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Influence of betaine on goat milk production and composition

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Abstract

A study was conducted to determine the effect of the inclusion of betaine in goat diets on milk production and physical-chemical characteristics of the goat milk. Thirty lactating goats free of intramammary infection were selected from a commercial Murciano-Granadina herd. Two homogeneous groups of 15 goats were used in this trial. One group received the control diet and the other the same diet in which 4 g betaine was included per kg of the diet. The intake of the experimental diets started 15 days before parturition and samples were taken over a period of four months. After four months the milk yield of the betaine group was significantly higher, 0.16 kg/day, than that of the control group. The percentage of fat was higher in the betaine group but did not differ significantly from that of the control group. Significantly higher concentrations of short chain fatty acid ($C_{8:0}$, $C_{10:0}$, and $C_{12:0}$) were measured in the milk of the goats receiving the betaine in their diet than in the milk from the control group.

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Introduction

Betaine is a natural occurring compound with methyl donor properties that is increasingly being used in animal nutrition. Betaine, an oxidative product of choline is able to replace methionine in some physiologically important body processes and has been shown to be involved in ruminal digestion in trials where radio labelled carbon was fed to sheep (Mitchell *et al.*, 1979). Mitchell *et al.* (1979) found that 83% of the betaine was lost in the rumen, but nearly 100% of the labelled betaine carbons were recovered in the body tissues. Within the rumen, microbes convert betaine to acetate, which is then absorbed into the blood and utilized in the body. Fatty acids (FA) with ≥18 carbon atoms are taken up by the mammary gland from neutral lipid fractions in the blood, while FA with 4-16 carbon atoms are synthesized *de novo* in the mammary gland from precursors in the blood, such as acetate (Moore & Christie, 1979).

The objective of this research was to study the effect of betaine supplementation on milk production, chemical composition and profile of FA in the milk of Murciano-Granadina dairy goats during four months of lactation.

Materials and Methods

Thirty lactating goats were selected from a commercial Murciano-Granadina goat herd (EXCAMUR S.L.) from the Murcia Region in Spain. Selection was based on age, stage of lactation, sanitary status of the udder and type of birth. Two homogeneous groups of 15 goats were selected. The control group was fed 1.5 kg of a compound feed and 1 kg of lucerne hay per goat per day. The experimental group received the same diet as the control group, but the diet was supplemented with 4 g betaine/kg feed (betaine anhydrous, Danisco Animal Nutrition). The betaine, the raw dietary ingredients and a vitamin-mineral mixture were supplied by Nordos (TROUW Nutrition España S.A.). The goats were fed twice a day, at 9:00 (after milking) and at 15:00. Water was provided *ad libitum*. The diets, presented in pellets, were formulated according to INRA (1988) recommendations. Chemical analyses were carried out according to the methods of AOAC (1995) and Robertson & Van Soest (1981). Ingredients and chemical composition of diets are presented in Table 1. The experimental diets were provided from 15 days before parturition and continued for four months postpartum.

The herd was machine milked (Casse) once at day (morning milking). Individual milk production was recorded daily and the chemical composition of the milk determined each 15 days. Physical-chemical

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parameters of the milk (fat, crude protein, true protein, whey protein, casein, lactose, dry matter, ash) were determined by near-infrared reflectance spectroscopy (NIRS, InfraAlyzer 500 D, Bran+Luebbe, Germany) previously calibrated using official milk standards (Muelas *et al*., 2001). The pH of milk was determined using a glass electrode pH meter (691 pH meter, Methrohm, CH910 Herisau, Switzerland). Somatic cell counts (SCC) were done monthly for each goat, using a Fluoro-opto-electronic counter (Fossomatic 90. Foss Electric, Hillerød, Denmark). Gas chromatographic identification of milk fatty acids (FA) was conducted, using a 5890 Hewlett Packard gas chromatograph equipped with a split injector and flame ionization detector.

Analysis of variance and comparison between means were carried out using the GLM procedure and Tukey test (SAS, 1997).

Table 1 Feed ingredients and chemical composition of the diets

	Control	Betaine
Ingredients, g/kg		
Maize grain	250	246
Barley grain	193.2	193.2
Rye grain	100	100
Carob bean	80	80
Beet liquid molasses	30	30
Lucerne	31.9	31.9
Soyabean meal, 44%	259.2	259.2
Fat	10	10
Betaine	-	4
Salt	7	7
Dicalcium phosphate	14.4	14.4
Calcium carbonate	19.3	19.3
Vitamin /mineral mix[#]	5	5
Chemical analysis, g/kg DM		
Dry matter	893	904
Crude protein	170	180
Neutral detergent fibre	320	330
Ether extract	27	31

[#]Provided by Trouw Nutrition España S.A. to give (mg/kg or IU per kilogram of diet): Se, 40; I, 250; Co, 80; Cu, 3000; Fe, 6000; Zn, 23400; Mn, 29000; S, 60000; Mg, 60000; vitamin A, 2000000; vitamin D3, 400000; vitamin E, 2000; nicotinic acid, 10000; choline, 20300

Results and Discussion

The effect of feeding betaine on milk production performance in Murciano-Granadina goats in the fourth month is shown in Table 2. The goats that received the diet containing betaine had a higher milk yield than the goats fed the control diet (1.48 *vs*. 1.32 kg/d; $P < 0.05$), in agreement with Fernández *et al*. (2000) who detected a similar tendency ($P < 0.09$) when incorporating betaine in the diet at the level of 2 g/kg, and with Fernández *et al*. (2004) who observed a significant increase of 0.28 kg in milk production per day when including betaine at 4 g/kg in the diets of Murciano-Granadina dairy goats. Similarly, using betaine at 4 g/kg diet, Sánchez *et al*. (2001) observed an improvement in the milk production of goats that did not suffer from a subclinical intramammary infection, but no response when the goats were infected.

In the present experiment, no significant differences were found in the chemical composition of milk but percentage of fat was numerically higher for the betaine group than for the control (4.32 *vs*. 4.16%; $P > 0.05$). This is in line with the results of Fernández *et al*. (2000) who did not find significant differences in the chemical composition of milk between betaine supplemented and unsupplemented goats. However, Fernández *et al*. (2004) observed a significant response ($P < 0.05$) in the milk fat level upon supplementing betaine to goats.

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The effect of betaine on the FA profile in milk is shown in Table 2. The composition of FA in goat milk fat as related to the stage of lactation was not studied. The five most important FA's in quantitative terms ($C_{16:0}$, $C_{18:1}$, $C_{10:0}$, $C_{14:0}$, $C_{18:0}$) accounted for 77% of total FA content. Individually, the percentages of the major FA were within the range of those reported by other authors (Alonso *et al.,* 1999). Higher values ($P < 0.05$) for medium chain fatty acids in milk were found when betaine was added to the goats' diet: $C_{8:0}$, 2.67 *vs*. 2.94%; $C_{10:0}$, 9.54 *vs*. 10.17% and $C_{12:0}$, 4.66 *vs*. 4.79% for control and betaine diets, respectively. Previous results of Fernández *et al.* (2004) also showed that the concentrations of caprylic and capric acids in goat milk were higher ($P < 0.05$) when betaine was added to the diet compared to the control (3.03 *vs*. 2.8% for caprylic acid and 11.14 *vs*. 10.05% for capric acid, respectively). Under similar conditions Alonso *et al.* (1999) obtained concentrations of 2.7% and 9.9% for caprylic and capric acids, respectively.

Table 2 Effect of dietary betaine on milk yield, composition (average of 4th months) of milk and fatty acid concentrations in milk from Murciano-Granadina dairy goats

	Control	Betaine	s.e.m.
Milk yield and composition			
Milk yield, kg/d[#]	1.32[b]	1.48[a]	0.152
Fat, %	4.16	4.32	0.161
Crude protein, %	3.42	3.43	0.009
True protein, %	3.30	3.29	0.038
Whey protein, %	0.60	0.60	0.011
Caseine, %	2.67	2.68	0.051
Lactose, %	4.87	4.89	0.044
Dry matter, %	13.47	13.58	0.104
Ash, %	0.75	0.75	0.005
pH	6.7	6.7	0.003
log SCC	5.35	5.33	0.214
Fatty Acid composition, % of total methyl esters			
Saturated			
Butyric, $C_{4:0}$	1.93	2.28	0.033
Caproic, $C_{6:0}$	2.34	2.66	0.044
Caprylic, $C_{8:0}$	2.67[b]	2.94[a]	0.045
Capric, $C_{10:0}$	9.54[b]	10.17[a]	0.190
Lauric, $C_{12:0}$	4.66[b]	4.79[a]	0.182
Miristic, $C_{14:0}$	9.5	9.15	0.194
Palmitic, $C_{16:0}$	30.1	29.73	0.531
Estearic, $C_{18:0}$	5.34	5.57	0.244
Araquidonic, $C_{20:0}$	0.15	0.16	0.022
∑ saturated	66.23	67.45	0.189
Monounsaturated			
Oleic, $C_{18:1}$	22.88	22.01	0.586
Polyunsaturated			
Linoleic, $C_{18:2}$	3.74	3.56	0.157
Linolenic, $C_{18:3}$	0.09	0.08	0.090
∑ unsaturated	26.71	25.65	0.151
Unsaturated/saturated ratio	0.40	0.38	0.151
Others	7.06	6.9	0.012

[#]Different superscripts, a –b, within a row indicate differences at $P < 0.05$
s.e.m. - standard error of the mean; SCC - somatic cell count

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Conclusions

Betaine supplementation to the goat diets (4 g/kg) increased milk production and medium chain fatty acid concentrations, but physical-chemical parameters of milk were not affected. Further studies are necessary to understand the mechanism of the action of betaine on the physical-chemical characteristics of milk.

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