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INFLUENCE OF EXTENSIVE GRAZING ON CHEESE COMPOSITION, YIELD AND FATTY ACIDS CONTENT OF GOATS

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Abstract

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The aim of present study was to investigate the effect of extensive grazing on the composition, yield and fatty acids content of goat cheese. Twenty lactating Hungarian Native goats were randomly allocated to two treatment groups. The goats in the first group were kept indoors and fed with alfalfa hay; the goats in the second group were kept on a natural pasture. Utilization of native pasture has been extensive level in order to avoid over-grazing of the grassland. The stocking density of the pastures grazed by the goat was about 0.5 AU/ha. The cheese from grazed goats had significantly higher fat (15.50 vs. 21.50 g/100g cheese; $P<0.01$) and protein (20.58 vs. 22.57 g/100g cheese; $P<0.05$) composition and cheese yield (10 % vs. 11 %; $P<0.01$) than goats kept indoors. Grazing significantly increased the rumenic acid (66.45 vs. 156.95 mg/100g cheese; $P<0.001$) and n-3 fatty acids (99.28 vs. 233.48 mg/100g cheese; $P<0.01$) contents in cheese. In this study, n-6/n-3 ratio of 4.31 and 2.48 were found for cheese samples of goats that fed indoor and grass, respectively. It is concluded that nutritional quality of cheeses from goats kept on the natural pasture are more advantageous in human nutrition.

Key words: goat, extensive grazing, cheese, fatty acids

Introduction

In recent years there has been increased interest in ways to manipulate the fatty acid composition of foods. Unfortunately, the typical Western diet is characterized by a high intake of n-6 and a low intake of n-3 fatty acids. A high ratio of n-6/n-3 fatty acids is a risk factor in coronary heart disease (CHD). It is well known that α-linolenic acid is the precursor of n-3 PUFAs such as eicosapentaenoic acid (EPA) ($C_{20:5}$ n-3) and docosahexaenoic acid (DHA)($C_{22:6}$ n-3) are required for many metabolic process in human and efficiently prevent coronary heart disease (CHD). Nutritionists (such as Simopoulos, 2004) recommend value for the n-6/n-3 ratio less 4:1.

The *c9t11*CLA isomer (Rumenic acid) has been demonstrated to have a range of positive health effects such as suppression of carcinogenesis (Parodi, 2002), and reductions of atherogenesis (Nicolosi et al., 1997). The number of studies on the effects of pasture and other diet compositions on fatty acids, especially on rumenic acid concentration and on its precursors, is rather limited in goat milk and cheese (such as Tsiplakou et al., 2006; Galina et al., 2007; Pajor et al., 2009), compared with cows. Nevertheless, more authors reported that grazing is important in developing of the economic small ruminant keeping technology (Póti, 1998; Bedő and Póti, 1999; Jávor et al., 2001).

Previous result was suggested grazing revealed positive effect on milk and cheese fatty acid concentra-

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tion of fat (Pajor et al., 2009), but influence of grazing on the cheese composition, yield and fatty acid content (mg/100g cheese) is less known. The goat cheeses are generally produced by small-scale enterprises, therefore artisan cheese and other milk based products may be able to help in developing the goat sector and improving the rural conditions (increases the ratio of labour) in Hungary and in the World.

The aim of this study was to investigate the effect of extensive grazing of a natural pasture on the composition, yield and fatty acids content of semi-hard goat cheese.

Material and Methods

Experimental animals

The study was carried out in a goat farm on lowland (Bösztör, Bács-Kiskun County, Hungary). Twenty mixed age Hungarian Native goats were randomly allocated to two treatment groups (average days in milk: 18-22). The groups were balanced for parity and time of kidding. The control goats were kept indoors and fed with alfalfa hay (n=10), the goats from the other group were kept on a natural pasture (n=10). The stocking density of the pastures grazed by the goat was about 0.5 AU/ha. The average annual rainfall of the area is approx. 450 mm.

Utilization of native pasture was extensive in order to avoid over-grazing. On the natural pasture were identified forty-nine plant species. The plant cover averaged was 94 %. The main species were *Festuca pseudovina,* the main legume was *Lotus corniculatus*. The annual green grass yield was 3.2 t/ha. During the daily routine, the grazed goats were driven to pasture after the morning milking, and collected in the afternoon to be milked and confined for the entire night. The other group was kept indoors in full confinement during the study.

The experimental period lasted 5 weeks, which involved the period of the first 3 weeks for adaptation to the diet and the last 2 weeks for experimental period. Grazing started in mid-April. The grazed group stayed all day long on the pasture; however, they were fed with 300-400 g/day grain mix (barley 40%, wheat 20%, and maize 20% and wheat bran 20%). The control animals received *ad libitum* alfalfa hay and also 300-400 g/day grain mix. Both groups had the same composition of the grain mix, which was given twice a day in equal amounts.

The individual milk samples were collected from animals once a week during the first 2 weeks of the investigated period for the analysis of chemical composition.

Cheese processing

15 kg of goat milk per group were processed into cheese (about 1.5 kg per cheese) at 2, 5, 8, 11 and 14 days throughout the experimental period. The semi-hard cheese was processed by description as shown in Table 1. One semi-hard cheese for each group was taken for chemical analysis per each batch. The cheese samples were collected after the 4-week-ripening period. Samples were analyzed for dry matter, fat and ash as described below.

Chemical analysis

Fat, protein, lactose and solids non-fat contents of milk were determined using a MilkoScan device (Combi Foss 5000 apparatus, Foss Electric, Denmark).

Table 1
Description of semi-hard cheese manufacturing

Characteristic of processing	
1	Pasteurizing at 63-65°C, 30 min
2	Cooling down to 40°C
3	Addition bacterial culture (1.5 %) and $CaCl_2$ (15 g/100 l milk), 1 hour incubation
4	Cooling down to 32°C
5	Addition bacterial commercial rennet, 30 min coagulation time
6	Scooping and draining (wheat size)
7	Post heating up to 38°C, duration: 15 min
8	Formation of cheeses and moulding in block of ~1.5 kg
9	Press: 12 hours, initial pressure: 5 kg/kg cheese; final pressure: 15 kg/kg cheese
10	Salt bath: duration: 36-48 hours, cc: 18 %, temperature: 13°C
11	Ripen: 17-18°C, 85% relative humidity for 4 weeks on oak board

Determinations for dry matter, fat, protein and ash content of cheese samples are described in the Hungarian Standards (1978, 1980, 2000, 2002).

The milk and cheese fat were dissolved in sodium hydroxide methanol solution and re-esterified to methyl-esters according to the AOAC (1990) method using boron trifluoride (BF_3). Methyl esters of fatty acids were determined by gas chromatography using a Shimadzu GC 2010 apparatus (Japan) with a flame ionization detector (FID) and column (CP-SIL-88, 100 m × 0.25 mm × 0.2 μm).The split injection ratio was 50:1. The column oven temperature was held at 80°C for 0 min, then programmed at a rate of 2.5°C/min up to 205°C and held for 20 min and then increased again to 225°C at 10°C/min, and held for 5 min. Temperature injector and detector were 270°C and 300°C, respectively. Helium was used as a carrier gas, applying a flow rate 28 cm/s. Peaks were identified on the basis of the retention times of standard methyl esters of individual fatty acids (Mixture Me 100, Larodan Fine Chemicals AB, Sweden).

Statistical analysis

Statistical analysis was processed by SPSS 14.0 program package (Shapiro-Wilk test for normality distribution, F test for equality of Variances, t- and Welch's corrected t-test).

Results and Discussion

The daily milk yield average was lower ($P<0.01$) in indoor fed goats at 2.7 kg, compared to 3.1 kg milk yield for grazed goats. Hay diet caused lower ($P<0.001$) fat (2.96 g/100g), protein (2.90 g/100g) and solids non-fat (7.72 g/100g), compared to milk form grazed goats (3.62, 3.18 and 8.05 g/100g respectively) (data no presented in Table). Furthermore, grazing resulted in a significantly higher ($P<0.05$) cheese yield (11.0 %) compared with indoor diet (10.0 %). Fat and protein compositions in grazed goats' cheeses were 21.50 g and 22.57 g/100g cheese, respectively, while indoor goats had 15.50 g and 20.54 g/100g cheese. Ash and dry matter contents of cheeses did not show any significant differences during the experimental period (Table 2).

Grazing significantly increased the cheese yield and composition of milk and cheese during experimental investigation period. It is well known that the goat milk fat and protein content is affected by many factors, such as diet, breed, parity and stage of lactation (Kuchtik et al., 2008; Novotna et al., 2009) and thus the milk composition determines the composition of cheese. Soriano et al. (2001) in Holstein cows and Soryal et al. (2004) in Alpine goat also found that pasture feeding slightly increased the milk fat, protein and solids non-fat contents.

Results of the fatty acid analysis of the cheese samples are summarized in Table 2.

Grazing significantly increased the short chain fatty acids (such as caprylic and capric acids) in cheese samples. The cheese fat plays important role in dairy products, e.g. the flavour of dairy products are influenced by short chain fatty acids, especially caproic, caprylic and capric acids (Zan et al., 2006). Previously the cheeses made from milk of grazed animals (cattle and goat) had higher aromatic components, which made the flavour and taste more favourable to customers has been reported by Galina et al. (2007).

The rumenic acid has a range of positive health properties such as anticarcinogenic and antiatherogenic effects (Nicolosi et al., 1997; Parodi, 2002). Grazing significantly increased the rumenic acid, and rumenic acid ratio in cheese samples. It is well known that forages is influenced the bacterial fermentation in the rumen. Type of forage could affect the resulting rumenic acid content in milk. The concentrate diets, reduces the ruminal pH and biohydrogenation, which consequently affect negatively rumenic acid production compared to forage diets (Kukuk et al., 2001). The water content of the grass affects microbiological fermentation and pH in the rumen. Rumen pH has an important role in maintaining a viable

Table 2
Composition and yield of goat semi-hard cheeses (mean±SD)

Items, g/100 g	Indoor group (n=5)	Grazed group (n=5)	P
Dry matter	52.19±3.25	53.05±1.33	N.S.
Fat	15.50±1.29	21.50±1.32	<0.01
Fat in dry matter	36.87±2.25	43.11±1.21	<0.05
Protein	20.58±1.47	22.57±1.15	<0.05
Ash	5.19±0.60	4.85±0.32	N.S.
Cheese yield	10.05±0.60	11.01±0.28	<0.05

rumen environment suitable for *B. fibrisolvens*. It has been shown that a ruminal pH of 6.0 or above has a positive effect on rumenic acid production (Tsiplakou et al., 2008). The rumenic acid ratio in cheese was 82.6-84.9 %. This is agreement with literature references record. Chin et al. (1992) found rumenic acid ratio between 75 and 90% in dairy products. Grazing considerably increased the ratio of rumenic acid in cheese (82.6 % vs. 84.9 %; P<0.01). The *t10c12*CLA isomer is produced in the rumen according to rumen conditions, such as minor bacterial populations or the alternative biohydrogenation pathway (Tsiplakou et al., 2006).

Grazing significantly increased the content of saturated, mono- and polyunsaturated fatty acids, moreover n-3 fatty acids (such as eicosapentaenoic and docosahexaenoic acids) and significantly decreased the n-6/n-3 ratio in cheese samples. The cheese from non-grazed goats had lower α-linolenic acid content (63.1 mg/100g vs. 173.6 mg/100g cheese; P<0.01). Grass origin is rich in α-linolenic acid; authors reported that 50-60 % of the total fat is n-3 fatty acids in grass (Tsvetkova and Angelow, 2010). Grass is a dietary source of n-3 fatty acids like linseed (Zhang et al., 2006) and micro algae (Póti et al., 2006; Póti et al., 2007). Increasing the supply of

Table 3
Fatty acid content (mg/100g cheese) of goat semi-hard cheeses

Fatty acids	Indoor group (n=5)	Grazed group (n=5)	P
C4:0	105.77±13.00	225.03±9.69	<0.001
C6:0	222.81±3.17	498.80±6.45	<0.001
C8:0	341.48±3.47	274.82±13.26	<0.001
C10:0	1128.55±97.29	1955.45±107.52	<0.001
C12:0	649.41±19.81	628.34±10.07	N.S.
C14:0	1849.05±50.84	2160.03±144.06	<0.05
C14:1	29.31±2.96	27.21±8.97	N.S.
C16:0	4876.45±217.44	5568.89±178.59	<0.05
C16:1	100.47±2.53	98.20±2.30	N.S.
C18:0	1273.73±34.23	1603.90±96.82	<0.01
C18:1n-9c	3414.23±53.25	5103.38±159.80	<0.001
Total CLA	80.40±9.62	184.96±18.57	<0.001
*c9t11*CLA	66.45±8.25	156.95±15.50	<0.001
*t10c12*CLA	13.95±1.42	28.01±3.13	<0.01
*c9t11*CLA ratio, %	82.6±0.56	84.9±0.37	<0.01
C18:2n-6	383.90±21.47	528.13±19.24	0.001
C18:3n-3	63.10±4.07	173.61±16.75	<0.01
C20:4n-6	43.81±5.76	41.56±7.78	N.S.
C20:5n-3	7.75±1.55	15.77±1.24	<0.01
C22:5n-3	20.16±0.64	27.62±1.03	<0.001
C22:6n-3	8.27±0.89	16.48±1.24	<0.001
SCFA	1.692.51±99.44	2.729.31±96.99	<0.001
SFA	11.042.32±155.45	13.892.12±452.23	<0.01*
MUFA	3.773.74±68.90	6.258.08±180.96	<0.001*
PUFA	663.49±42.96	1.338.49±32.90	<0.001
Total n-6	427.71±27.02	569.69±12.25	<0.001
Total n-3	99.28±24.46	233.48±35.04	<0.01
n-6/n-3	4.31±0.23	2.48±0.38	<0.01

NS - non significantly difference; CLA - conjugated linoleic acid; SCFA: Short chain fatty acids (C_4-C_{10}); SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; *= Welch's corrected t-test n-3 fatty acids in the diet is one of the most important ways of improving the n-3 content of ruminant milk. α-linolenic acid is the precursor of n-3 PUFAs such as eicosapentaenoic acid (EPA) (C20:5 n-3) and docosahexaenoic acid (DHA)(C22:6 n-3), which are required for many metabolic process in human and efficiently prevent coronary heart disease (CHD). The amount of the α-linolenic, eicosapentaenoic and docosahexaenoic acids were higher in the cheese from grazed animals than in those of the goat group kept indoors (Table 3).

The n-6/n-3 ratio is generally used to assess the nutritional value of fats. By Simopoulos (2004) recommend value for the n-6/n-3 ratio less 4:1. In the present study, n-6/n-3 ratio of 4.31 and 2.48 were found for cheese samples of goats that fed indoor and grass, respectively. The low ratio of n-6/n-3 in the cheese of grazing goats that received grass is according meeting with the new recommendations for human nutrition.

Conclusions

There was significant difference in cheese composition, yield and fatty acids content between two feeding management. The pasture, compared with indoor fed increased fat and protein composition and yield of cheese. Diet with pasture significantly increased the content of short chain fatty acids, mono and polyunsaturated fatty acids with special interest in sensory characteristics of cheeses and human health repercussions n-3 fatty acids such as α-linolenic, eicosapentaenoic acid (EPA) (C20:5 n-3) and docosahexaenoic acid (DHA)(C22:6 n-3), which are efficiently prevent cardiovascular diseases. Consumer benefit from the nutraceutical effects of cheese produced by grazed animals due to rumenic acid increase, which improve the human health.

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