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Determination of Minerals in Kefir by Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES)

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The concentrations of the minerals, Ca, P, Na, K and Mg and the trace elements, Fe, Cu, Zn and Mn were determined in plain and flavoured kefir. The mean concentrations of minerals and trace elements were recorded in plain and flavoured samples: Ca, 1.28 ± 0.11; 1.11 ± 0.05, P, 8.71 ± 0.64; 8.02 ± 1.44, Na, 0.70 ± 0.15; 0.78 ± 0.20, K, 0.66 ± 0.30; 0.49 ± 0.30, Mg, 0.14 ± 0.02; 0.16 ± 0.05 as g/kg total solids and Zn, 6.82 ± 4.54; 6.35 ± 2.75, Fe, 3.38 ± 0.88; 3.71 ± 0.96, Cu, 1.10 ± 0.69; 1.22 ± 0.70, Mn, 0.02 ± 0.08; 0.38 ± 0.67 as mg/kg total solids, respectively. It was observed that trace element contents were higher in flavoured kefir samples than in plain kefir, probably due to the use of adjuncts.

Key Words: Kefir, Mineral elements, ICP-OES.

INTRODUCTION

Fermented milk and milk products have an important role in the diets of people around the world. They produce a wide range of physiological and therapeutic effects, including stimulation of the immune system. These products are capable of supplying highly bioavailable minerals and trace elements[1-3]. There are 20 minerals that are considered to be nutritionally essential for humans and these are generally classified into two main groups, namely, the macrominerals (sodium, potassium, chloride, calcium, magnesium and phosphorus) and the trace elements (iron, copper, zinc, manganese, selenium, iodine, chromium, cobalt, molybdenum, fluoride, arsenic, nickel, silicon and boron)[4,5]. The minerals content of milk depends on numerous factors, such as the lactation period, the breed of animal, species and health of animal, agro-climatic conditions and the dietary composition of animal feed[6-8].

Kefir, a fermented dairy product originating in the Caucasus Mountains, has become popular in many European countries. The word 'kefir', meaning 'good feeling', is said to have originated from the Turkish word 'keyf' due to the overall sense of health and well-being when consumed[9]. Kefir is produced by the fermentation of milk with a grain-like starter culture. These grains are gelatinous irregular masses, white or light yellow in colour and they usually contain a relatively stable and specific balance of yeast, lactic acid bacteria and acetic acid bacteria that exist in a complex symbiotic relationship. The different groups of microorganisms present in the grains are active at different stages of the fermentation and are trapped in a complex matrix of polysaccharides and proteins[10-13].

The acidic, mildly alcoholic kefir drink contains about 0.6-0.9 % lactic acid, as well as formic acid, succinic acid and propionic acid, CO_2, 0.6-0.8 % ethyl alcohol, aldehydes and trace amounts of isoamyl alcohol and acetone. Since the lactose from milk is mostly (75 %) fermented, people who are lactose-sensitive can safely consume kefir [14,15].

Beyond its high nutritional value as a source of protein and calcium, kefir has a long tradition of being regarded as good for health. In the former Soviet Union, kefir has been recommended to lower the risk of chronic diseases and it has also been given to certain patients for the clinical treatment of a number of gastrointestinal and metabolic diseases, hypertension and allergies[16]. In addition to beneficial bacteria and yeast, kefir contains minerals that help the body by playing an essential role in regulating enzyme activities, maintaining acid-base balance and osmotic pressure, facilitating membrane transfer of essential nutrients and maintaining nerve and muscular irritability[15].

The composition and flavour of kefir vary significantly depending on a variety of factors including the source (cow, ewe, goat or mare)[15-18] and the fat content (regular, low fat or nonfat) of the milk used, the composition of the starter grains and the technological conditions of production[19]. Although the composition, sensory properties and health impact of kefir have been widely reported, there have been no studies on the mineral and trace element contents of kefir. In this paper, we determined the concentrations of various metals in Turkish kefirs.

EXPERIMENTAL

Samples of plain (n = 24) and flavoured (n = 16) kefir were collected monthly from autumn 2008 to spring 2009 from retail markets in Bursa.

Methods: The kefir samples, stored at ambient temperature, were thoroughly mixed prior to determination of the minerals and trace elements. Three-gram samples of each were weighed in crucibles. The crucibles were placed in a cold furnace and ashed at 550 ± 5 ºC for 6 h. 1 mL 25 % HNO_3 solution was added to the cooled samples and they were kept overnight and re-ashed at 550 ± 5 ºC for 6 h. The mixtures were transferred into 250 mL of volumetric flasks, high purity deionized water was added to adjust the final volume and the mixtures were centrifuged for 20 min at 2000 rpm (Hettich Universal 30F, Tuttlingen, Germany). The kefir samples were analyzed by OPTIMA© 2100 DV inductively coupled plasma-optical emission spectrometer (Dual View, Perkin-Elmer Life and Analytical Sciences, USA). Appropriate standards for each element were made within the concentration range of the element in the samples. The operational conditions, analytical lines used, measurement parameters and wavelengths of the elements are shown in Table-1. Three water blanks were run with each batch of samples.

TABLE-1
OPERATING PARAMETERS FOR ICP-OES

		Detection wavelengths (nm^{-1})	
Nebulization gas flow rate	0.55 L min^{-1}		
Auxiliary gas flow rate	0.2 L min^{-1}	P	214.914
Plasma gas flow rate	17 L min^{-1}	Na	589.592
Sample flow rate	1.5 mL min^{-1}	K	766.490
Operating power	1 450 W	Ca	393.366
View	Axial	Mg	279.553
Interface	Shear gas	Fe	259.940
Sample uptake rate	1.0 mL min^{-1}	Cu	324.754
Spray chamber	Cyclonic	Zn	213.857
Nebuliser type	Meinhard	Mn	257.610
Nebuliser set up	Instant	–	–
Replicates	3	–	–

RESULTS AND DISCUSSION

The statements about the minerals content of milk and other dairy products are very controversial because the determined composition of milk is not constant but depends on a number of factors, such as the manufacturing conditions and the methods of analysis[5,20,21].

The mean concentrations of minerals and trace elements in kefir are displayed in Table-2. The values obtained for the main mineral elements show an important variability. This variability may be related to the composition of the raw milk, the manufacturing technology or the fermentation conditions.

Kefir contains relatively high proportions of Ca and P. The average concentrations of Ca in plain and flavoured kefir were 1.28 ± 0.11 and 1.11 ± 0.05 g/kg total solids, respectively. Calcium, the most abundant divalent cation in the human body, helps the formation of bones and teeth, regulates the permeability of cell membranes and promotes muscle contractions as well as normal heart rhythm and blood clotting. It is involved in neuromuscular, enzymatic, hormonal and other metabolic activity[22,23]. It is well-documented that diets deficient in dairy products and calcium are a risk factor for pre-eclampsia, cardiovascular disease, hypertension, cancer and osteoporosis and that adequate dairy intake may independently reduce the risk of obesity[19,24-26]. The average P contents of plain and flavoured kefir were 8.71 ± 0.64 and 8.02 ± 1.44 g/kg total solids, respectively. Phosphorus is a major element in hydroxyapatite crystals. It is an essential component of bones (Ca:P~2:1) and the nervous system and it plays important roles in maintenance of the acid/base equilibrium and the synthesis of nucleic acids, amino acids, phospholipids and high-energy bonds (ATP)[27].

Sodium is necessary for the regulation of the osmotic pressure of bodily fluids and the acid-base balance[28]. The sodium contents of plain and flavoured kefir were 0.70 ± 0.15 and 0.78 ± 0.20 g/kg total solids, respectively (Table-2).

TABLE-2
MINERAL AND TRACE ELEMENT CONCENTRATIONS OF KEFIR

Mineral		Plain Kefir			Flavoured Kefir		
		Min	Max	Avg±SD	Min	Max	Avg±SD
Expressed as g/kg total solids	Ca	1.10	1.52	1.28±0.11	0.99	1.16	1.11±0.05
	P	7.78	9.71	8.71±0.64	7.00	11.27	8.02±1.44
	Na	0.60	0.99	0.70±0.15	0.53	1.28	0.78±0.20
	K	0.11	1.03	0.66±0.30	0.17	0.89	0.49±0.30
	Mg	0.10	0.16	0.14±0.02	0.11	0.23	0.16±0.05
Expressed as mg/kg total solids	Zn	1.67	12.36	6.82±4.54	2.69	9.52	6.35±2.75
	Fe	2.45	4. 81	3.38±0.88	2.26	4. 86	3.71±0.96
	Cu	0.54	2.87	1.10±0.69	0.25	2.20	1.22±0.70
	Mn	0.00	0.24	0.02±0.08	0.00	1.57	0.38±0.67

As seen in Table-1, the concentrations of potassium were 0.66 ± 0.30 and 0.49 ± 0.30 g/kg total solids for plain and flavoured kefir, respectively. Potassium is an important component of living cells that is involved in osmotic pressure, acid and base regulation, transmission of nerve impulses and formation of collagen and elastin, especially as related to rheumatoid arthritis[28].

The mean Mg contents of plain and flavoured kefir were 0.14 ± 0.02 and 0.16 ± 0.05 g/kg total solids, respectively (Table-2). The intake of dietary magnesium is associated with a reduced risk of coronary heart disease[26,29]. Other possible benefits of magnesium intake in relation to heart disease include decreased blood pressure due to the dilation of arteries, prevention of heart rhythm abnormalities and inhibition of blood clotting. Magnesium is also important in nucleic acid and protein metabolism and heart muscle regulation, together with calcium[30,31].

Zinc is an essential nutrient for growth and development in all life forms. Milk and dairy products are considered to be good sources of Zn, as they contribute readily assimilable zinc to the diet[32-34]. Zinc concentrations in plain and flavoured kefir were 6.82 ± 4.54 and 6.35 ± 2.75 mg/kg total solids, respectively (Table-2).

As shown in Table-2, the concentrations of iron in plain and flavoured kefir were 3.38 ± 0.88 and 3.71 ± 0.96 mg/kg total solids, respectively. Milk and milk products were not stated as a main iron source and the iron content of these products is mainly affected by the composition of the animal feed and the adjuncts used in the processing of milk[33]. On the other hand, iron may be introduced from contamination during milking or processing in factories as a result of contact with iron in the equipment[34].

Copper plays an essential role as a cofactor for enzymes that generate cellular energy, cross-link connective tissue and mobilize iron in the synthesis of hemoglobin[35,36]. The mean Cu contents were 1.10 ± 0.69 mg/kg in plain kefir samples and 1.22 ± 0.70 mg/kg in flavoured samples (Table-2).

The mean manganese contents in plain kefir samples were 0.02 ± 0.08 and those of flavoured samples were 0.38 ± 0.67 (Table-2). Manganese is a cofactor for certain enzymes, including pyruvate carboxylase, an enzyme used in carbohydrate metabolism and superoxide dismutase[37].

Conclusion

Fermented dairy products are good dietary sources of minerals necessary for optimal health. Kefir can contribute a considerable amount of mineral element supplementation to the human diet. The intake of calcium, magnesium, iron, copper, zinc, sodium and potassium, which are essential minerals for good nutrition, is mainly through the consumption of food. Kefir appears to contain high amounts of calcium, potassium and phosphorus, which are keys in the development of strong bones and teeth and many other metabolic activities. There is rather limited literature on the mineral constituents of kefir and this work provides functional information for scientists in the field of fermented dairy products.

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