Available online at www.sciencedirect.com
SCIENCE DIRECT®
Food Chemistry 87 (2004) 163–171
Food Chemistry
www.elsevier.com/locate/foodchem

Basic nutrients and element contents of white cheese of diyarbakır in turkey

Melek Merdivan[b,*], Evrim Yilmaz[a], Candan Hamamci[a], R. Sezer Aygun[c]

[a]Department of Chemistry, Faculty of Sciences and Arts, Dokuz Eylul University, Izmir, Turkey
[b]Department of Chemistry, Faculty of Sciences and Arts, Dicle University, Diyarbakır 21280, Turkey
[c]Department of Chemistry, Faculty of Sciences and Arts, Middle East Technical University, Ankara, Turkey

Received 25 April 2003; received in revised form 6 November 2003; accepted 6 November 2003

Abstract

Basic nutrients, moisture, fat and protein, and concentrations of 15 major and trace elements in total and fatty parts of Diyarbakır white cheese were evaluated for compositional differences. Elements were determined using inductively coupled plasma atomic emission spectrometry, while fat was determined by supercritical extraction and protein by protein/nitrogen analyzer. Diyarbakır brine and melt cheeses have lower humidity and higher protein than market brine cheese samples. The fat level was 14–18% for all cheeses. The levels of investigated major and trace elements were much higher in three types of cheese samples. Except for Zn and Mn, the other investigated elements were found in fairly low concentrations and at variable ranges in the fatty part of cheese samples. The elements, Mg among major elements and Fe among trace elements, were highest in that part. Na and Ca as major and Zn, Fe and Al as trace elements were found at maximum levels, especially in Diyarbakır melt cheese. Also, levels correlations between basic nutrients, basic nutrients and elements and element pairs were investigated.

Keywords: White cheese; Element; Nutrient; Turkey

1. Introduction

Nowadays, studies on dietary adequacy assessment are focused more on the qualitative aspects of the diet composition than on the quantitative adequacy of daily dietary intake. The levels of some minerals and trace elements, important for nutritional and/or toxicological properties, in some traditional and innovative dairy products, contribute to the characterization of the quality and the adequacy of the Turkish diet.

Among food sources, particular attention is paid to milk and dairy products, due to its nutritional importance. Minor and trace elements in food are probably associated with macromolecular compounds such as proteins, lipids or carbohydrates in such a way that their effects on the human body can be dramatically different (Abollino, Aceto, Bruzzoniti, Mentasti, & Sarzanini, 1998). The importance of elements such as Cu, Cr and Fe is related to lipid oxidation involved in storage and processing. Serious attention is paid to the toxicological effects of other heavy metals such as Cd, Co, Ni and Pb in view of the importance of dairy products in the diet of infants and children (Merian, 1991).

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 levels of essential minerals and trace elements that occur in cow's milk depend on a number of factors, such as genetic characteristics, environmental condition, stage of lactation, types of pasture. The levels in which they are present in dairy products depend also on the technological treatment of these products (Demirozu-Erdinc & Saldamli, 2000; Moreno-Rojas, Pozo-Lora, Zurera-Csano, & Amaro-lopez, 1994).

In general, the existing literature on trace element composition of cheese is rather scarce at the international level and also in Turkey. Yanardag and Orak (1999) used atomic absorption spectrometry (AAS) to determine the selenium content of milk and milk products of Turkey.

* Corresponding author. Tel.: +90-412-2488550.
E-mail address: melek.merdivan@due.edu.tr (M. Merdivan).

0308-8146/$ - see front matter © 2003 Published by Elsevier Ltd.
doi:10.1016/j.foodchem.2003.11.002

The levels of lead, cadmium, arsenic and mercury in milk and various stages of white cheese production were investigated (Demirozu-Erdinc & Saldamli, 2000). Minerals and trace element contents of various kinds of cheese in the USA (Park, 2000), Italy (Coni, Caroli, Ianni, & Bocca, 1994; Coni, Caroli, Ianni, & Bocca, 1995; Coni et al., 1996; Gambelli, Belloni, Ingrao, Pizzoferrato, & Santaroni, 1999; Zucchetti & Contarini, 1993), Spain (Carazo & Juarez, 1997; Moreno-Rojas, Amaro-Lopez, Garcia-Gimeno, & Zurera-Cosano, 1995; Prieto, Franco, Gonzalez Prieto, Bernardo, & Carballo, 2002), Brazil (Cichoseki, Valduga, Valduga, Tornadijo, & Fresno, 2002) and Switzerland (Pillonel et al., 2003) have been reported.

Melted cheese, especially in Diyarbakır and the South East Anatolia region, is one of the important regional cheese types in Turkey. It is widely consumed and manufactured in Turkey. In production of melted cheese, sheep's milk is especially preferred, but goat's, water-buffalo's or cow's milk are also used.

The objectives of this study were the determination of basic nutrients, major, minor and trace elements in white cheese of Diyarbakır, Turkey and the comparison in the nutrient contents with other white cheeses in the world.

2. Materials and methods

2.1. Sample collection

Twenty brine white, 20 melted cheese from around Diyarbakır (Karacadağ, Çınar, Çüngüş, Mardin, Siverek) and 10 market white brine cheese samples were collected as 300 g samples in polyethylene bags in Turkey in Spring 2002 and were stored under refrigerated conditions.

2.2. Moisture

The moisture of the cheese samples was determined by a moisture analyzer (Mettler Toledo, HR73) at 150 °C for 6 min. The results were cross-checked with the oven-drying in a laboratory oven at 105 °C for 2 h. All samples were analyzed in triplicate.

2.3. Protein

The measurement of total protein was done using a protein/nitrogen analyzer (LECO FP-528). Total protein was calculated by percent total $N \times$ factor of 6.38, automatically by the instrument. For calibration, standards having nitrogen as 1.82% and 9.5% were used.

2.4. Fat

Percent fat in cheese samples was determined by supercritical fluid extraction (SFE) using a SFX^{TM} 3560 model ISCO SFE system. SFE was carried out with pure liquid carbon dioxide. Extraction pressure, extraction temperature, restrictor temperature, collection temperature, static and dynamic time periods and flow rates were tested in order to establish the experimental parameters of the recommended extraction procedure (Table 1). Quantities (1.0 g) of previously grated and homogenized cheese samples were extracted under optimized extraction conditions. Later, the extracted fatty parts of cheese samples were used for element determination. The petroleum ether extraction method using a conventional Soxhlet extraction system was used for cross-checking of results (AOAC, 1990).

Table 1
Optimized extraction conditions for fat analysis

Gas	CO_2
Pressure	550 atm
Extraction temperature	90 °C
Restrictor temperature	120 °C
Collection temperature	20 °C
Flow rate	2 ml/min
Static phase time	5 min
Dynamic phase time	20 min

2.5. Sample treatment for element determination

For the determination of element concentrations, cheese samples were preliminarily digested by means of a closed-pressurized system microwave (MW) oven, using MLS 1200 Mega Model Milestone MW, rated at 650 W, featuring programmable time and power and a rotating sample carousel. Approximately 0.5–1.0 g of cheese samples (as total and fatty part, extracted using supercritical fluid extraction method) were weighed into the TEFLON® vessels, mixed with 5 ml of 65% HNO_3 plus 2 ml of 30% H_2O_2 and digested by microwave irradiation in steps, increasing power from 250 to 650 W by 5 min increments. Within 15 min, completely clear and colourless solutions were obtained which were subsequently diluted with double-distilled water. Samples were prepared in triplicate runs.

2.6. Analytical determination

Analysis of major, minor and trace elements in cheese samples (total and fatty part) was by inductively coupled plasma atomic emission spectrometry (ICP-AES) using PS 950 model Leeman Labs ICP-AES. The sample flow rate was 1.2 ml/min. Wavelengths used for the tested elements were: Na: 588.995, K: 766.490, Ca: 393.386, Mg: 280.270, Ba: 455.403, Al: 308.215, Zn: 213.856, Fe: 259.640, Cu: 324.754, Co: 236.379, Cr: 284.325, V: 211.071, Mn: 257.690, Ni: 231.604 and Mo: 201.511 nm, respectively.

2.7. Statistical analysis

All data were statistically analyzed using SPSS 10.0 professional Statistics 1999. Correlations between basic nutrients and concentrations of metals were tested by Pearson statistics.

3. Results and discussion

In order to assess the accuracy of the procedure, a certified reference material, the MBH CRM No. 063 skim milk powder (natural) was used. Differences between certified and experimentally found concentrations were up to 0.3–1.2% for N, Ca, Cu and up to 2–4% for K, Na, Mg, Fe and Zn. The repeatability of the procedure was studied by carrying out five (moisture and protein) or ten (fat and element determination) replicate assays on a single sample of cheese. The detection limit depended on the sensitivity and fluctuations in the background signal and it is calculated on the basis of 3s criteria. Detection limits, for each element were: 0.05 ng/ml for Na, 0.02 ng/ml for K, 0.001 ng/ml for Ca, 0.04 ng/ml for Ba, 0.25 ng/ml for Al, 0.01 ng/ml for Mg, 0.004 ng/ml for Mo, 0.005 ng/ml for V, 0.025 ng/ml for Ni, 0.001 ng/ml for Cr, 0.012 ng/ml for Cu, 0.07 ng/ml for Mn, 0.085 ng/ml for Fe and 0.6 ng/ml for Zn. The precision, expressed as relative standard deviation (RSD), was almost equal to or better than 2.5%. The repeatabilities of humidity protein and fat were 2.3%, 2.1% and 1.6%, respectively.

The basic nutrient analysis of white cheese produced in Diyarbakır (Table 2) revealed that brine and melt type of white cheese samples have lower moisture and higher protein than commercially manufactured brine (market) cheese samples. The differences in moisture between products might account for the differences in the extent of draining. All studied cheese samples are classified as soft cheese due to their moistures being above 40% (Demirci & Gunduz, 2000). The Diyarbakır melted cheese had the lowest fat and the highest protein contents. Changes in the levels of fat and protein of studied cheese samples could be due to different ratios of cow's and sheep's milk and the different production steps during the manufacturing. Investigated cheese samples were classified as half fatty (>20), fatty (>30) and full fat (>40) cheeses with respect to their fat contents in dry matter. The humidity and protein contents of cheese samples in this study were in the same range as those of other countries and only fat content was lower than those other countries. The protein and fat contents of Prato cheese from Brazil and Leon raw cow's milk cheese from Spain were twice those of others. A Pearson correlation analysis, performed on protein, fat and humidity data, showed only an inverse correlation between humidity and protein (r: −0.658, $P < 0.01$). The other correlations were not statistically significant.

The concentrations of the elements measured in brine and melted types of white cheese (total and fatty part) are shown in Tables 3 and 4.

Na, Ca, K and Mg were found as major elements. The concentration of Na was most high in all types of cheese samples. In brine white cheese samples, the range of Na is large due mainly to the addition of this element during the manufature and the ripening time. Because of being found in the free state, the level of Na in the fatty part of cheese samples was very low and this was observed in only five samples.

Ca is the second major element. The range in three types of cheese samples was not large. The level of Ca in brine cheese was much higher than that in melt cheese (in fatty part). The reason could be that substantial

Table 2
Basic nutrient contents (%) of white cheese samples in this study and other countries

Cheese	Moisture	Fat ($x \pm s$)	Protein	Fat in dry matter
Turkey, soft cheese	–	–	–	–
Brine (Diyarbakır)	50 ± 12	18 ± 4	18 ± 4	40
Melted (Diyarbakır)	51 ± 7	14 ± 3	23 ± 5	26
Brine (Market)	65 ± 3	16 ± 5	13 ± 3	44
Italy, soft cheese[a]	48–78	20–30, >30	–	–
USA, soft cheese[b]	60	22–23	17–19	–
Greece, soft cheese[c]	–	–	–	–
Feta	53 ± 3	26 ± 3	17 ± 1	–
Telemes	56 ± 4	24 ± 2	16 ± 1	–
Brazil, Prato cheese[d]	–	50 ± 3	43 ± 5	–
Italy, Mozzarella[e]	–	25 ± 1	–	–
Spain, Leon cow's milk[f]	–	56 ± 2	37 ± 1	–

[a] Gambelli et al. (1999).
[b] Park (2000).
[c] Andrikopoulos et al. (2003).
[d] Cichoseki et al. (2002).
[e] Bergamo, Fedele, Iannibelli, and Marzillo (2003).
[f] Prieto et al. (2002).

Table 3
Levels of some minerals and trace elements in soft white cheese samples as total, $n = 3$

Samples	Na	Ca	K	Mg	Zn	Fe	Al
	mg/100 g edible portion				μg/100 g edible portion		
Brine							
Diyarbakır	1066 ± 74	254 ± 1	77 ± 3	14 ± 1	1956 ± 4	18 ± 1	206 ± 10
Diyarbakır	15 ± 3	289 ± 2	79 ± 5	17 ± 1	1867 ± 21	450 ± 10	770 ± 12
Diyarbakır	2980 ± 68	323 ± 2	86 ± 1	28 ± 1	2167 ± 18	389 ± 12	530 ± 13
Diyarbakır	1158 ± 62	195 ± 8	80 ± 3	17 ± 1	917 ± 25	158 ± 19	650 ± 15
Diyarbakır	2524 ± 79	199 ± 6	89 ± 1	21 ± 1	997 ± 37	878 ± 15	320 ± 15
Diyarbakır	1426 ± 25	256 ± 4	68 ± 2	22 ± 1	1258 ± 13	254 ± 12	456 ± 16
Diyarbakır	1889 ± 72	247 ± 9	58 ± 2	18 ± 1	1785 ± 18	1057 ± 11	568 ± 18
Çınar	1534 ± 11	350 ± 7	83 ± 3	24 ± 1	2223 ± 10	90 ± 3	395 ± 15
Çınar	591 ± 2	294 ± 3	93 ± 2	25 ± 1	1545 ± 18	135 ± 11	415 ± 16
Çınar	1889 ± 32	329 ± 7	97 ± 11	25 ± 2	1533 ± 17	3842 ± 25	224 ± 17
Çınar	1456 ± 23	325 ± 8	88 ± 9	25 ± 1	1468 ± 20	158 ± 14	286 ± 21
Çüngüş	3039 ± 26	337 ± 4	70 ± 3	28 ± 1	2119 ± 14	96 ± 9	1047 ± 21
Karacadağ	2918 ± 10	323 ± 4	100 ± 2	19 ± 1	2624 ± 12	154 ± 5	452 ± 18
Karacadağ	178 ± 2	333 ± 3	118 ± 5	30 ± 2	2222 ± 24	940 ± 12	790 ± 27
Karacadağ	23 ± 1	319 ± 2	37 ± 3	36 ± 1	1581 ± 15	265 ± 4	760 ± 21
Karacadağ	156 ± 5	320 ± 2	54 ± 5	30 ± 1	1687 ± 14	389 ± 6	526 ± 25
Mardin	2599 ± 17	340 ± 3	51 ± 1	20 ± 1	1952 ± 15	355 ± 5	590 ± 18
Mardin	2345 ± 15	336 ± 3	62 ± 2	20 ± 1	1986 ± 18	1150 ± 7	562 ± 21
Siverek	1878 ± 29	321 ± 13	89 ± 2	20 ± 1	1696 ± 12	54 ± 2	550 ± 27
Siverek	1986 ± 24	336 ± 8	65 ± 2	20 ± 1	1896 ± 17	58 ± 5	512 ± 24
Mean ± SD*	1583 ± 650	300 ± 58	79 ± 20	23 ± 6	1774 ± 422	543 ± 852	531 ± 207
Melted							
Diyarbakır	1678 ± 25	359 ± 5	31 ± 1	21 ± 1	2157 ± 14	655 ± 9	1182 ± 24
Diyarbakır	1491 ± 14	345 ± 3	40 ± 2	14 ± 1	4931 ± 19	747 ± 7	1055 ± 24
Diyarbakır	1124 ± 12	338 ± 12	82 ± 4	16 ± 1	2168 ± 25	<DL	<DL**
Diyarbakır	1245 ± 15	356 ± 4	45 ± 2	20 ± 1	3900 ± 18	655 ± 12	1065 ± 20
Diyarbakır	1658 ± 24	358 ± 4	56 ± 3	17 ± 1	2856 ± 22	686 ± 9	1086 ± 27
Diyarbakır	1235 ± 26	326 ± 4	74 ± 3	15 ± 1	1898 ± 16	740 ± 10	1065 ± 31
Diyarbakır	1187 ± 12	358 ± 2	32 ± 2	16 ± 1	3598 ± 26	687 ± 11	1076 ± 18
Diyarbakır	1190 ± 18	354 ± 4	35 ± 2	19 ± 1	2678 ± 28	685 ± 8	1120 ± 24
Karacadağ	1586 ± 24	348 ± 2	64 ± 3	16 ± 1	2670 ± 20	675 ± 6	1124 ± 32
Karacadağ	1335 ± 14	378 ± 2	68 ± 2	20 ± 1	1978 ± 18	698 ± 12	1163 ± 24
Karacadağ	1246 ± 16	335 ± 4	48 ± 2	18 ± 1	3472 ± 24	724 ± 15	1168 ± 18
Karacadağ	1588 ± 20	349 ± 2	54 ± 1	14 ± 1	3780 ± 26	675 ± 14	1147 ± 20
Mardin	1456 ± 14	345 ± 5	65 ± 3	15 ± 1	3290 ± 25	694 ± 10	1124 ± 21
Mardin	1669 ± 21	338 ± 2	60 ± 2	18 ± 1	3864 ± 28	712 ± 8	1180 ± 25
Mardin	1586 ± 24	358 ± 4	48 ± 3	14 ± 1	2867 ± 28	742 ± 13	1135 ± 34
Çınar	1648 ± 32	340 ± 4	37 ± 4	20 ± 1	2887 ± 30	695 ± 16	1134 ± 24
Çınar	1526 ± 26	368 ± 8	62 ± 5	19 ± 1	1890 ± 16	732 ± 14	1105 ± 35
Çınar	1579 ± 24	338 ± 4	48 ± 6	18 ± 1	3540 ± 18	732 ± 15	1175 ± 18
Çınar	1357 ± 22	340 ± 6	57 ± 2	15 ± 1	3579 ± 21	678 ± 10	1114 ± 23
Çınar	1248 ± 21	358 ± 2	59 ± 4	18 ± 1	1889 ± 28	698 ± 15	1067 ± 26
Mean ± SD	1431 ± 190	347 ± 13	53 ± 14	17 ± 4	2992 ±	701 ± 30	1119 ± 43
Market	769 ± 12	336 ± 4	102 ± 1	13 ± 1	1169 ± 15	240 ± 11	225 ± 12
	1228 ± 25	281 ± 13	79 ± 1	14 ± 1	1356 ± 21	155 ± 5	248 ± 12
	1501 ± 21	311 ± 4	76 ± 1	23 ± 1	1218 ± 14	231 ± 14	230 ± 14
	960 ± 14	292 ± 6	99 ± 2	21 ± 1	1286 ± 18	160 ± 12	234 ± 11
	780 ± 14	298 ± 6	86 ± 4	19 ± 1	1243 ± 15	187 ± 18	238 ± 14
	886 ± 12	308 ± 5	98 ± 2	20 ± 1	1269 ± 14	214 ± 16	226 ± 15
	1023 ± 24	312 ± 4	78 ± 4	17 ± 1	1135 ± 20	188 ± 12	228 ± 12
	1012 ± 12	336 ± 7	86 ± 4	13 ± 1	1328 ± 18	218 ± 18	238 ± 14
	845 ± 10	304 ± 5	82 ± 4	21 ± 1	1356 ± 12	180 ± 8	245 ± 11
	988 ± 14	310 ± 5	90 ± 6	15 ± 1	1278 ± 21	208 ± 14	240 ± 12
Mean ± SD	999 ± 225	309 ± 18	90 ± 10	18 ± 4	1263 ± 75	198 ± 30	237 ± 8

Table 3 (*continued*)

	Ba	Cu	Co	Ni	Mo	V	Cr	Mn
	µg/100 g edible portion							
Brine								
Diyarbakır	62 ± 2	16 ± 3	<DL	<DL	13 ± 1	<DL	4 ± 1	<DL
Diyarbakır	98 ± 2	21 ± 3	<DL	10 ± 1	10 ± 1	2 ± 1	4 ± 1	12 ± 1
Diyarbakır	83 ± 2	28 ± 2	18 ± 1	11 ± 1	16 ± 1	10 ± 1	2 ± 1	11 ± 1
Diyarbakır	31 ± 1	15 ± 2	31 ± 1	49 ± 2	7 ± 1	15 ± 1	2 ± 1	<DL
Diyarbakır	30 ± 1	29 ± 1	45 ± 1	53 ± 3	24 ± 2	28 ±	11 ± 1	<DL
Diyarbakır	38 ± 1	43 ± 3	12 ± 2	15 ± 1	14 ± 1	6 ± 1	5 ± 1	<DL
Diyarbakır	68 ± 3	30 ± 2	28 ± 2	26 ± 2	18 ± 1	12 ± 1	10 ± 1	10 ± 1
Çınar	102 ± 2	28 ± 2	2 ± 1	22 ± 2	29 ± 1	50 ± 2	12 ± 1	<DL
Çınar	59 ± 1	24 ± 2	350 ± 7	410 ± 13	<DL	7 ± 1	<DL	<DL
Çınar	85 ± 2	124 ± 5	375 ± 10	287 ± 11	<DL	55 ± 4	3 ± 1	<DL
Çınar	71 ± 2	35 ± 2	75 ± 4	21 ± 1	27 ± 1	15 ± 1	3 ± 1	<DL
Çüngüş	58 ± 2	14 ± 1	21 ± 4	76 ± 1	10 ± 1	21 ± 1	8 ± 1	<DL
Karacadağ	57 ± 1	33 ± 2	<DL	<DL	8 ± 1	3 ± 1	13 ± 1	6 ± 1
Karacadağ	78 ± 1	145 ± 2	<DL	14 ± 1	98 ± 2	29 ± 2	89 ± 4	5 ± 1
Karacadağ	125 ± 2	138 ± 3	<DL	2 ± 1	78 ± 2	10 ± 1	63 ± 2	8 ± 1
Karacadağ	85 ± 3	56 ± 2	<DL	13 ± 1	48 ± 2	16 ± 1	46 ± 2	9 ± 1
Mardin	108 ± 2	47 ± 2	347 ± 5	287 ± 12	22 ± 3	28 ± 2	9 ± 1	3 ± 1
Mardin	86 ± 2	52 ± 3	210 ± 6	134 ± 10	18 ± 1	12 ± 1	12 ± 2	3 ± 1
Siverek	122 ± 2	88 ± 3	352 ± 12	384 ± 10	<DL	48 ± 1	7 ± 1	<DL
Siverek	85 ± 3	94 ± 4	286 ± 6	376 ± 8	<DL	43 ± 2	10 ± 1	<DL
Mean ± SD	77 ± 27	53 ± 44	154 ± 155	122 ± 155	28 ± 26	22 ± 17	17 ± 24	7 ± 4
Melted								
Diyarbakır	141 ± 2	52 ± 2	41 ± 3	45 ± 1	14 ± 1	19 ± 1	17 ± 2	<DL
Diyarbakır	52 ± 2	37 ± 2	49 ± 2	74 ± 2	20 ± 1	33 ± 2	20 ± 2	25 ± 1
Diyarbakır	124 ± 3	46 ± 2	142 ± 10	148 ± 4	<DL	16 ± 2	10 ± 1	<DL
Diyarbakır	53 ± 3	38 ± 4	<DL	<DL	16 ± 3	32 ± 2	15 ± 4	<DL
Diyarbakır	65 ± 4	52 ± 3	56 ± 2	40 ± 1	14 ± 1	22 ± 2	16 ± 2	10 ± 1
Diyarbakır	48 ± 2	45 ± 3	43 ± 2	46 ± 2	15 ± 1	28 ± 2	14 ± 3	8 ± 1
Diyarbakır	80 ± 1	42 ± 2	48 ± 2	70 ± 2	16 ± 2	35 ± 2	18 ± 3	8 ± 1
Diyarbakır	102 ± 2	50 ± 2	<DL	65 ± 2	20 ± 1	16 ± 1	14 ± 2	<DL
Karacadağ	98 ± 2	51 ± 4	<DL	48 ± 1	20 ± 2	17 ± 2	20 ± 3	5 ± 1
Karacadağ	110 ± 2	52 ± 2	<DL	60 ± 1	17 ± 2	8 ± 1	21 ± 2	6 ± 1
Karacadağ	86 ± 3	46 ± 3	<DL	50 ± 1	16 ± 2	21 ± 1	18 ± 2	9 ± 1
Karacadağ	96 ± 1	38 ± 4	<DL	<DL	15 ± 1	18 ± 1	11 ± 1	<DL
Mardin	82 ± 2	45 ± 1	78 ± 10	123 ± 6	16 ± 1	30 ± 1	10 ± 1	3 ± 1
Mardin	78 ± 2	38 ± 1	103 ± 10	127 ± 8	20 ± 1	18 ± 1	12 ± 1	5 ± 1
Mardin	68 ± 1	48 ± 2	110 ± 12	130 ± 10	20 ± 1	21 ± 2	18 ± 1	8 ± 1
Çınar	56 ± 2	50 ± 1	87 ± 8	134 ± 12	17 ± 1	16 ± 1	12 ± 1	10 ± 1
Çınar	85 ± 3	36 ± 1	124 ± 10	128 ± 8	15 ± 1	24 ± 2	16 ± 1	<DL
Çınar	74 ± 2	42 ± 2	65 ± 6	136 ± 14	18 ± 2	26 ± 1	11 ± 1	<DL
Çınar	72 ± 3	40 ± 2	76 ± 10	85 ± 5	16 ± 1	32 ± 3	19 ± 1	<DL
Çınar	75 ± 4	46 ± 1	60 ± 8	88 ± 10	16 ± 1	17 ± 2	10 ± 1	<DL
Mean ± SD	82 ± 25	45 ± 6	77 ± 32	89 ± 38	17 ± 2	23 ± 7	15 ± 4	9 ± 6
Market	41 ± 1	61 ± 2	27 ± 1	132 ± 5	45 ± 8	12.0 ± 0.1	5.3 ± 0.1	<DL
	24 ± 1	24 ± 2	13 ± 1	95 ± 5	23 ± 3	12.1 ± 0.1	5.5 ± 0.1	<DL
	28 ± 1	32 ± 2	15 ± 1	104 ± 2	37 ± 3	12.3 ± 0.1	5.8 ± 0.1	<DL
	33 ± 2	59 ± 2	18 ± 1	98 ± 2	34 ± 2	12.1 ± 0.1	5.6 ± 0.1	10.2 ± 0.2
	35 ± 1	33 ± 2	20 ± 1	126 ± 4	28 ± 1	12.0 ± 0.1	6.2 ± 0.1	3.3 ± 0.1
	32 ± 2	48 ± 1	16 ± 1	106 ± 2	32 ± 2	12.2 ± 0.1	6.0 ± 0.1	4.2 ± 0.1
	32 ± 2	28 ± 2	21 ± 2	118 ± 2	24 ± 1	12.3 ± 0.1	6.2 ± 0.2	3.1 ± 0.1
	39 ± 2	42 ± 2	26 ± 1	127 ± 3	42 ± 2	12.4 ± 0.1	5.6 ± 0.1	<DL
	26 ± 1	56 ± 1	22 ± 1	114 ± 2	33 ± 2	12.3 ± 0.1	5.8 ± 0.2	<DL
	38 ± 2	43 ± 2	25 ± 2	122 ± 2	39 ± 1	12.1 ± 0.1	15.5 ± 0.2	<DL
Mean ± SD	33 ± 7	43 ± 13	20 ± 5	114 ± 13	34 ± 7	12.2 ± 0.2	5.8 ± 0.3	5.2 ± 3.4

* SD, standard deviation.
** DL, Detection limit.

Table 4
Levels of some minerals and trace elements in soft white cheese samples as fatty part

	Na	Ca	K	Mg	Fe	Al	Cu
	μg/100 g edible portion						
Brine							
Diyarbakır	<DL	180 ± 20	300 ± 10	40 ± 2	9 ± 1	35 ± 4	<DL
Diyarbakır	<DL	90 ± 15	150 ± 10	500 ± 20	156 ± 5	8 ± 1	<DL
Diyarbakır	<DL	280 ± 35	240 ± 24	960 ± 40	170 ± 12	58 ± 7	<DL
Diyarbakır	<DL	460 ± 28	610 ± 20	1200 ± 40	84 ± 8	127 ± 12	<DL
Diyarbakır	100 ± 15	280 ± 30	600 ± 20	260 ± 10	302 ± 11	<DL	5.0 ± 0.2
Diyarbakır	120 ± 5	128 ± 18	505 ± 22	220 ± 10	225 ± 12	56 ± 10	<DL
Diyarbakır	169 ± 2	268 ± 26	368 ± 35	180 ± 10	186 ± 18	35 ± 3	7.0 ± 0.2
Çınar	<DL	190 ± 27	760 ± 10	1100 ± 20	33 ± 3	7 ± 1	<DL
Çınar	1386 ± 12	1630 ± 32	1870 ± 35	670 ± 5	45 ± 3	<DL	4.0 ± 0.2
Çınar	<DL	150 ± 14	650 ± 31	160 ± 2	924 ± 25	<DL	9.0 ± 1.0
Çınar	58 ± 3	240 ± 28	670 ± 30	205 ± 15	186 ± 18	18 ± 1	9.0 ± 0.5
Çüngüş	<DL	150 ± 10	742 ± 32	550 ± 10	83 ± 4	28 ± 2	<DL
Karacadağ	<DL	60 ± 9	<DL	780 ± 20	72 ± 3	<DL	<DL
Karacadağ	<DL	148 ± 26	1320 ± 30	1600 ± 90	298 ± 7	8 ± 2	38.0 ± 1.0
Karacadağ	<DL	658 ± 35	680 ± 25	1500 ± 85	128 ± 5	86 ± 8	35.0 ± 1.0
Karacadağ	<DL	245 ± 23	680 ± 32	935 ± 52	186 ± 6	36 ± 5	25.0 ± 1.2
Mardin	<DL	224 ± 28	120 ± 5	1520 ± 30	145 ± 6	27 ± 1	1.0 ± 0.1
Mardin	48 ± 2	258 ± 23	256 ± 12	950 ± 45	246 ± 9	28 ± 1	3.0 ± 0.1
Siverek	1276 ± 29	110 ± 10	1380 ± 10	110 ± 5	32 ± 3	<DL	12.0 ± 0.3
Siverek	1186 ± 24	95 ± 12	246 ± 14	360 ± 16	88 ± 4	12 ± 2	9.0 ± 0.5
Mean ± SD	543 ± 616	300 ± 351	640 ± 456	690 ± 505	180 ± 195	39 ± 33	14.0 ± 13.0
Melted							
Diyarbakır	240 ± 18	110 ± 10	100 ± 10	70 ± 4	287 ± 9	<DL	<DL
Diyarbakır	<DL	80 ± 8	360 ± 12	850 ± 20	305 ± 10	31 ± 2	<DL
Diyarbakır	230 ± 20	260 ± 18	198 ± 18	960 ± 20	<DL	<DL	<DL
Diyarbakır	230 ± 11	180 ± 20	200 ± 22	560 ± 18	285 ± 12	<DL	25.0 ± 1.0
Diyarbakır	235 ± 14	136 ± 8	245 ± 20	730 ± 24	288 ± 18	18 ± 2	12.0 ± 0.8
Diyarbakır	236 ± 16	110 ± 10	165 ± 10	615 ± 20	294 ± 24	15 ± 1	9.0 ± 0.8
Diyarbakır	240 ± 21	104 ± 8	334 ± 15	816 ± 23	302 ± 3	27 ± 2	8.0 ± 0.2
Diyarbakır	236 ± 26	126 ± 12	278 ± 16	874 ± 24	298 ± 10	18 ± 2	12.0 ± 0.8
Karacadağ	230 ± 10	210 ± 12	140 ± 10	645 ± 24	288 ± 22	18 ± 3	<DL
Karacadağ	<DL	165 ± 14	188 ± 16	720 ± 21	287 ± 120	14 ± 2	<DL
Karacadağ	<DL	168 ± 16	230 ± 20	480 ± 11	296 ± 24	26 ± 2	<DL
Karacadağ	237 ± 10	187 ± 20	286 ± 22	636 ± 21	302 ± 14	17 ± 2	8.6 ± 0.9
Mardin	<DL	98 ± 6	104 ± 10	715 ± 18	302 ± 6	26 ± 2	14.2 ± 1.2
Mardin	<DL	84 ± 2	214 ± 15	750 ± 32	288 ± 18	24 ± 2	10.6 ± 0.7
Mardin	236 ± 4	134 ± 10	236 ± 16	450 ± 33	306 ± 21	19 ± 3	16.4 ± 0.5
Çınar	230 ± 18	142 ± 12	154 ± 8	800 ± 18	304 ± 31	31 ± 2	<DL
Çınar	<DL	158 ± 14	145 ± 10	619 ± 22	300 ± 24	22 ± 3	<DL
Çınar	240 ± 28	220 ± 3	164 ± 18	425 ± 25	290 ± 10	17 ± 1	8.6 ± 0.3
Çınar	239 ± 24	148 ± 10	232 ± 22	390 ± 10	292 ± 10	21 ± 2	6.7 ± 0.4
Çınar	236 ± 26	168 ± 14	218 ± 20	488 ± 16	304 ± 11	16 ± 2	14.2 ± 1.1
Mean ± SD	235 ± 4	150 ± 47	210 ± 70	630 ± 210	296 ± 7	21 ± 6	12.0 ± 5.0
Market	<DL	180 ± 20	120 ± 10	400 ± 28	94 ± 14	12 ± 1	10.1 ± 2.0
	<DL	710 ± 40	590 ± 28	1500 ± 98	65 ± 2	35 ± 2	<DL
	<DL	450 ± 23	423 ± 30	523 ± 64	74 ± 4	16 ± 1	<DL
	<DL	264 ± 24	345 ± 26	621 ± 25	65 ± 2	27 ± 1	<DL
	<DL	534 ± 24	487 ± 32	460 ± 65	74 ± 8	35 ± 1	8.2 ± 0.6
	<DL	328 ± 10	310 ± 20	935 ± 87	85 ± 5	34 ± 1	11.0 ± 1.2
	45 ± 4	286 ± 16	186 ± 12	1430 ± 144	78 ± 2	23 ± 2	<Dl
	28 ± 6	426 ± 20	424 ± 18	935 ± 45	88 ± 3	17 ± 3	9.4 ± 0.8
	145 ± 28	658 ± 18	421 ± 10	886 ± 85	72 ± 8	14 ± 1	6.4 ± 0.7
	126 ± 16	530 ± 30	360 ± 24	1372 ± 110	86 ± 4	33 ± 2	10.5 ± 0.8
	98 ± 12	587 ± 27	298 ± 10	1380 ± 140	94 ± 2	16 ± 2	<DL
Mean ± SD	88 ± 58	450 ± 174	360 ± 138	950 ± 412	80 ± 10	24 ± 9	9.3 ± 2.0

Table 4 (*continued*)

	Ba	Co	Ni	Mo	V	Cr
	μg/100 g edible portion					
Brine						
Diyarbakır	<DL	<DL	<DL	4.56 ± 0.02	<DL	1.29 ± 0.05
Diyarbakır	<DL	<DL	<DL	0.68 ± 0.001	<DL	<DL
Diyarbakır	<DL	<DL	<DL	5.20 ± 0.01	0.26 ± 0.02	<DL
Diyarbakır	0.20 ± 0.02	45 ± 2	15.0 ± 2.0	0. 10 ± 0.01	7.39 ± 0.50	0.43 ± 0.02
Diyarbakır	2.30 ± 0.06	6 ± 1	1.0 ± 0.2	5.85 ± 0.30	<DL	8.00 ± 0.20
Diyarbakır	<DL	8 ± 1	8.0 ± 0.5	0.55 ± 0.04	2.60 ± 0.02	3.00 ± 0.01
Diyarbakır	045 ± 0.03	21 ± 2	10.0 ± 0.8	1.12 ± 0.12	0.85 ± 0.01	3.40 ± 0.03
Çınar	<DL	<DL	<DL	3.54 ± 0.40	<DL	6.00 ± 0.20
Çınar	0.47 ± 0.01	87 ± 8	70.0 ± 2.0	<DL	3. 65 ± 0.05	2.00 ± 0.20
Çınar	0.65 ± 0.02	106 ± 9	110.0 ± 2. 0	<DL	11.1 ± 1.00	2.60 ± 0.20
Çınar	0.87 ± 0.03	86 ± 8	85.0 ± 3.0	0.98 ± 0.01	4.80 ± 0.06	5.60 ± 0.08
Çüngüş	1.12 ± 0.11	1.00 ± 0.02	15.0 ± 0.3	1.68 ± 0.08	5.68 ± 0.07	2.04 ± 0.20
Karacadağ	<DL	<DL	<DL	<DL	<DL	<DL
Karacadağ	4.70 ± 0.02	<DL	<DL	25.00 ± 2.00	<DL	31.2 ± 1.00
Karacadağ	3.70 ± 0.20	<DL	<DL	25.00 ± 2.00	3.52 ± 0.02	25.2 ± 1.00
Karacadağ	1.86 ± 0.08	<DL	<DL	15.00 ± 2.00	1.96 ± 0.02	14.0 ± 1.00
Mardin	1.58 ± 0.10	116 ± 2	19.0 ± 2.0	4.10 ± 0.20	5.60 ± 0.07	0.90 ± 0.01
Mardin	1.68 ± 0.08	58 ± 3	22.0 ± 2.4	3.50 ± 0.05	1.98 ± 0.02	4.20 ± 0.01
Siverek	0.54 ± 0.01	124 ± 5	107 ± 2.0	<DL	9.00 ± 1.00	6.80 ± 0.50
Siverek	0.84 ± 0.02	76 ± 4	85.0 ± 3.0	3.25 ± 0.02	8.50 ± 0.08	3.20 ± 0.10
Mean ± SD	1.48 ± 1.36	61 ± 45	45.8 ± 42.0	6.26 ± 8.24	4.78 ± 3.30	7.05 ± 8.70
Melted						
Diyarbakır	0.94 ± 0.02	<DL	3.0 ± 0.1	2.00 ± 0.04	0.30 ± 0.02	1.00 ± 0.09
Diyarbakır	1.20 ± 0.06	7 ± 1	10.0 ± 0.2	0.47 ± 0.02	3.30 ± 0.10	0.10 ± 0.01
Diyarbakır	<DL	25 ± 3	<DL	<DL	0.10 ± 0.02	0.70 ± 0.02
Diyarbakır	0.98 ± 0.04	<DL	<DL	2.00 ± 0.02	1.40 ± 0.02	0.60 ± 0.04
Diyarbakır	1.12 ± 0.06	<DL	3.0 ± 0.2	2.00 ± 0.08	1.20 ± 0.04	0.85 ± 0.03
Diyarbakır	1.02 ± 0.04	8 ± 1	3.0 ± 0.1	1.80 ± 0.06	1.50 ± 0.02	0.86 ± 0.01
Diyarbakır	0.96 ± 0.05	15 ± 2	9.0 ± 0.2	1.50 ± 0.03	0.89 ± 0.02	1.25 ± 0.02
Diyarbakır	1.12 ± 0.06	8 ± 1	<DL	1.70 ± 0.02	0.75 ± 0.01	0.36 ± 0.02
Karacadağ	1.15 ± 0.10	<DL	<DL	0.50 ± 0.02	<DL	0.68 ± 0.03
Karacadağ	1.14 ± 0.13	<DL	<DL	0.85 ± 0.01	<DL	0.48 ± 0.02
Karacadağ	1.10 ± 0.04	<DL	<DL	1.90 ± 0.15	1.10 ± 0.04	0.28 ± 0.02
Karacadağ	1.08 ± 0.10	<DL	<DL	<DL	0.56 ± 0.05	0.68 ± 0.0.2
Mardin	0.99 ± 0.02	21 ± 5	4.0 ± 0.2	0.50 ± 0.02	1.20 ± 0.04	0.20 ± 0.02
Mardin	1.02 ± 0.03	22 ± 3	5.0 ± 0.2	0.84 ± 0.03	2.14 ± 0.07	0.40 ± 0.02
Mardin	1.00 ± 0.02	16 ± 5	4.0 ± 0.1	1.00 ± 0.02	1.25 ± 0.10	1.00 ± 0.30
Çınar	0.99 ± 0.02	18 ± 4	5.0 ± 0.2	0.80 ± 0.02	2.10 ± 1.00	1.00 ± 0.002
Çınar	<DL	16 ± 6	6.0 ± 0.1	1.20 ± 0.04	0.64 ± 0.09	0.58 ± 0.02
Çınar	1.16 ± 0.01	13 ± 6	6.0 ± 0.2	1.10 ± 0.25	1.10 ± 0.08	0.30 ± 0.02
Çınar	1.12 ± 0.08	21 ± 6	8.0 ± 0.2	1.20 ± 0.10	1.47 ± 0.06	0.64 ± 0.02
Çınar	1.14 ± 0.10	22 ± 6	10.0 ± 0.3	0.90 ± 0.08	0.90 ± 0.03	0.47 ± 0.05
Mean ± SD	1.07 ± 0.08	16 ± 6	6 ± 3	1.24 ± 0.60	1.22 ± 0.70	0.62 ± 0.30
Market	1.40 ± 0.05	1.00 ± 0.20	8.0 ± 1.0	2.00 ± 0.08	2.00 ± 0.30	<DL
	0.80 ± 0.02	<DL	4.0 ± 0.5	3.00 ± 0.30	3.00 ± 0.02	<DL
	0.96 ± 0.04	<DL	7.5 ± 0.6	2.20 ± 0.02	2.50 ± 0.01	<DL
	0.64 ± 0.06	0.80 ± 0.02	5.3 ± 0.6	2.60 ± 0.10	2.10 ± 0.02	0.60 ± 0.02
	0.88 ± 0.10	0.68 ± 0.04	4.5 ± 0.4	3.10 ± 0.06	2.10 ± 0.03	1.10 ± 0.01
	0.96 ± 0.05	1.20 ± 0.10	6.4 ± 0.2	2.600.10	2. 60 ± 0.02	0.50 ± 0.01
	1.10 ± 0.04	<DL	4.8 ± 0.2	2.60 ± 0.12	2.80 ± 0.02	0.80 ± 0.02
	1.32 ± 0.04	<DL	6.6 ± 0.3	2.80 ± 0.15	2.90 ± 0.03	0.40 ± 0.01
	1.28 ± 0.08	0.95 ± 0.04	7.4 ± 0.2	2.10 ± 0.10	2.50 ± 0.02	0.80 ± 0.02
	1.35 ± 0.10	0.86 ± 0.08	5.2 ± 0.4	2.40 ± 0.10	2.40 ± 0.04	0.60 ± 0.04
Mean ± SD	1.07 ± 1.00	0.75 ± 0.30	6.0 ± 1.4	2.54 ± 0.40	2.50 ± 0.30	0.69 ± 0.20

amounts of Ca are linked to the casein micelles and the rest is soluble. K and Mg levels were higher in brine cheese than in melt cheese samples (in total, dried and fatty parts).

The other elements were found in trace amounts. The sequence of these elements, with respect to mean levels of all samples, was: Mn < Cr < V < Mo < Cu < Ba < Ni < Co < Al < Fe < Zn. Zn and Mn concentrations in the fatty part of cheese samples were below their detection limits. Zn is the highest trace element in total, especially in melted cheese. This can be explained by binding of 95% of Zn to casein micelles. Although manganese is a required cofactor for the enzymes of lipid, glucose and cholesterol metabolism, it was not detected in the fatty part of cheese because it is the lowest trace element and was seen in only Diyarbakır brine cheese.

The highest amounts of Fe and Al were detected in the three parts of Diyarbakır melted cheese, and Diyarbakır brine and, market brine cheese. The metal containers used in the heat treatment of manufacturing processes are a probable source of such mineral contamination. Fe was observed in the fatty part of all samples as was Ca and was found to be in the range 20–39%. This can be explained by binding of fifty percent of iron to the fat globules of milk fat.

The range of other trace elements, Co, Ni, Ba, Cu, Mo, V, Cr were found similar in all types of cheese samples. The percentages of these elements were in the range of 0.4–37% in the fatty part. The concentrations of fifty percent of those elements in the fatty part of all samples were below their detection limits. The levels of Co, Ni and Cr were much larger in the fatty part of Diyarbakır brine cheese. Copper, 14 μg/100 mg edible portion, was obtained only in the fatty part of Diyarbakır brine cheese. This high concentration could be explained by traditional copper vats used during manufacture and it would promote oxidation of copper.

The concentrations of studied elements for cheese samples in this study were comparable to the values referred to in the literature (Cichoseki et al., 2002; Coni et al., 1996; Gambelli et al., 1999; Jodral-Segado, Navarro-Alorcon, Lopez-G de la Serrana, & Lopez-Martinez, 2003; Moreno-Rojas et al., 1994; Moreno-Rojas et al., 1995; Park, 2000; Pillonel et al., 2003; Prieto et al., 2002). Na, Zn, Fe, Co, Ni and Mn levels were mostly higher, and Mg and K lower and the others, Ca, Cu and Cr were about the same range as other studies.

The correlations were found among the percentages or concentrations of basic nutrients, basic nutrients and elements and element pairs in the brine and melted cheeses.

A statistical analysis, carried out between basic nutrients and elements, shows only statistically significant

Table 5
Significant correlations, r, between elements in cheese, T, total; F, fatty

	Na	K	Ca	Zn	Cu		Co		Ni		Mo	Cr		V		Mn
	F	T	T	T	T	F	T	F	T	F	F	T	F	T	F	T
K								0.510*		0.753**					0.564**	
Ca	0.838**															
Ba			0.523*	0.536*		0.871**					0.912**		0.911*			0.460*
Mg													0.462*			
Fe		0.575**			0.445*		0.447*		0.487*					0.566**	0.467*	
Zn			0.477*													0.816**
Cu												0.806**	0.955**	0.482*		
Co														0.471*	0.545*	
Ni							0.965*	0.835**						0.513*	0.705**	
Mo					0.708**	0.903**						0.911**	0.958**			

* $P < 0.05$.
** $P < 0.01$.

correlation. Inverse correlations between protein and K (r: −0.506, $P < 0.01$) and fat and Ca (r: −0.597, $P < 0.01$) and direct correlation between protein and Zn (r: 0.544, $P < 0.05$) were found.

The correlation coefficients were calculated for all pairs of elements in all studied cheese samples. The significant linear correlations found among element concentrations for total and fatty parts of cheese samples are shown in Table 5. Except for Na, Mg and Al, the concentrations of elements are directly correlated with at least one or more than two elements, whether in the total or fatty parts of cheese samples. Mo with Cr, and Cu and Ni with Co and V, showed good correlation in the total and fatty parts of samples. The levels of Cu, Ba, Ca, K and Fe were highly or moderately correlated with Cr, V, Cu, Mo, Cr, Na, Ni, K, Cu, Co, N, V, mostly in the fatty part. The lack of a cross-correlation of all the elements demonstrates that the concentration of a single element cannot be used to calculate the ingestion level of elements from cheese (Gambelli et al., 1999).

Traditionally and locationally produced Diyarbakır brine and melted cheese were characterized by evaluating of basic nutrients and major and trace elements and also to estimate the contribution to the daily dietary intake. Data gained in this investigation make it possible to assess the distribution of elements in the total and fatty parts of cheese, primarily of importance for nutrition and health.

The daily dietary intake that is most influenced by the consumption of the cheese is that of calcium with a value that is about 50% of that relative to dietary requirement. The contribution to the daily intake of Na due to cheese consumption is about 20% of the total dietary intake. However, the contribution of cheese to daily intakes of Mg and K is low. The contributions of Fe, Co and Zn as trace elements, to daily dietary intake, by cheese are important and about 10%. The other trace elements of toxicological importance, could not be expected to cause any problems because of their small contributions to the daily intake.

References

Abollino, O., Aceto, M., Bruzzoniti, M. C., Mentasti, E., & Sarzanini, C. (1998). *Analytica Chimica Acta, 375*, 299–306.

Andrikopoulos, N. K., Kalogeropoulos, N., Zerva, A., Zerva, V., Hassapidou, M., & Kapoulas, V. M. (2003). Evaluation of cholesterol and other nutrient parameters of greek cheese varieties. *Journal of Food and Computational Analysis, 16*, 155–167.

AOAC (1990). *Official methods of analysis* (15th ed.). Washington: Association of official analytical chemists.

Bergamo, P., Fedele, E., Iannibelli, L., & Marzillo, G. (2003). Fat-soluble vitamin contents and fatty acid composition in organic and conventional Italian dairy products. *Food Chemistry, 82*, 625–631.

Carazo, B., & Juarez, M. (1997). Determination of major minerals in dairy products digested in closed vessels using microwave heating. *Journal of Dairy Science, 80*(5), 806–811.

Cichoseki, A. J., Valduga, E., Valduga, A. T., Tornadijo, M. E., & Fresno, J. M. (2002). Characterization of Prato cheese, a Brazilian semi-hard cow variety: Evolution of physico-chemical parameters and mineral composition during ripening. *Food Control, 13*, 329–336.

Coni, E., Caroli, S., Ianni, D., & Bocca, A. (1994). A methodological approach to the assessment of trace elements in milk & dairy products. *Food Chemistry, 50*(2), 203–210.

Coni, E., Caroli, S., Ianni, D., & Bocca, A. (1995). Preliminary evaluation of the factory influencing the trace element content of milk and dairy products. *Food Chemistry, 52*, 123–130.

Coni, E., Bocca, A., Coppolelli, P., Caroli, S., Cavallucci, C., & Marinucci, M. T. (1996). Minor and trace element content in sheep and goat milk and dairy products. *Food Chemistry, 57*(2), 253–260.

Demirci, M., & Gunduz, H. (2000). *Handbook of milk technologists*. Istanbul, Turkey: Hasad Press.

Demirozu-Erdinc, B., & Saldamli, I. (2000). Variation in some heavy metals during the production of white cheese. *International Journal of Dairy Technology, 53*(3), 96–99.

Gambelli, L., Belloni, P., Ingrao, G., Pizzoferrato, L., & Santaroni, G. P. (1999). Minerals and trace elements in some Italian dairy products. *Journal of Food Computational Analysis, 12*, 27–35.

Jodral-Segado, A. M., Navarro-Alorcon, M., Lopez-G de la Serrana, H., & Lopez-Martinez, M. C. (2003). Mg and Ca contents in foods from SE Spain: Influencing factors and estimation of daily dietary intakes. *The Science of the Total Environment, 312*, 47–58.

Merian, E. (1991). *Metals and their compounds in the environment occurrence analysis and biological relevance*. Weinheim: VCH.

Moreno-Rojas, R., Pozo-Lora, R., Zurera-Csano, G., & Amaro-lopez, A. (1994). Ca, Mg, Mn, Na and K variations in Machego-type cheese during ripening. *Food Chemistry, 50*, 373–378.

Moreno-Rojas, R., Amaro-Lopez, M. A., Garcia-Gimeno, R. H., & Zurera-Cosano, G. (1995). Effects of Manchego-type cheese making process on contents of mineral elements. *Food Chemistry, 53*(4), 435–439.

Park, Y. W. (2000). Comparison of mineral & cholesterol composition of different commercial goat milk products manufactured in USA. *Small Ruminant Research, 37*(1–2), 115–124.

Pillonel, L., Badertscher, R., Froidevaux, P., Haberhauer, G., Hölzl, S., Horn, P., Jakob, A., Pfammatter, E., Piantni, U., Rossmann, A., Tabacchi, R., & Bosset, J. O. (2003). Stable isotope ratios, major, trace and radioactive elements in emmental cheeses of different origins. *Lebensmittal-Wissenschaft and Technologie, 36*, 615–623.

Prieto, B., Franco, I., Gonzalez Prieto, J., Bernardo, A., & Carballo, J. (2002). Compositional and physicochemical modifications during the manufacture and ripening of Leon raw cow's milk cheese. *Journal of Food and Computational Analysis, 15*, 725–735.

Yanardag, R., & Orak, H. (1999). Selenium content of milk products of Turkey. *Biological Trace Element Research, 68*(1), 79–95.

Zucchetti, S., & Contarini, G. (1993). AAS determination of Ca, Na, K in dairy product using TCA for extraction. *Atomic Spectroscopy, 14*(2), 60–64.