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IMPLEMENTATION OF BIOLOGICAL ACTIVE COMPOUND BIO-AP-IRGA: CHEMICAL FEATURES OF ENRICHED YOGURT AND COTTAGE CHEESE

Assem Sagandyk
Master of Technical Sciences, PhD Student*
Kadyrzhan Makangali
Corresponding author
PhD*
E-mail: k.makangali@kazatu.kz
Gulmira Zhakupova
Candidate of Technical Sciences, Associate Professor*
Tamara Tultabayeva
Doctor of Technical Sciences, Associate Professor*
Gulzhan Tokysheva
PhD Student*
*Department of Food Technology and Processing Products
S.Seifullin Kazakh Agrotechnical Research University
Zhenis str., 62, Astana, Republic of Kazakhstan, 010000

The imbalance of micro- and macronutrients is a significant health issue, often due to poor nutrition, vitamin deficiencies, and disruptions in mineral metabolism. To address these challenges, biologically active supplements (BASs) are gaining popularity. In Kazakhstan, the BIO-AP-IRGA dietary supplement, derived from dried saskatoon berry, chokeberry, and whey, was developed to improve local food products. The study explored integrating BIO-AP-IRGA into yogurt and cottage cheese, assessing the impact on their nutritional and chemical properties.

Standard analytical methods were used to evaluate the fortified products. The results showed that the addition of BIO-AP-IRGA significantly increased the carbohydrate content, nearly doubling it in yogurt and increasing it by eight times in cottage cheese. Additionally, the polyphenol content increased in both yogurt and cottage cheese; yogurt showed a slight increase, while cottage cheese saw nearly a twofold rise. However, the amino acid content decreased with the increasing amount of BIO-AP-IRGA, showing an inverse relationship.

These findings highlight the physicochemical changes that occur when BIO-AP-IRGA is incorporated into dairy products. The supplementation improves the nutritional quality of yogurt and cottage cheese, particularly by enhancing polyphenol and vitamin C levels. This innovation presents an opportunity for the food industry to develop functional dairy products with potential health benefits, addressing nutrient deficiencies and promoting better health

Keywords: nutritional value, amino acid composition, BIO-AP-IRGA, Saskatoon berry, chokeberry, antioxidant

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1. Introduction

Modern trends in the food industry are increasingly focused on the creation of products that not only have high nutritional value but also possess functional properties that promote health. Biologically active supplements (BAS) or natural health products (NHPs) play an important role in enriching the human diet with essential micronutrients, vitamins, antioxidants, and other beneficial substances. The development of products enriched with local plant-based ingredients containing high concentrations of bioactive substances, such as polyphenols, flavonoids, and organic acids, is becoming particularly relevant.

One promising direction in this field is the use of wild berries such as serviceberry and black chokeberry. These fruits are known for their potent antioxidant properties and high vitamin content, making them valuable for the creation of functional food products. Serviceberry (Amelanchier ovalis), in particular, is rich in polyphenols, anthocyanins, and other bioactive compounds that support the immune system and protect the body from oxidative stress. Black chokeberry (Aronia melanocarpa) has long been recognized as an effective source of antioxidants that positively affect the cardiovascular system and help reduce the risk of chronic diseases.

One of the current areas of research involves the fortification of dairy products with such supplements, which not only increase their nutritional value but also impart additional functional properties. Combining dairy products with powder from local berries, such as serviceberry and black chokeberry, can enhance the antioxidant and protein content of the final product, making these products particularly appealing to consumers seeking to improve their health through functional nutrition.

2. Literature review and problem statement

The article [1] presents the results of research aimed at the development and evaluation of the BIO-AP-IRGA dietary supplement, designed to be added to dairy products to increase health benefits.

According to research of scientists, dietary supplements are products that meet the needs of consumers who prioritize their health and are looking for natural health products that support immunity, well-being and prevent diseases. In papers [2, 3] shown that supplements containing rich sources of antioxidants, vitamins, and trace elements can provide valuable dietary benefits, particularly for individuals with nutrient-deficient diets due to processed and stored food consumption [2, 3]. The BIO-AP-IRGA supplement, developed from locally sourced ingredients such as Saskatoon berry, chokeberry, and whey, is formulated to meet these needs by delivering a concentrated dose of bioactive compounds that are known to positively influence health outcomes.

But there were unresolved issues related to the limited availability of locally produced NHPs in Republic of Kazakhstan, driven by several objective challenges. The primary issue involves the high cost of importing raw materials required for the production of such supplements, which constrains local production capacity and affordability. Additionally, fundamental challenges persist, such as ensuring consistent quality and bioactivity in plant-based ingredients, which are naturally variable due to environmental factors. The cost component, especially related to sourcing and processing local botanicals, often exceeds feasible limits for wide-scale commercial production, which makes relevant research impractical. Consequently, the current market is largely dominated by imported products, leading consumers to rely on NHPs with extended shelf lives, such as powders, tablets, and bars, often from international suppliers [4].

A way to overcome these difficulties can be the strategic use of local raw materials that are both nutrient-dense and compatible with the bioactive profiles required for NHPs. This approach was used in the formulation of BIO-AP-IRGA. Wild fruits and berries, such as black chokeberry (*Aronia melanocarpa*) and Saskatoon berry *(Amelanchier ovalis*), represent abundant and underutilized resources that have a documented capacity to synthesize various bioactive compounds.

According to some research [5, 6] Saskatoon berries (*Amelanchier alnifolia*) contain substantial amounts of polyphenols, including anthocyanins, flavonols, and phenolic acids, with cyanidin-3-glucoside and chlorogenic acid being predominant. The high antioxidant activity of these compounds helps to reduce oxidative stress, which is associated with a lower risk of cardiovascular and inflammatory diseases, as well as type 2 diabetes, highlighting the potential of Saskatoon berries as an ingredient in functional foods and nutraceuticals [6].

Their research primary aimed at exploring nutritional value and antioxidant activity. However, there were no data on how these berries impact and correlate within food products.

The antioxidant activity and polyphenolic compound content in Saskatoon berries (*Amelanchier alnifolia*) were analyzed using high-performance liquid chromatography with a diode-array detector (HPLC-PDA), along with ABTS and DPPH radical scavenging assays. The findings demonstrated that the "Northline" Saskatoon berry variety exhibited the highest antioxidant activity among the varieties studied, attributed to its elevated anthocyanin and other phenolic compound levels. The concentration of phenolic compounds in this variety reached 504.2 mg/100 g of fresh weight, substantially exceeding that in other varieties, likely due to a higher peel-to-pulp ratio, where polyphenols are predominantly localized. Anthocyanins, which constitute the largest portion of phenolic compounds (42–55 %), contributed most significantly to antioxidant activity, followed by flavonols and hydroxycinnamic acids. These results underscore the considerable potential of Saskatoon berry extracts and juice processing by-products as natural antioxidant sources for application in the food industry, particularly for inhibiting oxidative processes in lipid-rich products [5]. In this work, there is also no assessment of the effect of irgi berries on the overall nutritional profile of dairy products. These studies require sophisticated methodologies and a deep understanding of the science of food and human nutrition, which may not have been the main purpose of the research.

In the other study the antioxidant activity and anthocyanin content in black chokeberry (*Aronia melanocarpa*) were analyzed, revealing a high concentration of anthocyanin compounds such as cyanidin-3-O-glucoside and cyanidin-3-O-galactoside. These compounds demonstrate significant antioxidant activity, neutralizing free radicals and reducing oxidative stress. Anthocyanins were isolated and identified using high-performance liquid chromatography with a diode-array detector (HPLC-PDA), and their antioxidant activity was confirmed through DPPH and ABTS radical scavenging assays. The findings highlight the broad spectrum of health benefits associated with black chokeberry anthocyanins, including their potential for protecting cells from oxidative damage and reducing the risk of chronic diseases such as atherosclerosis and diabetes. These properties underscore the relevance of black chokeberry as a promising source of natural antioxidants for use in the food and pharmaceutical industries, particularly in lipid-rich products to inhibit oxidation processes [7]. The study focuses on anthocyanins from Aronia in isolation or in supplements, but it does not investigate the impact of these compounds when consumed as part of a whole food matrix, like in juices, jams, or dietary supplements.

The article [8] provides an in-depth analysis of the health-promoting properties of black chokeberry (*Aronia melanocarpa*), which is characterized by a high content of bioactive compounds, particularly polyphenols and anthocyanins. These compounds grant black chokeberry significant antioxidant activity, helping to reduce oxidative stress and strengthen the immune system. Additionally, the berry's antioxidants exhibit pronounced anti-inflammatory properties and have a beneficial impact on cardiovascular health, reducing the risk of atherosclerosis and other chronic diseases. The anthocyanins in black chokeberry also display antimicrobial potential, which may aid in the prevention of infectious diseases [8]. The paper focuses on the raw bioactive compounds in berries and their antioxidant activity, but it does not address how these compounds are affected by processing methods (e.g., drying, freezing, or turning the berries into juices, jams, or powders). Processing often influences the bioavailability and retention of bioactive compounds, and the impact of different processing techniques on the efficacy of these compounds has not been studied.

Overall, Saskatoon berry and black chokeberry are globally acknowledged for their pharmacological benefits, including antioxidant and anti-inflammatory properties, which contribute to the prevention of chronic conditions like cardiovascular diseases and diabetes [5, 6].

Despite these advantages, wild berries are often underestimated as primary sources of essential macronutrients, leading to a lack of integration into functional food products.

All this suggests that it is advisable to conduct a study on the optimization and integration of BIO-AP-IRGA into local food matrices, particularly fermented dairy products, to improve both nutritional and bioactive profiles. Such studies could reveal pathways for broadening the market for Kazakh-produced NHPs by tapping into local botanical resources, thus addressing consumer demand for health-enhancing supplements at competitive prices. By reducing reliance on imported raw materials, the development of supplements from local sources may also bolster the national economy and contribute to sustainable agricultural practices [9, 10].

3. The aim and objectives of the study

The aim of the present study was to assess the combination of fermented dairy products with the supplement called BIO-AP-IRGA and evaluate its impact on the nutritional, chemical, and bioactive profiles of the final product. The practical application of these results is expected to enable improvements in product quality and potential health benefits, ultimately making it possible to enhance the functional properties and market appeal of fermented dairy products.

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

– to determine the nutritional value of the product enhanced with BIO-AP-IRGA;

– to determine the amino acid profile of the studied products;

– to determine bioactive properties of the studied products – their Vitamin C content, polyphenolic content (PPs) and antioxidant activity.

4. Materials and methods

4. 1. Object and hypothesis of the study

Objects of this study are yogurt and cottage cheese enriched with biologically active supplement BIO-AP-IRGA.

The main hypothesis of the study is that the addition of the supplement BIO-AP-IRGA to fermented dairy products will enhance the nutritional, chemical, and bioactive profiles of the final product, leading to improved functional properties and potential health benefits.

Assumptions made in the study are that the inclusion of BIO-AP-IRGA will add health benefits to the dairy product due to its bioactive components, enhancing the nutritional and functional value of the final product. Also, the study assumes that BIO-AP-IRGA is compatible with fermented dairy products and will integrate well without negatively impacting the texture, flavor, or overall sensory quality.

Simplifications adopted in the study is that the impact of BIO-AP-IRGA on the product have been evaluated over a short period, simplifying the study by not examining long-term effects such as shelf life or bioactive stability over time.

4. 2. Samples

Biological active compound BIO-AP-IRGA was made from mix of dried powder of Saskatoon berry *(Amelanchier ovalis)*, Chokeberry *(Aronia melanocarpa)* and dried whey powder. Saskatoon berries and Chokeberries were collected in suburb near Astana city, Republic of Kazakhstan, and were frozen to be storage in laboratory of Food Technology and Processing product, S. Seifullin Kazakh Agrotechnical Research University. Dry whey powder was produced in Laboratory of Food Technology and Processing products Department as well.

During assays there were analyzed 1 control sample and 1 sample of each enriched yogurt and cottage cheese, represented in Table 1.

Table 1

The content of the studied samples (per 100 g)

Name of the sample	Number of basis product in %	Number of added BIO-AP-IRGA in %
Yogurt control	100	0
Yogurt sample 1	90	10
Cottage cheese control	100	0
Cottage cheese sample 1	86	14

Traditional methods were used to make yogurt and cottage cheese. The yogurt and cottage cheese were made using pasteurized milk with a fat content of 3.2 %, sourced from a local market in North Kazakhstan. The fermentation starter cultures for yogurt containing *Streptococcus thermophilus* and *Lactobacillus bulgaricus*, for cottage cheese containing *Lactococcus (lactis subsp. Lactis, lactis subsp. Cremoris, lactis subsp. lactis biovar. diacetylactis)*, were purchased as lyophilized cultures from a sourdough store in Astana, Republic of Kazakhstan under the brand Yolactis.

4. 3. Preparation of samples

Dry powder of Saskatoon berry and Chokeberry were gained from fresh berries. Berries were dried at 30±2 °C for 2 days. Then milled, vacuumed and storage for the next use.

Dry whey powder was produced from whey, that leaved after production of cottage cheese. This whey was pasteurized, filtered by using ultrafiltration system (Sartorius, Germany). Then whey permeates dried by using freeze drying.

To produce yogurt pasteurized milk with 3.2 % of fat content (LLP“My Farm”, Republic of Kazakhstan) and lyophilized fermentation starter cultures of direct application, with *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (5 %), (Yolactis, Republic of Kazakhstan) were used. To get a cottage cheese the same milk were used and lyophilized fermentation starter cultures of direct application, with *Lactococcus (lactis subsp. Lactis, lactis subsp. Cremoris, lactis subsp. lactis biovar. diacetylactis)* (5 %), (Yolactis, Republic of Kazakhstan) were used.

4. 4. Chemical features of the samples

4. 4. 1. Nutritional value

The mass fraction of proteins, fat, ashes and carbohydrates in g/100 g of dried weight were established in yogurt and cottage cheese enriched with BIO-AP-IRGA according to the AOAC procedures [11]. The protein level was determined by using the Kjeldahl method, which involves digesting the sample with heated sulphuric acid to convert Kjeldahl nitrogen to ammonium salts. The digest is then distilled after being made alkaline. The resulting distillate is collected in an acid solution and the nitrogen content is measured using acid-base volumetry [12]. Total fat content (%) was determined using the Gerber method [13]. Briefly, a test portion of milk is pipetted into a Gerber milk butyrometer containing sulfuric acid. Isoamyl alcohol is added, and the contents of the butyrometer are mixed to dissolve the curd and release the fat. The released fat is isolated in the neck of the butyrometer by centrifugation. The percentage of fat in milk is determined by reading the calibrated scale on the neck of the butyrometer.

The mass fraction of carbohydrates (%) was determined using capillary electrophoresis [14], which determines the mass fractions of mono- and disaccharides. This method is based on their separation under an electric field in a quartz capillary under favorable conditions to suppress the influence of foreign substances. The identification and quantitative determination of the analyzed mono and disaccharides is performed by an indirect method, recording optical absorption at a wavelength of 230 nm. Ashes was determined by incineration of samples at 550±10 °C. Energy value was calculated by formula: Energy (kcal kg –1 dw)=4×(g proteins+g carbohydrates)+9×(g fat).

4. 4. 2. Amino acids

Amino acids were assessed through the determination of the mass fraction of proteinogenic amino acids in the form of phenylisothiocarbamyl derivatives (PTC-derivatives) using capillary electrophoresis [15], which allows determining the total content (free and bound forms in total) of individual amino acids in samples. This method is based on the breakdown of samples by acid hydrolysis, with the conversion of amino acids into free forms, obtaining PTC-derivatives amino acids. A Kapel capillary electrophoresis system with a high voltage source of positive polarity, equipped with a quartz capillary 75 cm long and an internal diameter of 50 microns, a photometric or spectrophotometric detector that allows measurements at a wavelength of 250 to 260 nm and a computer with special software for recording and processing electropherograms was used. The mass fraction of each amino acid in the sample X, %, is calculated by the formula:

$$X = \frac{V_{hydr} \cdot V_{KOH} \cdot C_{ch} \cdot 100}{m \cdot V_{al} \cdot 1{,}000},$$

where V_{hydr} – total volume of the hydrolysate, cm^3;

V_{KOH} – volume of the final (analyzed) solution, cm^3;

C_{ch} – measured value of the mass concentration of an amino acid in solution, mg/dm^3;

100 – conversion coefficient of the result to a percentage;

m – mass of the analyzed sample, mg (100 mg);

V_{al} – volume of aliquot portion of hydrolysate taken to obtain PTC derivatives, cm^3;

1,000 – conversion coefficient of volume units.

If there is a visible volume of the solutions, the mass fraction of each amino acid in the samples (%), is calculated using the formula:

$$X = \frac{C_{ch} \cdot 10}{m},$$

where X – measured value of the mass concentration of an amino acid in solution, mg/dm^3;

m – mass of the analyzed sample, mg;

10 – conversion coefficient.

4. 4. 3. Vitamin C content

The amount of Vitamin C is determined by calorimetry, which determines the optical density of the solution during interaction 2 6-dichlorophenolindophenolates with sample. First, the filtrate is prepared by the mass concentration of vitamin C in the filtrate is determined according to the calibration schedule [16].

4. 4. 4. Polyphenolic content (PPs)

Phenolic compounds of fermented milk were determined by colorimetric method using Folin-Ciocalteu reagent, Folin-Ciocalteu reagent contains phosphoric-tungsten acids, which are reduced when interacting with easily oxidizing OH groups of phenol. In this case, a tungsten blue is formed, which has a black absorption band with a maximum of 725 nm, giving the investigated solution a blue color [17].

4. 4. 5. Antioxidant activities

The antioxidant activity in the products was checked by the amperometric method according to State Standart R 54037-2010 [18]. The amperometric method consists in measuring the strength of the electric current that occurs during the oxidation of the test substance (or mixture of substances) on the surface of the working electrode when determining the divided potential and comparing the received signal with the signal from the standard (quercetin) under the same measurement conditions.

5. Results of research of chemical composition of yogurt and cottage cheese fortified with biologically active supplement BIO-AP-IRGA

5. 1. Nutritional value and chemical composition of products enriched with BIO-AP-IRGA

The results attained for the nutritional value and chemical composition of studied yogurt and cottage cheese samples are shown in Table 2.

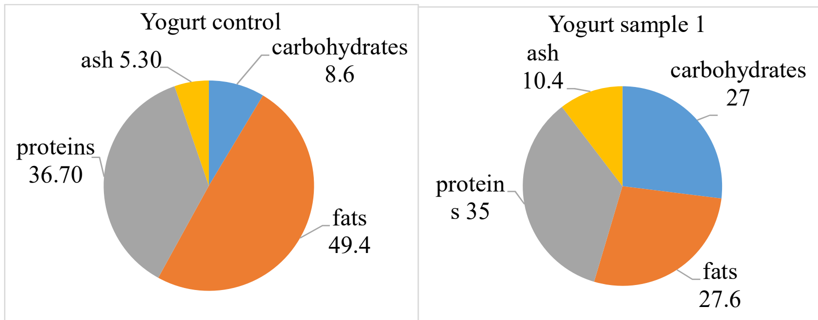
Table 2

Proximate composition of enriched yogurt and cottage cheese

Name of parameters	Yogurt control	Yogurt sample 1	Cottage cheese control	Cottage cheese sample 1
Fats (g/100 g dw)	29.48±0.43	10.64±0.16	36.03±0.54	24.14±0.36
Proteins (g/100 g dw)	13.51±0.20	21.98±0.33	34.56±0.52	41.88±0.79
Ash (g/100 g dw)	3.18±0.04	4.02±0.06	2.17±0.03	3.76±0.04
Carbohydrates (g/100 g dw)	5.17±0.07	10.42±0.15	1.67±0.03	9.8±0.15
Moisture, %	48.66±0.01	52.94±0.01	25.57±0.1	20.42±0.01
Energy (Kcal/100 g dw)	340.04	225.36	469.19	423.98

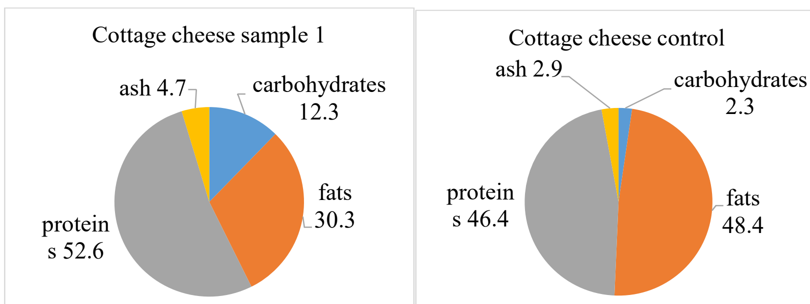
Note: dw – dry weight.

As can be seen from Table 2, Fig. 1, 2 fats level are getting lower as biologically active substance BIO-AP-IRGA added to samples of yogurt and cottage cheese. Inversely, protein, carbohydrates and moisture content are getting higher from control to studied samples. Thus, the sums of lipids decreased almost three times from Yogurt Control (10.64 g/100 g dw) to Yogurt Sample 1 (29.48 g/100 g dw). Meanwhile, the sums of proteins up almost two times from Yogurt Control (13.51 g/100 g dw) to Yogurt Sample 1 (21.98 g/100 g dw). In cottage cheese the difference of results between control samples and studied ones are decreased slightly. Numbers of proteins in Cottage cheese getting higher from 34.56 g/100 g in Control to 41.88 g/100 g in Sample 1. Level of lipids in Cottage cheese also decreased from 36.03 g/100 g to 24.14 g/100 g in Sample 1.



a *b*

Fig. 1. Nutritional value of studied yogurts: *a* – yogurt control; *b* – yogurt sample 1



a *b*

Fig. 2. Nutritional value of studied cottage cheese: *a* – cottage cheese control; *b* – cottage cheese sample 1

On the other hand, the addition of BIO-AP-IRGA supplement influences to the carbohydrates obtained in samples. As BIO-AP-IRGA contain berries it is logical that carbohydrates increased both in Yogurt samples and in cottage cheese samples. Their content increased twice for Yogurt from 5.17 g/100 g dw to 10.42 and 10.07 g/100 g dw and almost eight times for Cottage cheese from 1.67 g/100 g dw to 9.8 g/100 g dw.

The changes of protein, fat and carbohydrate levels are influence to the energy value of final product (Fig. 3).

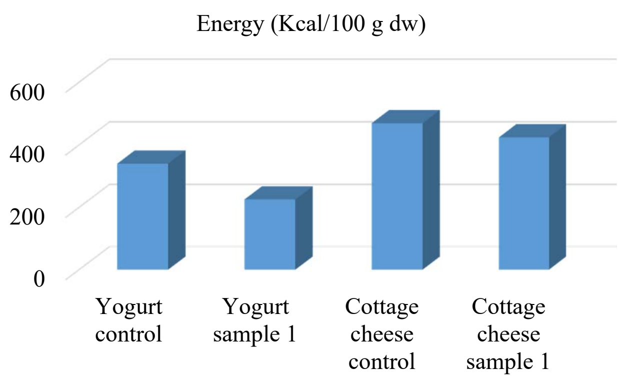


Fig. 3. Energy value of studied products

the body. As can be seen from Table 3 and Fig. 4 amino acids composition in studied samples are lower than in control samples in yogurt and cottage cheese because its concentration connected with protein content in products.

Table 3

Amino acid composition of studied products, %

Name of amino acid	Yogurt control	Yogurt sample 1	Cottage cheese control	Cottage cheese sample 1
Arginine	1.99±0.79	4.63±1.85	3.23±1.3	3.12±1.25
Lysine	0.04±0.013	3.96±1.35	2.00±0.68	4.68±1.59
Tyrosine	1.26±0.38	3.30±0.99	1.13±0.34	3.35±1.00
Phenylalanine	0.35±0.1	3.96±1.19	1.78±0.53	3.79±1.13
Histidine	0.66±0.33	1.47±0.74	0.52±0.26	2.09±1.05
Leucine+Isoleucine	0.62±0.16	5.3±1.37	1.94±0.5	4.68±1.21
Methionine	0.23±0.08	2.12±0.72	0.9±0.31	1.78±0.60
Valin	0.49±0.2	4.41±1.76	1.97±0.79	4.01±1.60
Proline	0.76±0.2	8.6±2.23	1.52±0.39	6.92±1.79
Threonine	0.31±0.12	3.30±1.32	1.23±0.49	2.67±1.07
Serine	0.41±0.1	2.64±0.68	1.1±0.28	2.45±0.63
Alanine	0.27±0.07	1.80±0.47	1.78±0.46	1.71±0.44
Glycine	0.12±0.04	1.036±0.35	0.9±0.3	1.04±0.34

The sums decreased significantly from control samples (340.04 Kcal/100 g dw in yogurt, 469.19 Kcal/100 g dw in cottage cheese) to studied samples (225.36 Kcal/100 g dw for yogurt sample, 423.98 Kcal/100 g dw in cottage cheese by turns) as the numbers of lipids are lost.

5. 2. Amino acid composition

Amino acids are the constituent components of proteins. Each of the amino acids has its own important functions in

According to the general trend, in control samples of both yogurt and cottage cheese, most amino acids showed lower level than in the samples. This may indicate that the samples contain more proteins, or their amino acid profile is richer. In both yogurt sample 1 and cottage cheese sample 1 there is a significant increase in essential amino acids, like lysine, phenylalanine, valine, and methionine. But, unlike others arginine showed a slight decrease from cottage cheese control 3.12 % to cottage cheese sample 1 3.01 %.

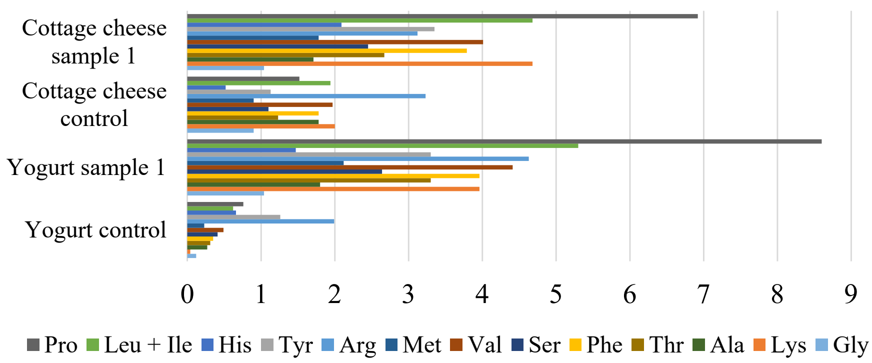


Fig. 4. Amino acid content of studied products

presence of saskatoon berry and chokeberry consisting in BIO-AP-IRGA. The increased numbers of carbohydrates in yogurt sample 1 and cottage cheese 1 could be due to the presence of berries in added biologically active supplement BIO-AP-IRGA too. There is no analogue of yogurt and cottage cheese fortified with biological active supplements like BIO-AP-IRGA in the dairy market, however, there are many studies of enriched dairy products with berries. Hence, in some research work [19] studied yogurt fortified with sea buckthorn and probiotics and investigated that sea buckthorn positively effect on nutritional value of final product. In another research work [20] studied a high-protein yoghurt-type product enriched with bioactive-loaded double emulsion, that loaded with refined rapeseed oil, milk protein concentrate, vitamin A palmitate, vitamin D3, folic acid powder, vitamin B12 and vitamin C. The developed yogurt has lower protein content (10 g/100 g), fat (6.5 g/100 g), carbohydrates (8.6 g/100 g) and energy value (130 g/100 g) than in proposed research.

In overall, all these changes influenced to energy value of studied yogurt sample 1 and cottage cheese sample 1, that can be seen in Fig. 3. The reduction in caloric content makes studied products be suggested as low-fat dairy products, while the increased protein content enhances their nutritional value.

Also, the increased content of proteins has linear impact in amino acid profile of studied dairy products. As can be seen in Table 3, the increases in essential amino acids, such as leucine, isoleucine, lysine and tyrosine, suggest that the treated products could provide better support for muscle growth, tissue repair, cognitive function and immune health. These changes indicate that the treated products could be marketed as enhanced, functional foods. This statement brings to another deep investigation of studied dairy products.

5. 3. Bioactive properties

Bioactive properties of studied samples may be seen by their Vitamin C, PPs and antioxidant activities (Table 4).

Table 4

Bioactive properties of studied samples

Name of parameters	Yogurt control	Yogurt sample 1	Cottage cheese control	Cottage cheese sample 1
Vitamin C content, mg/100g	3.79±0.05	7.36±0.06	7.38±0.06	7.59±0.07
PPs, %	0.02±0.01	0.08±0.01	0.02±0.01	1.86±0.01
Antioxidant activity, mg/g	0.09±0.01	0.13±0.01	0.03±0.01	0.11±0.02

Their presence in studied products depends on the input biologically active substances BIO-AP-IRGA. The highest content of Vitamin C is identified in yogurt sample 1 (7.36 mg/100 g) and in cottage cheese sample 1 (7.59 mg/100 g). Presence of PPs in studied samples are increased four times in yogurts sample 1 (0.08 %) and more than ten times in cottage cheese (1.86 %). Antioxidant activity was measured among fat soluble compounds and equal to 0.13 mg/g in yogurt samples 1 and 0.11 mg/g for cottage cheese sample 1. Overall, the numbers of antioxidant activity in Samples are higher than in control ones. The number of present PPs and antioxidants increase the resistance of the product against free radicals.

6. Discussion of the results of research into the chemical composition of yogurt and cottage cheese fortified with biologically active supplement BIO-AP-IRGA

It is clear from the getting data that the addition of developed supplement BIO-AP-IRGA to yogurt and cottage cheese has a notable impact on their composition, specifically in terms of fats, proteins, carbohydrates and moisture content. According to Table 2, Fig. 1, 2 there is a significant decrease in the fat content in both yogurt and cottage cheese samples in comparison with their respective controls. This suggests that the addition of BIO-AP-IRGA influences the reduction of fats, possibly due to its influence on fat-binding properties. On the contrary, the protein content increased, due to the presence of whey in biologically active supplement BIO-AP-IRGA. The elevated protein numbers can enhance the nutritional value of the product. The ash content, which is indicated by presence of minerals, slightly increased in yogurt sample 1 and cottage cheese sample 1. The mineral content can be increased because of the

The results of bioactive properties from Table 4 suggest that both yogurt sample 1 and cottage cheese sample 1 have higher levels of nutrients and antioxidant activity compared to their respective controls, making them potentially healthier options. In other research [21] finds out that extract from berry materials can increase concentration of PPs and straighten functional advantages in dairy products. In research work [22] investigated that the amount of added berry extract has linear effect on PPs concentration in final product. Some researchers [21] developed high-protein yogurt type that content 40 mg/100g of Vitamin C. They reached such numbers because they added multiple bioactive-loaded double emulsion from berries. In [23] work the addition of grape or aronia juice to yogurt presented higher content of polyphenols than in control yogurt.

The results of the study proved the positive effect of a dietary supplement BIO-AP-IRGA on the nutritional and energy value of studied yoghurts and cottage cheese. Also, these studied products are enriched with polyphenol and vitamin C, which allows them to be further recommended as functional products. The obtained results can be used in the field of the food industry as a recommendation for manufacturers. In addition, this study was conducted as part of a scientific project, and the results of the study are used in the preparation of reports and in the preparation of a project on the commercialization of food products in the Republic of Kazakhstan.

It is worth noting that during the production of the studied products, the amount of biologically active supplement BIO-AP-IRGA should be controlled. During the study, the optimal amount of biologically active supplement BIO-AP-IRGA was prescribed – 10 % from the total volume for yogurt and 14 % from the total volume for cottage cheese. Adding more of the claimed amount of biologically active supplement BIO-AP-IRGA will affect to the organoleptic parameters of the finished products, and a smaller amount will not give the desired component composition.

Thus, this investigation can be used by industry and scientists to create new healthy products, thereby increasing the range of dairy products. These getting dairy products could be placed at the health-conscious market for those seeking higher protein content and lower fat content functional foods.

The data obtained is insufficient and for the introduction of the studied dairy products, more in-depth studies of the structural and mechanical properties and sensory properties of the products offered are needed.

A minor disadvantage of this study is the problem of supplying saskatoon berries for the production of biologically active supplement BIO-AP-IRGA. The main problem is that berries are a seasonal product. In Republic of Kazakhstan saskatoon berries are not found in supermarket shops, but are sold in outdoor markets only during their ripening season (late summer). Therefore, when adapting the proposed technology for the production of proposed yogurt and cottage cheese with the addition of biologically active supplement BIO-AP-IRGA, the manufacturer should be aware about the issue of supplying enough berries for continuous production of dairy products all year round.

To further develop this study, long-term storage and stability of BIO-AP-IRGA should be studied. Investigation of the BIO-AP-IRGA stability when stored over extended periods and under various conditions could help determine the optimal storage conditions to maintain the bioactive properties of the supplement for prolonged production cycles. Also, conduction of clinical or in vivo studies will help to confirm the health benefits of BIO-AP-IRGA-enriched products on specific health outcomes, such as antioxidant levels or cardiovascular health, which would strengthen its positioning as a functional food product.

7. Conclusions

1. The results from the nutritional composition showed BIO-AP-IRGA influence to the composition of final product. It can be seen from the energy value of studied products – in enriched samples these numbers are lower than in control ones. Thus, changes are presenting slightly lower content of fat and protein concentrations, but a higher content of carbohydrates. These changes in chemical profile affect to the energy value of products.

2. The content of amino acids seems to be affected by the BIO-AP-IRGA addition, with lower percentages being detected in the samples with biologically active supplements. Hence, in yogurt samples with BIO-AP-IRGA, there was a notable increase in essential amino acids, like, proline increased from 0.76 in the control to 8.6 in the sample, and leucine with isoleucine increased from 0.62 to 5.3. Similarly, in cottage cheese with BIO-AP-IRGA, most amino acids also showed a substantial increase compared to the control. Notably, lysine increased from 2.00 to 4.68, tyrosine from 1.13 to 3.35, and phenylalanine from 1.78 to 3.79. The addition of BIO-AP-IRGA particularly impacted the levels of amino acids like proline, leucine with isoleucine, and lysine in both yogurt and cottage cheese, highlighting a strong increase in these essential amino acids that are crucial for protein synthesis and metabolic functions.

3. Regarding bioactive compounds like Vitamin C and polyphenols it is obvious that their content depends on presence of BIO-AP-IRGA in product. The BIO-AP-IRGA contains saskatoon berry and black chokeberry in it, which are known for their rich composition of polyphenols. In yogurt, vitamin C increased from 3.79 mg/100g in the control to 7.36 mg/100g with the addition of BIO-AP-IRGA. In cottage cheese, there was a slight increase from 7.38 mg/100g to 7.59 mg/100g. This suggests that BIO-AP-IRGA enriches the vitamin C levels, particularly in yogurt. Moreover, BIO-AP-IRGA had a marked effect on PPs, especially in cottage cheese, where PPs rose from 0.02 % in the control to 1.86 %. In yogurt, PPs also increased from 0.02 % to 0.08 %. This indicates a substantial enhancement in polyphenol content, more pronounced in cottage cheese. Additionally, antioxidant activity in samples are higher than in control samples, which also is connected to the presence of berries in biologically active supplement BIO-AP-IRGA. In yogurt, antioxidant activity rose from 0.09 mg/g to 0.13 mg/g, while in cottage cheese, it increased from 0.03 mg/g to 0.11 mg/g.

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.

Use of artificial intelligence

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

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