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FUNCTIONAL WHEY-BASED DRINKS WITH GRAPE POMACE EXTRACT AND FRUIT JUICE

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Industrial waste leads to pollution and deterioration of the environment, as well as harming the living population and animals. Whey, being a by-product of milk processing, is a source of protein and nitrogenous compounds, carbohydrates, lipids, mineral supplements, vitamins, organic acids, enzymes and macro- and microelements. Amino acid content of whey is represented by amino acids of protein substances and free amino acids. The next valuable secondary raw material is grape pomace, which is practically not processed and becomes a factor of anthropogenic load, polluting the environment. Grape pomace has a rich chemical composition, especially a large number of phenolic compounds, which have antioxidant properties. Currently, there is a significant increase in the production and consumption of soft drinks with various additives, the composition of which is replete with unnecessary colors and flavors. The aim of the work is to use milk whey for the development of technology of drinks of functional purpose, which will directly increase the efficiency of its processing, as a secondary raw material in industrial production, as well as serve the purpose of improving the environmental situation in places where milk processing plants are located. In particular, the creation of functional drinks on the basis of milk whey with the addition of grape pomace, fruit juices and pectin, will enrich the milk drink with a complex of biologically active substances, trace elements, antioxidants, vitamins. Using organoleptic and physico-chemical parameters, two technologies of functional drinks based on milk whey with 25% Husein Black grape pomace extract, in the first 25% cherry and in the second 25% peach juices were developed. The first formulation demonstrated noteworthy macro- and microelement content, including calcium (12.10%), sodium (5.04%), magnesium (1.60%), phosphorus (7.31%), and potassium (24.61%). Similarly, the second formulation exhibited significant macro- and microelement composition, including calcium (9.50%), sodium (4.28%), magnesium (1.33%), phosphorus (6.37%), and potassium (21.91%). All microbiological indicators meet the requirements of GOST and indicate the absence of pathogenic microflora, which is one of the indicators of guaranteed sanitary well-being of the proposed products. The developed drinks have pleasant organoleptic indicators, high biological value and low cost price.

Keywords: Functional food products, secondary raw materials, polyphenols, antioxidants, macro- and microelements.

ЖҮЗІМ КҮНЖАРАСЫ СЫҒЫНДЫСЫ МЕН ЖЕМІС ШЫРЫНЫ ҚОСЫЛҒАН САРЫСУ НЕГІЗІНДЕ ФУНКЦИОНАЛДЫ СУСЫНДАР

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Өнеркәсіптік қалдықтар қоршаған ортаның ластануына және нашарлауына әкеледі, сонымен қатар тұрғындар мен жануарларға зиян келтіреді. Сүт сарысуы, сүтті өңдеудің жанама өнімі, ақуыз және азотты қосылыстардың, көмірсулардың, липидтердің, минералды қоспалардың, витаминдердің, органикалық қышқылдардың, ферменттердің және макро - және микроэлементтердің көзі болып табылады. Сарысудың аминқышқылдарының құрамы ақуызды заттардың аминқышқылдары мен бос аминқышқылдарынан тұрады. Келесі құнды қайталама шикізат-жүзім сығындылары, олар іс жүзінде өңделмейді және қоршаған ортаны ластайтын антропогендік факторға айналуда. Жүзім сығындылары бай химиялық құрамға ие, әсіресе антиоксидантты әсері бар фенолды қосылыстардың көп мөлшері бар. Бүгінгі таңда құрамы қажетсіз түстер мен хош иістерге толы әртүрлі қоспалары бар алкогольсіз сусындарды өндіру мен тұтынудың айтарлықтай өсуін атап өтуге болады. Жұмыстың мақсаты сүт сарысуын функционалды мақсаттағы сусындар технологиясын әзірлеу үшін пайдалану болып табылады, бұл оны өнеркәсіптік өндірістерде қайталама шикізат ретінде өңдеудің тиімділігін тікелей арттырады, сондай-ақ сүт өңдеу зауыттарының орналасқан жерлеріндегі экологиялық жағдайды жақсарту мақсатына қызмет етеді. Атап айтқанда, жүзім сығындысы, жеміс шырындары мен пектин қосылған сүт сарысуы негізінде функционалды сусындар әзірлеу өнімді биологиялық белсенді заттар, микроэлементтер, антиоксиданттар, дәрумендер кешенімен байытады. Органолептикалық және физика-химиялық көрсеткіштерді пайдалана отырып, 25% қара Хусейн жүзім сығындысына қосымша 25% шие және 25% шабдалы шырыны қосылған сүт сарысуы негізінде функционалдық сусындардың екі технологиясы әзірленді. Алынған үлгілерде келесі маңызды макро және микроэлементтер бар. Бірінші үлгіде кальций -12,10%,натрий-5,04%,магний -1,60%,фосфор-7,31%,калий -24,61%, ал екіншісінде -кальций-9,50%, натрий -4,28%, магний -1,33%, фосфор-6,37%, калий -21,91% және басқалар. Барлық микробиологиялық көрсеткіштер МЕСТ талаптарына сәйкес келеді және патогендік микрофлораның жоқтығын көрсетеді, бұл ұсынылатын өнімнің кепілдендірілген санитарлық әл-ауқатының көрсеткіштерінің бірі болып табылады. Әзірленген сусындардың жағымды органолептикалық көрсеткіштерге ие, биологиялық құндылығы жоғары және де өнімнің өзіндік құны төмен болып табылады.

Негізгі сөздер: Функционалды тамақтану өнімдері, қайталама шикізат, полифенолдар, антиоксиданттар, макро-және микроэлементтер.

ФУНКЦИОНАЛЬНЫЕ НАПИТКИ НА ОСНОВЕ СЫВОРОТКИ С ЭКСТРАКТОМ ВИНОГРАДНОЙ ВЫЖИМКИ И ФРУКТОВЫМ СОКОМ

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Промышленные отходы приводят к загрязнению и ухудшению состояния окружающей среды, а также наносят вред населению и животным. Сыворотка, являясь побочным продуктом переработки молока, является источником белков и азотистых соединений, углеводов, липидов, минеральных добавок,

витаминов, органических кислот, ферментов, макро- и микроэлементов. Аминокислотный состав молочной сыворотки представлен аминокислотами белковых веществ и свободными аминокислотами. Еще одним ценным вторичным сырьем являются виноградные выжимки, которые практически не перерабатываются и становятся фактором антропогенной нагрузки, загрязняющим окружающую среду. Виноградные выжимки имеют богатый химический состав, в их составе особенно большое количество фенольных соединений, обладающих антиоксидантными свойствами. В настоящее время можно отметить значительный рост производства и потребления безалкогольных напитков с различными добавками, состав которых изобилует ненужными красителями и ароматизаторами. Целью работы является использование молочной сыворотки для разработки технологии напитков функционального назначения, что непосредственно повысит эффективность ее переработки, в качестве вторичного сырья при промышленном производстве, а также послужит цели улучшения экологической обстановки в местах расположения молокоперерабатывающих предприятий. В частности, создание функциональных напитков на основе молочной сыворотки с добавлением виноградных выжимок, фруктовых соков и пектина позволит обогатить молочный напиток комплексом биологически активных веществ, микроэлементов, антиоксидантов, витаминов. Были разработаны две технологии функциональных напитков на основе молочной сыворотки с добавлением 25% экстракта выжимок черного винограда Хусейна, в первой 25% вишневого, а во второй 25% персикового соков. Первая рецептура продемонстрировала значительное содержание макро- и микроэлементов, включая кальций (12,10%), натрий (5,04%), магний (1,60%), фосфор (7,31%) и калий (24,61%). Аналогичным образом, вторая рецептура имела значительный состав макро- и микроэлементов, включая кальций (9,50%), натрий (4,28%), магний (1,33%), фосфор (6,37%) и калий (21,91%). Все микробиологические показатели соответствуют требованиям ГОСТ и свидетельствуют об отсутствии патогенной микрофлоры, что является одним из показателей гарантированного санитарного благополучия предлагаемой продукции. Разработанные напитки обладают хорошими органолептическими показателями, высокой биологической ценностью и низкой себестоимостью.

Ключевые слова: продукты функционального питания, вторичное сырье, полифенолы, антиоксиданты, макро- и микроэлементы.

Introduction

The utilization of secondary dairy raw materials presents an opportunity for diversification within the dairy industry, particularly through the exploration of whey-based products. Whey, a by-product of cheese, cottage cheese, or casein production, boasts a rich nutritional profile comprising proteins, nitrogenous compounds, carbohydrates, lipids, vitamins, enzymes, mineral salts, and organic acids. Notably, whey proteins are distinguished by their abundance of essential amino acids, making them highly valued in the realm of functional foods and beverages [1].

Recent studies have shed light on the nuanced differences between cheese and curd whey, with curd whey exhibiting higher concentrations of select amino acids such as valine, phenylalanine, leucine, and isoleucine. Moreover, the presence of α-lactalbumin and β-lactoglobulin in whey proteins further contributes to its superior biological value compared to proteins from other sources [2-4]. This nutritional richness positions whey as a promising ingredient in the development of functional beverages, particularly when combined with extracts from plant sources.

Whey is also utilized with vegetables for the development of beverages. A whey based herbal beverage was developed with carrot, beetroot, mint and ginger [5].

Research evidences have proved that the supplementation of various fruits can be very effective for the treatment for various diseases. One of the research evidence claimed that that the daily consumption of whey guava beverage has shown a significant impact on the hemoglobin levels of the school-adeg children [6].

Development and optimization of whey-mango beverage with ginger extracts were developed successfully. The herbal beverage was developed with different percentages of ingredients 5%, 7% and 10 % of mango pulp, 82-87% whey was used, 0.5% ginger extract and 0.05% of guar gum was used [7]. Study aimed to develop whey-based herbal beverages. The cost of the formulated whey brahmi drink, whey mint drink, and whey jaljeera drinks were Rs.18.33/250ml, Rs.20.20/250ml and Rs.14.75/250ml, respectively. The study concluded that nutritionally rich whey-based herbal drinks can be recommended to all group of people [8].

Whey beverages supplemented with fruit juice, milk or milk permeate, or nutraceutical compounds are estimated to occupy a larger stake in the dairy and functional foods market in the near future. Heat-triggered sedimentation is the major challenge of whey-based beverage industry. To overcome this handicap and protect the nutritional value of whey beverages, nonthermal food

processing technologies may well be considered as alternatives to heat treatment.

Functional beverages fortified with whey protein and fruit fillers have garnered attention for their potential to deliver both nutritional benefits and sensory appeal. Studies have shown that blending traditional whey with fruit juices or pulps enhances the sensory attributes and consumer acceptance of these beverages [9]. Fruit-flavored whey beverages have demonstrated higher acceptability scores compared to control formulations containing 100% traditional whey [10,11].

Further exploration into the integration of whey protein with various fruits and vegetables has yielded promising results. Homemade fruit and vegetable whey beverages, comprising a blend of acid whey and other ingredients such as carrot puree, rosehip puree, sea buckthorn jam, pear puree, concentrated cherry juice, parsley, and banana puree, have shown potential in enriching dairy products with enhanced health-promoting properties [12].

In addition to fruit juices, grape pomace extract has emerged as a valuable additive in whey-based beverages. Grape pomace, rich in phenolic compounds and antioxidants, offers functional properties that can augment the nutritional profile and health benefits of beverages [13,14-17]. Moreover, the recycling of grape pomace contributes to sustainability efforts within the food industry, mitigating ecological disturbances caused by its disposal [18].

Besides all these factors various research evidences have proved that functional whey beverages have potential to be utilized in various forms and can be alternate healthy source of nutrition in daily diet when compared to other thirst-quenchers. The various nutrient content and their health potential health benefits of whey protein makes it to be equally suitable for utilization rather than wasting and treating it as a byproduct.

In terms of chemical composition, grape pomace is rich in a polysaccharide complex and contains significant amounts of phenolic substances and lignin (Table 1).

Table 1. Chemical composition of the skins of some technical grape sorts [19]

Components	**Content in grape varieties, mg /100 g dry preparation**	
	White	**Red**
Polysaccharides (total of monomer components), including L-cellulose	42-44 24-25	41-45 24-25
Phenolic and lignin-like substances	36-38	37-39
Nitrogenous substances (nitrogen content)	1.4-1.6	1.5-1.8
Residual ash	2.5-2.7	2.6-2.8

The development of functional beverages, such as apple-whey-based ready-to-serve (RTS) beverages, underscores the potential for innovation in this field. By blending apple juice with whey and jaljeera extract, researchers have produced beverages that maintain quality under various storage conditions [20]. Building upon these findings, our research aims to investigate the additive effects of grape pomace extract and fruit juices, particularly cherry and peach, in whey-based beverages.

In summary, this study seeks to contribute to the advancement of functional beverage development by exploring innovative combinations of whey protein with grape pomace extract and fruit juices. By leveraging the nutritional richness of whey and the bioactive compounds present in grape pomace extract and fruit juices, we aim to develop beverages that meet consumer preferences for taste, convenience, and health-promoting benefits. Through a comprehensive analysis of previous research and consistent experimental methodologies, this study aims to bridge existing knowledge gaps and offer insights into the formulation of functional whey-based beverages.

Materials and research methods

Studies of raw materials and finished products to determine physical and chemical properties were carried out using appropriate methods:

1) One of the main physico-chemical indicators of whey beverage is the dry matter content. The dry matter content was determined using a GOST ISO 2173-2013 [21]. This method is highly accurate and technically simple. The method is based on determining the refractive index (refraction coefficient) and some of its functions. It is applied for identification of chemical compounds, quantitative and structural

analysis, and determination of physical and chemical parameters of substances;

2) Titratable acidity of the product was determined according to GOST ISO 750-2013 (GOST 750) [22].

3) Organoleptic evaluation of finished products is carried out by closed tasting method, developed based on GOST 33957-2016 (GOST 33957) [23]. The following indicators are monitored: appearance and consistency, smell and taste, colour.

4) The mass fraction of protein was determined in accordance with GOST 23327-98 (GOST 23327) [24].

5) The antioxidant activity was determined according to the amperometric method (GOST 54037) [25] on the device "Svet-Yauza-01-AA".

6) Microbiological parameters of whey-based drinks were analyzed in accordance with the Methods for detection and enumeration of lactic acid bacteria (GOST 10444.11) [26].

To determine the composition of micro- and macroelements, the method of inductively coupled plasma mass spectrometry (ICP-MS) and also scanning electron microscope (SEM) were used. ICP-MS is very useful in determining all elements simultaneously, thereby shortening the measurement process [27-29].

In the course of the study, recipes and technologies for the preparation of whey based drinks with the addition of grape extracts were developed, the physico-chemical properties of beverages were determined.

Results and discussion

The technological process for the production of whey-based drinks includes the following technological operations:

- Raw material reception and preparation;
- Preparation of milk whey;
- Preparation of dairy-free beverage components (apple pectin, citrus pectin, grape extract, fruit juices);
- Mixing of all ingredients;
- Cooling and packaging.

During the process milk whey pasteurized, cooled up to 10 C, then grape pomace extract and peach or cherry juice are added in an amount of 20-25% and pasteurized by heating to 65-67°C with 1.0-2.0 min of soaking, as well as a mixture of apple and citrus pectin in equal proportions of 0.5-1% is added, all ingredients are thoroughly mixed for 5 minutes, cooled, poured and packaged.

Thus, the process of preparing a functional whey-based drink with grape pomace extract consists of the following main process steps shown in Figure 1.

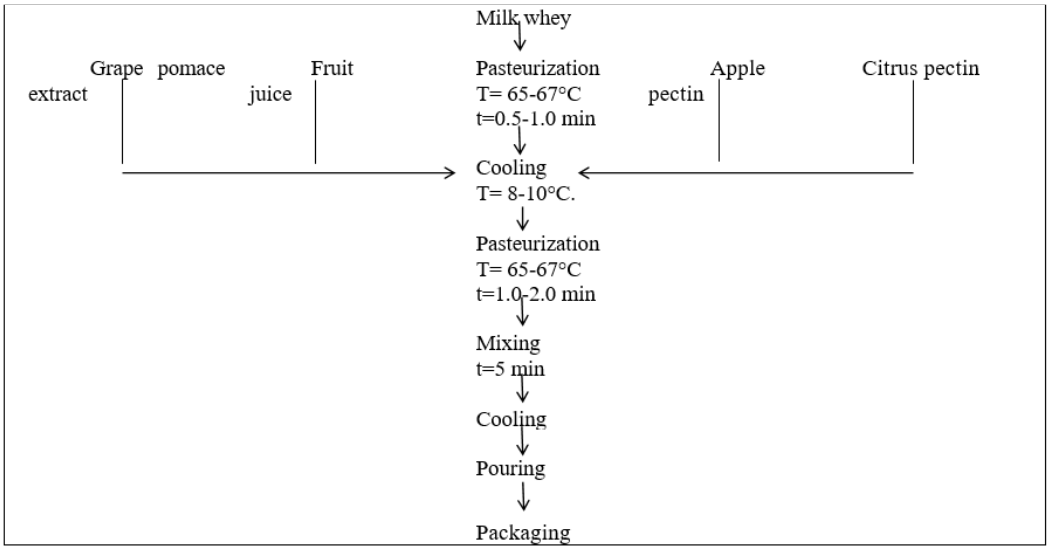


Figure 1. Technological scheme of the functional whey-based drink with grape pomace extract

A recipe was compiled in accordance with the technology and the organoleptic characteristics of the whey drink with extracts were studied from two different varieties of Hussein Black and Taifi Pink grapes pomace were investigated. Tables 2 and 3 show the experimental recipe for a functional whey-based drink with different fruit juice and grape pomace extract compositions.

Table 2. Recipes for a functional whey-based drink with Hussein Black grape pomace extract and cherry juice

Raw materials	**Samples**				
	No 1	No 2	No 3	No 4	No 5
Milk whey	39	49	49	49	49
Hussein Black grape pomace extract	30	50	35	25	15
Cherry juice	30		15	25	35
Apple pectin	0.5	0.5	0.5	0.5	0.5
Citrus pectin	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Table 3. Recipes for functional whey-based drink with Pink Taifi grape pomace extract and peach juice

Raw materials	**Samples**				
	No 1	No 2	No 3	No 4	No 5
Milk whey	39	49	49	49	49
Taifi Pink grape pomace	30	50	35	25	15
Peach juice	30		15	25	35
Apple pectin	0.5	0.5	0.5	0.5	0.5
Citrus pectin	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Table 4. and figure 2 show the organoleptic characteristics of a functional whey-based drink with Hussein Black grape pomace extract and cherry juice.

Table 4. Organoleptic characteristics of functional whey-based drink with Hussein Black grape pomace extract and cherry juice

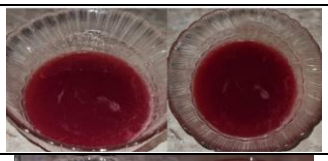
Samples		**Appearance and consistency**	**Taste**	**Smell**	**Color**
	Photo				
1		Homogeneous liquid and with slight sediment	Sweet and sour whey, astringent taste	Sweet and sour whey	Deep red
2		Homogeneous liquid and with slight sediment	Mild, not sour, slightly sweet, hints of grape and a slight lactic flavour	Milky acidic with a slight grape aroma	Transparent pink
3		Homogeneous liquid with slight sediment	Mild, not sour, slightly sweet	Sweet and sour whey	Clear burgundy
4		Homogeneous liquid with slight sediment	Mild, not too sour slightly sweet, astringent taste	Sweet and sour whey	Dark burgundy
5		Homogeneous liquid with slight sediment	Very sour	Sweet sour	Dark burgundy

Table 5 and Figure 3 show the organoleptic characteristics of a functional whey-based drink with Taifi Pink grape pomace extract and peach juice.

Table 5. Organoleptic characteristics of a functional whey-based drink with Pink Taifi grape pomace extract and peach juice

Samples		Appearance and consistency	Taste	Smell	Color
№	Photo				
1		Homogeneous liquid and with slight sediment	Brightly sweet, but no grape or peach flavours	Whey or milky	Light yellow
2		Homogeneous liquid with slight sediment	Sweet	It has a sour smell of lactic acid	Clear yellow
3		Homogeneous liquid with slight sediment	Slightly sweet	It has a sour smell of lactic acid	Light yellow
4		Homogeneous liquid with slight sediment	Sweet	Milky and sour with a hint of peach	Light yellow
5		Homogeneous liquid with slight sediment	Brightly sweet with a milky taste	It has a sour smell of lactic acid	Light yellow

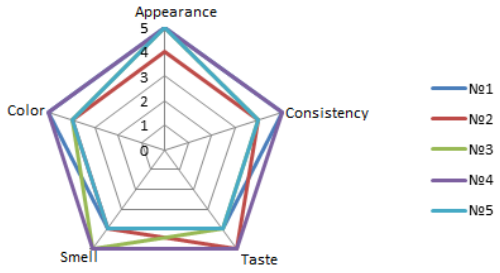


Figure 2. Organoleptic parameters of functional whey-based drink with Hussein Black grape pomace extract and cherry juice

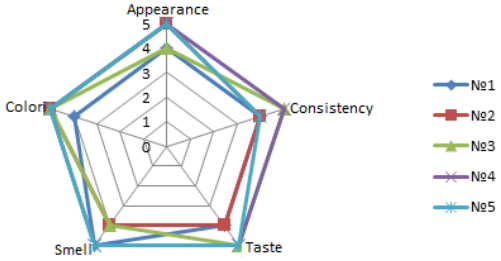


Figure 3. Organoleptic parameters of functional whey-based drink with Taifi Pink grape pomace extract and peach juice

The results of the organoleptic studies on functional whey-based drinks enriched with Hussein Black grape pomace extract and cherry juice, as well as Taifi Pink grape pomace extract and peach juice, indicate that recipe number 4 outperformed the alternative recipe across all assessed parameters, including appearance, color, smell, taste, and consistency (refer to Figures 3 and 4). This preference for recipe number 4 aligns with the sensory expectations of consumers and underscores its potential for market acceptance.

Building upon these sensory findings, a comprehensive analysis of the physical and chemical properties of the two formulations was conducted according to GOST 33957-2016 standards:

1) Whey-based functional drink with 25% Hussein Black grape pomace extract and 25% cherry juice and 0.5% apple and 0.5% citrus pectin;

2) Whey-based functional drink with 25% Taifi Pink grape pomace extract and 25% peach juice and 0.5% apple and 0.5% citrus pectin.

The results, presented in Table 6, shed light on the compositional characteristics of the whey-based functional drinks.

Table 6. Physico-chemical properties of the whey-based functional drinks enriched with grape pomace extract and fruit juice

Name, units	**No 1**	**No 2**
Mass fraction of protein, %	0.52	0.63
Mass fraction of carbohydrates, %	0.69	5.68
Mass fraction of fat, %	Not found	Not found
Antioxidant content, mg/g	0.69±0.0170	0.37±0.0003
Titratable acidity, T°C	55	49
Mass fraction of dry matter, %	10.2 ± 0.02	9.8 ± 0.03
Density, kg/m^3	1030.5	1038.5
Content of elements , %		
Carbon (C)	-	11.23
Oxygen (O)	41.37	36.89
Sodium (Na)	5.04	4.28
Magnesium (Mg)	1.60	1.33
Aluminum (Al)	-	0.43
Silicon (Si)	0.40	2.04
Phosphorus (P)	7.31	6.37
Sulfur (S)	0.87	0.69
Chlorine (Cl)	6.70	5.33
Potassium (K)	24.61	21.91
Calcium (Ca)	12.10	9.50

Comparing these results with existing literature on similar formulations and methodologies, we observe trends consistent with the known properties of whey-based beverages fortified with grape pomace extract and fruit juice. The observed protein and carbohydrate contents align with previous studies, highlighting the potential for these drinks to serve as sources of essential nutrients. Additionally, the presence of antioxidants underscores the potential health benefits associated with consumption. The variations in titratable acidity and elemental composition between the two recipes may reflect differences in grape pomace varieties and fruit juice compositions, further emphasizing the importance of ingredient selection in product development.

The developed samples of whey-based functional drinks in terms of mineral substances, formulation No 1, consisting of 25% Hussein Black grape pomace extract and 25% cherry juice, demonstrates higher levels of several elements compared to formulation No 2, which includes 25% Taifi Pink grape pomace extract and 25% peach juice. Notably, formulation No 1 exhibits elevated levels of sodium (Na) – 5.04%, magnesium (Mg) – 1.60%, phosphorus (P) – 7.31%, potassium (K) – 24.61%, and calcium (Ca) – 12.10 compared to formulation No 2 sodium (Na) –4.28%, magnesium (Mg) –1.33%, phosphorus (P) – 6.37%, potassium (K) – 21.91% and calcium (Ca) –9.50%.

This suggests that the whey-based functional drink enriched with Hussein Black grape pomace extract and cherry juice (formulation No 1) contains a higher concentration of mineral

substances compared to the variant with Taifi Pink grape pomace extract and peach juice (formulation No 2).

The results obtained are shown in the following Figures 4-5.

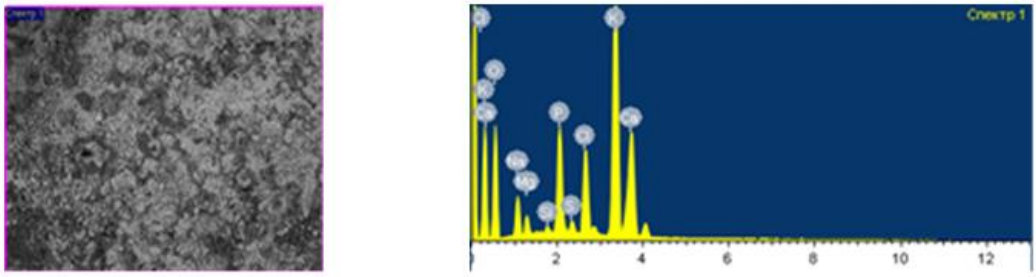


Figure 4. Mineral content spectrum of whey -based functional drink no 1.

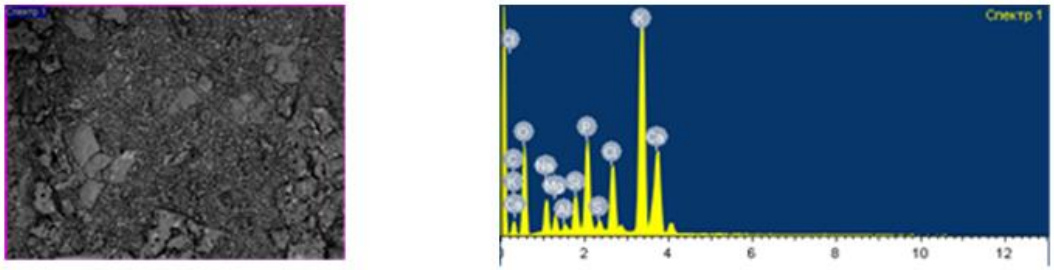


Figure 5. Mineral content spectrum of whey-based functional drink no 2.

The macroelement calcium supports the condition of tooth enamel, is involved in the formation and maintenance of bone mineral density and prevents the absorption of non-cracked proteins. There are established norms of daily intake for adults (calcium) - 800÷1000 mg, for children - 400÷1200 mg.

Macroelements - phosphorus and magnesium - play an important role in reducing osteoporosis. Their average daily requirement for phosphorus for adults is 600÷800 mg, for children – 300÷1200 mg.

The established average daily requirement for the macronutrient potassium for adults is 2,500 mg, for children it is between 400 and 2,500 mg.

The established average daily requirement of the microelement of iron for adults is 10 mg for males and 18 mg for females, and 4 to 18 mg for children [30].

Thus it is proved that the obtained products contain vital macro- and microelements.

The microbiological parameters of whey-based drinks are presented in Table 7 and compared between two formulations over a span of 15 days. These parameters are crucial indicators of product safety and quality, ensuring that the drinks are free from harmful microorganisms.

Table 7. Microbiological parameters of whey-based drinks

Microbiological parameters of whey-based drinks according to the TR CU 033/2013		**No 1**			**No 2**		
		1 day	**7 days**	**15 days**	**1 day**	**7 days**	**15 days**
Number of mesophilic aerobic and facultative anaerobic micro-organisms, CFU/ g(cm^3), no more than	1×10^5	1×10^4	1×10^4	1×10^5	1×10^3	1×10^4	1×10^5
Weight of the product (g/cm^3), not allowed:							
E. coli bacteria (Coliformes)	0.1	Not found			Not found		
Pathogenic, *Salmonella*	25	Not found			Not found		
S.aureus	1.0	Not found			Not found		
L.monocytogenes	25	Not found			Not found		

For both formulations, the number of mesophilic aerobic and facultative anaerobic microorganisms is within the permissible limits throughout the observation period, as specified by the requirements of the Technical Regulations of the Customs Union "About the safety of milk and dairy products" (TR CU 033/2013) [31]. This indicates that the drinks maintain microbial stability and meet regulatory standards for microbial contamination and guaranteed sanitary well-being of the products produced [32].

Regarding specific pathogenic microorganisms, including E. coli bacteria (Coliformes), *Salmonella, S.aureus*, and *L.monocytogenes*, none were detected in either formulation during the entire 15-day period. This absence of pathogenic bacteria underscores the hygienic production process and the effectiveness of microbial control measures applied during manufacturing.

Comparing the microbiological parameters between the two formulations, no significant differences are observed in terms of microbial counts or presence of pathogenic bacteria. Both formulations exhibit similar microbiological profiles, indicating that the choice of grape pomace extract and fruit juice does not substantially impact the microbial stability of the whey-based drinks.

These findings align with previous research demonstrating the microbiological safety of whey-based beverages and the effectiveness of good manufacturing practices in controlling microbial contamination. Studies have shown that factors such as pH, water activity, and antimicrobial compounds present in ingredients can influence the microbial growth and survival in dairy-based products [33, 34].

In conclusion, the microbiological analysis confirms the safety and quality of the whey-based drinks, providing assurance to consumers and regulatory authorities. The absence of pathogenic bacteria and compliance with microbial standards highlight the suitability of these drinks for consumption over the specified storage period.

Conclusion

It was developed technology and new recipes of functional whey-based drinks aimed at enriching the realm of functional foods:

1) Whey-based functional drink with 25% Hussein Black grape pomace extract and 25% cherry juice and 0.5% apple and 0.5% citrus pectin;

2) Whey-based functional drink with 25% Taifi Pink grape pomace extract and 25% peach juice and 0.5% apple and 0.5% citrus pectin.

The first formulation, a whey-based functional drink infused with 25% Hussein Black grape pomace extract and 25% cherry juice, alongside 0.5% apple and 0.5% citrus pectin, demonstrated noteworthy macro- and microelement content, including calcium (12.10%), sodium (5.04%), magnesium (1.60%), phosphorus (7.31%), and potassium (24.61%). Similarly, the second formulation, comprising 25% Taifi Pink grape pomace extract and 25% peach juice, with 0.5% apple and 0.5% citrus pectin, exhibited significant macro- and microelement composition, including calcium (9.50%), sodium (4.28%), magnesium (1.33%), phosphorus (6.37%), and potassium (21.91%).

Both formulations met essential microbiological standards, confirming the absence of pathogenic microflora and ensuring the products' sanitary well-being. Moreover, the developed drinks boasted favorable organoleptic characteristics, rendering them appealing to consumers. These beverages offer high biological value and cost-effectiveness, making them accessible to a wide consumer base.

Furthermore, developed functional drinks contribute to enhancing antioxidant protection, promoting calcium bioavailability, and supporting immunity. This is attributed to the inclusion of pectin, natural antioxidants from grape pomace extracts rich in anthocyanins and flavonoids, and other beneficial compounds. Thus, our research presents a significant advancement in the field of functional beverage development, offering products that align with consumer preferences for taste, convenience, and health-promoting benefits.

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The authors declare that there is no conflict of interest.

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