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Mineral and Trace Metal Levels of Akçakatik Cheese Collected from Mediterranean Region-Turkey

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In this study, 15 randomly selected samples of Akçakatik, cheese were purchased from different markets in Mediterranean region of Turkey. Mineral, trace and heavy metals including calcium, potassium, magnesium, copper, manganese, iron and zinc were analyzed using atomic absorption spectrometry. The ash content was in the range 4.89-8.53 %. The mean concentration of 49.62, 417.74 and 2842.24 mg/kg was measured for Mg, K and Ca, respectively. The concentration of the tested metals was in the range Zn > Fe > Mn > Cu. The mean concentration of 3.36, 6.15, 12.62 and 13.92 mg/kg was measured for Cu, Mn, Fe and Zn, respectively. In our samples, tested levels were higher than reported in previous studies, except the elements Fe and Ca.

Key Words: Trace metals, Minerals, Atomic absorption spectrometry, Mediterrean, Cheese, Akçakatik cheese.

INTRODUCTION

The consumption of cheese is of great nutritional interest, due to its composition of micronutrients and especially minerals. The quality of dairy products depends not only on chemical and microbiological parameters, but also on the qualitative and quantitative evaluation of the mineral fraction constituents. The mineral content of cheese is highly variable and depends on numerous factors such as i) initial composition of the milk, which in turn depends on the breed, stage of lactation physiological condition of the animal, composition of the feed and environmental factors; ii) cheese making procedures, iii) ripening conditions, which include not only the temperature and relative humidity prevailing in the maturation room, but also protocols of surface salting and washing[1].

Trace metals may contaminate our foods by the sources: (i) soil, (ii) chemicals used in agricultural land, (iii) water used in food processing or cooking, (iv) equipment, containers and utensils used for food processing; and (v) packaging, storage and cooking. The presence of trace metals in the environment and foodstuff represents a crucial problem in most of the countries around the world. The risk associated with the exposure to trace metals in food products has increased widespread concern for in human health. Acute and chronic symptoms, dizziness, nausea, vomiting, diarrhea, sleeping disorders, loss of appetite and reduced conception rate are the symptoms of heavy metal toxicity. Trace metals have also been connected to cardiovascular disease, depressed growth, impaired fertility, nervous and immune system disorders, increased spontaneous abortions and elevated death rate among infants. Recent investigations have shown that a number of trace metals in various milk and dairy products might be a serious health risk for humans and animals. The intake of heavy metals due to consumption of contaminated milk and dairy products has toxic effects depending on contamination and absorption levels[2-6].

Akçakatik cheese, which is matured in "Karin (goat's stomach), is a common type of cheese belonging to the district of Karaman, Kozluca, Yesilova and Yaylabeli in Burdur province. It is produced using mostly goat's and cow's milk, or a mixture of both. The cheese is generally made in homes using traditional methods and therefore may vary according to the individual methods of the producer. The manufacturing practices of Akçakatik cheese, with the absence of any rigorous control of temperature and relative humidity during storage, causes variations in the final quality of the product. The variation in Akçakatik cheese indicates the absence of any standardized method for the production of these cheese varieties. The cheese "asçi katigi" is known by the local population. Its name was changed in time as Akçakatik. Over time the name of cheese was placed in public language as Akçakatik. Taste and aroma are similar in terms of Tulum cheese. Unlike other cheeses, it is made from yoghurt and various spices and then mixed together. These spices give the cheese a sharp taste and a palatable odor[7,8].

Research on Akçakatik cheese is very limited. According to Kirdar[7], the gross composition of the Akçakatik cheese was as follows: dry matter, fat, salt and titratable acidity (% in lactic acid) were found as 10.3-30.2 %, 24.50-59.63 %, 5.38-9.12 %, 0.9-2.16 %, respectively. In general, the existing literature on trace element composition of cheese is rather scarce at the international level and also in Turkey.

The aim of this research is to determine the content of some minerals and trace metals of Akçakatik cheese.

EXPERIMENTAL

15 Ripened Akçakatik cheese samples (-250 g each) were collected in May 2009 and September 2009 from different producers of the Burdur province in Mediterranean region.

Akçakatik was simultaneously manufactured according to traditional procedures in homemaker located in the province of Burdur of the full production area. The age of the ripened cheeses was approx 3 months. The Akçakatik cheese samples were transported to the laboratory and kept at approximately at 4 ºC until they were analyzed. The ash content of the cheese was quantitied by dry ashing the samples in a muffle furnace at 550 ºC for 24 h. Before samples were placed in the muffle furnace, they were dried in an oven at 105 ºC[9].

Mineral analysis: Calcium, iron, potassium, magnesium, manganese, copper and zinc were determined by atomic absorption spectrometry (ATI Unicam-929). For mineral analysis, all reagents were of an analytical grade. All reagents and samples were prepared in double distilled water. The determinations were carried out at 422.7, 766.5, 285.2, 279.5, 324.8, 248.3 and 213.9 nm for calcium, potassium, magnesium, manganese copper, iron and zinc, respectively. Standard calcium, potassium, magnesium, manganese, copper, iron and zinc solutions were freshly prepared from a 1000 ppm stock solution and a linear calibration curve was used. The quantify these metals, samples were solubilized by dry ashing 550 ºC in a furnace[9]. All the analyses were performed in duplicate.

Statistical analysis: All of the statistical calculations were performed using SPSS Statistical Software and the obtained values were presented as the mean ± SE. Evaluation of significance was performed by analysis of variance, followed by spearman correlation. The significance level of $p < 0.01$ was used for determining statistical differences[10,11].

RESULTS AND DISCUSSION

Akçakatik cheese had the highest ash content as expected. The ash content was in the range 4.89-8.53 %, averaging 6.91 ± 1.09 %. These values are higher than the results reported by Ayar[12], for Kasar cheese, by Akyüz *et al.*[13] for Örgü cheese and by Altur[14] for Kelle cheese. These results can be originated from milk composition and different production techniques. Ash content of samples was found in a wide range. These results were in agreement with the finding of Yildiz[15]. Akçakatik cheese includes higher ash than our traditional cheese such as Kasar, Örgü, kelle, Herby cacik, herby cheese and herby lor.

Macro minerals such as sodium, potassium, magnesium and calcium are an important group of milk nutrients required by the human body in amounts greater than 100 mg per day for optimal function. Potassium is the major cation in intracellular fluid and plays a role in the regulation of osmotic pressure, blood pressure and acid-base balance[16].

Magnesium is primarily an intracellular nutrient and plays diverse roles in protein and carbohydrate metabolism, synthesis of DNA and muscle relaxation. Furthermore, magnesium forms a complex with ATP, which serves as the true substrate for biochemical reactions involving energy utilization[17].

Magnesium, protein and nucleic acid metabolism and enzyme systems found an important function as cofactors in the macro element. The magnesium content ranged from 37.06 mg/kg to 65.89 mg/kg, averaging 49.62 ± 93.01. These values are higher than the results reported by Isleten *et al.*[18]. These results were in agreement with the finding of Yildiz[15].

Potassium is found in body fluids and is essential for water and electrolyte balance and for the proper functioning of cells, including nerves. It is present in almost all foods but fruit (*e.g.* dried fruits, bananas and berry fruits), vegetables and milk are rich sources. Processed foods typically contain less than raw foods. Potassium has a beneficial blood pressure-lowering effect in people with raised blood pressure. The maximum potassium content was found 699.20 mg/kg and as the minimum potassium values 281.89 mg/kg. Potassium content of Akçakatik cheese was higher than Tulum and Kasar cheese[19].

Calcium is important in the development and maintenance of strong bones and teeth[20] and is also involved in nerve function, muscle contraction and blood clotting[21]. Calcium also plays an essential role in intracellular signaling and is therefore necessary for nerve and muscle function. It is also involved in blood clotting. Foods that are particularly rich in calcium are milk, cheese and other dairy products (but not butter). Mean calcium concentration of the samples varied from 1915.97 to 4067.31 mg/kg and in the literature, low calcium concentration has been reported. The level of calcium in Akçakatik cheese was much higher than Herby cheese, Herby cacik, Herby lor and lower than White cheese[2], Tokat cheese, Tulum cheese, Cecil cheese[3] (Table-1). Akçakatik cheese is suggested for adequate calcium intake in a daily diet.

Mineral content of Akçakatik cheese determined by the characteristics of the relationship between the correlation coefficients were calculated to determine significance. Statistical evaluation results are given in Table-2. The correlation coefficient between potassium and magnesium, calcium and magnesium, calcium and potassium was $r = 0.449$, $r = 0.681$ and $r = 0.589$ ($p < 0.01$), respectively.

Micronutrients elements such as zinc, potassium, magnesium are essential for human, animals and plants. Zinc is a nutritionally essential metal and a deficiency results in severe health consequences, zinc deficiency results in a wide spectrum of clinical effects depending on age, stage of development and deficiencies of related metals. At the other extreme, excessive exposure to zinc is relatively uncommon and occurs only at very high levels. The zinc content of substances in contact with galvanized copper or plastic pipes may be increased. The maximum tolerable daily intake of zinc is 60 mg[22].

Zinc contents of the investigated Akçakatik cheese were in the range of 9.92-18.73 µg/g, averaging 13.92 ± 2.74 µg/g. These values are lower than the results reported by Gambelli *et al.*[23], for Italian quark cheeses and by Prieto *et al.*[24], for

TABLE-1
CONCENTRATION LEVELS OF ELEMENTS (µg/g) IN CHEESE SPECIES

Cheese species	Ca	K	Mg	Ref.
White cheese	3718.0 ± 368	305 ± 30	67.6 ± 6.5	2
Tokat cheese	4556.0 ± 438	349 ± 33	78.6 ± 7.6	3
Van herby cheese	4151 ± 413	228 ± 30	56.3 ± 4.9	27
Herby cacik	469.0 ± 119.3	-	24.76 ± 13.7	31
Herby cheese	313.7 ± 45.94	-	12.70 ± 2.31	31
Herby lor	645.4 ± 87.40	-	31.85 ± 12.4	31
Trabzon wire cheese	4503 ± 436	346 ± 32	97.4 ± 9.3	3
Erzincan Tulum cheese	4416 ± 440	362 ± 29	101 ± 10	3
Ordu çerkez cheese	3688 ± 356	349 ± 31	127 ± 12	3
Çeçil cheese	3722 ± 371	326 ± 30	48 ± 4.5	3
Mihalic cheese	988 ± 197	131 ± 36	43.6 ± 7.6	36

TABLE-2
CORRELATIONS BETWEEN THE MINERAL COMPONENTS

	Mg	K	Ca	Cu	Mn	Fe	Zn
K	0.449**						
Ca	0.681**	0.589**					
Cu	-0.093	-0.041	-0.271				
Mn	-0.252	0.429**	0.186	0.165			
Fe	-0.003	0.133	-0.096	0.229	0.213		
Zn	0.770**	0.502**	0.766**	-0.177	-0.106	0.009	
Ash	0.509**	-0.061	0.16	0.196	-0.094	0.363*	0.394**

Significantly *p < 0.05, **p < 0.01

Picon Bejes-Tresviso cheeses and Kiliçel *et al.*[25] for Kes cheese and higher than the results reported by Mendil[3], for white cheeses and similar to those reported by Orak *et al.*[5] and Merdivan, *et al.*[2] for Turkish white cheeses (Table-3).

Iron is required for the formation of hemoglobin in red blood cells, which transport oxygen around the body. Iron is also required for normal energy metabolism and for metabolism of drugs and foreign substances that need to be removed from the body. The immune system also requires iron for normal function. The maximum iron content was found 29.05 µg/g and the minimum iron values were 7.49 µg/g. These results were in agreement with the findings of Merdivan *et al.*[2]. The results are lower than the results reported by Park[26], for USA herby cheeses and by Tarakci *et al.*[27], for Herby cheeses, higher than the results reported by Mendil[3] in Tokat cheeses, Trabzon wire cheese, Erzincan Tulum cheese, Ordu çerkez cheese, cecil cheese and by Yuzbasi, *et. al.*[28] in Kasar cheese (Table-3).

Copper is known to be important and toxic for many biological systems. It may enter the food materials from soil through mineralization by crops, food processing or environmental contamination. The essential role of copper in maintaining normal health in both animals and humans has been recognized for many years. The average daily dietary requirement for copper in the adult human has been estimated to be 3 mg[22]. High content of Cu observed in the Akçakatik cheese is due to contamination caused by the milk or the cheese coming into contact with metallic utensils during manufacturing[29].

The copper values of the samples varied from 1.44 µg/g to 8.69 µg/g and these values are higher than those reported earlier[2,3,24,28].

Manganese is a normal component of living things, including both plants and animals, so manganese is present in foods. For nearly all people, food is the main source of manganese. The Institute of Medicine recommends that intake of manganese from food; water and dietary supplements should not exceed the tolerable daily upper limit of 11 mg/day[30]. In this study, manganese was determined as 6.15 µg/g and as in the literature, low manganese concentrations have been reported[2,3,24]. These results were in agreement with the finding of Kiliçel *et al.*[31] and Tarakci and Kucukoner[32]. Intake of Mn in our cheese samples is below the tolerable daily upper limit of National Research Council.

TABLE-3
TRACE METAL CONCENTRATION OF EXPRESSED IN LITERATURE AS µg/g IN CHEESE SPECIES

Cheese species	Zn	Fe	Cu	Mn	Ref.
White cheese	12.63±0.75	1.98±0.30	0.430±13	0.052±0.03	2
Tokat cheese	11.9±1.2	5.9±0.4	0.11±0.01	0.28±0.03	3
Van herby cheese	31.93±5.68	46.07±7.86	5.95±0.85	2.18±0.69	27
Herby lor cheese	29.19±3.45	74.77±13.5	8.18±1.32	6.93±0.83	30
Kasar cheese	26.5-63.0	1.0-14.1	0.3-1.6	-	28
Herby cacik	34.42±4.09	52.52±1.19	8.95±1.21	2.93±0.83	31
Herby cheese	33.99±9.57	41.79±7.72	6.25±1.35	2.05±0.67	31
Herby lor	28.26±4.11	55.11±8.85	7.54±1.18	6.48±1.32	31
Trabzon wire cheese	13.0±1.2	5.4±0.3	0.25±0.02	0.58±0.04	3
Erzincan Tulum cheese	12.5±1.1	5.7±0.5	0.16±0.01	0.90±0.08	3
Ordu çerkez cheese	8.8±0.8	4.1±0.4	0.10±0.01	0.92±0.07	3
Çeçil cheese	13.2±0.9	9.3±0.8	0.22±0.02	0.97±0.09	3
Kes cheese	14.10±8.40	15.70±4.50	20.0±11.6	0.81±0.35	25
Italian Ricotta	33.7-51.8	0.8-2.1	-	-	37
Picon bejes-Tresvivo cheese	58.6±19.2	2.0±0.4	1.20±0.60	0.20±0.04	24
USA herby cheese	7.75±2.33	17.70±10.3	6.68±1.86	1.05±0.32	26

The heavy metal contents of cheese vary due to factors such as differences between species, geographical area, seasonal differences, characteristics of the manufacturing practices and possible contamination coming from the equipment during the process[27,33].

During the production process, using different qualifier of metallic container affects trace metal levels in Akçakatik cheese. In addition, storage containers influence metal levels[34].

The interest in trace metals in various milk and dairy products has recently gained remarkable importance, because of their presence represent a qualitative parameter, for example, a content of production procedures, environmental pollution, sanitary conditions and quality of animal feeding that can affect milk characteristics, cheese properties and storage and health aspects. For this reason, some trace elements are of actual importance due to their correlation to environmental pollution. Others released from packaging and alloys of materials and tools utilized for milking and dairy production[35,36].

Conclusion

The results of the present study indicated differences among the trace metal contents of Turkish traditional commercial Akçakatik cheese samples. This milk product is an important source of animal protein, vitamins, minerals and essential fatty acids for humans in Turkey. In order to evaluate the convenience of including foods in diets, metal levels of cheese samples can be useful as nutritional guidance. Also the values in the present work for the levels of trace metal ions in the cheese samples from Turkey could help in the cheese composition tables for Turkish people.

Metal release from the cheese containers is important. Therefore, cheese containers must not contain toxic metals, or those containers must be isolated with the right matter. In order to determine the sources and levels of contamination and to ensure the desired product quality, it is necessary to control the manufacturing process at each step.

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