Trace and Major Element Concentration in Cottage Cheese from Latvia

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Abstract: - Cottage cheese, a dairy product derived from cow milk by fermentation, traditionally is known as a component of healthy human diet and is widely consumed mostly in Northern Europe and Russia. The aim of the study was to investigate content of trace and major elements in cottage cheese and to discover a merit of cottage cheese in daily nutrition as well as to reveal possible ways of product contamination with potentially toxic elements. Twenty seven cottage cheese samples were obtained from individual dairy farms and supermarkets of Latvia. Samples were acid digested and analysed by atomic absorption spectrometry methods. Results revealed concentration rates for eleven trace and major elements (Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Zn). Seasonal fluctuations of element content in cottage cheese were found. Average content of some potentially toxic elements (Pb, Ni) was estimated as inappropriate high for cottage cheese samples derived in summer season. Amount of essential major elements in cottage cheese with different origin was not significantly variable, except for calcium which was detected in lower concentration in cottage cheese obtained in supermarkets, while range of potentially toxic elements was higher in cottage cheese samples derived from individual dairy farms.

Key-Words: - Cottage cheese, trace elements, major elements, food analysis, environmental contamination.

1 Introduction

Cottage cheese, also called as curds or quark, is protein rich dairy product obtained from whole milk or skimmed milk by fermentation with lactic starter, with or without adding enzymes and separating whey after milk coagulation.

Milk and its products already historically are known as valuable human daily nutrition components, in particular as source of amino acids, vitamins and minerals. Calcium and phosphorus are the main major elements that make dairy products irreplaceable for growing organisms of children in process of bone and teeth formation. Other essential elements (e.g., F, Fe, K, Mg, Na, S, Si) also can be found in milk products and are coupled in such chemical formations that can be easily absorbed by human body [1, 2, 3]. Fermented milk products including cottage cheese can be posed even as more valuable products due to their decreased percentage of fat and low amount of lactose which are the reasons that motivate adults to consume dairy products on a day-to-day basis. Some fermented milk products can contain essential elements in much higher amounts than they are available in unprocessed milk, for example, some kinds of cheese can be rich of calcium up to 1120 mg per 100 g while calcium amount in milk varies round about 120 mg per 100 g [4] or in average 1.12 g per 1 litre [5].

However, it is possible that not only valuable elements can appear in composition of food commodities. Contamination of dairy products with such elements as Cd and Pb can change otherwise healthy foodstuffs to potentially toxic products especially in a long term consumption, while other trace elements, for example, Cr, Cu, Mn, Zn are essential for human body only in tiny amounts but can become harmful if their quantities rise up [6, 7].

Current study was carried out with the aim to investigate content of trace and major elements in cottage cheese which is available for consumers in Latvia, and to discover a merit of cottage cheese in daily nutrition, as well as to reveal possible ways of product contamination with potentially toxic elements.

2 Material and Method

2.1 Sampling and sample preparation for analysis

In total 27 cottage cheese samples were purchased from randomly selected individual dairy farms and supermarkets in Latvia over two seasons

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(summer of 2009 and winter of 2010). All samples chosen were labelled as cottage cheese derived from whole milk, i.e., cottage cheese with content of fat not lower than 9%. For the reason to assess potential environmental impact on cottage cheese manufacturing only products of local origination were obtained. The samples were packed into disposable plastic bags and stored frozen at temperature -20 °C until sample preparation for analysis as it is described in literature [8].

Prior analysis frozen samples of cottage cheese were desiccated at temperature 60 °C by using drying oven "Gallenkamp Plus II Oven" and triturated subsequently. Sample decomposition were done by wet digestion using concentrated nitric acid as described by many authors and as it is widely used for pre-treatment of biological and environmental samples [e.g., 8, 9, 10, 11]. Following sample pre-treatment procedure steps were performed: a) 1 g (± 0,0002 g) of triturated cottage cheese sample was dissolved in 25 ml analytically pure concentrated HNO_3; b) 5 ml of concentrated analytically pure H_2O_2 were added; c) dissolution was accelerated by heating at temperature 160 °C until nitrogen oxides were vaporized. Afterwards solution was cooled and diluted to the final amount of 50 ml with ultra pure deionised water. All the pre-treatment procedure was carried out for triplicates of every single cottage cheese sample. For determination of accuracy of analytical methods a sample of reference material was prepared in the same mode as for samples of cottage cheese. Certified skimmed milk powder BCR-063R was used as reference material.

2.2 Applied analytical methods

Several analytical methods can be applied for detection of quantitative amounts of trace and major elements in miscellaneous biological and environmental samples. The main demands for choice of analytical techniques are sensitivity and selectivity which can be achieved by such methods as atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP-MS) or atomic emission spectrometry (ICP-OES), as well as total reflection X-ray fluorescence spectrometry (TXRF) or neutron activation analysis can be applied [11, 12]. Limitations for use of wide range analytical techniques are mostly connected with relatively high expenses.

In the current study of cottage cheese analysis it was decided to use atomic absorption spectrometry methods while in prior experimental analysis of one cottage cheese sample this methodology revealed the highest rate of recovery among such methods as TXRF and ICP-MS. Electrothermal atomic absorption spectrometry (GFAAS) was applied for detection of Cd, Cr, Ni and Pb in cottage cheese samples. Potassium and sodium were determined by flame atomic emission spectrometry (FAES), but Ca, Mg, Fe, Mn, Zn and Cu were detected by flame atomic absorption spectrometry (FAAS). Atomic absorption spectrometry procedure was carried out by using certified spectrometer "Perkin Elmer AAnalyst 200". Absorption was measured by background correction. Limit of detection, level of quantification and standard deviation was determined by using blank samples.

3 Results and Discussion

3.1 Assessment of major element content

Most abundant major elements quantified in cottage cheese samples were calcium and potassium following by sodium and magnesium with detected concentration ranges: Ca 1.38-12.29 g/kg, K 0.75-8.87 g/kg, Na 0.23-1.78 g/kg and Mg 0.13-0.53 g/kg. As it was impossible to find any previous studies of cottage cheese elemental content the achieved results were compared with average content of trace and major elements in milk (Table 1). Numerical outcomes discovered about threefold distinctions between average major element content for calcium, potassium and magnesium in favour of cottage cheese.

Table 1. Comparison of average content of trace and major elements in milk [5] and cottage cheese.

Element	Cottage cheese, content per 1 kg of dry weight	Milk, content per 1 l
Ca, g	4.12	1.12
K, g	4.51	1.36
Na, g	0.97	0.53
Mg, g	0.33	0.11
Zn, mg	30.52	3.90
Fe, mg	5.88	0.50
Cu, mg	0.87	0.09
Mn, mg	0.56	0.03
Pb, mg	0.41	-
Ni, mg	0.18	0.026
Cr, mg	0.09	0.002

Such differences can be associated mostly with the impact of milk fermentation and cottage cheese manufacturing peculiarities. But this assumption could be verified only if the whole process of cottage cheese making would be investigated step by step according to quantitative analysis of intermediate products.

In general content of major elements in dairy products mostly is be dependent on elemental composition of dairy animal feed [9] in particular if animals have been fed with fodder enriched with mineral substances and held under indoor conditions which is most typical for large farms. If animals have possibility to live outdoor and get as feed natural grass then content of major elements is also dependent on element levels in the environment [9, 12] as well and can reveal elemental composition of soil, water and vegetation.

3.2 Content of trace elements in cottage cheese

In total it was possible to determine seven trace elements in analyzed cottage cheese samples. The highest concentration rates were found for zinc and iron, 15.34-95.32 mg/kg and 0.51-23.16 mg/kg, respectively. Other trace elements detected by applied atomic absorption spectrometry methods were: Cu (0.13-1.69 mg/kg), Mn (0.15-1.31 mg/kg), Pb (0.013-1.070 mg/kg), Ni (0.017-0.710 mg/kg) and Cr (0.023-0.250 mg/kg). As it was summarized in Table 1 not only major element content but also trace element content appear to be much higher in cottage cheese samples than in unprocessed milk. Unlike the determined content of major elements elevated levels of trace elements in cottage cheese can be explained by possible contamination during milk collection and transport, and contamination during production by technical equipment used which may contain details made from heavy metals and their alloys. It can be assumed that also site specific environmental impact is of great importance for trace element appearance in final product. Dairy animal breeding under outdoor conditions, as it is typical for small individual dairy farms, can result in excess of contamination with heavy metals.

Too high amount of possibly toxic trace elements (Pb, Ni, Cr) in cottage cheese arise qualms of potential risk for consumer safety while these elements can bring harmful effects for human health especially in long term intake. There are no maximum contamination levels set for heavy metals in milk products except for lead. Taking into account the legal regulations of European Commission the limit for concentration of lead in raw milk, heat-treated milk and milk for manufacture of milk-based products is set 0.02 mg/kg of wet weight [13].

3.3 Seasonal distinctions of trace and major element content in cottage cheese

Comparison of trace and major element content in cottage cheese samples obtained over different seasons showed evidence of substantial environmental impact on element occurrence in the final product of milk processing.

Content of all detected major elements in cottage cheese derived in winter season was higher than in samples from summer season especially concerning calcium and potassium (see Fig. 1) which can be explained by animal feed and breeding distinctions between seasons. As it was mentioned before dairy animals are fed by supplemented fodder during a winter season and this factor can be most relevant for the increase of major element content in subsequently derived food products such as milk and also cottage cheese.

Impact of seasonality is obvious also for content of trace elements. Obtained results revealed that potentially toxic elements such as lead and nickel prevailed over in the samples derived in summer season that can be associated with telling impact of environmental pollution on food chain soil-feed-milk.

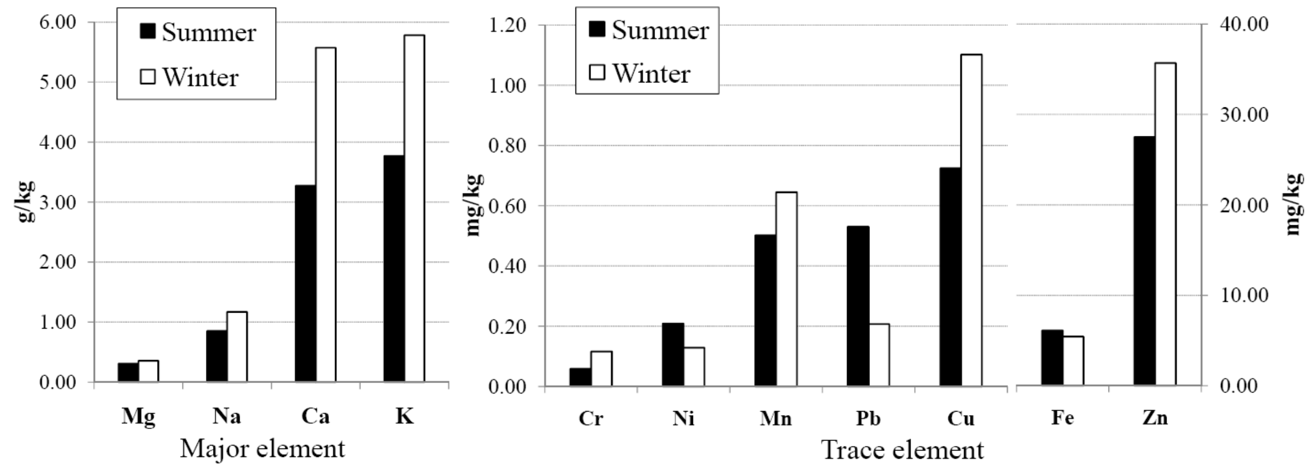

Fig. 1. Average content of trace and major elements in cottage cheese depending on season.

3.4 Impact of provenance of cottage cheese on the element content

As the provenance of the cottage cheese samples was established at the moment of purchasing it was enough easy to compare content of trace and major elements in cottage cheese produced by individual dairy farms with those obtained from supermarkets where dairy products comes from large-scale manufacturers (Fig. 2).

The results revealed considerable interconnections. Firstly, range of major elements did not varied significantly but it showed stable tendency that major elements, especially calcium, prevailed in cottage cheese samples from individual dairy farms. Secondly, concerning trace elements all except nickel and copper were also detected in higher amounts in cottage cheese samples from individual dairy farms. These coherences indicate of both, better dairy animal breeding conditions in small individual dairy farms as well as higher possibility to contaminate the product with potentially toxic elements. Conversely, animals in large-scale dairy farm complexes mostly have less possibility to contact with environmental pollutants and they get more balanced supplemented fodder equally all over the year. Another assumption for these distinctions can be related to milk processing equipment and manufacturing practice asset while in large-scale farms cottage cheese production process is organized in more closed processing chains by applying automation which allows to avoid an unexpected contamination.

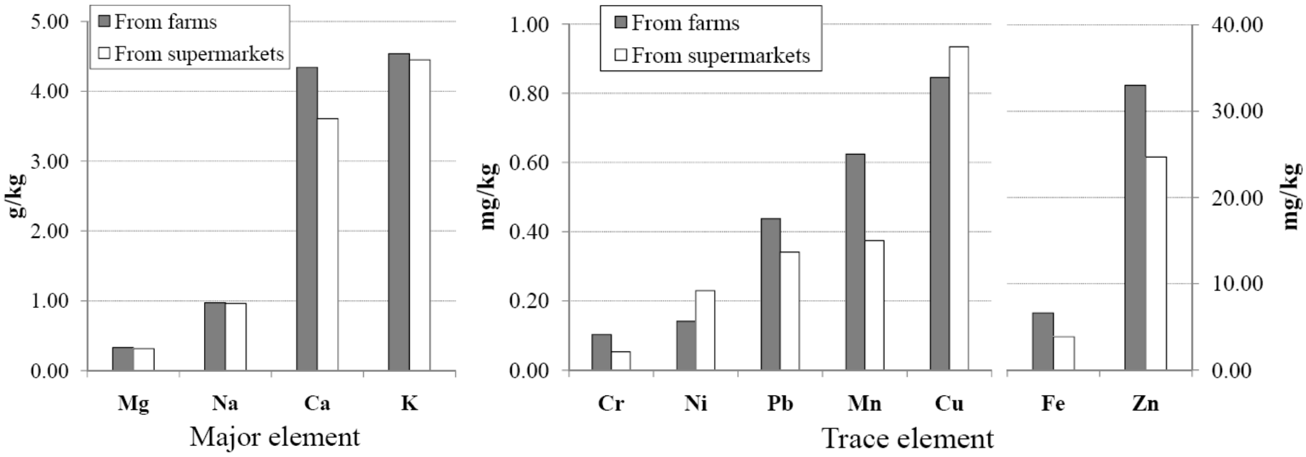

Fig. 2. Average content of trace and major elements in cottage cheese depending on producer.

4 Conclusions

1) Quantitative detection of trace and major elements is a good indicator of the quality of dairy products that can be affected by several factors such as environmental pollution, peculiarities of processing techniques, hygienic conditions or dairy animal breeding and feeding specifics.

2) Assessment of trace and major element content in cottage cheese reveal benefits that can be achieved from valuable nutrients as well as risks from potentially toxic element contamination. Current study discovers higher amounts of heavy metals in cottage cheese manufactured by small individual dairy farms.

3) Content of trace and major elements detected in food samples can discover site specific environmental impacts such as geological or climatic conditions that can distinctively influence existing food chains.

For higher statistical certainty the results of current study will be supplemented with analysis of extra cottage cheese samples as well as data analysis and detailed risk and benefit calculations.

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