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Effect of forage/concentrate ratio and soybean oil supplementation on milk yield and quality from dairy goats

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RIASSUNTO – Effetto del rapporto foraggio/concentrato e dell'integrazione con olio di soia sulla produzione e sulla qualità del latte di capra. Dodici capre di razza Saanen, in un disegno sperimentale a quadrato latino 4x4 con tre repliche, sono state alimentate con quattro diete caratterizzate da due livelli di rapporto foraggio/concentrato (alto 63/37; basso 34/66), integrate o meno con olio di soia non protetto. I risultati hanno evidenziato un significativo aumento del contenuto percentuale di grasso del latte e della secrezione giornaliera di grasso in funzione del maggior contenuto di foraggio e dell'integrazione con olio di soia. Anche la produzione giornaliera di latte è stata influenzata positivamente dall'aggiunta di olio alla dieta, mentre il tempo di coagulazione è risultato significativamente inferiore nelle diete con un maggior contenuto di foraggio.

Key words: milk, goats, quality, soybean oil.

INTRODUCTION – Dietary energy level is a limiting factor of milk production mainly in early lactation goats. Energy intake may be increased by incorporation of fat in ration. Currently, rumen protected fat is mainly adopted in goats nutrition, since the several studies have clearly confirmed that supplies of protected fat markedly improved the fat percentage of goat milk (Schmidely and Sauvant, 2001; Chilliard *et al.*, 2003). Similar results were obtained by using oilseeds (Morand-Fehr *et al.*, 2000). Moreover, the supply of protected lipids is an efficient means to reduce risks of percentage inversions between milk fat and protein in the case of diet with low fibre effectiveness or fat content (Chilliard *et al.*, 2003). Little knowledge is available about the effects of dietary supplementation with unprotected oil in goat nutrition. When dairy cows are fed low forage diets added with vegetable oils (rich in polyunsaturated fatty acids) milk fat content decrease (Bauman and Griinari, 2001), on the contrary to what observed in dairy ewes (Mele *et al.*, 2002). Aim of this paper was to determine the effects of the inclusion of unprotected soybean oil in diets at two forage/concentrate ratios on yield and composition of milk from dairy goats.

MATERIAL AND METHODS – The experimental design was 4x4 Latin square with 3 replicates per diet. The animals were 12 Saanen goats in early-mid lactation (40±3 days in milking), fed 4 different diets based on grass hay and a concentrate mixture of barley meal, soybean meal, maize meal, beet pulp, minerals and vitamins. The diets were isonitrogenous (16% CP on DM) at 2 F/C ratios (high, 63/37 or low, 34/66 DM), supplemented or not with rumen unprotected soybean oil (100 g/head/d). The composition and chemical analysis of the experimental diets are reported in table 1. Milk yield and dry matter intake (DMI) from each goat were daily recorded. At the end of each experimental period the goats were weighed and individual samples of milk and blood were collected. Milk samples were analysed for fat, protein, lactose, casein content and somatic cell count.

Linear score transformation was applied to somatic cell score data in order to normalize them. Milk reological properties were determined by Formagraph apparatus (Foss Italia, Padova). Blood samples were analysed for glucose, urea and NEFA content by spectrophotometer, using specific commercial kits. Statistical analysis was performed using a linear model including the fixed effects of: diet, replicate, period within replicate and goat within replicate. Contrasts for F/C ratio and SO treatment were tested for significance.

Table 1. Composition and chemical analysis of the experimental diets (as% DM)

	Diets			
	HF/NO	HF/O	LF/NO	LF/O
Barley	14.5	14.5	21.4	21.4
Beet pulp	7.4	7.4	21.8	21.8
Hay	63	63	34.5	34.5
Maize	7.6	3.6	11.2	7.2
Soybean meal	7.5	7.5	11.1	11.1
Soybean oil	0	4	0	4
F/C ratio	63/37	63/37	34/66	34/66
CP	16.0	15.6	16.1	15.7
CF	1.5	5.5	1.3	5.2
NDF	43.1	42.5	37.7	37.2
NSC	31.5	29.1	39.0	36.4
Ashes	8.0	7.3	5.8	5.4
Net energy (MFU/kg DM)	2.0	2.1	2.3	2.4

Diets: HF/NO = high forage no oil; HF/O = high forage with oil; LF/NO = low forage no oil; LF/O = low forage with oil; MFU: milk forage units.

RESULTS AND CONCLUSIONS – Soybean oil partially replaced maize meal in fat supplemented diets, therefore no great differences in dietary net energy concentration are detectable among diets with the same forage/concentrate ratio (table 1). All diets met the goat energy requirements; in fact the mean body weights of the experimental groups did not differ. The average daily dry matter intake (DMI) did not differ among treatments and reflected the amount of feed offered, as a consequence of the negligible amounts of feed refusal by the goats (table 2). Plasma concentration of glucose, urea and NEFA were not affected by treatments and their values are similar to those reported in literature (Brown-Crowder *et al.* 2001). The inclusion of soybean oil in the diet allowed to increase milk yield and milk fat yield and content, while milk protein and casein content and milk cheese ability were not affected by oil supplementation. These results confirm previous data about the use of supplies of protected fat or oilseeds in dairy goat nutrition as reviewed by Chilliard *et al.* (2003). Similar results in terms of milk yield and composition were observed also when Sarda dairy ewes were fed diets with two levels of forage/concentrate ratio, supplemented or not with unprotected soybean oil (Mele *et al.*, 2002). In small ruminants, therefore, the interaction between low levels of dietary fibre and fat supplies rich in polyunsaturated fatty acids (PUFA) did not induce any milk fat depression as it was very clearly observed in dairy cows (Bauman and Griinari, 2001). The reasons for these differences in dairy performance response to unprotected fat supplementation between ruminant species are not yet clear. Some differences could be related to the rate of passage of digesta that is higher in goat and sheep than in cows (Chilliard *et al.*, 2003). This could affect the behaviour of ruminal biohydrogenation processes that produce fatty acids that have an inhibitor effect on mammary lipogenesis in cows (Baumgard *et al.*, 2002). Milk fat secretion and percentage resulted enhanced also when goats were fed diets with higher levels of forage. Although milk protein and casein content did not vary among treatments, milk reological parameters resulted positively related to the higher forage/concentrate ratio, as reflected by better values of milk rennetting time (table 2).

In conclusion, the inclusion of unprotected soybean oil in diet allowed to improve dairy performance of goats, regardless of the level of diet forage/concentrate, provided that the milk technological properties did not worse. Although the experiment was carried out during early-mid lactation of goats, high levels of dietary concentrate did not allow to improve milk yield and composition. Therefore, in terms of dairy performance, the inclusion of fat (unprotected or not) in the diet of dairy goats seems to be preferable to an increase of concentrate level.

Table 2. DMI, milk yield and composition from goats fed with the experimental diets.

	Diets[1]					Contrasts	
	HF/NO	HF/O	LF/NO	LF/O	SE	Oil	Forage
DMI (kg/d)	2.43	2.41	2.43	2.42	0.02		
Body weight (kg)	64.70	63.99	63.18	63.31	0.58		
Milk yield (kg/d)	2.16	2.39	2.28	2.26	0.05	**	
Fat content (%)	3.19	3.41	3.01	3.23	0.08	**	*
Fat yield (g/d)	69.04	81.39	68.68	73.05	0.03	**	*
Protein content (%)	3.33	3.30	3.25	3.22	0.13		
Casein content (%)	2.44	2.50	2.39	2.44	0.12		
Lactose content (%)	4.40	4.45	4.38	4.48	0.03		
Linear score SCC	6.36	6.47	6.35	6.55	0.23		
r (min.:sec.)	12:56	13:16	18:09	15:06	01:21		
A30 (cm)	10.48	9.42	9.77	9.19	1.25		
Glucose (mg/dl)	57.95	58.82	57.98	53.75	2.23		
Urea (mg/dl)	46.87	44.05	40.86	44.04	4.03		
NEFA (mmol/L)	0.08	0.11	0.07	0.07	0.02		

** P≤0.01; * P≤0.05.

Diets: HF/NO = high forage no oil; HF/O = high forage with oil; LF/NO = low forage no oil; LF/O = low forage with oil; DMI: dry matte intake; NEFA: non esterified fatty acids.

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