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Effects of dietary NDF concentration on milk yield and composition in dairy goats in mid-late lactation

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SUMMARY – Fourteen Sarda goats in mid-late lactation were housed in individual pens where they received a common total mixed ration (TMR) during the preliminary period (21 d). During the experimental period (24 d) the goats were divided in two isoproductive groups and fed differentiated TMR: one group received a high NDF-low no fibre carbohydrate (NFC) total mixed ration (H-NDF diet = 44.7% NDF, 29.3% NFC, DM basis), while the other received a low NDF-high NFC total mixed ration (L-NDF diet = 36.9% NDF, 36.0% NFC, DM basis). These differences were achieved substituting ground corn and barley grains with beet pulp shreds and soybean hulls. Both diets contained 50% of dehydrated chopped alfalfa on a DM basis. Soybean meal completed the diets. Dry matter intake was higher in the H-NDF group, while dietary energy intake and body weight variations did not differ significantly between the two groups. Milk yield was significantly higher in the L-NDF group, while milk protein and milk urea were higher in the H-NDF group. Milk fat concentration and somatic cell count did not differ between groups, while milk fat and milk protein yields were higher in the L-NDF group. These results are in clear contrast to what was previously observed in sheep, fed diets similar to the ones used here, in which H-NDF diets induced higher milk yield than L-NDF ones.

Keywords: Fibre, diet composition, goat, milk.

***RESUME –** "Effets du contenu en NDF de l'alimentation sur le rendement et la composition laitières des chèvres en phase descendante de lactation". Quatorze chèvres de race Sarde, en phase descendante de lactation, ont été alimentées individuellement avec une même ration mixte pendant toute la période préliminaire (21 jours). Pendant la période expérimentale (24 jours), les chèvres ont été divisées en deux lots de 7, ayant la même production de lait, et ont reçu différentes rations mixtes. Un lot a reçu une ration mixte à NDF (fibre neutro-détergente) élevé et faible en glucides non pariétaux (GLU) (H-NDF ration = 44,7% NDF, 29,3% GLU, sur la matière sèche), tandis que l'autre lot a reçu une ration mixte à NDF faible et GLU élevé (L-NDF ration = 36,9% NDF, 36,0% GLU, sur la matière sèche). Les différences ont été réalisées en substituant maïs et orge par pulpe de betteraves et cosses de soja. Les deux rations contenaient aussi de la luzerne déshydratée et des tourteaux de soja. L'ingestion alimentaire a été plus haute dans le groupe H-NDF, alors que l'énergie ingérée et les variations de poids corporel ne différaient pas de manière significative entre les deux lots. La production de lait a été significativement supérieure dans le groupe L-NDF, alors que la protéine et l'urée du lait étaient supérieures dans le groupe H-NDF. La concentration en matière grasse du lait et la concentration en cellules somatiques n'ont pas différé entre les groupes, alors que les rendements laitières et en matière graisse ont été supérieurs dans le groupe L-NDF. Ces résultats contrastent clairement avec les résultats moyens obtenus chez des brebis qui ont été alimentées avec des rations semblables à celles employées ici, tandis que les brebis qui étaient alimentées avec les rations H-NDF ont produit plus de lait que les autres.*

***Mots-clés :** Parois cellulaires, alimentation, chèvre, lait.*

Introduction

During the first part of lactation, energy-rich diets, i.e. high in non-fibre carbohydrates (NFC = sugars + starch + pectins) and low in NDF (neutro-detergent fibre), provide the readily fermentable carbohydrates and energy necessary to reduce the negative energy balance and to stimulate milk yield of ruminants. Diets with the same characteristics fed to dairy sheep in mid-late lactation decreased or did not improve milk yield, while it stimulated fattening (Molle *et al*., 1997; Bocquier *et al*., 2002; Bomboi *et al*., 2002). In goats, similar diets increased milk yield in some experiments (Rapetti *et al*., 1997), while in others they did not affect it (Kawas *et al.,* 1991) or gave variable results (Goetsch *et al*., 2001). Both in sheep and goats high NDF-low NFC diets containing large proportions of forages usually do not improve milk production because they decrease feed intake and digestibility compared to richer diets. However, in some experiments on sheep in mid-late lactation, high NDF-low

NFC diets allowed higher milk yield and favoured less body fat deposition compared to low NDF-high NFC diets (Cavani *et al.,* 1990; Cannas *et al*., 1998; Cannas *et al*., 2003; Bovera *et al*., 2003; Boe *et al*., 2004; Cannas *et al*., 2004a). In all these experiments, the increase in NDF in the diets was achieved using highly digestible fibre sources (mostly soybean hulls and beet pulps) with small particle size. Both factors favoured DMI (dry matter intake), which was higher for high NDF than for high NFC diets, while daily energy intake was similar between treatments.

Based on these previous results, an experiment was carried out to test if the responses of dairy goats in mid-late lactation to diets rich in highly digestible fibre were similar to those already observed in sheep.

Materials and methods

The effects of dietary NDF and NFC on milk production were studied in fourteen Sarda goats (mean milk yield 1336±242 g/d) in the 5th month of lactation (i.e. mid-late lactation). Goats were kept in individual pens and fed *ad libitum* during the preliminary (21 d) and the experimental (24 d, from the 29th of April to the 22nd of May 2004) periods. During the latter, one group was fed a high NDF-low NFC total mixed ration diet (H-NDF diet = 44.7% NDF, 29.3% NFC, DM basis), while the other received a low NDF-high NFC total mixed ration diet (L-NDF diet = 36.9% NDF, 36.0% NFC, DM basis) (Table 1). Diets were very similar to those that caused higher milk yield in high-NDF compared to low-NDF diets in sheep in mid-late lactation (Boe *et al*., 2004; Cannas *et al*., 2004a).

Table 1. Preliminary and experimental diets. All values are expressed as % of DM, except for NEL (net energy for lactation), which is in Mcal/kg DM

Composition	Preliminary diet	H–NDF	L-NDF
Ingredients			
Dehydrated chopped alfalfa	50.1	49.9	50.6
Soybean meal	6.9	6.9	8.0
Soybean hulls	16.0	10.0	-
Beet pulp shreds	7.1	23.3	9.1
Ground corn	9.9	-	16.2
Ground barley	10.0	9.9	16.1
Chemical composition			
CP	17.5	18.3	18.2
NDF	45.0	44.7	36.9
Ash	6.6	7.7	7.4
NFC*	30.4	29.3	36.0
NEL**	1.516	1.496	1.547

*NFC = 100 - NDF_{CPfree} - CP - ash - fat.
**As estimated by the Sheep CNCPS (Cannas *et al*., 2004b).

Both diets included 50% of DM of dehydrated chopped alfalfa. The remaining part was composed mostly of soybean hulls and beet pulp shreds (H-NDF diet) or cereal grains (L-NDF diet). Soybean meal was used to make the diets isoproteic (Table 1). Milk yield was measured daily (Fig. 1). However, only the yields recorded on the milk composition sampling days were used in the statistical analysis. Milk composition, DMI and orts were measured in the last day of the preliminary period and in the days 8, 14 and 21 of the experimental period. TMR and orts were also sampled for chemical analysis. Crude protein was measured with the Kjieldhal method, while NDF was based on Van Soest *et al.* (1991). Statistical analysis was based on ANCOVA in which diet and time were considered as factors and the covariates were the preliminary values for each variable tested. Somatic cell count values were transformed with logarithms prior statistical analysis.

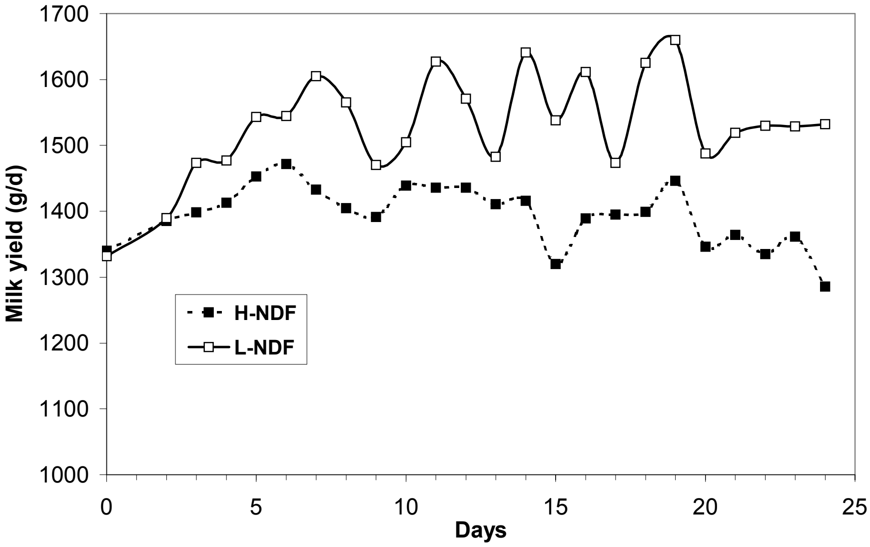

Fig. 1. Actual daily milk yield of mid-late lactation goats during the experimental period. Day 0 represents the milk yield in the last day of the preliminary period (28th of April 2004).

Results and discussion

Diet selection was very limited, probably because of the small particle size of the diets. For this reason, only the values of the supplied diets are given. DMI was high in both groups, due to the high quality of the dehydrated chopped alfalfa and the small particle size of all fibrous ingredients (Table 2). Covariated DMI was higher (P = 0.053) for the H-NDF group while energy intake did not differ significantly between the two groups (Table 2), as already observed in similar experiments on sheep fed diets of small particle size (Cannas *et al*., 1998; Cannas *et al*., 2003; Boe *et al*. 2004; Cannas *et al*., 2004a). BW (body weight) variations did not differ significantly between the two groups (Table 2). In the first part of the experimental period milk yield increased in both groups compared to the preliminary period, probably for an improvement of meteorological conditions, which in the preliminary period were characterized by temperatures much lower than the seasonal average. Milk yield was significantly higher in the L-NDF than in the H-NDF group (Table 2). However, the more regular production pattern of the H-NDF groups (Fig. 1) suggests that they had a more regular rumen function than that of the L-NDF group. Milk fat concentration did not differ between the two groups, despite the higher milk yield of the L-NDF group; as a result, milk fat yield was higher (P<0.001) for the L-NDF than for the H-NDF group. Milk protein concentration was higher (P<0.005) for the least productive group (H-NDF), probably as a result of the concentration effect; indeed, milk protein yield was higher for the most productive group (L-NDF) (Table 2). Milk urea was significantly higher in the H-NDF than in the L-NDF group (P = 0.012; Table 2). However, in biological terms the difference was small and not important, probably reflecting small differences in dietary protein concentration and intake, as suggested for sheep by Cannas *et al*. (1998), or in the synchronization between carbohydrate and protein degradation rates. Somatic cell count was always low and not different between treatments (Table 2).

The herein reported effects of digestible fibre on the milk yield of goats are in clear contrast to what previously observed in sheep in mid-late lactation (Cannas *et al*., 2002). In fact, in several experiments, diets rich in digestible fibre of small particle size have increased milk yield of dairy ewes compared to diets rich in starchy concentrates (Cavani *et al*., 1990; Cannas *et al*., 1998; Cannas *et al*., 2003; Bovera *et al.,* 2003; Boe *et al*. 2004; Cannas *et al*., 2004a). In particular, the diets used here were very similar to those diets rich of digestible fibre that induced higher milk yield in sheep in previous trials (Boe *et al*. 2004; Cannas *et al*., 2004a).

The observed differences between the sheep and goats might be due to differences in the concentrations of hormones (e.g. GH and insulin) that regulate energy partitioning in mid-late lactation or in their acetate requirements, because of the different fat to lactose ratio typically observed in milk of the two species (Cannas *et al*., 2002).

Table 2. Effect of treatments on intake and performances goats in mid-late lactation. Covariated adjusted means

Composition	Preliminary period	Experimental period		
		H–NDF	L-NDF	P <
DMI (g/d)	1656	1990	1840	0.053
NEL intake (Mcal/d)	2.510	2.978	2.854	NS
BW (kg)	40.0	42.3	43.1	NS
Milk yield (g/d)	1336	1384	1612	0.001
Fat (%)	4.09	4.09	4.08	NS
Fat yield (g/d)	54.8	57.6	65.3	0.001
Protein (%)	4.43	4.30	4.20	0.005
Protein yield (g/d)	59.1	59.5	67.4	0.001
Urea (mg/dl)	46.4	49.8	46.6	0.012
SCC (number/ml x1000)	296	54	64	NS

SCC = somatic cell count. Values back transformed from the logarithmic transformation used for the statistical analysis.

Conclusions

The substitution of corn grain with beet pulps in total mixed rations caused a reduction in milk yield of goats in mid-lactation. This is in contrast with what reported in the literature for lactating ewes, which produced more milk when fed diets rich in digestible fibre compared to diets rich in starch. The reasons for such differences are not clear, but they might be related to differences in the hormonal control of dietary energy partitioning or in acetate requirements between sheep and goats. Specific comparative studies are required to elucidate these effects.

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