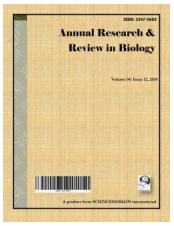

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Study of Chemical and Mineral Composition of New Sour Milk Bio-product with Sapropel Powder

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OG, YS, EO and MR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SK, VK and OL managed the analyses of the study. Authors NA, SH, MT and ID managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

In this paper the results of chemical and mineral composition of new sour milk bio-product with sapropel powder are presented. Sapropel in powder form added to the formulation of sour milk of 1.5% of total mass. Sapropel is characterized by high percent of mineral elements concentration (50.97%), particularly it is rich in manganese 316.0 mg/kg, calcium 148.0 mg/kg (in the form of calcium carbonate), zinc 59.7 mg/kg, copper 24.1 mg/kg. In new sour milk bio-product the protein

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content was significantly higher (20.95%) than in control sample (18.40%) with decreasing of moisture content to 76.0-76.3% than in control sample 79.50%. Addition of 1.5% of plant sapropel increases the nutritive value of final product up to 15.3 kcal or 16.4% because of high content of protein and fat.

Keywords: Sapropel; milk; nutritive; mineral composition; technology.

1. INTRODUCTION

In recent years among the population of Russia there has been an increase of allergy risk to food products, caused by food supplements such as preserving agents, food coloring agents, antioxidants etc. Moreover, the number of obese people has grown rapidly [1]. On these facts, the scientists and specialists of food industry aim to develop new functional foods, able to provide a human being with necessary nutrients and decrease the harmful environmental impacts (dust, radioactive pollution, chemicals etc.) to human body.

In last decades, there is an increased number of new food products appearing on the global market including milk products. Among the milk products, especially a considerable quantity belongs to sour milk products. The sour milk products vary in milk ferments and fillers, which have impact on the chemical composition and sensory characteristics.

The most widespread functional milk products in the market of Russia are “Kurunga”, “Sour milk drink”, “Tan” and others which have a positive effect to the human being. This effect is associated with the impact of lactic-acid-producing bacteria to the organism [2,3,4].

Sapropel is fine-grained colloid sediments of freshwater bodies rich in organic matter and mineral elements. Sapropel is used as a biologically active substance in medicine and agriculture in pure form or in combination with other ingredients.

Sapropel has three main components: organic, mineral and biologically active components which are in close interaction with each other [5]. Biologically active components mainly represented by high and low molecular bioactive compounds, such as estrone, estradiol, ferments, α- and β-carotene, chlorophyll, sterols, organic acid and alcohols. Moreover, the nitrogen compounds make a significant contribution to the bioactivity [6].

The mineral component of sapropel includes macro- and microelements. The macroelements are in the form of oxides – SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO, Na_2O_3, K_2O, P_2O_5 [7]. The iron concentration in sapropel varied from 2% to 18%, aluminum – from 0.3% to 11%. The microelements are represented by Mn, Co, Mo, Cu, Ni, B, V, Cr.

Sapropel and preparations based on it have a positive effect to nervous, endocrine, cardiovasculare systems; improve the state of locomotor system; stimulate the metabolism processes in liver [8,9].

The purpose of this paper is to study the effect of sapropel powder on chemical and mineral composition of new sour-milk bio-product.

2. MATERIALS AND METHODS

2.1 Sour Milk Production Technology

The nonfat milk was used in the formulation of sour milk product. This type of milk is a dietary product with high level of complete protein and can be used for all types of population. The fermented milk culture was isolated from the national food “kurt” – fermented dry milk product. This product contains in general 34 species of bacteria, including *Lactobacillus, Bifidobacterium and Lactococcus*.

Sapropel was sampled from the sediments of Orenburg Lake. Sapropel dried at a temperature of 35°C and milled using vibratory miller. Obtained powder was filtered through the membrane filter.

The amount of sapropel powder was determined experimentally by production of sour milk product with different amount of sapropel from 0.5% to 5.0% (0.5%, 1.5%, 2.5%, 3.5%, 5.0%).

Sour milk bio-product with sapropel manufacturing process included ripening in milk ripener with addition of starter culture of 3% from milk mass. After ripening, milk clot was cut to small pieces with 8-10 or 12-14 cm in length. These clot pieces were stored for 20-30 min for whey separation. Then, for decreasing the acidity of whey until 36-40°T, warm water (45±2)°C was poured to the milk ripener. The total mass of

water must be 10-15% from the total mass of milk clot.

After adding the water, the clot was carefully mixed simultaneously with heating the milk ripener until 48-55°C. After that, the mixture was mixed for 30-60 min for hardening with whey draining. After hardening the curd was washed with water and dried. Then obtained curd was mixed with cream and sapropel powder and stored at 0-6°C.

The physico-chemical properties were determined in accordance with the "Technical Regulation for milk and milk products" of Russia. The safety of ready product was evaluated in accordance with National Standard GOST 31453-2013 [10].

2.2 Statistical Analysis

Statistical analysis was performed using Statistica 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The differences between samples were evaluated using ANOVA method. The differences were considered to be statistically significant at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

On the first stage we studied the nutritional value of sapropel. The chemical composition of sapropel mainly depends on the geographical locations. The sapropel sampled from the lake of Orenburg contains organic and non-organic compounds, including essential amino acids, vitamins and mineral elements (Table 1).

The organic matter of sapropel was more than half of the dry matter of sapropel and contained high level of crude protein and crude fibre. The amino acid composition of dry matter was represented by 61% of nonessential and 39% of essential amino acids.

The dry matter of sapropel contains significant amount of carotene (20.0 mg/kg) and vitamin B group. The high amount of vitamin B group increases the biological value of sapropel.

Sapropel is characterized by high percent of ash concentration (50.97%), which is represented by macro- and microelements. Sapropel from the lake of Orenburg is rich in manganese 316.0 mg/kg, calcium 148.0 mg/kg (in the form of calcium carbonate), zinc 59.7 mg/kg, copper 24.1 mg/kg and others. Sapropel classified as a safe, environmental friendly, without acute and chronic toxicity, non-allergenic.

Table 1. Chemical composition and nutritive value of sapropel

Index	
Organic matter, %	56,30
Protein, %	11,40
Fat (oil), %	0,24
Fibre, %	30,63
Ash, %	50,97
Non-essential amino acid, g/kg	32,5
Essential amino acid, g/kg	20,67
Carotene, mg/kg	20,00
Thiamine (B_1), mg/kg	4,65
Riboflavin (B_2), mg/kg	3,48
Cyancobalamin (B_{12}), mg/kg	65,89
Calcium, g/kg	148,00
Phosphorus, g/kg	2,50
Potassium, g/kg	3,09
Iron, g/kg	1,44
Sulfur, g/kg	3,02
Nitrogen, g/kg	1,67
Copper, mg/kg	24,10
Zinc, mg/kg	59,70
Manganese mg/kg	316,00
Cobalt, mg/kg	9,13
Iodine, mg/kg	19,70

Sapropel in powder form added to the formulation of sour milk of 1.5% of total mass.

We determined that in new sour milk bio-product the protein content was significantly higher (20.95%) than in control (18.40%) with decreasing of moisture content to 76.0-76.3% than in control sample 79.50% (Table 2). The mean fat amount is more in the new bio-product (2.85%) than in the control sample (2.15%). Both type of sour milk were classified by sensory characteristics as high grade sour milk. It has soft and homogenous consistency, white and slightly yellow color uniformly distributed throughout the mass of the product.

The sensory analysis showed that addition of more than 1.5% of sapropel powder leads to the abnormal flavor of sour milk product. The highest nutritive and biological value was determined in the sample of sour milk product with 2.0% of sapropel powder, but this difference was insignificant. In view of the obtained results, the optimal dose of sapropel powder in the formulation of sour milk product was approved as 1.5%. Addition of 3.5% and 5.0% of sapropel powder had a negative effect to the consistency (the product became dry and flake) and the flavor of the sour-milk product.

Table 2. Chemical composition of sour milk bio-product

Sample	Index				
	Protein, %	Moisture, %	Fat, %	Acidity, (°T)	Nutritional value, kcal
Control	18.4	79.4	2.2	210	93.4
	18.5	79.3	2.2	220	93.8
	18.5	79.3	2.2	210	93.8
	18.1	79.9	2.0	220	90.0
Mean	18.4±0.24	79.5±0.71	2.15±0.06	210±5.73	93.1±5.36
Bio-product	20.3	76.1	3.6	210	113.6
	21.0	76.2	2.8	200	109.2
	21.5	76.0	2.5	200	108.5
	21.0	76.3	2.7	210	108.3
Mean	20.95±0.53*	76.2±0.22*	2.85±0.79	200±4.69	108.4±8.96

**P<0.001*

Table 3. Mineral composition of sour milk bio-product

Element	Control sample, mg/kg	New sour milk bio-product, mg/kg	Maximum allowable concentration, up to mg/kg
Fe	0.41	0.30	3.0
Cu	0.09	0.12	0.5 – 1.0
Zn	3.88	3.19	5.0
Co	0.13	0.42	3.0
Pb	0.01	0.01	0.05-1.0
Mn	0.06	0.10	0.1-0.3
Mg	13.3	21.6	Not applicable
Ni	0.1	0.03	0.05-0.1

Mineral elements among other food components are responsible for high biological value of milk [11]. The food safety of sour milk was evaluated by the presence of heavy and toxic metals.

From the given Table 3, the concentrations of such elements as Cu, Co and Mg were higher in the new sour milk bio-product than in the control. These elements in high concentrations may be involved in causing a serious damage on human health and considered as heavy metals. Our findings revealed the concentrations of heavy metals in bio-product were lower than the maximum allowable concentration.

4. CONCLUSION

The new sour milk bio-product is a cow milk product with addition of non-milk ingredients for enriching the nutritive value of bio-product. Addition of 1.5% of plant sapropel increases the nutritive value of final product up to 15.3 kcal or 16.4% because of high content of protein and fat. The developed sour milk bio-product has more protein than in control, less moisture than in control sample and fat content is more in the new bio-product than in the control sample. The final bio-product meets the requirements of national standard GOST 31453- 2013.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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