

Mineral and trace metal levels in some cheese collected from Turkey

Durali Mendil *

Gaziosmanpaşa University, Faculty of Science and Arts, Chemistry Department, 60250 Tokat, Turkey

Received 19 July 2004; received in revised form 19 July 2004; accepted 7 March 2005

Abstract

Concentrations of elements (Fe, Mn, Zn, Cu, Pb, Cr, Ni, Na, K, Ca and Mg) in cheese samples were analyzed using flame and graphite furnace atomic absorption spectrometry after microwave digestion. The order of levels of the elements in the samples was determined to be Na > Ca > K > Mg > Zn > Fe > Pb > Mn > Cr > Ni. The concentration ranges in the samples were found to be 4.1–12.5, 0.28–1.1, 8.8–13.2, 0.10–0.27, 0.14–1.2, 0.02–0.62, 0.18–0.34, 3957–6558, 305–362, 3473–4556 and 28.9–127 µg/g for iron, manganese, zinc, copper, lead, chromium, nickel, sodium, potassium, calcium and magnesium, respectively. High trace metal and mineral accumulation levels in the samples were found in Van otlu cheese for Fe, Ordu çerkez cheese for Na, Kayseri çömlük cheese for Mn, Pb, Çeçil cheese for Zn, Kars kaşar cheese for Cu, Cr, Tokat cheese for Ni, Ca and Erzincan tulum cheese for K, Mg, respectively.

© 2005 Elsevier Ltd. All rights reserved.

Keywords: Trace metals; Minerals; Atomic absorption spectrometry; Cheese

1. Introduction

Milk and milk products are important components of the human diet. Cheese, being one of the basic dairy products, is rich in protein, fat, calcium, riboflavin and some other vitamins (Scott, 1981; Yüzbaşı, Sezgin, Yıldırım, & Yıldırım, 2003).

Cheese evolved in the “Fertile Crescent” between the Tigris and Euphrates, rivers, about 8000–9000 years ago (Fox, O’Connor, McSweeney, Guinee, & O’Brien, 1996; Hayaloglu, Güven, & Fox, 2002; Kosikowski & Mistry, 1997). This area now forms part of Turkey, Iraq and Iran. More than 1000 varieties of cheese are produced around the world. In Turkey, 40–50 cheese varieties are known, but only three of them are national: Turkish white (original name is Beyaz peynir), Kasar and Tulum cheeses. According to Anonymous (2001), milk production in Turkey is about 10.1 million tonnes per annum

and 243,000 tonnes of white cheese are produced annually. Other cheeses important in Turkey are Kasar (like Kashkaval or Kasseri cheese), Tulum (ripened in skin bags or plastic material) or Lor, Dil, Otlu (with herbs), Cökelek and Mihalic (Hayaloglu et al., 2002). Melted cheese, especially in the Diyarbakır and East Anatolia region, is one of the important regional cheese types in Turkey (Merdivan, Yılmaz, Hamamci, & Aygun, 2004). Typically, a food product can be correlated with its geographical localisation, the quality of raw material, and the production techniques (Brescia, Monfreda, Buccolieri, & Carrino, 2005). The heavy metal content of cheese is variable due to factors such as differences between species, geographical area, characteristics of the manufacturing practices and possible contamination from the equipment during the process (Feeley, Criner, Murphy, & Toefer, 1972; Moreno-Rojas, Amaro-Lopez, & Zuerera-Cosano, 1994; Yüzbaşı et al., 2003). The levels of trace elements important for nutritional and/or toxicological properties, in some traditional and innovative dairy products, contribute to the characterization of

* Tel.: +90 356 252 1582; fax: +90 356 252 1585.

E-mail addresses: dmendil@gop.edu.tr, dmendil@hotmail.com.

the quality and adequacy of the Turkish diet (Merdivan et al., 2004).

The heavy metals enter the human body through inhalation and ingestion. The intake via ingestion depends upon food habits. It is well established that Pb and Cd are toxic and children are more sensitive to these metals than are adults. The metals, namely Cu and Zn, are essential micro nutrients and have a variety of biochemical functions in all living organisms. While Cu and Zn are essential, they can be toxic when taken in excess; both toxicity and necessity vary from element-to-element (Tripathi, Raghunath, Sastry, & Krishna-moorthy, 1999).

In this study, the levels of trace metals and minerals in some cheese samples collected from Turkey were determined by flame and graphite furnace AAS, after a microwave digestion method.

2. Materials and methods

In total, 45 samples and nine varieties of cheese (Van otlu cheese, Tokat cheese, Trabzon wire cheese, Erzincan tulum cheese, Ordu çerkez cheese, Çeçil cheese, Kars kaşar cheese, Kayseri çömlük cheese and white cheese) were collected in Turkey during 2003. The collected samples were homogenized and packed in polyethylene bags and stored below -20°C prior to analysis.

All reagents were of analytical reagent grade unless otherwise stated. Double-deionized water was used for all dilutions. HNO_3 and H_2O_2 were of suprapure quality (Merck, Darmstadt, Germany).

Samples (1.0 g) were digested with 6 ml of HNO_3 (65%) and 2 ml of H_2O_2 (30%) in a microwave digestion system for 31 min and diluted to 10 ml with deionized water. A blank digest was carried out in the same way (digestion conditions for microwave system were: 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, vent: 8 min, respectively). This procedure was preferred because of its higher accuracy with respect to both time and recovery values. The recovery values were nearly quantitative (>95 %) for the above-mentioned digestion method.

A Perkin–Elmer Analyst 700 model atomic absorption spectrometer with deuterium background corrector was used in this work. Pb, Cr and Ni in samples were determined by HGA graphite furnace, using argon as the inert gas. Other measurements were carried out in an air/acetylene flame.

3. Results and discussion

Trace metal and mineral concentrations were determined on a wet weight basis as $\mu\text{g/g}$. The relative standard deviations were less than 10% for all elements.

Table 1
The concentration levels of elements ($\mu\text{g/g}$) in cheese species

Cheese species	Fe	Mn	Zn	Cu	Pb	Cr	Ni	Na	K	Ca	Mg
Van otlu cheese	12.5 ± 1.1	0.38 ± 0.03	10.8 ± 1.0	0.13 ± 0.01	0.32 ± 0.03	0.10 ± 0.01	0.22 ± 0.02	6229 ± 619	328 ± 30	4151 ± 413	56.3 ± 4.9
Tokat cheese	5.9 ± 0.4	0.28 ± 0.03	11.9 ± 1.2	0.11 ± 0.01	0.61 ± 0.05	0.16 ± 0.01	0.34 ± 0.03	6083 ± 596	349 ± 33	4556 ± 438	78.7 ± 7.6
Trabzon wire cheese	5.4 ± 0.3	0.58 ± 0.04	13.0 ± 1.2	0.25 ± 0.02	1.1 ± 0.1	0.12 ± 0.01	0.22 ± 0.02	5615 ± 543	346 ± 32	4503 ± 436	97.4 ± 9.3
Erzincan tulum cheese	5.7 ± 0.5	0.90 ± 0.08	12.5 ± 1.1	0.16 ± 0.01	0.63 ± 0.05	0.34 ± 0.02	0.26 ± 0.02	3957 ± 396	362 ± 28	4416 ± 440	101 ± 10
Ordu çerkez cheese	4.1 ± 0.4	0.92 ± 0.07	8.8 ± 0.8	0.10 ± 0.01	0.96 ± 0.08	0.14 ± 0.01	0.21 ± 0.02	6558 ± 645	349 ± 31	3688 ± 356	127 ± 12
Çeçil cheese	9.3 ± 0.8	0.97 ± 0.09	13.2 ± 0.9	0.22 ± 0.02	0.14 ± 0.01	0.04 ± 0.004	0.24 ± 0.02	5405 ± 523	326 ± 30	3722 ± 371	48.0 ± 4.5
Kars kaşar cheese	7.5 ± 0.6	1.0 ± 0.1	10.6 ± 1.0	0.27 ± 0.01	0.53 ± 0.05	0.62 ± 0.05	0.18 ± 0.01	4994 ± 489	322 ± 32	3869 ± 385	36.8 ± 2.9
Kayseri çömlük cheese	8.9 ± 0.9	1.1 ± 0.1	10.1 ± 0.9	0.19 ± 0.01	1.2 ± 0.1	0.02 ± 0.002	0.20 ± 0.01	5037 ± 498	311 ± 29	3473 ± 345	28.9 ± 2.7
White cheese	10 ± 0.1	0.83 ± 0.07	12.0 ± 1.1	0.21 ± 0.02	0.31 ± 0.03	0.55 ± 0.04	0.23 ± 0.02	4154 ± 405	305 ± 30	3718 ± 368	67.6 ± 6.5

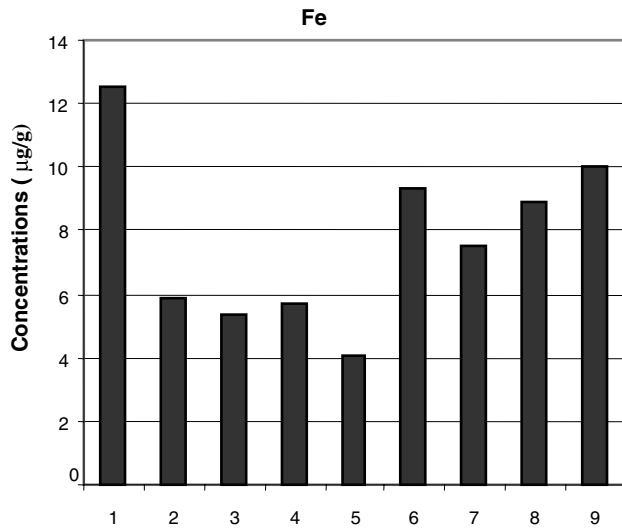


Fig. 1. Distribution of iron in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

The concentration levels of the elements (Fe, Mn, Zn, Cu, Pb, Cr, Ni, Na, K, Ca and Mg) measured in the nine different typical Turkish cheese species are given in Table 1. The order of the levels of the elements in the samples was determined to be: Na > Ca > K > Mg > Zn > Fe > Pb > Mn > Cr > Ni.

The iron values of the samples varied from 4.1 to 12.5 µg/g and the highest average values were found in Van otlu cheese (Fig. 1). These values were reported by Yüzbaşı et al. (2003) and Park (2000) as 1–14 µg/kg and 7.68–17.8 ppm, respectively. Mean zinc concentra-

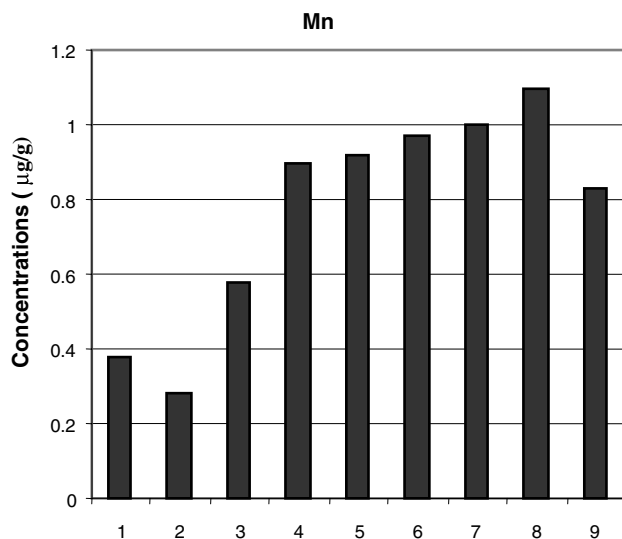


Fig. 2. Distribution of manganese in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

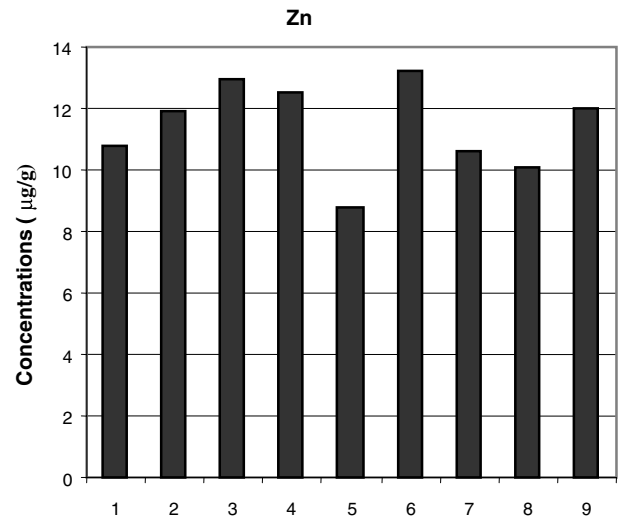


Fig. 3. Distribution of zinc in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

tions ranged from 8.8 to 13.2 µg/g. The maximum and minimum zinc levels were found in Çeçil cheese and Ordu çerkez cheese (Fig. 3), respectively. Zinc values are reported to be 0.35–4.50 mg/100 g and 26.5–63.0 µg/kg in the literature (Gambelli, Belloni, Ingraio, Pizzoferrato, & Santaroni, 1999). The average copper concentration was 0.10–0.27 µg/g in the samples (Fig. 4). These values are lower than in the literature (Park, 2000). Our results were higher than those reported earlier (Yüzbaşı et al., 2003). The maximum lead level was as 1.2 µg/g in Kayseri çömlük cheese (Fig. 5). In the literature, low lead concentrations have

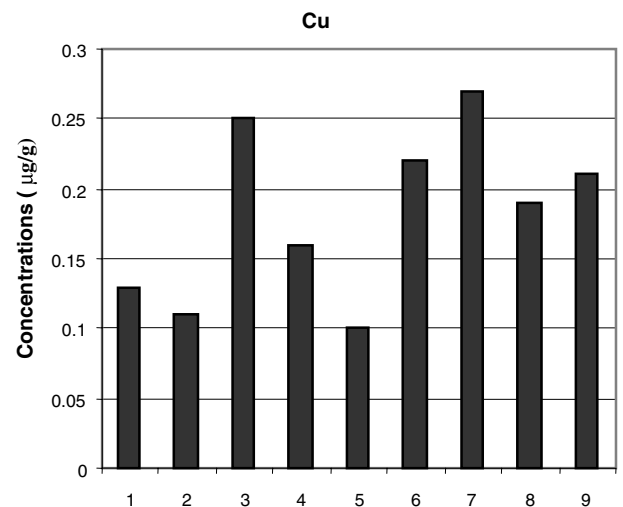


Fig. 4. Distribution of copper in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

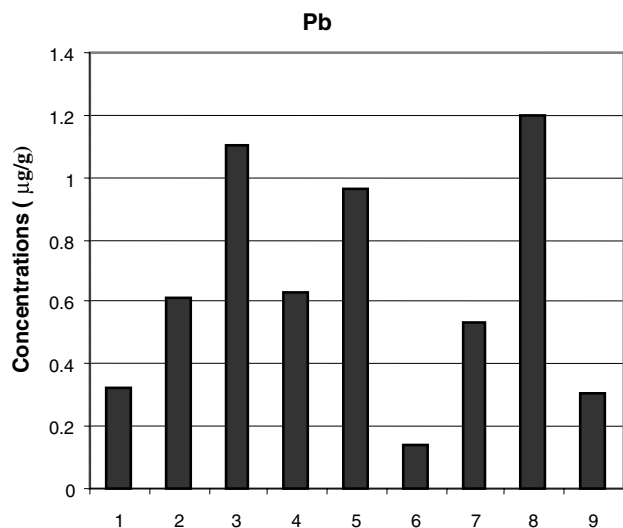


Fig. 5. Distribution of lead in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

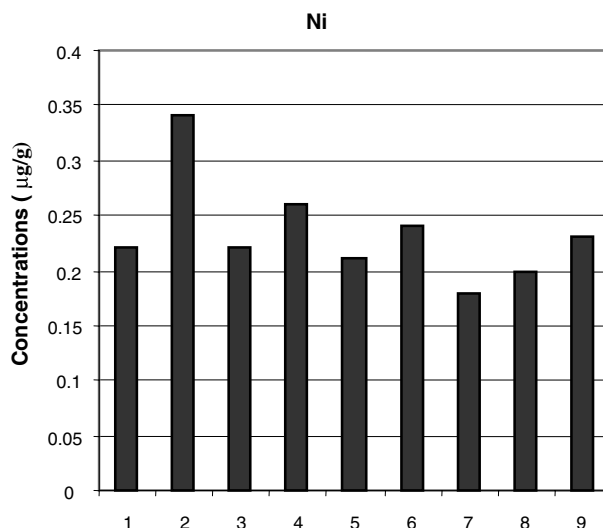


Fig. 7. Distribution of nickel in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

been reported, e.g., 10–422 µg/kg and 1.8–8.3 µg/100 g of lead in cheese (Alberti-Fidanza, Burini, & Perriello, 2002; Yüzbaşı et al., 2003). The FAO/WHO has set a limit for heavy metal intakes based on body weight. For an average adult (60 kg body weight), the provisional tolerable daily intakes (PTDI) for lead, iron, copper and zinc are 214 µg, 48 mg, 3 mg and 60 mg, respectively (Joint FAO/WHO Expert Committee on Food Additives, 1999; Yüzbaşı et al., 2003).

The manganese contents of samples were between 0.28 and 1.1 µg/g. The lowest and highest manganese concentrations were found in Tokat cheese and Kayseri

çömlük cheese (Fig. 2), respectively. These values are in agreement with reported data from the literatures (Park, 2000; Tinggi, Reilly, & Patterson, 1997). Chromium and nickel contents in the samples were 0.02–0.62 and 0.18–0.34 µg/g (see Figs. 6 and 7) respectively. Nickel and chromium contents were reported to be 33.1–34.7 and 1.00–29 µg/100 g, respectively. Our chromium and nickel values are higher than those reported earlier (Alberti-Fidanza et al., 2002; Gambelli et al., 1999). Mn and Cr are recognised as essential trace elements for humans, and several of their metabolic roles have been determined. These include Mn-containing enzyme systems

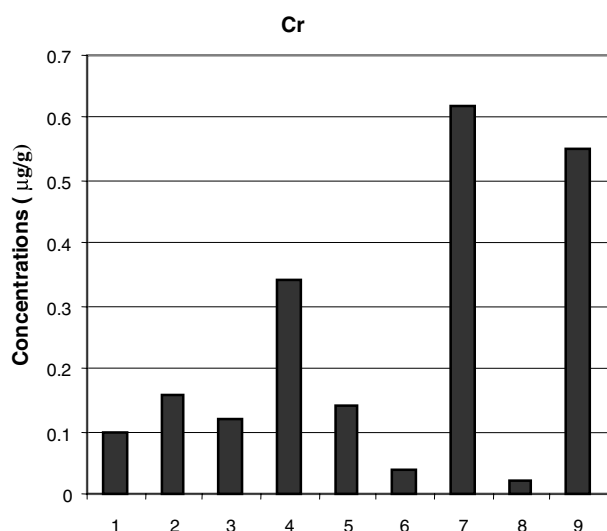


Fig. 6. Distribution of chromium in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

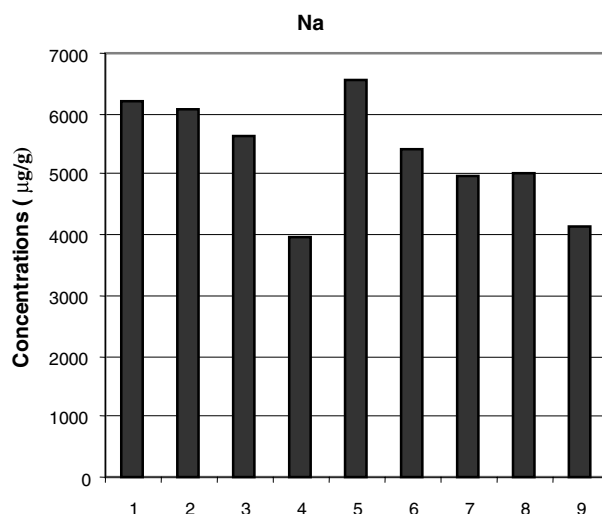


Fig. 8. Distribution of sodium in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

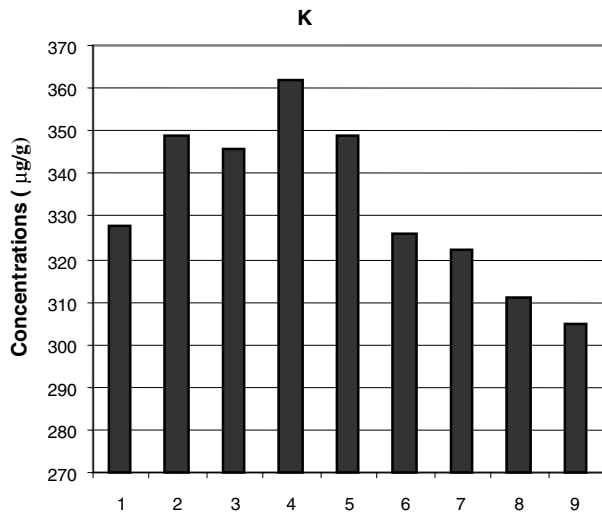


Fig. 9. Distribution of potassium in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

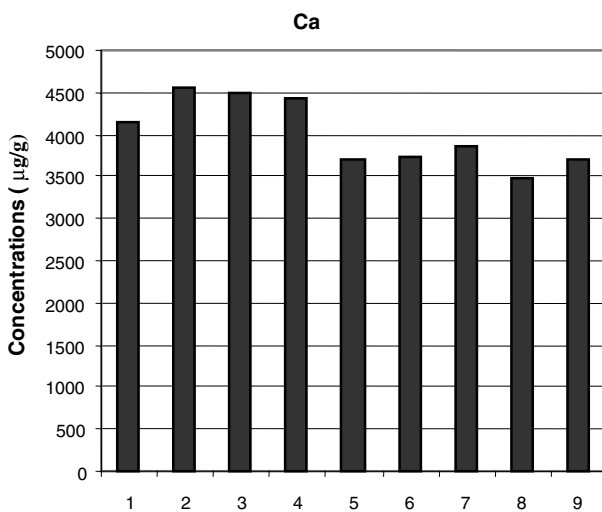


Fig. 10. Distribution of calcium in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

(Hurley, 1984; Tinggi et al., 1997) and Cr involvement in insulin function. However, for neither of the elements have human requirements or levels of absorption from the diet been clearly determined (Offenbacher & Pi-Sunyer, 1988; Tinggi et al., 1997).

Maximum sodium and potassium levels were found in Ordu çerkez cheese (6558 µg/g) (Fig. 8) and Erzincan tulum cheese (362 µg/g) (Fig. 9), respectively. These values are lower than those reported earlier (Gambelli et al., 1999; Merdivan et al., 2004; Park, 2000). The calcium and magnesium levels in cheese samples were found to be in the range of 3473–4556 µg/g (Fig. 10)

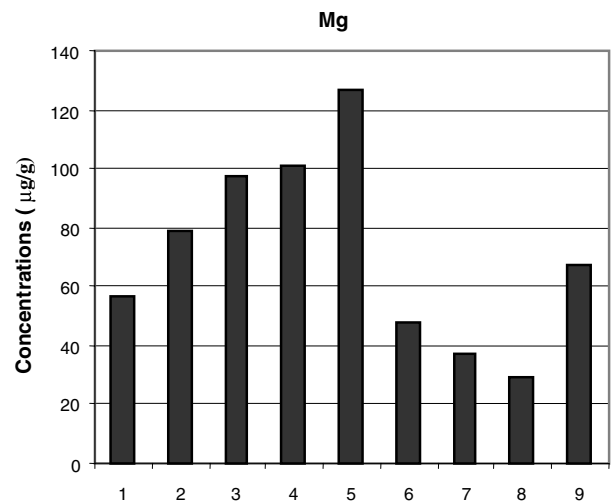


Fig. 11. Distribution of magnesium in cheese species. 1. Van otlu cheese, 2. Tokat cheese, 3. Trabzon wire cheese, 4. Erzincan tulum cheese, 5. Ordu çerkez cheese, 6. Çeçil cheese, 7. Kars kaşar cheese, 8. Kayseri çömlük cheese, and 9. White cheese.

and 28.9–127 µg/g (Fig. 11), respectively. The literature values for calcium and magnesium are 1120–8410 and 146–423 ppm (Park, 2000).

References

- Alberti-Fidanza, A., Burini, G., & Perriello, G. (2002). Trace elements in foods and meals consumed by students attending the faculty cafeteria. *The Science of the Total Environment*, 287, 133–1490.
- Anonymous (2001). Sekizinci bes yıllık kalkınma planı gıda sanayi özel ihtisas komisyonu raporu sut ve sut ürünleri sanayi alt komisyon raporu. No: DTP: 26360-OIK: 644, Ankara.
- Brescia, M. A., Monfreda, M., Buccolieri, A., & Carrino, C. (2005). Characterisation of the geographical origin of buffalo milk and mozzarella cheese by means of analytical and spectroscopic determinations. *Food Chemistry*, 89(1), 139–145.
- Feeley, R. M., Criner, P. E., Murphy, E. W., & Toefer, E. W. (1972). Major mineral elements in dairy products. *Research*, 61, 505–510.
- Fox, P. F., O'Connor, T. P., McSweeney, P. L. H., Guinee, T. P., & O'Brien, N. M. (1996). Cheese: physical, chemical, biochemical and nutritional aspects. *Advances in Food and Nutrition Research*, 39, 163–328.
- Gambelli, L., Belloni, L., Ingrao, G., Pizzoferrato, L., & Santaroni, G. P. (1999). Minerals and trace elements in some Italian dairy products. *Journal of Food Composition and Analysis*, 12, 27–35.
- Hayaloglu, A. A., Güven, M., & Fox, P. F. (2002). Microbiological, biochemical and technological properties of Turkish White cheese "Beyaz peynir". *International Dairy Journal*, 12, 635–648.
- Hurley, L. S. (1984). Nutritional aspects of manganese. In P. Bratter & P. Schramel (Eds.), *Trace elements analytical chemistry in medicine and biology* (pp. 239–251). Berlin: W. de Gruyter.
- Joint FAO/WHO. (1999). *Expert committee on food additives*. Summary and conclusions, 53rd meeting, Rome, 1–10 June.
- Kosikowski, F.V., & Mistry, V.V. (1997). *Cheese and fermented milk foods*, 1. West port: F.V. Kosikowski LLC.
- Merdivan, M., Yılmaz, E., Hamamci, C., & Aygun, R. S. (2004). Basic nutrients and element contents of white cheese of Diyarbakır in Turkey. *Food Chemistry*, 87, 163–171.

- Moreno-Rojas, R., Amaro-Lopez, M. a., & Zuerera-Cosano, G. (1994). Copper, iron and zinc variations in Manchego-type cheese during the traditional cheese-making process. *Food Chemistry*, *49*, 67–72.
- Offenbacher, E. G., & Pi-Sunyer, F. X. (1988). Chromium in human nutrition. *Annual Review of Nutrition*, *8*, 543–563.
- Park, Y. W. (2000). Comparison of mineral and cholesterol composition of different commercial goat milk products manufactured in USA. *Small Ruminant Research*, *37*, 115–124.
- Scott, R. (Ed.). (1981). *Nutritional aspects of cheese: Cheese making practice*. London: Applied Science Publications.
- Tinggi, U., Reilly, C., & Patterson, C. (1997). Determination of manganese and chromium in foods by atomic absorption spectrometry after wet digestion. *Food Chemistry*, *60*(1), 123–128.
- Tripathi, R. M., Raghunath, R., Sastry, V. N., & Krishnamoorthy, T. M. (1999). Daily intake of heavy metals by infants through milk and milk products. *The Science of the Total Environment*, *227*, 229A–235A.
- Yüzbaşı, N., Sezgin, E., Yıldırım, M., & Yıldırım, N. (2003). Survey of lead, cadmium, iron, copper and zinc in Kaşar cheese. *Food Chemistry*, *20*(5), 464–469.