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THE CONTENT OF SELECTED MACROELEMENTS AND MICROELEMENTS IN ACID TVOROGS WITH A DIFFERENT FAT CONTENT

ZAWARTOŚĆ WYBRANYCH MAKROELEMENTÓW I MIKROELEMENTÓW W TWAROGU KWASOWYM O RÓŻNEJ ZAWARTOŚCI TŁUSZCZU

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Streszczenie. Przeprowadzono analizę zawartości wybranych makroelementów i mikroelementów w twarogu kwasowym o różnej zawartości tłuszczu. Materiał badawczy stanowił twaróg kwasowy chudy (0% tłuszczu), półtłusty (4% tłuszczu) i tłusty (8% tłuszczu), pochodzący od jednego producenta. W badanym twarogu oznaczono zwartość suchej masy oraz popiołu całkowitego. Próbki twarogu poddano mineralizacji na mokro, a następnie oznaczano w nich zawartość wybranych makroelementów (P, Ca, Mg, K, Na) i mikroelementów (Zn, Fe, Cu, Mn). Zawartość Ca, Mg, Zn, Fe, Cu i Mn oznaczono techniką płomieniowej spektrometrii absorpcji atomowej (płomień acetylen – powietrze). K i Na oznaczano techniką emisyjną (płomień acetylen – powietrze). Do oznaczenia zawartości P zastosowano metodę kolorymetryczną. Badany twaróg kwasowy chudy, półtłusty i tłusty różnił się istotnie pod względem zawartości suchej masy. Twaróg kwasowy chudy charakteryzował się istotnie większą zawartością popiołu całkowitego niż twaróg kwasowy półtłusty i tłusty. W przeprowadzonych badaniach wykazano istotne różnice między badanym twarogiem kwasowym w zawartości P, Ca, K, Na, Zn, Fe, Cu i Mn, nie wykazano natomiast istotnych różnic w przypadku zawartości Mg. Bez względu na zawartość tłuszczu w badanym twarogu kwasowym w największych ilościach spośród oznaczonych makroelementów (około lub powyżej 100 mg · 100 g^{-1} produktu) występował: fosfor, potas i wapń, natomiast spośród mikroelementów (w ilości powyżej 600 µg · 100 g^{-1} produktu) – cynk.

Key words: acid tvorog, macroelements, microelements.
Słowa kluczowe: makroelementy, mikroelementy, twaróg kwasowy.

INTRODUCTION

Acid tvorog is one of the most popular unripened curd cheeses in Poland (Śmietana et al. 2003). Its popularity can be attributed to tradition, consumers' eating habits and low price (Górska-Warsewicz 2005). Tvorog is characterized by a relatively low-energy value and a high content of complete and easily digestible proteins. Acid tvorog contains also sugars, easily digestible milk fat, vitamins and minerals. As a low-energy product abundant in

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complete and easily digestible protein, tvorog is recommended for healthy consumers as well as consumers affected by pathological and non-pathological disorders who require a modified diet (Siemianowski and Szpendowski 2014).

Tvorog is produced by processing skimmed or normalized milk curd to reduce its fat content or, less frequently, by processing butter milk or butter milk and milk mixtures. Curd is produced by acidifying milk with lactic acid bacteria until its active acidity achieves the isoelectric point of casein fraction proteins. Curd processing involves cutting, stirring, heating and separation of the resulting curd grain from whey. The separated tvorog is formed, pressed, chilled and packaged. Subject to their fat content, the final pressed products are classified as skim, medium-fat and full-fat tvorogs (Holanowski 1986; Śmietana et al. 2003; Szpendowski et al. 2007).

Dairy products are a rich source of minerals in the human diet. Their mineral content differs subject to the applied production technology (Zaręba et al. 2012). During production, the mineral compounds in the raw material are separated between the curd and whey, a by--product of the cheese-making process. Only approximately 20% of calcium from processed milk is retained in the acid tvorog mass. The majority of mineral compounds in curd cheese are found in the aqueous phase. Curd cheeses with a varied fat content differ in their dry matter content and composition (Chmura et al. 2002).

The aim of this study was to determine the content of selected macroelements and microelements in acid tvorogs with a different fat content.

MATERIAL AND METHODS

The experimental material comprised skim, medium-fat and full-fat acid tvorogs supplied by the same manufacturer. Tvorogs were purchased in a chain store in Olsztyn. According to the label information, the analyzed tvorogs had a fat content of 0% (skim), 4% (medium-fat) and 8% (full-fat).

The dry matter content (PN-EN ISO 5534:2005) and total ash content (Krełowska-Kułas 1993) of tvorogs was determined. The mineral composition of tvorogs was analyzed to determine the content of selected macroelements: phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na), and microelements: zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn). The mineral content of tvorogs was established by wet mineralization in a mixture of nitric acid and perchloric acid (3 : 1 v/v). The samples were mineralized in a block heating digester (DK 20, VELP Scientifica, Italy) for 4–5 hours by gradually increasing the temperature from 120 to 200ºC. Mineralized samples were transferred to 25 cm^3 volumetric flasks and deionized water was added to the mark on the neck of the flask. Reagent samples were prepared simultaneously. The Ca, Mg, Zn, Fe, Cu and Mn content of mineralized tvorogs was determined by atomic absorption spectrometry (acetylene-air flame) in a spectrometer (iCE 3000 Series AAS, Thermo Scientific, UK) equipped with the GLITE data system, a deuterium lamp for background correction and cathode lamps. The elemental analysis was carried out at a wavelength of 422.7 nm (Ca), 285.2 nm (Mg), 213.9 nm (Zn), 248.3 nm (Fe), 324.8 nm (Cu) and 279.5 nm (Mn). In determinations of Ca content, an aqueous solution of lanthanum chloride was added to obtain La^{+3} concentrations of 0.5%

with the aim of eliminating the effects of P (Whiteside and Miner 1984). The content of K and Na was determined by atomic emission spectrometry (acetylene-air flame) at a wavelength of 766.5 nm (K) and 589.0 nm (Na). The content of P were determined by colorimetric detection (Markiewicz 2000), and absorbance was measured in a spectrophotometer (VIS 6000, KRÜSS – OPTRONIC, Germany) at 610 nm.

Dry matter content, total ash content, and the content of macroelements and microelements were expressed per 100 g of the product on a wet basis.

The results were processed statistically using Statistica 10 (StatSoft, Poland) software. Mean values and standard deviation were computed by one-way ANOVA at a significance level of p = 0.05. Differences between means were determined by Tukey's test.

RESULTS AND DISCUSSION

The dry matter content and total ash content of skim, medium-fat and full-fat tvorogs are presented in Table 1.

Table 1. Dry matter content and total ash content of acid tvorogs with a different fat content
Tabela 1. Zawartość suchej masy oraz popiołu całkowitego w badanym twarogu kwasowym o różnej zawartości tłuszczu

Component Składnik		Acid tvorog – Twaróg kwasowy		
		skim chudy	medium-fat półtłusty	full-fat tłusty
Dry matter Sucha masa	%	23.22a ± 0.06	26.94b ± 0.08	28.71c ± 0.14
Total ash Popiół całkowity	%	0.89b ± 0.01	0.85a ± 0.02	0.84a ± 0.01

Mean value ± standard deviation. Mean values marked with different letters in the same row are significantly different (p ≤ 0.05).
Wartość średnia ± odchylenie standardowe. Wartości średnie oznaczone w tym samym wierszu inną literą różnią się statystycznie istotnie (p ≤ 0,05).

The dry matter content of the evaluated tvorogs ranged from 23.22% (skim) to 28.71% (full-fat). Significant differences (p < 0.05) were observed in the dry matter content of skim, medium-fat and full-fat tvorogs. The dry matter content of the analyzed products increased with their fat content. According to label information, the analyzed tvorogs had the fat content of 0% (skim), 4% (medium-fat) and 8% (full-fat). The content of fat in dry matter was determined at 0.0% in skim tvorog, 14.9% in medium-fat tvorog and 27.9% in full-fat tvorog.

The total mineral content of the analyzed tvorogs was evaluated based on their total ash content. The average mineral content in terms of total ash content were determined in the range of 0.84% (full-fat) to 0.89% (skim). Skim tvorog was characterized by a significantly higher (p < 0.05) total ash content than medium-fat and full-fat tvorogs. In other studies, the ash content of curd cheese also increased with a decrease in its fat content. Szpendowski et al. (2007) evaluated acid curd cheeses with varied fat content and reported 4.50% fat content and 0.76% ash content in medium-fat cheese, and 0.50% fat content and 0.84% ash content

in skim cheese. In a study by Śmietana et al. (2003), full-fat acid tvorog was characterized by 8.05% fat content and 0.72% ash content, and medium-fat acid tvorog was characterized by 3.69% fat content and 0.75% ash content.

The content of macroelements and microelements in the analyzed acid tvorogs with a different fat content are presented in Table 2.

Table 2. The content of macroelements and microelements in acid tvorogs with a different fat content
Tabela 2. Zawartość makroelementów i mikroelementów w twarogu kwasowym o różnej zawartości tłuszczu

Element Pierwiastek	Acid tvorog – Twaróg kwasowy		
	skim chudy	medium-fat półtłusty	full-fat tłusty
Macroelements – Makroelementy [mg · 100 g^{-1} of tvorog – twarogu]			
P	217.68c ± 2.37	207.38b ± 2.75	202.65a ± 1.35
Ca	109.58b ± 5.51	96.18a ± 3.12	94.00a ± 1.58
Mg	8.30a ± 0.06	8.29a ± 0.04	8.25a ± 0.06
K	126.88b ± 1.32	124.18a ± 1.75	123.70a ± 1.30
Na	31.78b ± 0.43	32.07b ± 0.55	30.02a ± 0.33
Microelements – Mikroelementy [µg · 100 g^{-1} of tvorog – twarogu]			
Zn	669.58a ± 15.80	710.78b ± 10.75	669.22a ± 4.11
Fe	69.67b ± 1.71	66.65a,b ± 2.21	65.33a ± 2.96
Cu	22.72b ± 1.74	19.27a ± 0.31	21.75b ± 1.40
Mn	9.68a ± 0.37	11.38b ± 1.02	9.90a ± 0.45

Mean value ± standard deviation. Mean values marked with different letters in the same row are significantly different ($p \leq 0.05$).
Wartość średnia ± odchylenie standardowe. Wartości średnie oznaczone w tym samym wierszu inną literą różnią się statystycznie istotnie ($p \leq 0,05$).

Phosphorus was the most abundant macroelement in the analyzed tvorog samples. The average phosphorus content were determined at 217.68 mg · 100 g^{-1} in skim tvorog, 207.38 mg · 100 g^{-1} in medium-fat tvorog, and 202.65 mg · 100 g^{-1} in full-fat tvorog, and they decreased significantly ($p < 0.05$) with an increase in fat content. The average calcium content ranged from 94.00 mg · 100 g^{-1} in full-fat tvorog to 109.58 mg · 100 g^{-1} in skim tvorog. The calcium content of skim tvorog was significantly higher ($p < 0.05$) than in medium-fat and full-fat samples.

The calcium : phosphorus ratio is an important determinant of calcium bioavailability in humans. The Ca : P ratio in the diet should not be lower than 1.3 : 1 (Śmigielska et al. 2005). The average Ca : P ratio in the analyzed tvorogs was considerably below the above reference value at 0.50 : 1 in skim tvorog and 0.46 : 1 in medium-fat and full-fat tvorogs. Similar Ca : P values were noted in acid curd cheeses by Szpendowski et al. (2007). In the cited study, skim curd cheese contained 116.7 mg Ca · 100 g^{-1} and 270.2 mg P · 100 g^{-1}, and its Ca : P ratio was determined at 0.43 : 1, whereas medium-fat curd cheese contained 111.0 mg Ca · 100 g^{-1} and 231.6 mg P · 100 g^{-1} and was characterized by a Ca : P ratio of 0.48 : 1 (Szpendowski et al. 2007). In the work of Chmura et al. (2002), skim curd cheeses produced by centrifugation contained 104.1 to 107.0 mg Ca · 100 g^{-1} and 147.8 to 150.2 mg P · 100 g^{-1}, and their Ca : P ratio was estimated at 0.70 : 1.

The average magnesium content of the analyzed tvorogs ranged from 8.25 to 8.30 mg · 100 g^{-1}, and no significant differences were observed between skim, medium-fat or full-fat products. In a study by Chmura et al. (2002), acid curd cheeses with 0 to 21% fat content were characterized by magnesium content of 9.04 to 10.45 mg · 100 g^{-1}. Similar magnesium levels in acid curd cheeses with a varied fat content were reported by Szpendowski et al. (2007). In the above study, skim curd cheese contained 9.9 mg Mg · 100 g^{-1}, and medium-fat curd cheese – 10.3 mg Mg · 100 g^{-1}.

The average potassium content ranged from 123.70 mg · 100 g^{-1} in full-fat tvorog to 126.88 mg · 100 g^{-1} in skim tvorog. Sodium levels were determined in the range of 30.02 mg · 100 g^{-1} in full-fat tvorog to 32.07 mg · 100 g^{-1} in medium-fat tvorog. The skim product was significantly ($p < 0.05$) more abundant in potassium than medium-fat and full-fat tvorogs, whereas the sodium content of skim and medium-fat tvorog was significantly ($p < 0.05$) higher in comparison with full-fat tvorog. The potassium and sodium content of the evaluated products was similar to that noted by Chmura et al. (2002) in acid curd cheese. In the above study, 0% fat curd cheese contained 122.8 to 124.2 mg K · 100 g^{-1} and 32.14 to 33.60 mg Na · 100 g^{-1}, whereas 6–7% fat curd cheese contained 122.1 to 129.8 mg K · 100 g^{-1} and 32.78 to 33.32 mg Na · 100 g^{-1}.

Zinc was the most abundant microelement regardless of the fat content of the analyzed tvorogs. The highest average zinc content of 710.78 µg · 100 g^{-1} were reported in the medium-fat product. Skim tvorog contained 669.58 µg Zn · 100 g^{-1}, and full-fat tvorog – 669.22 µg Zn · 100 g^{-1} on average. The average manganese content of the evaluated products ranged from 9.68 µg · 100 g^{-1} in skim tvorog to 11.38 µg · 100 g^{-1} in medium-fat tvorog. Zinc and manganese content were significantly ($p < 0.05$) higher in medium-fat than in skim and full-fat tvorogs.

The average iron content of the evaluated tvorogs was determined in the range of 65.33 µg · 100 g^{-1} (full-fat) to 69.67 µg · 100 g^{-1} (skim). The skim product contained significantly ($p < 0.05$) more iron than full-fat tvorog, but its iron content did not differ significantly ($p < 0.05$) from that of medium-fat tvorog.

The average copper content in the analyzed products were determined at 22.72 µg · 100 g^{-1} in skim tvorog, 19.27 µg · 100 g^{-1} in medium-fat tvorog, and 21.75 µg · 100 g^{-1} in full-fat tvorog. The copper content of skim and full-fat tvorogs was significantly ($p < 0.05$) higher in comparison with medium-fat tvorog.

There is a general scarcity of information about the microelement content of acid-set tvorog in the available literature. The content of selected microelements in flavored homogenized quark cheese were analyzed by Kacprzak et al. (2011). The evaluated products contained 405 µg Zn · 100 g^{-1}, 73 µg Fe · 100 g^{-1}, 15 µg Cu · 100 g^{-1} and 20 µg Mn · 100 g^{-1} on average. In our study, acid tvorogs contained significantly more zinc, more copper, less iron and significantly less manganese on average than flavored homogenized quark cheese.

In dairy processing plants, tvorog is made from bulk milk. It is not certain whether the analyzed acid tvorogs with a different fat content were made from the same batch of milk. Therefore, it appears that the differences in the content of macroelements and microelements in tvorog could result from their different levels in the raw material.

CONCLUSIONS

The analyzed skim, medium-fat and full-fat tvorogs differed significantly in their dry matter content. The skim product was characterized by a significantly higher total ash content than medium-fat and full-fat products. Significant differences in phosphorus, calcium, potassium, sodium, zinc, iron, copper and manganese content were observed between tvorogs with a different fat content, whereas the magnesium content of the analyzed products did not differ significantly. In all analyzed tvorogs, the most abundant macroelements (about 100 mg $\cdot$ 100 g^{-1} or higher) were phosphorus, potassium and calcium, and the most abundant microelement (at 600 µg $\cdot$ 100 g^{-1} or higher) was zinc.

The results of this study indicate that regardless of its fat content, acid tvorog is abundant in macroelements and microelements. Despite the unfavorable Ca : P ratio (Ca : P = 0.46–0.5:1) of the analyzed products, acid tvorog can be a rich source of calcium in the diet if adequate amounts of phosphorus are supplied with other foods.

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Abstract. The objective of this study was to determine the content of selected macroelements and microelements in acid tvorogs with a different fat content. The analyzed material consisted of skim (0% fat), medium-fat (4% fat) and full-fat (8% fat) acid set tvorogs supplied by the same manufacturer. Dry matter content and total ash content was determined in the analyzed cheeses. Tvorog samples were subjected to wet mineralization, and the content of selected macroelements (P, Ca, Mg, K, Na) and microelements (Zn, Fe, Cu, Mn) was determined. The content of Ca, Mg, Zn, Fe, Cu and Mn were determined by atomic absorption spectrometry (flame acetylene-air). K and Na content was determined by atomic emission spectrometry (flame acetylene-air). The content of P were determined by colorimetric detection. The analyzed skim, medium-fat and full-fat tvorogs differed significantly in their dry matter content. Skim tvorog was characterized by a significantly higher total ash content than medium-fat and full-fat tvorogs. The evaluated tvorogs differed significantly in their P, Ca, K, Na, Zn, Fe, Cu and Mn content, but no significant differences in Mg content were observed. In all analyzed tvorogs, the most abundant macroelements (about 100 mg · 100 g^{-1} or higher) were phosphorus, potassium and calcium, and the most abundant microelement (600 µg · 100 g^{-1} or higher) was zinc.