Concentration of nutritional important minerals in Croatian goat and cow milk and some dairy products made of these

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Summary

The concentration of the minerals (Ca, Mg and P) and trace elements (Zn, Fe) were determined in goat and cow's dairy products. The aim of this work was to determine the concentrations of mentioned minerals and trace elements in fermented dairy products made of goat milk, as well as in East Croatia traditional White Slice goat cheese. Obtained results show that goat milk and dairy products from goat milk had higher concentration of Mg and Fe than these of cow milk. Goat milk and dairy products from goat milk also had higher concentration of P, whereas the concentration of Ca was equally in goat and cow milk. However, significantly lower concentrations of Zn in goat milk and goat milk products were determined. Levels of analyzed major and trace minerals were higher in fermented dairy products and cheeses than in liquid milk. The levels of major and trace minerals in White Slice cheese were greater than those in fermented milk products. High content of phosphorus in White Slice goat cheese than in White Slice cow cheese was determined.

Keywords: goat's milk, mineral composition, dairy products, White Slice goat cheese, Croatia

Introduction

Like in the most Eurepean countries, goats produce only small part of total annual milk supply in Croatia (Antunac et al., 2001). However, specific nutritional and functional properties of goat milk are the main reasons of higher interest for goat milk and goat's milk products. In last 10 years, production of goat milk and dairy products from goat milk in Croatia has been increased about 5 % annually (CCIS Statistical Annual, 2010). Goat milk has many unique characteristics, which supports the contention of high qualities of dairy products from goat milk for human nutrition (Haenlein, 2004). The physiological and biochemical facts of the unique qualities of goat milk are just barely known and little exploited (Freund, 2000).

In spite of the absence of fermented caprine milk products on the national market of Croatia, in the last 15 years many scientific studies of fermented caprine milk have been performed (Božanić et al., 2001; Slačanac et al., 2005; Slačanac et al., 2010). However, there is a poor scientifically evidence about mineral and trace elements concentrations in commercial liquid goat milk, as well as in dairy products from goat milk. Some minerals have been marked as critical when the nutritional value of milk and dairy products has been taken to be evaluated (Park et al., 2007). In this paper, the concentrations of three major (Ca, P, Mg) and two trace (Zn and Fe) nutritional important minerals in goats and cow milk and their products were determined. Furthermore, some new fermented dairy products from goat milk were prepared and analyzed.

Materials and methods

Samples of milk

Samples of goat and cow milk were collected from 2 big dairy factories located in two different zones of Croatia (east and west). Characteristic of east part of Croatia is lowland, whereas west part of Croatia is hilly with many pasture ground. The sampling was conducted in three occasions during the 18 months: spring – 2003, autumn – 2003 and spring – 2004. Total of 140 samples of goat milk and 140 samples of cow milk were collected. Before inoculation, the milk was treated by UHT (140 °C/2-3 sec). The average chemical composition of UHT goat and cow milk was determined using an FT 120 MILKOSCAN (FOSS Electric, Denmark). Titration acidity and pH values were determined in all samples of goat and cow milk, according to official methods cited by Sabadoš (1996).

Preparation of fermented milks

Fermented milk beverages from goat and cow milk were prepared in laboratory conditions. Six DVS (Direct Vat Set) lactic acid starters were used for fermentation of goat and cow milk. Milks were

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fermented in following incubation treatments: yogurt starter (*Lactobacilus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*) at 41 °C for 4 hours, ABT-2 culture (*Bifidobacterium lactis* Bb-12, *Lactobacillus acidophilus* La-5 and *Streptococcus thermophilus*) at 37 °C for 8 hours, *Bifidobacterium longum* Bb-46 at 37 °C for 25 hours, *Lactobacillus plantarum* at 37 °C for 30 hours, *Lactococcus lactis* subsp. *lactis* biovar. *dyacetilactis* at 24 °C for 24 hours and mezophilic CH-N19 culture (*Lactococcus lactis* subsp. *lactis, Lactococcus lactis* subsp. *lactis* biovar *diacetylactis, Lactococcus lactis* subsp. *cremoris, Leuconostoc mesenteroides*) at 24 °C for 16 hours. All fermentations were conducted until reaching pH 4.6, which is proximate isoelectrical point of milk proteins (Božanić et. al., 2004). Twenty samples of dairy beverages were taken in each sampling.

Preparation of "White Slice" goat's and cow's cheese

"White Slice" goat cheese is traditional product characteristic for Eastern part of Croatia, as well as for Istria region. It has not great marketing character, but it is very popular and favored rural product. "White Slice" goat cheese has been produced on farms and some small cheese factories in East Croatia. In laboratory conditions, fresh "White Slice" cheese was produced following the traditional cheese-making method. After coagulation with 80 % acetic acid at 70 °C, the cheese was matured at 12 °C and 80-90 % of relative humidity for 10 days. Small producers did not control humidity, but controlled the temperature during the ripening of cheese. After maturation, "White Slice" cheese has been traditionally brined in salt solution. Determination of analyzed minerals in goat and cow cheeses was conducted before brining. Half of analyzed samples were collected from 4 small cheese factories in Eastern Slavonia, while half of analyzed samples were prepared in laboratory conditions. Twenty samples of cheeses were taken in each sampling.

Mineral analysis

Preparation of samples was conducted according to official AOAC method (AOAC, 1984). Concentrations of analyzed minerals were quantified by the use of Atomic Absorption Spectroscopy (Perkin-Elmer, model 1100) with an auto-sampling system (AOAC, 1985). The sample flow rate was 0.6 l/min. Wavelengths used for the tested minerals were the follows: Ca – 422.9 nm (slit 0.7 nm), Mg – 285.5 nm (slit 0.7 nm), Zn – 213.9 nm (slit 0.7 nm), Fe – 271.4 nm (slit 0.7 nm).

Statistical analysis

All the results were statistically analyzed by the use of Descriptive statistics in STATISTICA 8.0 (StatSoft, Tulsa, USA). The differences in mineral contents between different products, as well as between goat and cow milk and their products were analyzed using a Fisher's Least Significance Differences (LSD) model in STATISTICA 8.0. The coefficient of variation (*CV*) was used to analyze the deviations between the results.

Results and discussion

The average chemical composition of goat and cow milk is reported in Table 1. There were no significant differences in composition between UHT goat and cow milk. Goat milk had inconsiderably lower average lactose content, but higher content of whey proteins compared with cow milk. Furthermore, SD values in Table 1 suggest very low variations in composition of 140 analyzed samples of goat and cow milk.

Table 1. Chemical composition (g 100 g^{-1}) and acidity of the cow and goat milk used to produce cheese and fermented milks

	Goat milk*			Cow milk*		
Component	$\bar{x}$	Range	SD	$\bar{x}$	Range	SD
Total solids	11.41	11.22-11.90	0.240	11.36	11.27-11.42	0.083
Ash	0.79	0.76-0.89	0.033	0.72	0.69-0.73	0.014
Fat	3.20	3.20	-	3.20	3.20	-
Lactose	4.25	4.20-4.35	0.036	4.90	4.87-4.96	0.053
Proteins	3.35	3.16-3.47	0.214	3.10	3.03-3.19	0.045
Whey proteins	0,69	0.61-0.74	0.043	0.58	0.52–0.63	0,031
Acidity	pH = 6.53 8.10 ^{0}SH	pH = 6.46-6.63 7.91-8.23 ^{0}SH	0.065 0.160	pH = 6.66 7.18 ^{0}SH	pH = 6.60-6.69 7.12-7.38 ^{0}SH	0.057 0.130

*- all 140 samples of milk analyzed for each component

Table 2 shows the results of mineral concentrations in liquid milk, as well as in goat and cow milk products. In general, the mineral concentrations presented in Table 2 were within the limits for some types of goat or cow dairy product reported in some previous studies (Jenness, 1980; Park, 1994; Park, 2000; Posecion et al., 2005). In this study, mineral concentrations of some new fermented dairy products from goat milk, such as mesophilic and probiotic fermented milks were analyzed.

The results in Table 2 show that liquid goat milk had inconsiderably higher, but statistically insignificant ($p<0.05$) concentration of calcium than liquid cow milk. Ca concentrations in liquid goat milk measured in this study were considerably lower in comparison with data which have been reported by some other authors (Franco et al., 2003; Garcia et al., 2006). Concurrently, mean concentrations of Ca in goat milk presented in our study were similar to those reported by Park (2000). The reasons for these different interpretations are different locality where the studies were performed, different conditions of dairy goat's farming, different types of dairy goat's diet, different seasons of production etc. Average increase of calcium content in fermented dairy products from goat milk in comparison with liquid goat milk was 37.24%. Average increase of calcium content in fermented dairy products from cow milk in comparison with liquid cow milk was as much as 56, 69%. Higher content of calcium in fermented dairy products from cow milk is a quite possibly consequence of firmer curd in fermented cow milk, with higher number of calcium phosphate molecules. It has been observed by many authors that fermented goat milk has weaker curd than fermented cow milk (Abrahamsen and Rysstad, 1991; Park, 1991; Božanić et al., 2004; Fekadu et al., 2005).

Great difference in magnesium concentration between goat and cow milk, as well as between their fermented products were identified by this study ($p<0.05$). Goat milk has average 61.30% higher concentration of Mg than cow milk. Additionally, content of magnesium was average 39.24% higher in fermented goat milk products than in fermented cow milk products ($p<0.05$). Concentrations of Mg in goat milk and goat milk products determined in this work are few higher than in some other studies (Park, 1991; Park, 2000; Güler, 2006). The highest concentration of Mg was determined in goat milk fermented with ABT-2 culture, whereas the lowest concentration of Mg had goat milk fermented with *Lactobacillus plantarum*. Like in case of goat milk, significantly higher contents of Mg in fermented cow milk products than in liquid cow milk was also determined ($p<0.05$). Fermented cow milk had average 33.83 % higher amount of Mg than unfermented (liquid) cow milk. Relationships in Mg concentration of White Slice cheese samples were very similar to these of analyzed fermented milks. Considerably higher concentration of Mg was measured in White Slice goat cheese (150.68 mg/l) than in White Slice cow cheese (99.24 mg/l) (Table 2). Concentrations of Mg were proportionally increased with the corresponding percentages of total solid in different dairy products, for both types of milk.

Phosphorus is one of the dominant minerals in milk. Furthermore, the Ca:P ratio has nutritional importance. As a structural component, calcium combines with phosphorus to comprise the mineral portion of bone and teeth (Weaver and Heaney, 1999). In this research, similar concentrations of phosphorus in goat milk, cow milk and their products were determined. However, slightly higher concentration of phosphorus was noted in goat milk than in cow milk. Concentration of phosphorus in liquid goat milk determined in this study is lower compared to some other scientific reports (in level of 20 mg/l) (El-Alamy and Mohamed, 1978; Park, 2000). Concentration of Ca was also approximately similar in goat and cow milk. The optimal nutritional ratio for the levels of Ca to P has been considered as 1.2:1 (Jenness, 1980). The Ca:P ratio of liquid goat milk in this study was 0.81:1. It is similar to the results published by Park (2000), but opposite to the results of some other authors (Jenness, 1980; Fuente and Juarez, 2000). Better value of Ca:P ratio was determined in fermented goat milk (from 1.03 to 1.1). Ca:P ratio in liquid cow milk in this study was very similar to that of goat milk (0.82). However, Ca/P ratio for samples of fermented cow milks analyzed in this study was near to proposed optimal value (1.13-1.23). Ca:P ratio in White Slice goat cheese was 0.78, whereas in White Slice cow cheese Ca:P ratio was 1.03. The reason for the lower Ca:P ratio in goat cheese than in cow cheese is probably high concentration of phosphorus in White Slice goat cheese.

Obtained results show that goat milk; as well as fermented product from goat milk, has significantly lower contents of zinc in comparison with cow milk and their fermented products. Concentration of zinc in liquid goat milk was 54.72% lower than in liquid cow milk. It was reported that goat milk had lower content of zinc than cow milk (Park et al., 2007). Additionally, concentrations of Zn in goat milk and goat milk products presented here are significantly lower than in some other reports (Park, 1994; Park, 2000; Caponio et al., 2004; Garcia et al., 2006). Average concentration of Zn in liquid goat milk in this study was 2.13. The reason for this significantly outcome is not known, but diet of dairy goats and farming conditions could be a possible reason. Samardžija et al. (2005) cited significant difference between areas in Croatia for Zn concentration in artisanal hard sheep cheeses. East Croatia is well known towards lowland vegetation, poor in some minerals. Half of all samples of goat milk and cheeses were collected in East Croatia region. Furthermore, fermented products prepared from goat milk had average 35.66 % lower concentration of zinc compared to these from cow milk. In comparison with the results that have been cited by Loewenstein et al. (1980) and Park (2000), lower concentration of zinc in goat yogurt was noted in this work. Concentration of zinc in White Slice goat cheese was 65.70 % lower than in White Slice cow cheese. These results on zinc are also out of the intervals described for different varieties of cheese from goat milk (Franco et al., 2003; Caponio et al., 2004; Fekadu et al., 2005).

The mean Fe content of the liquid goat milk in this study was 0.56 mg/l. This result is comparable with the results of some previous reports (Kataoka et al., 1972; El-Alamy and Mohamed, 1978; Garcia et al., 2006). Results in this study show that commercial liquid cow milk had multiply lower concentration of Fe than commercial fluid goat milk. Average Fe concentration in liquid cow milk was 0.208 mg/l. Coefficient of variation values (Table 2) did not suggest a possibility of contamination of goat milk from the metal containers. Concentrations of Fe in all analyzed samples were proportionally increased with the corresponding percentages of total solids in different milk products. However, White Slice goat cheese collected from the manufacturers contained unusually high iron content. Average content of iron in all analyzed samples of goat cheese (collected from manufacturers and prepared under the laboratory conditions) was 9.31 mg/l. However, average iron content in samples prepared under the laboratory conditions was only 5.7 mg/l. This indicates that there be might a strong possibility of Fe contaminations of goat milk from the metal containers in manufacture.

Table 2. Mean mineral concentrations of goat and cow milk products (mg/l)

Product		**Fe**	CV	**P**	CV	**Ca**	CV	**Mg**	CV	**Zn**	CV
Yogurt*****	C*	0,33ab**	15,2***	1076,9b-e	3,3****	1223,7bcd	2,4	74,4ab	7,9	3,43ef	4,8
	G	1,10c	4,7	1118,4c-g	5,5	1207,1bcd	3,7	135,1de	8,7	2,99cd	3,1
ABT-2***** FM	C	0,40ab	15,2	1020,4abc	3,8	1256,7bcd	2,9	80,9b	6,0	3,81fg	3,9
	G	1,02c	4,7	1162,0efg	5,6	1269,4bcd	6,6	144,3def	4,2	2,78bc	4,9
B. longum***** FM	C	0,37ab	20,6	1010,7ab	2,1	1168,5b	1,7	74,6ab	7,8	3,69fg	5,0
	G	1,05c	2,1	1194,4g	4,3	1292,4cd	6,4	145,4ef	5,8	2,41ab	6,7
L. plantarum***** FM	C	0,35ab	12,8	1026,3abc	2,6	1207,7bcd	2,2	77,1b	4,9	3,59efg	4,6
	G	1,08c	3,1	1104,3b-g	6,6	1215,3bcd	6,1	132,2d	4,9	2,86c	5,4
L. diacetilactis***** FM	C	0,35ab	24,7	1052,8a-d	1,9	1212,7bcd	2,3	84,2b	4,2	3,91g	3,8
	G	1,11c	2,3	1137,3d-g	7,9	1186,9bc	4,6	140,3def	3,5	2,59bc	5,8
CH-N19***** FM	C	0,31ab	10,7	1091,1b-f	3,2	1312,0d	2,5	86,6b	8,4	3,83fg	5,1
	G	1,02c	2,6	1192,8fg	4,3	1325,5d	5,1	147,6f	4,0	2,78bc	5,4
Fluid Milk	C	0,21a	26,0	962,3a	1,7	789,5a	3,0	62,5a	5,7	3,28de	4,4
	G	0,56b	7,8	1061,1a-e	5,2	805,1a	5,6	104,3c	5,2	2,12a	4,9
White cheese	C	1,99d	28,4	1726,5h	8,0	1786,5e	5,6	99,2c	11,7	7,93i	7,9
	G	14,56e	2,9	2126,4i	8,0	1748,0e	14,6	150,7f	15,4	4,79h	11,4

*C - cow milk; G - goat milk
** Mean values followed by the same letter in the same column are not significantly different ($P<0.05$) by Fisher's LSD test
***Mean of 20 replicates
****b-e = bcde
*****- starters
FM - fermented milk
CV - coefficient of variation

Conclusions

Obtained results show that goat milk from Croatian market had significantly higher content of Fe and Mg than cow milk. Results presented in this work also suggest significantly lower concentration of Zn in goat milk than in cow milk. Concentrations of analyzed major and minor minerals in analyzed samples were proportionally increased with the corresponding density of prepared milk products. It is obviously that fermented milk had higher concentration of minerals in mass unit than liquid milk. The higher concentration of P, Fe, and Mg were determined in White Slice goat cheese than in White Slice cow cheese. All the minerals concentrations were within the normal values for each type of dairy products described in previous works.

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