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Contribution of main and secondary meals to the daily intake of stall-housed dairy goats in mid lactation

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SUMMARY – In a 12-week experiment, 4 Alpine and 4 Saanen dairy goats in mid lactation were fed *ad libitum* 4 complete diets CR, CS, FR and FS in a 4 x 4 Latin square design, in order to conduct dietary behaviour studies. The forage/concentrate ratio in these diets was either low (C = 30/70) or high (F = 55/45) and the starch source rapidly (R) or slowly (S) degradable in the rumen (barley and maize respectively). Goats were fitted with jaw-movement recorders and housed in individual stalls. Intake levels were determined by weighing machines fixed under the feed containers. Data were recorded continuously for 4 periods of 48 hours each. Diets were distributed twice daily, one half in the morning and the other half in the evening. Results showed a higher correlation of total daily intake with intake in secondary (Sc) meals ($r = 0.45$; $P < 0.05$; $n = 32$) than with intake in main (M) meals ($r = 0.37$; $P < 0.05$; $n = 32$). Total daily intake exceeded 2 kg DM/d and was significantly higher on R diets (+0.2 kg DM/d). Significant differences (on CR, CS, FR and FS respectively) were noticed in intake rate (12.6, 12.2, 9.1 and 8.7 g DM/min), intake in M meals (1.36, 1.17, 1.36 and 1.36 kg DM/d), number of Sc meals (6.4, 6.0, 5.2 and 4.6/d) and intake in Sc meals (0.84, 0.88, 0.83 and 0.70 kg DM/d). Total daily chewing was higher when goats were fed high forage (more than 13 h/d) than high concentrate diets (less than 12 h/d). In both cases, eating lasted more than rumination. Goats may have adapted their dietary behaviour according to the diets offered to avoid possible digestive disorders.

Key words: Goats, meals, level of intake, feeding behaviour.

RESUME – *"Contribution des repas principaux et secondaires aux quantités quotidiennes ingérées chez des chèvres laitières en pleine lactation". Dans une expérience de 12 semaines, 4 rations complètes CR, CS, FR et FS ont été offertes* ad libitum *dans un dispositif expérimental en carré latin à 4 chèvres Alpines et 4 Saanen en vue d'étudier leur comportement alimentaire. Le rapport fourrage/concentré dans ces rations était faible (C = 30/70) ou élevé (F = 55/45) et la source d'amidon rapidement (R) ou lentement (S) dégradable dans le rumen (orge et maïs respectivement). Les chèvres étaient placées en cases individuelles et portaient des enregistreurs de mastication. Les quantités ingérées étaient déterminées par des balances fixées sous les bacs d'alimentation. Les données comportementales étaient enregistrées en continu pendant 4 périodes de 48 heures chacune. Les rations étaient distribuées 2 fois par jour, matin et soir, en quantités égales pour chaque chèvre. Les résultats ont montré une corrélation entre les quantités totales ingérées par jour (QTI) et les quantités ingérées (QI) dans les repas secondaires ($r = 0,45$; $P < 0,05$; $n = 32$) plus élevée que celle existant entre les QTI et les QI ingérées dans les repas principaux ($r = 0,37$; $P < 0,05$; $n = 32$). Les QTI ont dépassé 2 kg MS/j et ont été significativement plus élevées avec les rations R (+0,2 kg MS/j). Des différences significatives sont apparues (respectivement avec CR, CS, FR et FS) entre les vitesses d'ingestion des 4 régimes (12,6, 12,2, 9,1 et 8,7 g MS/min) ainsi que les QI dans les repas principaux (1,36, 1,17, 1,36 et 1,36 kg MS/j), le nombre de repas secondaires (6,4, 6,0, 5,2 et 4,6/j) et les QI dans ces repas (0,84, 0,88, 0,83 et 0,70 kg MS/j). La mastication journalière totale était plus élevée avec les rations riches en fourrage (plus de 13 h/j) qu'avec les rations riches en concentrés (moins de 12 h/j). Dans les 2 cas, l'ingestion a duré plus que la rumination. Selon les rations offertes, les chèvres auraient adapté leur comportement alimentaire afin d'éviter d'éventuels troubles digestifs.*

Mots-clés : *Chèvre, repas, niveau d'ingestion, comportement alimentaire.*

Introduction

A complete understanding of the feeding behaviour requires that all its components be studied. Daily feed intake can be described in terms of number of meals consumed per day, length and size of meals and also rate of eating that occurs during meals. Rumination can be characterized by the number and duration of periods spent ruminating and also by the number of boluses or chews. In general goats, like sheep and cows, eat during 2 long periods per day called main (M) meals which can be separated by several small meals called secondary (Sc) meals. This fact is noticed even with

only one daily distribution of feeds to pen-fed ruminants (Dulphy *et al.*, 1988). Some authors suggest that the daily intake (DI) is mainly determined by the ingested quantities during the 2 M meals (Geoffroy, 1974; Baumont *et al.*, 1997). Others think that the number of Sc meals is the most important factor determining DI (Morand-Fehr *et al.*, 1991).

Our aim was to determine the influence of M and Sc meals on DI, and the effect of the type of diet on M and Sc meals and also on chewing during eating and rumination.

Materials and methods

Four multiparous Alpine and 4 Saanen dairy goats in mid lactation (140 d postpartum, weighing 65.8 ± 10.9 kg and producing 2.2 ± 0.6 kg of milk/d) were used in a 12 week experiment. Goats were fitted with ruminal cannulae and were housed individually in 2 m x 1 m shaded pens with wooden floor. Animals were alloted in pairs. The 2 goats of each pair received the same diet. All goats had free access to water and to trace-mineralized salt blocks. They were offered 4 experimental mixed diets CR, CS, FR and FS (45% DM) which differed, on a dry matter basis, by the forage/concentrate ratio: low (C = 15% lucerne hay + 15% dehydrated lucerne + 35% pressed beet pulps) or high (F = 27.5% lucerne hay + 27.5% dehydrated lucerne + 10% pressed beet pulps) ratio, and by the starch source: rapidly (R = 26% barley) or slowly (S = 26% maize) degradable in the rumen. Soybean meal (8%) and minerals (1%) were added to all diets. Goats were fed *ad libitum* (refusals always exceeded 10% of the distributed mixed diets) in a 4 x 4 latin square design, every couple receiving one of the 4 diets for a period of 3 weeks. These diets were distributed twice daily at 08:00 and 17:00 hours. Refusals were weighed and discarded every evening. The goats were offered a mixture of the 4 experimental diets for 3 weeks before the onset of the experiment. During the first 10 days of each period, the animals were adapted to the daily diet.

The behavioural studies took place in the last part of each period and consisted of a series of computerized data recordings.

We have adopted the method described by Abijaoudé *et al*. (1999) to record manger weights and jaw movements continuously for 48 hours. Digital balances were fixed under the feed containers of 4 goats carrying the jaw movement recorders in order to determine exactly the intake dynamics. The weights were transmitted to an adapted electronic memorizer limited to 4 entries. The jaw movement recording system is composed of a submandibular pipe connected to a portable electronic device: APEC (Brun *et al*., 1984). The APEC transforms air pulses generated by the compression of the pipe whenever the goat opens its mouth to electric signals which are stored in memory. It is fixed on a U-shaped plastic base fastened by means of a harness to the back of the goats. With this system on their backs, the animals are able to move easily after a short period of adaptation without being disturbed or damaging the device. The animals carried the device only during the period of tests but kept the basal part, harness and a halter around the head and muzzle throughout the experiment to avoid problems of adaptation every time we put them in place.

Results

Data collected after the 4 x 48 hours of recordings for each goat show positive correlations between DI and intake levels during the M and Sc meals: $r = 0.37$ ($P < 0.05$; $n = 32$) with M meals while $r = 0.45$ ($P < 0.05$; $n = 32$) with Sc meals. A negative correlation ($r = –0.67$; $P < 0.05$; $n = 32$) exists between intake levels during M and Sc meals. The animal effect was always significant.

More than 2 kg of DM were ingested daily by the goats (Table 1) but intake did not exceed 95 g/kg $W^{0.75}$. The effect of the type of starch was significant on DI (+200 g of DM when goats were fed the R diets). Intake/kg $W^{0.75}$ was not significantly different among diets with a tendancy of the the goats fed CR to eat more than the others.

Intake in main meals (IMM) stood for 59 to 68% of the DI depending on the type of diet (Table 2). IMM was 190g DM less when goats were fed CS ($P < 0.05$) than the other diets; no differences were noticed between the other 3 diets. With the C diets, the goats reduced main meal duration (MMD) but increased IR significantly. The significant decrease in IMM when goats were fed CS, was the result of nonsignificant shorter meal duration and lower intake rate (IR) in MM.

Table 1. Effects of the experimental diets on daily intake in stallhoused dairy goats

Diets	Daily intake	
	kg of DM/d	g of DM/kgW$^{0.75}$
CR	2.2	94.6
CS	2.0	89.6
FR	2.2	90.2
FS	2.0	88.1
SEM†	0.04	0.2

†SEM: standard error of the mean.

Table 2. Effects of the experimental diets on daily M and Sc meals in stall housed dairy goats†

Diets	IMM (kg DM)	MMD (min)	IRMM (g DM/min)	NScM	IscM (kg DM)	I/ScM (g DM)
CR	1.36^{a}	108^{b}	12.6^{a}	6.4^{a}	0.84^{ab}	131^{b}
CS	1.17^{b}	96^{b}	12.2^{a}	6.0^{a}	0.88^{a}	147^{ab}
FR	1.36^{a}	150^{a}	9.1^{b}	5.2^{ab}	0.83^{ab}	160^{a}
FS	1.36^{a}	156^{a}	8.7^{b}	4.6^{b}	0.70^{b}	152^{ab}
SEM	1.1	19	0.5	0.5	1.0	1.5

^{a,b}Means with the same superscript in a column do not differ significantly (P > 0.05).
†IMM: intake in main meals; MMD: main meal duration; IRMM: intake rate in main meals; NScM: number of secondary meals; IScM: intake in secondary meals; I/ScM: intake per secondary meal; SEM: standard error of the mean.

The number of M meals was tightly linked to the 2 daily distributions of diets. Intake in Sc meals (IScM) was also positively correlated with the number of Sc meals (NScM). A variable number of Sc meals (Table 2) occured between the 2 M meals, more with CR and CS than with FR and FS. This resulted in higher IScM with the C diets after each MM. The more NScM was, the less quantity per ScM (I/ScM) was consumed.

Daily chewing exceeded 44% of day length and goats spent more time eating than ruminating (Table 3).

Table 3. Chewing activities in stall housed dairy goats fed experimental 4 diets

Diets	Chewing time (min)	Eating time (min)	Ruminating time (min)
CR	739^{ab}	418^{ab}	321^{ab}
CS	639^{b}	350^{b}	289^{b}
FR	896^{a}	548^{a}	348^{ab}
FS	823^{ab}	414^{ab}	409^{a}
SEM†	57.3	41.6	30.5

†SEM: standard error of the mean.
^{a,b}Means with the same superscript in a column do not differ significantly (P > 0.05).

F diets required significantly more chewing per day (21% more with FR than CR and 29% more with FS than CS). This resulted from longer eating and ruminating periods. The R starch diets required more eating time than the S starch diets at the same F/C ratio ($P > 0.05$). Daily ruminating time tended also to be higher when goats were fed the F diets with one significant difference between FS and CS. CS was the diet which required the least chewing activity.

Discussion

The levels of intake were similar to the ones obtained in dairy goats by Morand-Fehr and Sauvant (1980) and Lu (1987). The M meal took a greater part of the daily intake of sheep fed different hays (Baumont *et al*., 1997) than we found in goats. This could be due to the diet composition or to differences in the definition of the end of meal which was, in our case, determined by at least 20 minutes of idling. The meal length found by Dulphy *et al.* (1990) for goats was a little shorter than the ones we obtained.

DI was less influenced by the forage/concentrate ratio than by the type of starch. A phenomenon of compensation must have taken place between meal numbers and meal lengths and intake per meal.

The number of Sc meals was higher with the diets rich in concentrates (CR and CS). This caused differences in intake in Sc meals. The S starch diets were less ingested than the R starch diets probably because barley is more palatable than maize (Abijaoudé *et al*., 2000).

The higher correlation of DI with intake in Sc meals shows that the level of intake was more influenced by Sc meals than M meals in our case. This confirms the results of Morand-Fehr *et al.* (1991).

Feeding higher amounts of forage to dairy goats increased daily chewing. This confirms the results of Santini *et al*. (1991). Differences in daily eating and ruminating times between diets having the same forage/concentrate ratio but containing different types of starch might be related to digestive phenomena and ruminal parameters.

Conclusion

Intake in Sc meals appeared to be more correlated with total DI than intake in M meals. The differences in M meals among diets were more or less compensated by the level of intake in Sc meals. The higher the intake level is in M meals, the lower it will be in Sc meals. The number of Sc meals increased with the increase of concentrates in the diet causing an increase of the total intake in Sc meals. Chewing activity was influenced by the type of diet. We can suppose that the variations noticed are a kind of adaptation of the goats to the diets they eat, maybe to avoid acidosis in the rumen with diets rich in concentrates.

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