. International studies on this topic are described in the introduction. State Standards ensure that products are consistent within a brand and across the industry. For manufacturers, this can help scale production up and maintain product quality over time.

## 3. Results and Discussion

According to the tasks set, the first stage involved the acceptance and assessment of whey and the determination of its physicochemical indicators. The whey quality assessment scheme is presented in Figure 2.

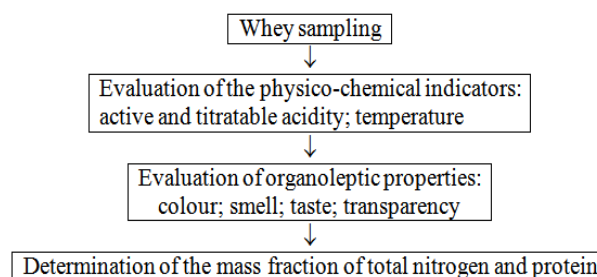


Figure 2. Quality assessment scheme for whey

Several batches of whey were used to assess physicochemical properties. [17] The results of the physicochemical indicators study are presented in Table 1.

A sensory assessment of whey was carried out by a tasting committee of students and teachers from the department according to the relevant standards. [14] The results are presented in Table 2.

The content of the mass fraction of total protein was determined by the Kjeldahl method and is presented in Table 3. [16]

Lemon juice was used in quantities of 2%, 4%, and 6% to improve the sensory indicators of the beverage. Lemon juice was added to the whey and allowed to stand for five days. The data are presented in Table 4.

As can be seen from the table, as the content of lemon juice increases, the acid formation process proceeds more intensively. In the control sample, acidity increases slower than in samples containing lemon juice. Samples with added lemon juice have more excellent acidity compared to the control sample. In this case, the content of lemon juice at 2% is optimal according to sensory indicators.

Data on the impact of lemon juice on the pH of the beverage are presented in Table 5. The data in Table 5 confirms the data in Table 4. With an increase in the content of lemon juice, the acid-forming process proceeds more intensively. In the control sample, acidity increases slower than in samples containing lemon juice.

**Table 1. Physico-chemical parameters of whey**

| Indicator             | Batch number |     |     |
|-----------------------|--------------|-----|-----|
|                       | 1            | 2   | 3   |
| Active acidity, units | 4,3          | 4,4 | 4,3 |
| Titrate acidity, °T   | 52           | 54  | 51  |
| Temperature, °C       | 24           | 20  | 23  |

**Table 2. Organoleptic characteristics of whey**

| Indicator    | Characteristic          |
|--------------|-------------------------|
| Transparency | not transparent, turbid |
| Colour       | light greenish hue      |
| Smell        | neutral, whey-like      |
| Taste        | sour, milky             |

**Table 3. Mass fraction of total nitrogen and total protein, %**

|                | Batch number |       |       |
|----------------|--------------|-------|-------|
|                | 1            | 2     | 3     |
| Total nitrogen | 2,06         | 1,88  | 1,97  |
| Total protein  | 13,14        | 11,99 | 12,57 |

**Table 4. Effect of lemon juice on the acidification process**

| Duration | Titrate acidity, °T             |      |      |      |
|----------|---------------------------------|------|------|------|
|          | Mass fraction of lemon juice, % |      |      |      |
|          | 0                               | 2    | 4    | 6    |
| 12 hours | 54                              | 55,2 | 56,5 | 57,3 |
| 24 hours | 56,7                            | 56,3 | 58,1 | 59,7 |
| 3 days   | 56,8                            | 56,9 | 59,6 | 61,2 |
| 5 days   | 57,4                            | 57,6 | 60,4 | 63,5 |

**Table 5. Effect of lemon juice on pH**

| Duration | pH                              |      |      |      |
|----------|---------------------------------|------|------|------|
|          | Mass fraction of lemon juice, % |      |      |      |
|          | 0                               | 2    | 4    | 6    |
| 12 hours | 4,3                             | 4,27 | 4,24 | 4,18 |
| 24 hours | 4,22                            | 4,23 | 4,17 | 4,12 |
| 3 days   | 4,14                            | 4,13 | 4,05 | 3,99 |
| 5 days   | 4,01                            | 3,98 | 3,92 | 3,82 |

**Table 6. Study of organoleptic characteristics at different mass fraction of lemon juice**

| Sample                           | Taste, smell                                    | Consistency |
|----------------------------------|-------------------------------------------------|-------------|
| Control sample                   | neutral, clear, sour-milky                      | Homogeneous |
| Mass fraction of lemon juice 2 % | sour-milky with a slight lemon juice aftertaste | Homogeneous |
| Mass fraction of lemon juice 4 % | sour-milky with distinct lemon juice flavour    | Homogeneous |
| Mass fraction of lemon juice 6 % | sour milk with strong lemon juice flavour       | Homogeneous |

The research established that an increase in the content of lemon juice in whey affects sensory indicators. Therefore, with a 2% mass fraction of lemon juice, the acidity of the beverage remains at the level of acidity of curd whey, while the sensory indicators change significantly.

The results are presented in [Table 6](#).

The same tasting committee performed the organoleptic evaluation of honey indicators according to the relevant standards. [\[18\]](#) The results are presented in [Table 7](#). According to the research, the honey used in work had a strong, pleasant aroma without foreign odours, sweet and pleasant to taste with a hint of slight bitterness that quickly disappears, a light-amber colour, and a viscous, sticky consistency.

**Table 7. Organoleptic characteristics of honey**

| Indicator   | Characteristic                                               |
|-------------|--------------------------------------------------------------|
| Aroma       | strong, pleasant and free of any extraneous smell            |
| Taste       | sweet, pleasant, with a slight bitterness that fades quickly |
| Colour      | light amber                                                  |
| Consistency | viscous and thick                                            |

**Table 8. Study of organoleptic characteristics at different mass fraction of natural honey**

| Sample                      | Taste, smell                                                           | Consistency |
|-----------------------------|------------------------------------------------------------------------|-------------|
| Control sample              | sour-milky with a strong lemon juice taste                             | Homogenous  |
| Mass fraction of honey 1%   | sour-milky with a strong lemon juice taste, without honey              | Homogenous  |
| Mass fraction of honey 2%   | sour-milky with strong lemon juice taste, with a slight touch of honey | Homogenous  |
| Mass fraction of honey 4%   | sour-milky with distinct lemon juice and honey taste                   | Homogenous  |
| Mass fraction of honey 10 % | sour-milky with strong taste of honey, no lemon juice present          | Homogenous  |

**Table 9. Physico-chemical, organoleptic and microbiological parameters of the finished beverage**

| Indicator name                                                                              | Standard for the product                                     |
|---------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| pH                                                                                          | 4,27                                                         |
| Temperature when leaving the factory, °C max.                                               | 8                                                            |
| Phosphatase                                                                                 | none                                                         |
| Saccharose, %                                                                               | 7,8                                                          |
| Colour                                                                                      | light greenish, evenly distributed over the entire mass      |
| Taste and aroma                                                                             | sour, with a characteristic flavour of the ingredients added |
| Consistency                                                                                 | homogeneous, liquid                                          |
| E. coli bacteria in 0.01 cm <sup>3</sup>                                                    | not allowed                                                  |
| Pathogenic microorganisms, including Salmonella in 25 cm <sup>3</sup> of the product        | not allowed                                                  |
| Staphylococcus aureus in 1.0 cc product                                                     | not allowed                                                  |
| Number of yeasts and moulds in 1 cm <sup>3</sup> of the product, CFU/cm <sup>3</sup> , max. | 50                                                           |

Honey was used in quantities of 1%, 2%, 4%, and 10% to improve the sensory indicators of the beverage. Honey was added to the whey, having previously added 2% lemon. The tasting committee conducted a sensory assessment of the beverage. [\[14\]](#) The results are presented in [Table 8](#).

According to the results of the tasting committee, the beverage with a 4% mass fraction of honey was recognized as optimal according to sensory indicators.

The components under study have been tested in preparing a beverage with honey and lemon juice, the technology of which is given below. Curd whey was pasteurized at 95 °C, then kept at the pasteurization temperature for 40 minutes, then cooled to 50 °C.

Vanillin was used in 0.1% of the product's weight in the form of a pasteurized 2% whey solution to improve the aromatic properties of the beverage. Honey and lemon juice (calculated as 4 kg of honey and 2 liters of lemon juice per 100 liters of whey) were added to the whey at a temperature of 50 °C. The mixture was filtered, pasteurized at a temperature of 78 °C for 10 seconds, and cooled to (13±1)°C. The finished beverage was sent for bottling.

Samples of the finished beverage were stored at a

temperature of 3...6°C after production. Every 24 hours, dilution samples were seeded into nutrient media: for determining *E. coli* bacteria — Kessler medium; for determining yeast and mold — Saburo medium. [19,20,21]

The standard indicators of the beverage are presented in Table 9.

Microbiological indicators of the freshly prepared beverage and during storage are presented in Table 10.

The results of the analyses show that the product fully meets the microbiological requirements of the technical regulations for milk and dairy products.

Also, every 24 hours, acidity level measurements of control samples were made. Indicators of the acidity level of the freshly prepared beverage and during storage are given in Table 11.

**Table 10. Microbiological characteristics of the finished beverage**

| Indicator         | Indicators during storage |        |         |
|-------------------|---------------------------|--------|---------|
|                   | fresh                     | 5 days | 10 days |
| Coliform bacteria | not detected              |        |         |
| Yeast             | not detected              |        |         |
| Mold              | not detected              |        |         |

**Table 11. Acidity levels in the finished beverage**

| Indicator | Indicators during storage |           |           |
|-----------|---------------------------|-----------|-----------|
|           | fresh                     | 5 days    | 10 days   |
| pH        | 4,27±0,05                 | 3,98±0,05 | 3,26±0,05 |

Given that curd whey and lemon juice have a high level of acidity, which begins to increase during storage, the beverage made from these components also gains acidity during storage. Thus, it was experimentally proven that the optimal storage period for the beverage is five days.

The effect of various mass fractions of lemon juice and honey on the state of consistency and the sensory indicators of a functional beverage based on whey was studied. It was found that when producing a beverage based on whey, the reasonable amounts of used ingredients, allowing to obtain a product with good sensory indicators, are as follows: 2% lemon juice, 4% natural honey dosage. Thus, a recipe and production technology for a beverage based on whey were developed.

The staff of the “Biotechnology” specialty of the “Chemistry and Chemical Technologies” department continued to improve the technology for producing alcohol-free beverages based on whey.

The following changes were made to the beverage recipe:

1. Cheese whey, which contains more beneficial substances, replaced curd whey.
2. Grated lemon was added instead of lemon juice. Using only lemon juice in the beverage is not economically beneficial, as much waste has to be thrown away. Meanwhile, lemon peel contains more vitamins than lemon juice and helps to combat toxic elements in the body.
3. Sugar syrup was added instead of honey because the presence of honey is dangerous for people allergic to this product. Also, using natural honey makes the beverage more expensive.

In this series of experiments, we used juice, grated lemon, and sugar syrup in 6%/2%/10%, 4%/1%/10%, and 3%/3%/10%, respectively. The organoleptic evaluation of the beverage was conducted by a tasting panel. The results are presented in Table 12.

**Table 12. Study of organoleptic characteristics at different mass fraction of sugar syrup, lemon zest and juice**

| No. | Sample                                                                                                   | Taste, smell                                         | Consistency |
|-----|----------------------------------------------------------------------------------------------------------|------------------------------------------------------|-------------|
| 1   | Mass fraction of lemon juice 6 %<br>Mass fraction of lemon zest 2 %<br>Mass fraction of sugar syrup 10 % | Sour milk with a strong lemon aroma                  | Homogeneous |
| 2   | Mass fraction of lemon juice 4 %<br>Mass fraction of lemon zest 1 %<br>Mass fraction of sugar syrup 10 % | Sour milk with a mild lemon aroma                    | Homogeneous |
| 3   | Mass fraction of lemon juice 3 %<br>Mass fraction of lemon zest 3 %<br>Mass fraction of sugar syrup 10 % | Milk-based sour milk with a pleasant taste and aroma | Homogeneous |

According to the conclusion of the tasting panel, this sample of beverage No.3 was deemed successful.

The elemental analysis results (Table 13) showed that whey contains small amounts of nitrogen, carbon, and hydrogen. In the beverage we propose, the content of the studied organogens increases, which indicates the activation of metabolism, namely the synthesis of proteins and carbohydrates. Molecular hydrogen protects DNA, RNA, and proteins from oxidative stress. Due to its ability to easily penetrate cells, it quickly neutralizes cytotoxic oxygen radicals that clog the human body.

**Table 13. Nitrogen, carbon and hydrogen content of whey**

| Name of sample   |    | Whey        | Whey with lemon juice |
|------------------|----|-------------|-----------------------|
| Nitrogen content | mg | 25,83±0,2   | 56,97±0,29            |
|                  | %  | 3,15±0,01   | 6,75±0,06             |
| Carbon content   | mg | 364,63±5,49 | 480,60±3,96           |
|                  | %  | 44,48±0,62  | 56,95±0,2             |
| Hydrogen content | mg | 58,1±0,76   | 73,97±0,62            |
|                  | %  | 7,09±0,08   | 8,76±0,04             |

The analysis of the nitrogen, carbon, and hydrogen content, carried out by the EA3100 Elemental Analyzer (made in Italy), showed that a beverage prepared based on cheese whey promotes the enhancement of protein and carbohydrate synthesis enhancement. Meanwhile, nitrogen, carbon, and hydrogen are structural components of all organic compounds, but pure elements do not play an essential biological role. Their presence in the beverage positively affects the enhancement of the synthesis of necessary organic molecules. In addition, hydrogen molecules are considered the most powerful natural antioxidant, which helps maintain the health of the body, contributes to its quick recovery, and reduces the load on the immune system.

## 4. Conclusion

The study successfully explored the potential of utilizing curd whey and cheese whey in the formulation of alcohol-free beverages, resulting in the development of two distinctive recipes. One beverage was formulated with curd whey, honey, and lemon juice, while the other

incorporated cheese whey, grated lemon, and sugar syrup. An extensive analysis of the beverages' chemical compositions was conducted, focusing on organoleptic indicators, macronutrient contents, and microbiological purity.

The elemental analysis demonstrated an increase in the content of organogens (nitrogen, carbon, and hydrogen) in the developed beverages compared to whey alone, which the authors suggest may enhance metabolic activity, particularly the synthesis of proteins and carbohydrates. The microbiological analysis ensured the absence of harmful microorganisms such as *Staphylococcus aureus*, *Salmonella* spp., and *E. coli*.

Furthermore, the beverages exhibited desirable organoleptic characteristics, including colour, smell, taste, density, viscosity, and homogeneity, with the honey used also adhering to the standards. The beverages developed in this study were found to have a shelf life of 5 days.

In conclusion, the results of this study offer good insights into the production of functional, refreshing, and nutritious alcohol-free beverages from curd and whey, thereby presenting a novel approach to the re-utilization of these byproducts. Further studies could research the impact of varying the recipe components or using different natural additives to expand the range of beverages produced.

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The authors declare no conflict of interest.

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