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SUMMARY – The objective of this study was to compare the effect of mode of administration of ration, as total mixed rations (TMR) or conventional rations (CR), on the digestibility, nitrogen balance, purine derivatives (PD) excretion and the yield of microbial nitrogen. Four castrated-male adult goats of Murciano-Granadina breed were used in each test. The ratio alfalfa:concentrate was 50:50, and the composition of DM intake was 89.6% and 89.9% of OM; 15.0% and 15.7% of CP; and 39.0% and 36.3% of NDF for TMR and CR, respectively. The digestibility of the OM was higher (P<0.01) for CR than TMR, which was not reflected in the intake of DOM (P>0.05). No differences were found for N balance and yield of microbial nitrogen (P>0.05). We can conclude that the use of TMR or CR in goats, does not affect the intake of DOM, N balance, PD excretion and microbial N yield.

Keywords: Purine derivatives, total mixed rations, digestibility, microbial nitrogen, goats.

RESUME – *"Digestibilité, bilan azoté, dérivés des purines et rendement en azote microbien chez les caprins de race Murciano-Granadina alimentées avec des régimes totaux mélangés et des rations conventionnelles". Deux techniques d'administration de la ration, TMR (rations totalement mélangées) et CR (rations conventionnelles), ont été comparées sur la base de la digestibilité* in vivo*, le bilan azoté, les dérivés de purins (PD) dans l'urine, et le rendement en azote microbien. Quatre caprins mâles adultes castrés de race Murciano-Granadina ont été utilisés dans chaque test. Le rapport luzerne:concentré était de 50:50, et la composition de la MS consommée avait 89,6% et 89,9 % de MO, 15% et 15,7% de PB, 39% et 36,9% de FND, pour TMR et CR respectivement. La digestibilité de MO était supérieure (P<0,01) pour CR par rapport à TMR, ce qui n'a pas été observé dans la consommation de MOD (P>0,05). Le bilan azoté, l'excrétion urinaire de PD, et le rendement en azote microbien étaient similaires entre les deux techniques de rationnement (P>0,05). Il ressort de cette étude que l'usage de TMR ou CR chez le caprin n'affecte pas la consommation de MOD, le bilan d'azote, les PD dans l'urine et le rendement en azote microbien.*

Mots-clés : *Dérivés de purins, rations mélangées totales, digestibilité, azote microbien, caprin.*

Introduction

The traditional intensive goat feeding systems for milk production consist of supplying in a separated form the concentrate and the forage. An excessive grain consumption can cause alterations in ruminal pH, with negative effects on the development of ruminal microorganisms, limiting the use of feeds, and causing the digestive problems (Abijaoudé *et al.*, 2000).

The total mixed rations (TMR) consist in the use of a forage and concentrate mixture of balanced form, avoiding selection and high consumption of concentrate, which can also prevent metabolic problems. In addition, the substrate provided to the ruminal microorganisms is more constant, and the nitrogen and the carbohydrates supplied have better synchronization, therefore it can have a greater synthesis of microbial protein (Colin-Schoellen *et al.*, 2000).

On the other hand, the mechanized process used in TMR systems help reducing the use of manual labour and distribution time of the ration, and make the utilization of agricultural by-products possible. The traditional problem is an increase of the costs. However, in arid zones (South of Spain) the intensive farm of dairy goats has increased but availability of the forages is limited and they are as expensive as concentrates. For this reason, the new farmers prefer the use of the TMR system for dairy goats (Sánchez *et al.,* 2000). The cost of TMR for dairy goats in September 2003 was 0.20 Euro/kg, the cost of alfalfa hay was 0.16 euro/kg and that of concentrates was 0.24 (Nanta™ Spain, Animal Feed Company unpublished data). If the farmer's labour cost is added, the TMR system is not more expensive than the conventional rations (CR).

Most of the studies on TMR have been made in cows, indicating higher consumption and better production and milk quality (Mc Cullogh, 1991). In goats fed with these rations, the studies have focused on analysing the effects on milk production (Maltz *et al*., 1991; Sánchez *et al*., 2000), the characteristics that the rations must have (Hervieu and Morand-Fehr, 1994), and their effects on the goats' food selection (Fedele *et al*., 2002; Goetsch *et al*., 2003). The objective of this study was to know the effect of the use of TMR in comparison with the use of CR, on the digestibility of the nutrients, nitrogen balance and the urinary excretion of purine derivatives, associated with the microbial nitrogen yield in goats.

Materials and methods

Two trials were conducted to determine the digestibility of TMR and CR. For each type of diet (Table 1), 4 castrated-male adult Murciano-Granadina goats were used in a cross-over design and kept in metabolic cages. Rations were offered in restricted form (40g/kg $BW^{0.75}$, Van Es and Van Der Meer, 1980) in order to avoid qualitative and quantitative differences in nutrient intake. The animals had free access to drinking water. The duration of the experimental period was 21 days, the first 14 days enabled animals to adapt to the experimental diets, followed by a 7-day period of faeces collection. Total daily faeces were collected and weighed individually. A sample was taken and dried in a forced-dry oven at 60°C for 48 h. During 5 days, urine excretion was collected daily in 100 ml 10% sulphuric acid. Daily urine production per animal and day was measured, and samples (25 ml) were frozen immediately at -20°C until analysis.

Table 1. Composition of the experimental diets (%)

Ingredients	TMR	CR
Corn	9.66	10.164
Alfalfa pellets	19.32	20.32
DDGs[†]	4.83	5.08
Energetic complement[††]	11.69	12.30
Cane molasses	2.02	2.12
Alfalfa hay	52.46	50.00
Total	100.00	100.00

[†]DDGs: Dry destiller grains.
[††]Energetic Complement NANTA®: Corn, wheat and barley pellets, by pass fat, gluten feed, cassava, alfalfa and minerals and vitamins (CP 13%, 1.02 UFL /kg of DM).

The samples of feed and faeces were ground to pass through a 1 mm mesh and analysed for DM, ash and CP according to AOAC (1984) and also cell components according to Van Soest *et al.* (1991). An adaptation of the method proposed by Terzuli *et al.* (1999) was used for purine derivatives (PD) determination in urine. They were analysed by HPLC using a Komptron pump (model 422), with a UV detector model 430, and an auto sampler model 465 and also a Komptron data systems 450-th integrator. The separation was made using a Kromasil 100 C-18 column (I.D. of 250 x 4 mm) without precolumn. Methanol (A) and 0.1 M phosphate dihydrogen potassium solution to a pH of 5.5 (B) were used for the mobile phase. The mobile phase was run to the following gradients: B: 98% at 0-10 min; 85% at 10-20 min; 75% at 20-30 min; and 98% at 30-35 min. The mobile phase was monitored at 220 nm.

Microbial nitrogen yield was calculated according to Chen and Gomes (1992) in sheep as recommended by Stangassinnger *et al.* (1995) for goats. Analyses of variance were performed following the procedures described by Steel and Torrie (1980).

Results and discussion

The composition of the rations offered and consumed (Table 2) were similar for TMR and CR, which indicated that selection of the food did not exist. The goat is a very selective animal (Goetsch *et al*., 2003; Fedele *et al*., 2002), and selectivity is more likely to occur if it is encouraged by the form of presentation or if the intake is *ad libitum*. Rubert-Aleman *et al*. (2000) and Maltz *et al*. (1991), using TMR at free access with a 78 to 89% of DM, observed high selection of the food, the food refused had a greater amount of small particles. Hervieu and Morand-Fehr (1994) recommended that the TMR must have a DM content between 45 and 65% to obtain a suitable homogeneity to avoid selectivity and obtain the best mix.

Table 2. Chemical composition of the rations

Nutrient	Total mixed ration (TMR)		Conventional ration (CR)	
	Offered	Consumed	Offered	Consumed
DM	93.90	94.16	92.46	90.59
Composition (% DM)				
OM	89.73	89.66	90.06	89.91
CP	15.18	15.05	16.58	15.75
NDF	38.76	39.06	36.27	36.29
ADF	17.62	17.69	17.70	17.71

The DM was 90%, which could affect the homogeneity of the ration, and allow the separating of the food particles and selection of the food. However, this was not reflected, because the rations were offered in restricted form (40 g DM/kgBW$^{0.75}$ and day).

The NDF content in the TMR and CR were 38.76% and 36.27%, respectively, from which, between 59% and 56% came from the forage that is superior to the minimum recommended from 40% to 50% of the NDF of forages (Hervieu and Morand-Fehr, 1994; Goetsch *et al*., 2003).

The digestibility of the OM was higher ($P<0.01$) for CR than TMR, which was not reflected in the intake of DOM ($P>0.05$) (Table 3). The effective digestibility of foods in ruminants depends on the amount of soluble material, indigestible material and potentially digestible material content, as well as the rate of passage and digestion of them in the rumen (Van Soest, 1982). Although, the experimental rations were similar in ingredients, the form of presentation could be an important factor in the degree of utilization. In this case, it is possible that the grains of the CR were fermented more quickly than when they were mixed with the forage. Other studies, in goats have obtained similar results with TMR of alfalfa and concentrates (Moumen *et al*., 2000; Yañez *et al*., 2000).

For the diets of our study, nitrogen intake was similar to nitrogen urine plus nitrogen faeces, determining that N balance was close to zero in both cases, and no differences were found for N balance ($P>0.05$) between TMR and CR.

The excretion of PD in urine has been proposed as a good estimator of the synthesis of microbial protein in the rumen. The excretion of PD has been used to predict the amount of absorbed puric bases in the small intestine, which is related to the synthesis of microbial protein (Balcells *et al*., 1991; Chen and Gomes, 1992). In the present study the excretion of PD (13.00 *versus* 12.61 mmol/day) and the microbial N production (11.2 *versus* 10.84 g/day) were not different ($P>0.05$) between TMR and CR rations. These values were similar to those obtained in sheep by other authors (White *et al*., 2002; Yu *et al*., 2002).

Table 3. Digestibility, intake, N balance, urinary excretion of purine derivatives and microbial protein production of TMR and CR

	Total mixed ration	Conventional ration	SEM	Significance level
OM digestibility (%)	66.17±1.05	70.69±0.81	1.0	**
DOM intake (g/day)	278.99±29.14	296.17±23.86	17.57	NS
N balance (g/day)	-1.00±0.457	-0.97±1.05	0.58	NS
PD excretion (mmol/day)	13.00±1.61	12.61±1.06	0.86	NS
Microbial N (g/day)	11.20±1.41	10.84±0.90	0.75	NS

NS: P>0.05; **: P<0.01.

Conclusions

It can be concluded that the use of TMR or CR in goats does not affect the intake of DOM, N balance, PD excretion and microbial N yield.

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