Safety and Quality of Farm Fresh Goat's Cheese in the Czech Republic

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Abstract

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The composition and selected physical and chemical parameters of 44 samples of fresh goat cheeses produced on a farm in the Czech Republic were determined. The following average values were obtained for the parameters analysed: pH 4.87 ± 0.14, titratable acidity (SH) 98.09 ± 4.93, dry matter 46.83 ± 1.57%, fat in dry matter 52.74 ± 5.24%, sodium chloride (NaCl) 2.08 ± 0.54%, and a_w 0.979 ± 0.007. All samples showed excellent sensory characteristics and their compositions corresponded to those declared by the producer. Microbiological tests were used for the detection of *Enterobacteriaceae* spp., lactic acid bacteria, *Escherichia coli*, *Enterococcus* spp., *Staphylococcus aureus*, *Bacillus cereus*, *Salmonella* spp. and *Listeria monocytogenes*. Under the applicable regulations, the analysed fresh goat's cheeses were microbiologically safe and had the appropriate physical and chemical characteristics.

Keywords: goat's cheese; farm; physical and chemical parameters; composition; microbiological safety

The reason for the growing interest in raising goats is the increasing demand for safe and healthy food. Goat's milk is most commonly used for the production of cheese (Fantová 2000) and in particular of fresh unripened cheese (Decree 77/2003).

The popularity of goat's milk products has been constantly increasing. Despite the growing numbers of farms and producers engaged in making goat's milk products, the demand exceeds the supply. Among the reasons are the hard-to-meet requirement for longer shelf life of the products while keeping their quality and sensory properties, and high costs of adhering to the strict rules of good hygiene practice during the production. The compositional differences between milk from cows, sheep, and goats (i.e. differences between the chemical compositions of lipids, phosphatase levels, freezing points, natural bacterial inhibitor levels, somatic cell counts, etc.) preclude the nondiscriminatory use of bovine standards for the regulatory purposes (Klinger & Rosenthal 1997).

The quality of cheese varies with the stage of lactation and milk composition, fatty acids content, and sensory characteristics (Soryal *et al*. 2005). Soryal *et al*. (2005) have also found year-round breeding to contribute to the minimisation of the variations in the composition, yield, and concentration of fatty acids in goat's milk cheese.

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The composition and energy value of goat's and cow's milks are roughly the same, however, goat's milk is easier to digest due to its different protein composition and finer milk fat dispersion (Fantová 2000). Of great importance is the use of goat's milk products for the nutrition of persons with digestive disorders, and its anti-cancer potential is also discussed. Goat's milk products play a very important role in the diet of persons with cow's milk casein allergy. The number of children allergic to cow's milk has been constantly growing and so does the importance of goat's milk products in the nutrition of the youngest generation. Fresh goat's milk is consumed by infants and persons with allergy to cow's milk and is also used for on-farm cheese production, with or without thermal treatment (Klinger & Rosenthal 1997).

The most important group of microorganisms in ripened goat's cheese are lactic acid bacteria that are capable of inhibiting the growth of other bacteria such as those of the *Enterobacteriaceae* family or coliforms (Psoni *et al*. 2003). The presence of coliforms, *E. coli*, and enterococci in goat's milk cheese indicates poor adherence to the good hygiene practice guidelines during the technological processing. Particularly enterococci that are thermoresistant and can grow even in the presence of high concentrations of salts form a significant group of organisms with proteolytic and lipolytic activities and biogenic amines formation capability. Furthermore, high counts of coliforms and *E. coli* can increase the risk of the occurrence of pathogenic or enterotoxigenic strains of *E. coli* (Caridi *et al*. 2003).

In the soft cheeses produced from cow's or goat's milk, *Listeria monocytogenes* can be present, as the bacterium is able to survive and grow even during cheese ripening and storage. It is relevant primarily to the cheese produced from raw milk (Morgan *et al*. 2001). Goat's milk can also be a source of other pathogens that can cause disease in humans. These pathogens are in particular verotoxin-producing *Escherichia coli* and enterotoxigenic *Staphylococcus aureus* (Foschino *et al*. 2002; Muehlherr *et al*. 2003).

The aim of this study was the assessment of physical and chemical parameters and microbiological safety of fresh goat's cheeses – natural or flavoured – produced from pasteurised goat's milk on a farm in the South Moravian Region of the Czech Republic. Microbiological analysis included the detection of genes encoding staphylococcal enterotoxins.

MATERIAL AND METHODS

Sampling. The fresh goat's cheese analysed was produced on a South Moravian farm in the Czech Republic. The farm raises 75 white shorthaired goats in the 1st to 8th lactation. The average daily milk yield is 2–3 l and the average annual milk yield is 600–800 litres. Goats are machine milked twice daily. Cheese was made from non-standardised goat's milk pasteurised at 72°C for 20 seconds. The milk was cooled to the rennet temperature and a microbial rennet and pure lyofilised lactic culture (*Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Leuconostoc mesenteroides* subsp. *cremoris*, *Leuconostoc mesenteroides* subsp. *dextranicum*, *Lactococcus lactis* subsp. *lactis* bv. *diacetycaltis*) were added. After renneting and curd processing, cheese was shaped, salted, and vacuum packed. The samples from cheese retail packs were collected twice a month over a period of 4 months in 2006 to be submitted for microbiological and physico-chemical analyses. They were cooled to 4–6°C and then transported at a temperature below 8°C to be processed immediately after the delivery to the laboratory. The selected parameters were monitored in 22 samples of natural fresh unripened goat's cheese (coded KA, Czech Republic, minimum dry matter content 48%, minimum fat content in dry matter 40%) and in 22 samples of fresh unripened goat's cheese with herbs (coded KB, Czech Republic, minimum dry matter content 48%, minimum fat content in dry matter 40%).

Physical and chemical parameters. The following parameters were assessed: pH, titratable acidity (Czech standard ČSN 57 0107:1966), dry matter (ČSN 57 0107-3:1982), fat (determined by acid butyrometry, ČSN 57 0107:1966), sodium chloride (ČSN 57 0107-12:1982), and water activity (ČSN ISO 21807:2006).

Microbiological analyses. The samples were processed as specified by the standard ČSN ISO 7218:1998. The following microbiological indicators were monitored: *Enterobacteriaceae* count (ČSN ISO 21528-2:2006), beta-D-glucuronidase positive *Escherichia coli* count (ČSN ISO 16649-2: 2003), lactic acid bacteria count (ČSN ISO 13721: 1998), enterococcal count (streaking 0.2 ml of the sample onto Slanetz-Bartley agar with subsequent culture at 37°C for 48 h), *Bacillus cereus* count (ČSN EN ISO 7932:2005), coagulase-positive staphylococci count (ČSN EN ISO 6888-1:1999) and the detection of *S. aureus* (enrichment in buffered

peptone water under aerobic conditions at 37°C for 24 h, followed by inoculation onto Baird-Parker agar and aerobic culture at 37°C for 24–48 h), the detection and count of *Listeria monocytogenes* (ČSN EN ISO 11290-1,2:1999), and the detection of *Salmonella* spp. (ČSN EN ISO 6579:2003) and *E. coli* O157 (ČSN EN ISO 16654:2002).

The suspected enterococci isolates were confirmed genotypically and were subsequently identified by polymerase chain reaction (PCR) (Table 1). In the *S. aureus* isolates, PCR was used for the detection of the specific SA442 DNA fragment and toxin genes *sea-sej* (Table 1). In addition to the culture analysis, *S. aureus* isolates from goat's cheese were also tested for the production of enterotoxins SEA-SED by the reversed passive latex agglutination (SET-RPLA, Denka Seiken, Japan).

Results interpretation. To the fresh cheese sampled at the site of production, the following microbiological criteria established by Commission regulation (EC) No. 2073/2005 are applicable: the absence of *L. monocytogenes* (0/25 g), *E. coli* count $m = 10^2$ CFU/g, and coagulase positive staphylococci count $m = 10^1$ CFU/g, or the detection of staphylococcal enterotoxins (negative/25 g).

Sensory analysis. Sensory analysis of all products was carried out by a five-member expert commission.

Statistical analysis. The statistical analysis of the results was performed using Stat plus software (Matoušková *et al*. 1992).

RESULTS AND DISCUSSION

The average, minimum, and maximum values of the selected physical and chemical parameters are summarised in Tables 2 and 3. In total, 44 samples of fresh goat's cheese were analysed. The expert commission that carried out the sensory analysis concluded that all products showed excellent to outstanding characteristics. The average pH value of natural goat's cheese was 4.87 ± 0.14 and the average titratable acidity was 98.09 ± 4.93 SH. From the standard deviation (SD) value it follows that the titratable acidity was stable throughout the monitoring. The average dry matter content of 48% declared by the producer on the label was exceeded in 4 samples. The average dry matter content was 46.83 ± 1.57%, with the range from 44.08% to 50.05%. Raw goat's milk is not standardised before processing. As the production procedure has to comply with strict hygienic standards, the observed variation is likely to result from the differences in the composition of raw goat's milk depending on the stage of lactation and season. In view of the fact that the minimum value is not indicated by the producer, the determined content is considered as appropriate.

Fat in dry matter in soft cheese varies between 40% and 65%. The producer declares the average proportion of fat in dry matter to be 40%, but in all samples, the determined percentage was above 40%. The average value was 52.74 ± 5.24% and the

Table 1. PCR assays used in the study

PCR assay	Target	Product lenlength size	Reference
Enterococcus spp.			
Genus identification	*tuf* gene	112 bp	Ke *et al.* (1999)
Species identification – *E. faecalis*	*sod*A gene	360 bp	Jackson *et al.* (2004)
– *E. faecium*	*sod*A gene	215 bp	Jackson *et al.* (2004)
S. aureus			
Species identification	SA442 fragment	108 bp	Martineau *et al.* (1998)
Enterotoxin SEA	*sea* gene	520 bp	Monday and Bohach (1999)
SEB	*seb* gene	667 bp	Løvseth *et al.* (2004)
SEC	*sec* gene	283 bp	Monday and Bohach (1999)
SED	*sed* gene	384 bp	Monday and Bohach (1999)
SEE	*see* gene	170 bp	Monday and Bohach (1999)
SEG	*seg* gene	327 bp	Monday and Bohach (1999)
SEH	*seh* gene	360 bp	Monday and Bohach (1999)
SEI	*sei* gene	465 bp	Monday and Bohach (1999)
SEJ	*sej* gene	142 bp	Monday and Bohach (1999)

Table 2. Natural fresh goat's cheese – monitored parameters

Sample code	pH	TA (SH)	Dry matter (%)	Fat in dry matter (%)	NaCl (%)	a_w
KA 1	5.08	100.00	44.29	48.41	1.99	0.982
KA 2	5.12**	104.00	47.11	45.47	2.05	0.988
KA 3	5.08	100.50	44.27	45.06	2.14	0.978
KA 4	5.12**	105.00	44.08*	52.11	2.03	0.978
KA 5	4.98	101.00	47.22	46.55	2.72	0.985
KA 6	5.12**	101.50	46.89	43.66*	2.49	0.983
KA 7	4.75*	95.50	46.00	52.09	2.04	0.973
KA 8	4.76	95.50	46.13	52.01	2.68	0.971
KA 9	4.76	97.50	46.64	51.31	2.70	0.969*
KA 10	4.76	84.50*	46.67	49.11	2.64	0.977
KA 11	4.76	93.00	46.82	55.53	1.18	0.985
KA 12	4.80	94.50	45.92	54.44	1.24	0.990**
Ka 13	4.79	95.00	45.78	56.79	1.33	0.984
Ka 14	4.81	97.00	45.84	54.54	1.08*	0.985
KA 15	4.82	99.50	48.52	55.61	2.47	0.989
KA 16	4.79	96.50	48.44	55.59	2.75**	0.978
KA 17	4.79	98.50	47.67	54.52	2.48	0.985
KA 18	4.82	95.50	49.63	56.24	2.52	0.984
KA 19	4.80	93.50	47.78	48.07	1.79	0.968
KA 20	4.80	106.50**	46.5	60.22	2.01	0.972
KA 21	4.84	98.50	47.94	64.31**	1.81	0.971
KA 22	4.80	105.00	50.05**	58.74	1.67	0.970
Average	4.87	98.09	46.83	52.74	2.08	0.979
SD	0.14	4.93	1.57	5.24	0.54	0.014

TA – titratable acidity; KA – natural fresh goat's cheese; *minimum value; **maximum value; SD – standard deviation

range was from 64.31% to 43.66%. The sodium chloride content in cheese can vary between 0.7% and 4.5% depending on the cheese type. The average value was 2.08 ± 0.54%, with the range from 2.75% to 1.08%. Water activity varied from 0.969 to 0.990, i.e. in the interval optimal for the growth of all microorganisms including pathogens. The average value was 0.979 ± 0.014 which, together with the detected acidity (pH > 4.4), is a risk factor for the growth of *L. monocytogenes*. However, the presence of *L. monocytogenes* was not confirmed by microbiological analysis.

The average pH value was almost identical in both fresh goat's cheese with herbs (4.89) and natural fresh goat's cheese (4.87), as the same production process and raw material were used in their production.

The titratable acidity was high, with the average value of 97.27 ± 6.06 SH. The measured values corresponded to those found in fresh cheese.

The dry matter content complied with the percentage declared on the label (48%) in five samples only (KB 15, 16, 17, 19, and 21) but was lower in the other samples. The average dry matter content in goat's cheese with herbs was 46.83%. The highest dry matter content of 49.44% was found in sample KB 15 and the lowest one of 45.28% in sample KB 1.

Fat in dry matter in all samples of fresh goat's cheese with herbs was above 40% as declared on the label. The average fat content in dry matter of fresh goat's cheese with herbs was 53.70%. The highest fat content in dry matter was 62.19% in sample KB 19 and the lowest one was 45.57% in sample KB 2.

The average sodium chloride content was 1.92%. The highest sodium chloride content was 2.78% in sample KB 22 and the lowest one was 1.09% in sample KB 13. This shows a considerable variation between the samples of the same type of cheese which is likely the result of the differences in salting and ripening times.

Water activity ranged from 0.920 to 0.990, with the average value of 0.977 ± 0.015. These are the optimum values for the growth of microorganisms in general and of pathogens in particular.

As shown in Table 4, the counts of the *Enterobacteriaceae* family were in the range of the order of 10^1–10^2 CFU/g in natural fresh cheese samples, and in the range of the order of 10^2–10^3 CFU/g in fresh cheese with herbs. None of the samples was positive for the presence of *E. coli*. The higher contamination of fresh cheese with herbs was likely caused by the added herbs. This assumption is supported by the higher incidence of enterococci in the samples of cheese with herbs in comparison with those of natural fresh cheese. A relatively low level of contamination in the samples of natural fresh cheese is also explained by the fact that the cheese was made from pasteurised milk. Novella-Rodríguez *et al*. (2004) confirm that the counts of *Enterobacteriaceae* and enterococci in cheese produced from raw milk increase in the course of

Table 3. Fresh goat's cheese with herbs – monitored parameters

Sample code	pH	TA (SH)	Dry matter (%)	Fat in dry matter (%)	NaCl (%)	a_w
KB 1	5.10	100.50	45.28*	47.35	1.97	0.974
KB 2	5.16**	99.00	46.14	45.47*	1.68	0.984
KB 3	5.12	100.50	46.36	48.38	1.70	0.987
KB 4	5.10	93.00	45.87	53.70	1.81	0.981
KB 5	5.10	92.00	46.48	47.29	2.29	0.978
KB 6	5.12	90.00	46.59	47.07	2.10	0.920*
KB 7	4.80	95.50	47.31	52.50	2.67	0.971
KB 8	4.74	94.50	46.20	51.90	2.74	0.970
KB 9	4.73*	90.50	46.18	51.69	2.07	0.982
KB 10	4.74	85.00*	46.99	46.69	2.69	0.973
KB 11	4.87	90.50	46.07	47.75	1.57	0.984
KB 12	4.88	93.00	45.58	52.65	1.47	0.985
KB 13	4.87	95.50	45.94	50.07	1.09*	0.987
KB 14	4.88	93.00	46.46	53.81	1.17	0.988
KB 15	4.78	102.00	49.44**	60.68	1.90	0.984
KB 16	4.79	101.00	49.32	54.70	1.51	0.990**
KB 17	4.76	100.50	49.02	57.10	1.77	0.985
KB 18	4.80	103.50	46.24	58.28	1.13	0.987
KB 19	4.77	107.00**	48.11	62.19**	2.20	0.962
KB 20	4.80	107.50	45.56	56.96	2.28	0.971
KB 21	4.83	101.50	48.35	55.62	1.56	0.966
KB 22	4.79	104.50	46.81	59.58	2.78**	0.974
Average	4.89	97.27	46.83	53.70	1.92	0.977
SD	0.15	6.06	1.21	4.69	0.52	0.015

TA – titratable acidity; KB – fresh goat's cheese with herbs; *minimum value; **maximum value; SD – standard deviation

maturing by 2 to 3 logarithmic orders of magnitude. All enterococcal isolates were identified as the species *Enterococcus faecalis*. The predominance of this species in goat's cheese has also been reported by others (Suzzi *et al*. 2000; Andrighetto *et al*. 2001), and has been observed even when different enterococcal species have been isolated. In contrast to our study that focused on a single farm, the aforementioned authors analysed cheese samples of different origins.

The average count of lactic acid bacteria was of the order of magnitude of 10^8 CFU/g in both monitored types of cheese (Table 4) and was in agreement with the data generally reported for raw cheese (Randazzo *et al*. 2002). The presence of *B. cereus* was not detected in any of the samples.

In two samples of natural fresh cheese, the *S. aureus* counts were 2.5×10^2 CFU/g and 5.0×10^1 CFU/g, while in the remaining samples they were below 5.0×10^1 CFU/g. After the enrichment, *S. aureus* was isolated from 9 samples of natural fresh cheese. In 8 isolates, PCR detected the presence of genes encoding staphylococcal enterotoxins SEB, SEG, and SEI, but one isolate remained negative for each of the nine genes monitored. RPLA confirmed the capability of *S. aureus* to produce SEB. These results are partially consistent with the data reported by Scherrer *et al*. (2004) who have detected the production of enterotoxin SEC in more than half of *S. aureus* isolates from goat's and sheep's milks, followed by the producers of SEA, SEG, SEI, and SEJ, with SEB and SED producers being less common. The predominance of *S. aureus* isolates from goat's and sheep's milks producing enterotoxins SEC and SEL has also been pointed out by Morandi *et al*. (2007). Most of our *S. aureus* isolates from raw goat's milk used for the production of fresh

Table 4. Selected bacterial counts (CFU/g) in goat's milk cheese samples

Natural fresh goat's cheese				Fresh goat's cheese with herbs			
Sample code	EB	ENT	LAB	Sample code	EB	ENT	LAB
KA 1	1.9×10^2	$< 5.0 \times 10^1$	7.5×10^7	KB 1	1.9×10^2	$< 5.0 \times 10^1$	$> 7.5 \times 10^7$
KA 2	4.3×10^2	5.8×10^2	7.0×10^6	KB 2	5.1×10^2	$< 5.0 \times 10^1$	$> 7.5 \times 10^7$
KA 3	2.2×10^2	$< 5.0 \times 10^1$	2.6×10^8	KB 3	1.1×10^3	$< 5.0 \times 10^1$	$> 7.5 \times 10^7$
KA 4	3.8×10^2	1.3×10^2	1.2×10^8	KB 4	9.4×10^2	4.0×10^2	$> 7.5 \times 10^7$
KA 5	1.5×10^1	1.7×10^3	8.0×10^8	KB 5	2.0×10^2	1.6×10^3	6.5×10^8
KA 6	2.3×10^2	1.3×10^3	7.2×10^8	KB 6	7.5×10^1	6.6×10^2	6.6×10^8
KA 7	1.5×10^1	1.8×10^3	7.0×10^8	KB 7	1.4×10^2	1.2×10^3	5.8×10^8
KA 8	1.9×10^2	1.9×10^3	$> 7.5 \times 10^8$	KB 8	5.7×10^2	2.0×10^3	8.0×10^8
KA 9	1.9×10^2	$< 5.0 \times 10^1$	4.7×10^8	KB 9	1.2×10^3	5.0×10^1	3.8×10^8
KA 10	1.9×10^2	$< 5.0 \times 10^1$	3.8×10^8	KB 10	5.8×10^2	$< 5.0 \times 10^1$	3.6×10^8
KA 11	6.0×10^1	$< 5.0 \times 10^1$	4.6×10^8	KB 11	4.8×10^2	$< 5.0 \times 10^1$	4.5×10^8
KA 12	1.5×10^2	5.0×10^1	3.9×10^8	KB 12	$> 1.5 \times 10^3$	$< 5.0 \times 10^1$	5.2×10^8
KA 13	2.5×10^1	$< 5.0 \times 10^1$	4.6×10^8	KB 13	2.1×10^2	5.0×10^1	1.6×10^8
KA 14	1.1×10^1	$< 5.0 \times 10^1$	5.6×10^8	KB 14	1.1×10^2	$< 5.0 \times 10^1$	6.0×10^7
KA 15	$< 1.0 \times 10^1$	$< 5.0 \times 10^1$	3.8×10^8	KB 15	1.7×10^3	$< 5.0 \times 10^1$	1.7×10^8
KA 16	1.5×10^1	$< 5.0 \times 10^1$	5.7×10^8	KB 16	3.5×10^1	$< 5.0 \times 10^1$	3.1×10^8
KA 17	1.5×10^3	$< 5.0 \times 10^1$	3.9×10^8	KB 17	6.7×10^2	5.0×10^1	4.4×10^8
KA 18	4.9×10^2	$< 5.0 \times 10^1$	6.0×10^8	KB 18	5.3×10^2	$< 5.0 \times 10^1$	6.5×10^8
KA 19	8.1×10^2	$< 5.0 \times 10^1$	4.4×10^8	KB 19	6.7×10^2	$< 5.0 \times 10^1$	4.6×10^8
KA 20	1.4×10^3	$< 5{,}0 \times 10^1$	6.5×10^8	KB 20	3.6×10^2	5.0×10^1	3.8×10^8
KA 21	3.5×10^1	$< 5.0 \times 10^1$	4.8×10^8	KB 21	5.8×10^2	$< 5.0 \times 10^1$	3.6×10^8
KA 22	1.0×10^1	$< 5.0 \times 10^1$	6.1×10^8	KB 22	1.4×10^2	1.2×10^3	5.8×10^8

EB – *Enterobacteriaceae*, ENT – enterococci, LAB – lactic acid bacteria

cheese were the producers of enterotoxin SEC (unpublished results), but were not detected in the products. It can thus be assumed that goat's milk pasteurisation results in the devitalisation of *S. aureus* strains producing enterotoxin SEC. Nevertheless, in the course of the cheese production, secondary contamination with *S. aureus* strains can occur and such strains may be the carriers of other genes encoding staphylococcal enterotoxins. This hypothesis is supported by our results.

The presence of *L. monocytogenes*, *Salmonella* spp. or *E. coli* O157 was not detected in any of the samples analysed.

CONCLUSION

Food safety is achieved, on one hand, by focusing on the prevention, i.e. by adhering to the good hygiene practice guidelines and to the principles of Hazard Analysis and Critical Control Points (HACCP), and on the other hand, by meeting the microbiological criteria set by Commission Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs. Under the applicable regulations, the goat's cheeses analysed are microbiologically safe and have appropriate physical and chemical characteristics. However, the reported detection of *S. aureus* strains that can be involved in food poisoning clearly indicates the need for safe handling during the distribution, storage and sale of the cheese products. A prerequisite for assuring the quality and safety of goat's milk products is a strict control of the microbiological quality pursuant to Commission Regulation (EC) No. 2073/2005 on the microbiological criteria for foodstuffs, and of the conformity with the characteristics declared on the label.

The composition of all samples analysed corresponded to the data declared on the label.

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