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Use of a Total Mixed Ration with Three Sources of Protein as an Alternative Feeding for Dairy Goats on Southeast of Spain

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Abstract: Voluntary intake, apparent total tract digestibility milk yield and composition was determined in a total mixed ration offered with three different sources of protein; soybean meal, sunflower meal and fish meal. Eighteen Murciano-Grenadine goats at third lactation (4 month) were used in individual metabolic cages during a period of 30 days. Although no significant differences were found for milk yield, somatic cell count, composition and energy and nitrogen balance among the three sources of protein, greater digestibility was found for fiber fractions and protein in the total mixed ration, which sunflower meal was the source of protein ($P < 0.05$). According to the results obtained at the present study, we observed the same efficiency when sunflower or soybean meal were used as a main sources of vegetable protein on the total mixed ration on dairy goats.

Key words: Intake, digestibility, milk performance, goats

Introduction

The Murciano-Grenadine goat is well adapted to the hot and dry conditions of the semiarid areas of the Southeast of Spain. At the same time, the social interest of the goat livestock increases, being located the same in zones where other productions could not be. In addiction, we must take into account the deep rooted tradition of the goat sector in the Murcia Region (Southeast of Spain) which have given the region one of the native breed of bigger protection and interest at national and international level (Falagán *et al*., 1995). The Murciano-Grenadine goat breed is well adapted to semiarid conditions with low rainfall and high temperatures (Molina Alcaide *et al*., 1997). In the Murcia region the average of minimum temperatures in the last 10 years was 14 °C and the average of the maximum temperatures was 25 °C.

In the last few years, the need to change from traditional extensive goat rearing to an intensive system has increased in semiarid Spanish lands as in other Mediterranean areas in order to increase productivity. Range goats are free to choose their diets, and in semiarid areas goats rely on browse most of the year, and when there are scarce or large variations in diets, lower milk performance may occur (Landau *et al*., 2000). The nature and availability of vegetation of semiarid Spanish lands may limit the animal productivity. Intensive system provides a more abundant and constant availability of forages, by-product and concentrates during the year, joined to a more efficient farm management. Given their selective abilities, goats adapted to intensive system would select the most nutritious mixture of feeds. It is clear that the demand for nutrients is affected by the physiological status of goats. Periods of high requirements, like lactation, needs more density of nutrients to reach optimal performance. The use of total mixed ration (TMR) may reduce this problem and moreover, concentrates are diluted with forage and over consumption of concentrates may be avoided. For this purpose use of a TMR, already widely used in cattle feeding, could be considered in order to enhance productivity of dairy goat by improving consistency of the selected diet nutrient content.

The TMR system involves the feeding of an intimate mixture of dietary ingredients on an *ad libitum* basis (Owen and Miller, 1971). This could increase the possibility of meeting nutritional requirements, facilitate management, allow full mechanization and, taking into account that goat are selective feeders, more flexibility for inclusion of a wide range of alternative feeds (Coppock *et al*., 1981; Owen, 1984).

In this trial a TMR was formulated and three sources of protein were tested. As protein source we use soybean meal from EEUU origin, sunflower meal from Spanish production, and fish meal from Spanish market. And the main objective was to asses the dairy goats performance; voluntary intake, apparent total tract digestibility, energy and nitrogen balance, milk yield and composition.

Material and Methods

Animals and Diets: The experiment was carried out with

18 healthy goats of Murciano-Grenadine breed, mid (4th month) through third lactation, with similar live weight (38.4 ± 0.3 kg), same number of births, similar previous milk production (561.53 ± 24.75 kg milk/210 days of lactation, as average) and similar recording of somatic cell count (SCC); geometric mean of 220 x 10^3 cell/mL as average. Goats were allocated at the Experimental Farm "Cabras de Murcia", Cobatillas (Murcia).

The TMR was formulated and distributed by NANTA S.A. (a Nutreco Company). Ingredients and chemical composition are showed on Table 1. Balance of the diet was obtained using the recommended values of INRA (1988) and AFRC (1993) for energy, protein, fiber, calcium, phosphorus, sodium and chloride. The diet was supplemented with a vitamin-mineral premix (5 g/kg) provided by Trouw Nutrition S.A. The present TMR are used by farmers under practical conditions but had never been evaluated.

Energy and nitrogen (N) balance was estimated on the 18 goats for 10 consecutive days simultaneously to digestibility. The time for the first energy and nitrogen balance period was selected to ensure that the rumen was totally adapted to experimental diets. During these periods, representative samples of diets were collected every 2 days, and representative samples of feces, and urine, were collected daily. Goats were ureter probed in order to collect all urine produced. The samples were frozen and pooled at the end of the period for analysis. Milk was collected daily and its energy and protein content were calculated as described below.

All goats were housed in a building in which the environment was partially controlled (temperature varied between 16 and 20 °C). Throughout the trial, the goats were handled according to the principles for the care of animals in experimentation published by NRC (1998).

Experimental Procedure: Goats were fed with three TMR at a level of feed offered of 3 kg / d. The number of goats per each TMR were six and refusal were reordered every day. Therefore, 18 Murciano-Grenadine goats were used to determine the apparent total tract digestibility of DM, OM, energy, fiber (CF, NDF and ADF), CP, ash and ether extract of the mixed diet. Goats were housed in individual metabolism cages that allowed separation of feces and urine. After 20 d adaptation period, feed intake (ad libitum access), refusal and total fecal output were recorded for each goat over a 10 d period (experimental period). Besides, body weight was recorded with an electronic scale (Grupanor-Cercampo) at the beginning and the end of experimental period.

Goats were fed twice a day; 9:00 (after milking) and 15:00h with a half quantity each time. Goats were milked out once a day and milk production of each goat was recorded daily at each milking during each digestibility period (portable milking machine, Flaco-J. Delgado) and water was free available all the time.

Measurements and Analyses: Samples of the TMR offered were collected to determine the composition. Aliquots of fecal and urine samples taken during the digestion trial were frozen at –20 °C until analysis. Samples of milk with azidiol (400 µL/100 mL) preservative were analyzed.

Chemical analyses of the diet and feces were conducted according to methods of AOAC (1995) for dry matter (DM), ash, crude fiber (CF) and crude protein (CP; Kjeldahl nitrogen from diet, feces and urine were converted to CP by multiplying N by a factor of 6.25). DM of the TMR was determined by oven-drying at 102 ± 2 °C for 24 h. Feces and urine were dried by lyophilization. The method of Van Soest *et al.* (1991) were used to determining acid detergent fiber (ADF) and those of Robertson and Van Soest (1981) for determining neutral detergent fiber (NDF). Different fiber fractions were determined by a Dosifiber, Selecta. Gross energy (GE) was determined using an adiabatic bomb calorimeter (Gallenkamp – CBA – 305). Ether extract (EE) was measured after acid hydrolysis (AOAC, 1995) to recover saponified fat with a DET-GRAS, Selecta equipment, by extraction with diethyl ether.

The dry matter and N contents of the milk samples, as well as milk fat, were analyzed in fresh samples. All other analyses (lactose, ash and energy) were performed on dried samples. The N content of milk was measured using the Kjeldahl method (FIL, 1993) with a Kjeltec 2300 analyzer unit (Fosstecator). The results were converted to CP by multiplying N by a factor of 6.38 for milk (Ribadeau Dumas and Grappin, 1989). The fat content of the milk was measured by the Gerber method (FIL, 1981) with a DET-GRAS, Selecta equipment. Milk lactose was calculated by the official method of chloramine T (FIL, 1974). Gross energy of milk was determined using an adiabatic bomb calorimeter (Gallenkamp – CBA – 305).

SCC was determined in each goat at the beginning of the adaptation period. Later, was determined again at the beginning and the end of the experimental trial. Analyses was for SCC by staining milk cells with ethidium bromide (Fossomatic-90).

The ash content of diet, feces, and milk was determined by incineration in an electric muffle furnace at 550 °C.

Statistical Analysis: The effect of different sources of protein incorporate to the TMR offered to goats on intake, digestibility and milk performance were analyzed using the GLM procedure of SAS (1997). The individual goat was the experimental unit and the experimental design was a protein source as fixed effect. Variance analysis and means comparison were carried out using the GLM procedure and Least Square Mean, respectively.

Results and Discussion

Dry Matter Intake: Intake data of the 3 total mixed rations

Table 1: Ingredient and chemical composition of the Total Mixed Ration based on different source of protein

Ingredient, g/kg	Soybean meal	Sunflower	Fish meal
barley	90	90	90
corn	150	150	170
alfalfa hay	330	310	330
dehydrated beet pulp (pellets)	215	175	215
beet molasses	80	80	80
cotton seed	70	90	80
soybean meal	46	60	10
sunflower 30 (pellets)		90	
fish meal 63			30
premix[a]	5	5	5
Dry Matter (DM), g/kg	902.53	921.12	911.18
Organic Matter, g/kg of DM	913.54	926.27	923.52
Ash, g/kg of DM	86.46	73.73	76.48
Crude Protein, g/kg of DM	157.53	163.64	150.39
Ether extract, g/kg of DM	42.66	45.97	63.68
Crude Fiber, g/kg of DM	156.6	163.91	136.54
Neutral Detergent Fiber, g/kg of DM	305.58	331.06	318.69
Acid Detergent Fiber, g/kg of DM	151.68	181.87	178.84
Gross Energy, MJ/kg of DM	17.18	18.26	18.16

[a] Provided by Trouw Nutrition España S.A. to give (ppm or UI per kilogram of diet) : Se. 30 ; I. 240 ; Co. 190 ; Cu. 1100; Fe. 4200 ; Zn. 27000 ; Mn. 13000 ; S. 69000 ; Mg. 45000 ; vitamin A. 1000000 UI ; vitamin D_3. 280000 ; vitamin E. 2000 ppm.

Table 2: Voluntary intake and apparent digestibility for goats fed with Total Mixed Ration with three different protein sources

	Soybean meal	Sunflower meal	Fish meal	SEM*	P**
Voluntary intake, g/d	1699.5	2036.2	2026.9	0.113	NS
Refusals, %	43.35	32.13	32.44	3.767	NS
Dry Matter Intake, g/d	1533.9[b]	1875.6[a]	1846.9[a]	0.103	NS
Average live weight, kg	38.13	38.68	34.63	1.376	NS
Dry Matter Intake, g/kg $BW^{0.75}$ d	101.70[b]	122.11[ab]	129.05[a]	6.145	0.0463
Digestibility, % of DM					
Dry Matter	71.56	70.64	69.61	0.957	NS
Ash	47.13	43.97	50.97	2.387	NS
Organic Matter	73.87	72.77	71.15	0.898	NS
Crude Fiber	30.10[b]	48.51[a]	29.76[b]	2.860	0.0054
Neutral Detergent Fiber	50.42[ab]	56.29[a]	46.23[b]	1.594	0.0121
Acid Detergent Fiber	25.47[b]	45.11[a]	26.92[b]	2.799	0.0044
Fat	68.57	69.42	73.16	1.749	NS
Crude Protein	71.87[b]	78.59[a]	73.88[ab]	1.839	0.0414
Energy	71.07	70.89	69.41	2.750	NS

*SEM = Standard Error of the Mean, **P = Probability; NS = not significant (Pr>0.1), [a,b,c] Means within a row with different superscript are significantly different

are showed in Table 2. The amount of food offered was of 3 kg/d and not significant differences were observed among diets with a mean voluntary intake of 1.92 kg/d. When intake was expressed on DM bases (DMI) an average intake of 1.75 kg DM/d with no significant differences was found. Lower value (1.45 kg DM/d) was obtained by Aguilera *et al.* (1990) in lactating Grenadine goats at mid first through second lactation, and the experimental diet was a traditional diet made by alfalfa hay and barley. The value obtained at the present work (1.75 kg DMI/d, as average of 3 TMR) is different that the value of DMI estimated when the equation of INRA (1988) was used to predict DMI in our experiment (1.29 kg DMI/d). This equation is based in typical French diets, based on maize silage and alfalfa hay with some concentrate supplement, and mature live weight is lower in Murciano-Grenadine goat than Alpine or Saanen goats. Morand-Ferh *et al.* (1987) stressed that the UEL

Table 3: Milk yield and milk composition for goats fed with Total Mixed Ration with three different protein sources

	Soybean meal	Sunflower meal	Fish meal	SEM*	P**
Milk yield, kg/d	1.84	2.14	2.23	0.204	NS
Milk composition, %					
Dry matter	14.25	13.54	13.87	0.367	NS
Ash	0.76[a]	0.76[a]	0.73[b]	0.003	0.0009
Fat	5.12	4.94	5.17	0.271	NS
Lactose	5.25	5.07	5.30	0.106	NS
Crude protein	3.78	3.38	3.31	0.241	NS
True protein	3.49	3.17	3.14	0.218	NS
Casein	2.87	2.68	2.62	0.136	NS
Whey protein	0.56	0.68	0.49	0.160	NS
Energy, MJ/kg	4.73	5.75	5.68	0.119	NS
pH	6.70	6.71	6.70	0.012	NS
Dornic Acid	13.87	13.57	12.86	0.447	NS
SCC, log	5.18	5.32	5.53	0.240	NS

*SEM = Standard Error of the Mean, **P = Probability; NS = not significant (Pr>0.1), [a,b,c] Means within a row with different superscript are significantly different

Table 4: Energy (E) and nitrogen (N) balance for lactating goats fed with Total Mixed Ration with three different protein sources

	Soybean meal	Sunflower meal	Fish meal	SEM*	P**
Dry Matter intake, g/kg $BW^{0.75}$ d	101.70	122.11	129.05	8.033	NS
Gross E intake, kJ/kg $BW^{0.75}$ d	1747.2[c]	2217.2[ab]	2355.9[a]	141.375	0.0928
Digestible E intake, kJ/kg $BW^{0.75}$ d	1243.70	1572.60	1637.30	110.740	0.0332
Metabolizable E intake, kJ/kg $BW^{0.75}$ d[1]	1069.60	1352.40	1408.00	95.237	0.0698
Metabolizable E Production, kJ/kg $BW^{0.75}$ d[2]	668.60	951.40	1007.00	95.237	0.0698
Milk E, kJ/kg $BW^{0.75}$ d	308.54	370.67	397.91	37.567	0.0698
DE intake / GE intake, %	71.07	70.89	69.41	0.965	NS
Milk E / DE intake, %	24.33	23.98	24.30	2.159	NS
Milk E / ME intake, %	28.29	27.88	28.26	2.511	NS
Milk E / ME Production, %	46.37	40.23	39.69	3.904	NS
N intake, g/kg $BW^{0.75}$ d	2.55	3.18	3.10	0.203	NS
Fecal N, g/kg $BW^{0.75}$ d	0.71	0.68	0.80	0.097	NS
Urinary N, g/kg $BW^{0.75}$ d	0.58	0.78	0.84	0.108	0.0594
Milk N, g/kg $BW^{0.75}$ d	0.70	0.73	0.81	0.070	NS
Retained N, g/kg $BW^{0.75}$ d	0.56	0.99	0.65	0.159	NS
Milk N / N intake, %	27.45[a]	22.96[b]	26.13[a]	4.995	0.0495
Retained N / N intake, %	21.96	31.13	20.97	5.830	NS

*SEM = Standard Error of the Mean, **P = Probability; NS = not significant (Pr>0.1), [a,b,c] Means within a row with different superscript are significantly different, [1]Metabolizable E intake: calculated assuming ME/DE=0.86 (Aguilera et al., 1990), [2]Metabolizable E Production: calculated as ME intake-ME for maintenance (ME_m), where ME_m=401 kJ/$kg^{0.75}$ per d (Aguilera *et al.*, 1990)

system (Fill Unit for Milk) should be applied to goats with extreme caution. Therefore, application of French standards to Spanish dairy goats would also depend on assuming that both Spanish diet system and goats have similar fill values and intake capacities, respectively, to French ones. Climate conditions and semiarid areas environment will affect dry matter intake (DMI), so, corroboration of the INRA (1988) standards under Spanish conditions and with more typical Spanish feeds needs to be undertaken.

When DMI was expressed by gram per metabolic body weight, significant differences ($P < 0.05$) was observed and lower intake was found by soybean diet (101.7 g/$kg^{0.75}$), followed by sunflower (122.1 g/$kg^{0.75}$) and fish (129.1 g/$kg^{0.75}$). Literature from both developed regions (Morand-Ferh and Sauvant, 1988) and developing ones (Kearl, 1982) were reviewed, and a mean DMI value of 119.6 g/$kg^{0.75}$ daily for lactation was obtained (using the French UEL system this value is 0.97). This value was similar to the average of the three diets used at the present study (117.6 g/$kg^{0.75}$; 0.95 UEL). The result obtained in a previous study using a TMR in Murciano-

Grenadine lactating goats was 111.6 g DMI/kg$^{0.75}$ daily (0.91 UEL), that is in agreement with the previous values (Fernández *et al.*, 2000; Fernández and Sánchez Seiquer, 2002).

Digestive Utilization of the Diets: Table 2 shows apparent total tract digestibility of nutrients by Murciano-Grenadine goats. No significant differences among the three TMR were found for DM, OM and fat digestibility (70.60, 72.59 and 70.38% as average, respectively), but greater values than other trial using different TMR than our experiment by Fernández *et al.* (2000) (66.4% DM; 68.41% OM; 65.87% fat, as average) were observed. When digestibility coefficient of different fractions of fiber were analyzed, significant differences ($P < 0.01$) were found. Greater digestibility of fiber was observed by sunflower diet in each fiber fraction (CF, NDF and ADF), while fish meal and soybean meal were similar. Significant differences was found for CP digestibility ($P < 0.05$) and greater digestibility was found for sunflower (78.59%) followed by fish meal (73.88%) and soybean meal (71.87). According to observations made for goats by Giger-Reverdin *et al.* (1994), the time the feed spends in the rumen is closely related to the digestibility of the NDF, which in the present study was higher for sunflower meal (56%) than soybean meal (50%) and fish meal (46%), although we did not measure retention time in the rumen. In the study of Fernández *et al.* (2000) lower values (48 and 62% for NDF and CP respectively) were obtained because the sources of fiber and protein were different than the present trial.

However, no significant differences was observed for apparent energy digestibility (70.46%, as average of the three diets). From these results, the net energy value of these three TMR was estimated. Digestible energy (DE), as average, was calculate and next value was obtained; 12.58 MJ/kg of DM. Aguilera *et al.* (1990) estimated metabolizable energy (ME) as 0.86 of DE, for Grenadine goats, and using the same coefficient in our experiment we obtain the value of 10.81 MJ ME/kg DM. The efficiency of utilization of ME for milk production ($kl = 0.63$) recommended by AFRC (1997) was used to estimated net energy for lactation (NEL). UFL (1UFL = 7.11MJ NEL) of the TMR was estimated and a value of 0.96 was obtained. This value is slighted higher than 0.83 UFL recommended by INRA (1988) for dairy goats at 5th month of lactation.

Milk Yield and Composition: Data of milk yield are shown in Table 3. Milk yield was not significantly different (2.07 kg/d, as average) among diets. When we analyze chemical composition of milk, again, no significant differences were observed for the TMR studied. The mean value obtained for fat (5.08%) and protein (3.49%) are into the range of the Murciano-Grenadine standard (5.2% of fat; 3.3% of protein according to Analla *et al.*, 1996). Although significant differences in digestibility for fiber fraction and protein were found for the TMR with sunflower added, no significant differences were found for milk yield and chemical composition.

Increase on goat milk SCC has been associated with subclinical intra mammary infection (Contreras *et al.*, 1996; Poutrel *et al.*, 1997). Moreover, different non infectious factors, like parity and stage of lactation, has been related to increase SCC (Wilson *et al.*, 1995). In this sense, the effect of nutrition on goat milk SCC is little know. In our trial, all the goat studied were free of intra mammary infection throughout both adaptation and experimental period. In the goats studied, the SCC geometric mean was of 220.461 cell/mL, this value agrees with data from other authors on uninfected goat halves (Contreras *et al.*, 1996; Poutrel *et al.*, 1997). In our study no significant variations on SCC was observed according to different source of protein. Moreover, in the goats selected, knowledge of other non infectious factors (3rd parity, and 4th month of lactation) that have been associated with an increase in goat SCC, allow us to observe that commercial and balanced TMR based on different source of protein no modified the SCC values from uninfected goat halves at mid lactation. Fedele *et al.* (1996) studied the effect of feeding system based on grazing versus zero grazing on goat SCC and concluded that diet unbalanced in energy, N and minerals could increase goat milk SCC, although comparison of feeding system is out of the subject of the present experiment.

Energy and Nitrogen Balance: Balance of energy and nitrogen was study in order to evaluate the utilization of these TMR for milk performance. Table 4 shows data regarding energy and N utilization.

Digestible energy intake was calculated and the intake of ME was estimated at 0.86 times the intake of digestible energy (Aguilera *et al.*, 1990). Table 4 shows as well ME intake and the ME available for production. The ME for production was calculated by the difference between the ME ingested and that necessary for maintenance and the ME required for maintenance was estimated using the values determined by Aguilera *et al.* (1990). All of this values are expressed as kilojoules per kilogram of body weight $^{0.75}$ per day (kJ/kg$^{0.75}$ d) and the ME required for maintenance was of 401 kJ/kg$^{0.75}$ d. The energy content of milk and the ratios between the energy content of milk and the ME ingested or available for production are presented (Table 4). Neither intakes of ME nor the values of ME available for production were different among the TMR with three different protein sources. A tendency of higher gross energy (GE) intake and milk energy were found for fish meal versus others, so as more energy was ingested more energy was obtained on milk, but no significant differences were found on chemical characteristics of milk (Table 3). The ratios between the energy in milk and the ME ingested

was of 28% as average of the three diets. Similar value (30%) was obtained by Sanz Sampelayo *et al.* (1998) and of 31% by Fernández *et al.* (2000).

The retained N was calculated as the difference between the N ingested and the sum of the N in feces, urine and milk. From these values, the ratios between the N in milk and that ingested or retained were calculated (Table 4). As was observed for energy balance, no significant differences were found for N balance. Only the relationship between milk N and the N intake was higher ($P < 0.05$) for soybean and sunflower meal (26.79%, as average) than the total mixed ration with sunflower added (22.96%). It seems that when the requirements of goats were already met, as happen with these commercial total mixed rations formulated according to INRA (1988) recommendations, the three sources of dietary protein did not affect milk production and composition.

Conclusion: The TMR studied had good acceptance by Murciano-Grenadine goats independently of the source of protein incorporate into the diet, due to these diets were well balanced in nutrients. As practical recommendation, under drought conditions in the Southeast of Spain, both sunflower and soybean meal are sources of vegetable protein recommendable for using on total mixed ration to fed dairy goats. In order to choose which source of protein is appropriate we should be guide for economical criteria (sunflower meal has Spanish origin and soybean meal from EEUU origin). Greater apparent total tract digestibility for protein and fiber fractions were found for TMR with sunflower meal than soybean meal added, although no significant differences for milk performance was observed.

By other hand, at the moment fishmeal is forbidden for feeding ruminants in the European Community (Royal Degree 3454/2000) due to the presence of Bovine Spongiform Encephalopathy (BSE). The present trial was conducted previous to that prohibition, and we have though results should be shown.

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