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Nature of the protein source in the diet and amount of the goat milk protein produced

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SUMMARY – In order to establish the main composition factors of a series of protein sources (beans, sunflower cake, corn gluten feed and cottonseed), affecting the milk protein production in goats, the ruminal degradation of these feeds was studied. Four diets were designed differing in that 20% of their protein was supplied by each of the different sources. Four groups of five Granadina breed goats were used to study the utilization of these diets for milk production. No significant differences were observed between dry matter intake rates and amounts of milk produced. The milk produced with the sunflower cake diet had the lowest protein concentration while the highest milk protein concentration corresponded to the corn gluten diet. By means of a multivariate analysis different and independent patterns for behaviour were observed for the rumen undegradable protein, quick rumen degradable protein and slowl rumen degradable protein for the protein sources. Therefore, it was deduced that the protein sources used consisted of different and independent entities. Furthemore, the quick rumen degradable protein fraction was the one most closely related to the milk protein produced. To a much lesser extent, the rumen undegradable protein fraction also was related to the milk protein.

Key words: Lactating goats, protein source, degradability characteristics, milk yield, milk composition.

RESUME – *"Nature de la source azotée du régime et quantité de protéines produites dans le lait de chèvre". Les caractéristiques de la dégradation dans le rumen d'une série de sources azotées différentes (fèves, tourteau de tournesol, gluten de maïs et graines de coton) ont eté étudiées avec l'objectif d'identifier leurs effets sur la production de proteínes du lait chez la chèvre. Quatre régimes expérimentaux ont été établis. Le 20% des matiéres azotées des régimes provenaient des fèves, du tourteau de tournesol, du gluten de maïs ou des graines de coton. Chacun des quatre groupes de 5 chèvres de race Granadina a utilisé pour étudier l'effet des régimes expérimentaux sur la production du lait. On n'a pas observé de différences significatives entre les ingestions de matiére sèche et les quantités du lait produit. La concentration la plus faible de protéines du lait a été obtenue chez les animaux recevant du tourteau de tournesol alors que la concentration la plus élevée correspondait au lait des qui ont consommé le gluten de maïs. Par analyse multivariée, on a observé des modéles de comportements différents et indépendants des sources protéíques étudiées en ce qui concerne la protéine non dégradée dans le rumen ainsi que les fractions protéiques rapidement et lentement dégradables dans le rumen. On a conclu que les sources protéíques utilisées sont composées de fractions différentes et indépendantes. La fraction rapidement dégradée dans le rumen etait la plus étroitement reliée à la protéine du lait produit. La fraction de protéine non dégradée dans le rumen était aussi reliée aux protéines du lait mais à un plus faible niveau.*

Mots-clés : *Chèvres en lactation, source proteique, dégradabilité dans le rumen, production laitière, composition du lait.*

Introduction

The new systems for evaluating the protein in the feeds for lactating ruminants suggest that what the animal needs is to absorb a certain amount of protein and to achieve this it is only necessary to ensure that there is a certain supply of rumen degradable and undegradable protein (ARC, 1980; NRC, 1985). Since the introduction of these new systems there has been much research effort to determine the effect that different protein sources with various degrees of degradability can have on the milk protein production (Murphy, 1995). All of these studies have aimed to optimise the yield of milk protein. The results obtained from such studies have not always, however, been those that were expected. A series of explanations have been proposed for this disparity and with greater frequency, opinions and experimental results are indicating that it would be necessary to take into account first, the kinetic of rumen degradation of the protein supplied (Shem *et al.,* 1995).

As far as goat is concerned, Rousselot (1995) points out that in addition to being scant, the research carried out to date has only aimed at analysing the effect of using soy protein supplements instead of other less degradable sources and has obtained few and even contradictory results (Hadjipanayiotou *et al.,* 1987; Morand-Fehr *et al.,* 1987). Morand-Fehr *et al*. (1991) have stressed that in the majority of cases in which isonitrogenated and isoenergetic diets were used, the total protein and casein contents of goat milk did not appear to be very sensitive to changes in the dietary protein sources. From the little information available, and bearing in mind that in Spain all the goat milk produced is destined to cheese production, the authors have analysed the effect of using protein sources with different degradability characteristics (beans, sunflower cake, corn gluten feed and cottonseed) on the yield and composition of Granadina goat milk. These variations have been examined as functions of the kinetic of rumen degradation of the protein supplied.

Material and methods

Rumen degradability of crude protein was estimated using the nylon bag technique according to an international standard procedure (Madsen and Hvelplund, 1994). Two animals with permanent rumen cannulae were used for the incubations and the incubations times were: 0, 4, 12, 24, 48 and 72 hours. The dimensions of the bags were 7.5 x 10 cm and the pore size was 46 x 46 micra. After incubations bags were washed in a washing machine and treated in a stomacher to remove microbial contamination.

For milk yield and composition assays, twenty Granadina goats that were midway through their second lactation were divided into four equal groups based on their body-weight and milk production. Before beginning the experiment, the goats consumed the experimental diets for a month. Then, they were housed individually in rates for 19 days more. The first 14 days of the experimental period were for adaptation, and the last 4 days constituted the principal trial period. Every goat received a ration consisting of 1.0 kg of alfalfa hay and 1.0 kg of concentrate. The specific N and energy requirements of this species and breed were considered in the dietary formulation (Aguilera *et al.,* 1990). The treatments consisted in the use of four diets, and 20% of the total protein was supplied by faba beans (diet 1), sunflower cake (diet 2), corn gluten feed (diet 3) and cottonseed (diet 4). The four diets were practically identical in terms of nitrogen and energy contents. At 09.00 every day, once the residues of forage and concentrates from the previous day had been collected, the goats were milked manually. After milking the daily diets were given: water was available to all animals *ad libitum*. Animals were weighed on the first and last days of the experimental period. During the principal assay phase the food intake and milk yield of each animal was recorded. Dry matter intake and milk production and composition in terms of DM, protein, fat, lactose and energy content, were determined.

The degradation kinetic parameters of each protein source was estimated using the model of Ørskov and McDonald (1979). The rates of DM intake, milk production and milk composition were analysed statistically in accordance with the general linear model. Besides this, a multivariate analysis factorial analysis was performed (SAS, 1987) to establish the pattern of relationships between those variables that defined the nature of the protein sources used and the amount of the milk protein produced, each goat was considered to be an experimental unit. To this end the algorithm used was PRO FACTOR. The correlation matrix was selected. The method for factor extraction and for rotation were principal component analysis and varimax, respectively.

Results and discussion

The degradation characteristics of the crude protein (CP) content of the protein sources in the rumen are shown in Table 1. Faba beans had higher ($P < 0.05$) values for the quickly degradable fraction of CP that did the other protein sources. In general, the concentrations of slowly degradable fractions of CP were greater ($P < 0.05$) than those of quickly degradable fractions. Sunflower cake had a higher ($P < 0.05$) rate of degradation than did the other protein sources. The lowest values for effective degradability were observed for cottonseed. Of the protein sources used, faba beans was chosen because goats show a distinct preference for this feed. The other three sources were chosen because of their supposed lower degradability. Boza and Ferrando (1989) reported that sunflower cake and corn gluten feed are good protein concentrates; cottonseed is a good source of bypass protein as well as an excellent energy source.

Table 1. Degradation parameters† (%) of the protein sources

	a	b	c	ED
Faba beans	53.50 ± 3.74	54.92 ± 11.35	3.00 ± 1.31	84.01
Sunflower cake	19.30 ± 3.94	79.85 ± 4.47	15.08 ± 2.00	88.20
Corn gluten feed	42.42 ± 5.97	56.32 ± 7.54	5.86 ± 2.50	82.41
Cottonseed	32.13 ± 4.64	43.65 ± 8.79	6.50 ± 3.21	64.01

†a = quickly degradable fraction; b = slowly degradable fraction;
c = rate of degradation; ED = effective degradability.

The mean live-weight of the goats was 43 ± 3.1 kg; no change greater than ±1 kg was observed throughout the experiment. Table 2 shows the mean dry matter intake, milk production and milk composition. Type of diet did not affect DMI and milk production ($P < 0.05$). However, type of diet induced changes in milk DM and protein content ($P < 0.05$). Thus, milk DM content was higher ($P < 0.05$) for goats fed diets containing corn gluten feed and cottonseed than for goats fed the diets containing faba beans. Milk protein content was greater ($P < 0.05$) for goats fed the diets containing corn gluten feed and faba beans than for goats fed the diet containing sunflower cake. Morand-Fehr *et al*. (1991) reported that in the majority of cases in which isoenergetic diets with the same N content are used, the protein content of the goat milk does not appear to be particularly sensitive to changes in the protein source of the diet. However, this has always been analysed comparing alternative protein sources with soya-bean protein. Results could vary with the nature of the protein that the less degradable protein replaces. Here, the best results were obtained when goats were fed the diet containing corn gluten feed. None of the other diets that were designed with the aim to obtain milk with a different protein content yielded the positive results expected.

Table 2. Dry matter intake and milk production and composition

Diet	1	2	3	4
DMI (g/kg$^{0.75}$/d)	69.3	61.5	65.2	68.4
Milk production (g/d)	1071	1153	971	1098
Milk composition				
DM (g/kg)	152.1^{b}	155.2^{ab}	164.0^{a}	163.3^{a}
Protein (g/kg)	32.5^{a}	28.7^{b}	35.0^{a}	31.8^{ab}
Fat (g/kg)	60.0	65.7	63.2	66.1
Lactose (g/kg)	51.2	57.1	57.7	56.3
Energy (MJ/kg)	3.9	4.1	4.0	4.1

^{a,b}Means within a row with unlike superscripts differ ($P < 0.05$).

According to this it was investigated the relationships existing between the nature of the protein sources used and the amount of the milk protein produced. For this and for each goat, the protein converted into quickly rumen degradable protein (QRDP), slowly rumen degradable protein (SRDP), effective rumen degradable protein (ERDP) and rumen undegradable protein (RUP), provided by the amount of each protein source ingested, was calculated as function of the degradation characteristics estimated for each source. All these values are shown in Table 3 together with the total milk protein produced (MP). With the aim of exploring the relationships among of all these variables, a multivariate factorial analysis was carried out and the results are shown in Table 4. Three different factors were derived, the first, second and third accounting for 37.0, 34.2 and 22.7% of the total variance. The results highlighted the different behaviour of SRDP, QRDP and RUP, these variables intervening only in the definition of Factor 1, 2 and 3, respectively. Furthermore, the QRDP was the one most closely related to the MP. To a much lesser extent, the RUP also was related to the MP. With regard to the significance of the QRDP as deduced here, it is worth bearing in mind the observations of Chandler (1993) who reported that to satisfy the protein requirements of lactating ruminant best, it is necessary

to identify those protein sources that will be quickly degraded, the N being supplied to the animal in the form of microbial protein. Chandler (1993) also pointed out that the supply of this microbial protein could be balanced using protein sources that are resistant to ruminal degradation.

Table 3. Overall means of the variables that define the nature of the protein sources and the amount of the milk protein produced

Diet†	1	2	3	4
QRDP (g/kg$^{0.75}$/d)	1.40 ± 0.10	0.49 ± 0.03	0.91 ± 0.15	0.72 ± 0.17
SRDP (g/kg$^{0.75}$/d)	1.43 ± 0.10	2.04 ± 0.13	1.21 ± 0.19	0.98 ± 0.24
ERDP (g/kg$^{0.75}$/d)	2.19 ± 0.16	2.26 ± 0.14	1.77 ± 0.28	1.52 ± 0.37
RUP (mg/kg$^{0.75}$/d)	23.5 ± 1.7	69.1 ± 4.4	97.0 ± 15.4	347.8 ± 84.0
MP (g/kg$^{0.75}$/d)	1.96 ± 0.37	1.51 ± 0.14	1.92 ± 0.28	1.90 ± 0.29

†QRDP = quickly rumen degradable protein; SRDP = slowly rumen degradable protein; ERDP = effectively rumen degradable protein; RUP = rumen undegradable protein; MP = milk protein.

Table 4. Variables that define the nature of the protein sources and amount of the milk protein produced. Results derived from multivariate analysis

Variable†	Factor matrix		
	Factor 1	Factor 2	Factor 3
SRDP	0.9943	0.0856	0.0441
ERDP	0.8777	0.4661	0.0368
QRDP	0.1895	0.9311	–0.1175
MP	0.2316	0.7852	0.3994
RUP	–0.0375	0.0537	0.9781
Variance explained (%)	37.0	34.2	22.7

†SRDP = slowly rumen degradable protein; ERDP = effectively rumen degradable protein; QRDP = quickly rumen degradable protein; MP = milk protein; RUP = rumen undegradable protein.

Conclusions

The composition of the milk produced by Granadina goats appears to be sensitive to diets with 20% of protein provided by faba beans, sunflower cake, corn gluten feed and cottonseed. With regard to the milk protein produced, the protein sources used consisted of different and independent entities.

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