Effects of an acidogenic diet on nycthemeral kinetics of feed intake, feeding behaviour and ruminal pH in dairy goats

Giger-Reverdin S., Rigalma K., Martin O., Duvaux-Ponter C.

in

Priolo A. (ed.), Biondi L. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.).
Advanced nutrition and feeding strategies to improve sheep and goat

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 74

2007
pages 337-342

Effects of an acidogenic diet on nycthemeral kinetics of feed intake, feeding behaviour and ruminal pH in dairy goats

S. Giger-Reverdin, K. Rigalma, O. Martin and C. Duvaux-Ponter
UMR INRA INA P-G, Physiologie de la Nutrition et Alimentation
16 rue Claude Bernard, 75231 Paris Cedex 05, France

SUMMARY – Sub-clinical acidosis (ruminal pH below 6.0) mainly concerns dairy ruminants and is associated with high levels of concentrate in the diet. It is frequently studied from digestive and metabolic points of view and feeding behaviour is seldom taken into account. The aim of this study was to compare, in the same eight mid-lactation goats, the kinetics of dry matter intake, feeding behaviour and rumen pH using two diets differing in their concentrate percentage: control (30% DM basis) *vs* acidogenic (60%). When the goats received the acidogenic diet, their dry matter intake was increased, they spent less time eating and ruminating, made more idling meals, and spent more time resting. Their minimum ruminal pH was on average lower. Feeding behaviour and level of intake can explain variations in pH. The originality of this work lies in the fact that data have been integrated from different research areas, which is seldom performed with goats.

Keywords: Nycthemeral kinetics, feeding behaviour, ruminal pH, dairy goats, acidosis.

RESUME – *"Effets d'un régime acidogène sur les cinétiques nycthémérales d'ingestion, de comportement alimentaire et de pH ruminal chez des chèvres laitières". L'acidose sub-clinique (pH ruminal inférieur à 6,0) concerne essentiellement les ruminants laitiers et est associée à des pourcentages élevés de concentré dans la ration. Elle est généralement étudiée des points de vue digestif et métabolique, mais rarement en relation avec le comportement alimentaire. Cette étude concerne la comparaison, sur 8 chèvres en milieu de lactation, des cinétiques d'ingestion, de comportement alimentaire et de pH ruminal avec deux régimes différant par leur pourcentage de concentré : témoin (30%/MS)* vs *acidogène (60%). Par rapport au régime témoin, les chèvres ingèrent le régime acidogène en plus grande quantité et plus rapidement, font plus de petits repas, ruminent moins longtemps et se reposent plus. En moyenne, leur pH ruminal est plus bas. Le comportement alimentaire et le niveau d'ingestion peuvent expliquer les variations de pH. L'originalité de cette approche réside dans l'acquisition de données issues de différents domaines, ce qui est original avec des chèvres.*

Mots-clés : *Cinétiques nycthémérales, comportement alimentaire, pH rumen, chèvres laitières, acidose.*

Introduction

Sub-clinical acidosis is currently defined as a decrease in ruminal pH below a threshold value of 6.0. This disease mainly concerns dairy cattle and is associated with the use of high levels of concentrate in the diet which are needed to cover the requirements of these high producing animals. It is frequently studied from digestive and metabolic points of view (Owens *et al.*, 1998; Giger-Reverdin *et al.*, 2002) and feeding behaviour is seldom taken into account. The aim of this study was to compare, in the same animals, the kinetics of dry matter intake, feeding behaviour and rumen pH using two diets (control and acidogenic).

Material and methods

Eight fistulated dairy goats in mid-lactation were given, for 4 weeks in a cross-over design, two total mixed rations: control, 30% concentrate on a DM basis (D30) and acidogenic, 60% concentrate (D60). The concentrate was a mixture of wheat (20%), barley (20%), oats (20%), soybean meal (35%) and a vitamin and mineral premix (5%). Forage was a mixture of Gramineae hay (2/3) and ensiled sugarbeet pulp (1/3) on a DM basis. Goats were fed *ad libitum,* after milking, with 2/3 offered in the afternoon and 1/3 in the morning.

Feed intake was measured every 4 minutes. Chewing behaviour was recorded every 2.5 seconds

with a portable electronic device (APEC, INRA, Theix, France) allowing the measurement of eating, ruminating and resting behaviour (Béchet *et al.*, 1989). A meal or a rumination period was defined as a period exceeding 7 min of the same activity and including pauses of less than 7 min. Chewing time excluded pauses. Intensive and idling intake periods were defined as when there was more or less than 50% of chewing during these periods, respectively. Rumen pH was measured every minute by an indwelling pH probe inserted through the rumen cannulae (Brossard *et al.*, 2003). A weight was attached to the electrode to ensure it remained in the ventral sac. The recording devices were placed on the back of the animal in the pockets of a kind of coat especially designed and adapted to the goats (Rigalma, 2004). All the measures were averaged every hour.

At the end of each experimental period, samples of filtered ruminal fluid were collected before morning feed distribution and every two hours during the following 8 hours (sampling at 2 h, 4 h, 6 h and 8 h). This was performed twice for each diet, at an interval of one week. Mean pH values were calculated for each goat and diet.

Results and discussion

One of the four goats which started with the D60 suffered from an acute bout of acidosis. Afterwards, its milk production decreased abruptly. This goat was removed from the following results.

Dietary effect

When the goats received the acidogenic diet, their dry matter intake increased significantly (D60: 47.8 *vs* D30: 42.8 g/kg LW/day) which agrees with the low rumen fill effect of concentrates compared to roughages (Jarrige *et al.*, 1995). The effects concerning diet, goat, hour in the day and first order interactions between these variables were tested on all feeding parameters. An hour effect and the interaction between hour and diet as well as diet effect, goat effect and their interaction were always highly significant.

Table 1. Variability of feeding behaviour parameters in seven mid-lactation goats receiving total mixed rations: control, 30% concentrate on a DM basis (D30) and acidogenic, 60% concentrate (D60)

Duration per 24h	D30	D60	Diet SE	Goat SE	Interaction SE
Intensive intake	5 h 43 min [a]	3 h 33 min [b]	1 h 36 min	47 min	1 h 6 min
Idling intake	50 min [a]	1 h 15 min [b]	38 min	18 min	26 min
Ruminating	6 h 39 min [a]	5 h 17 min [b]	1 h 4 min	1 h 34 min	46 min
Resting	6 h 22 min [a]	10 h 08 min [b]	53 min	53 min	1 h 15 min

Goats fed the acidogenic diet spent less time in intensive intake periods than goats fed the control diet. This was true whatever the hour of the day (Fig. 1). This behaviour was more pronounced after feed distribution, especially in the afternoon. The goats began to eat the D60 very quickly, then stopped for a while and showed a second intensive intake period around 4 hours after feed distribution. Moreover, with D60, goats divided their daily intake into more idling intake periods than with D30 (Fig. 2). Thus, the total duration of feed intake was higher for the control diet (6 h 33 min) than for the acidogenic one (4 h 48 min). This is in agreement with the literature since high concentrate diets are ingested more quickly than low concentrate diets (Jarrige *et al.*, 1995). Even if goats tended to replace intensive periods by idling ones when the diet was acidogenic, total replacement was not observed. However, this could be an adaptation in behaviour in response to acidosis.

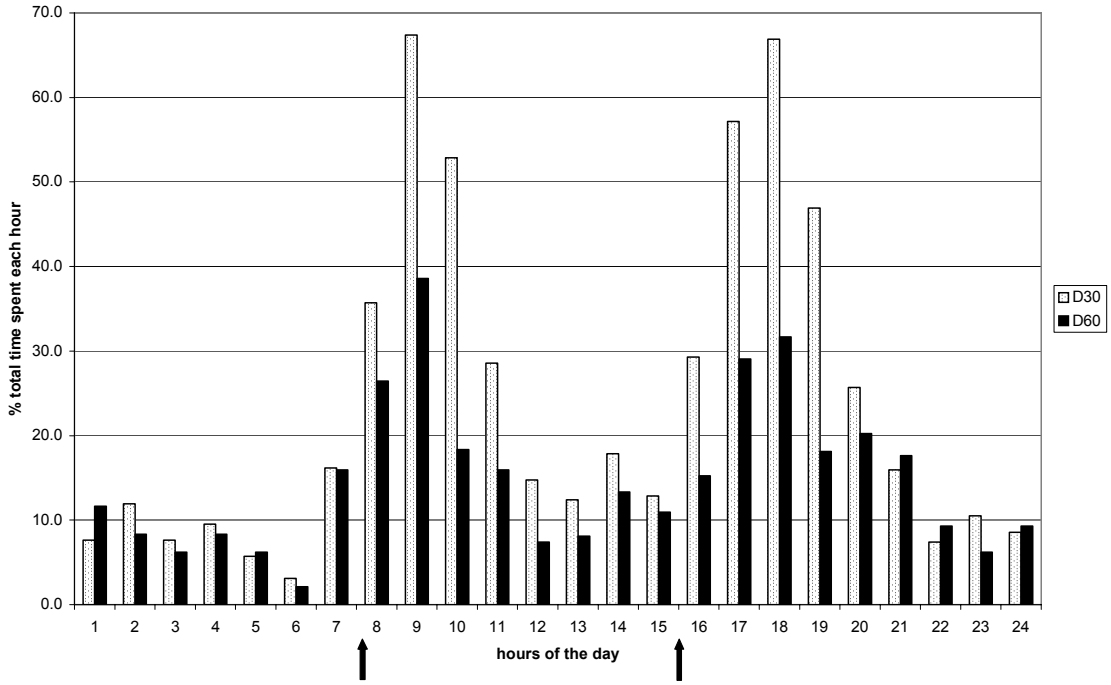

Fig. 1. Nycthemeral kinetic of intensive intake periods in seven mid-lactation goats (arrows indicate feed distribution) receiving total mixed rations: control, 30% concentrate on a DM basis (D30) and acidogenic, 60% concentrate (D60)

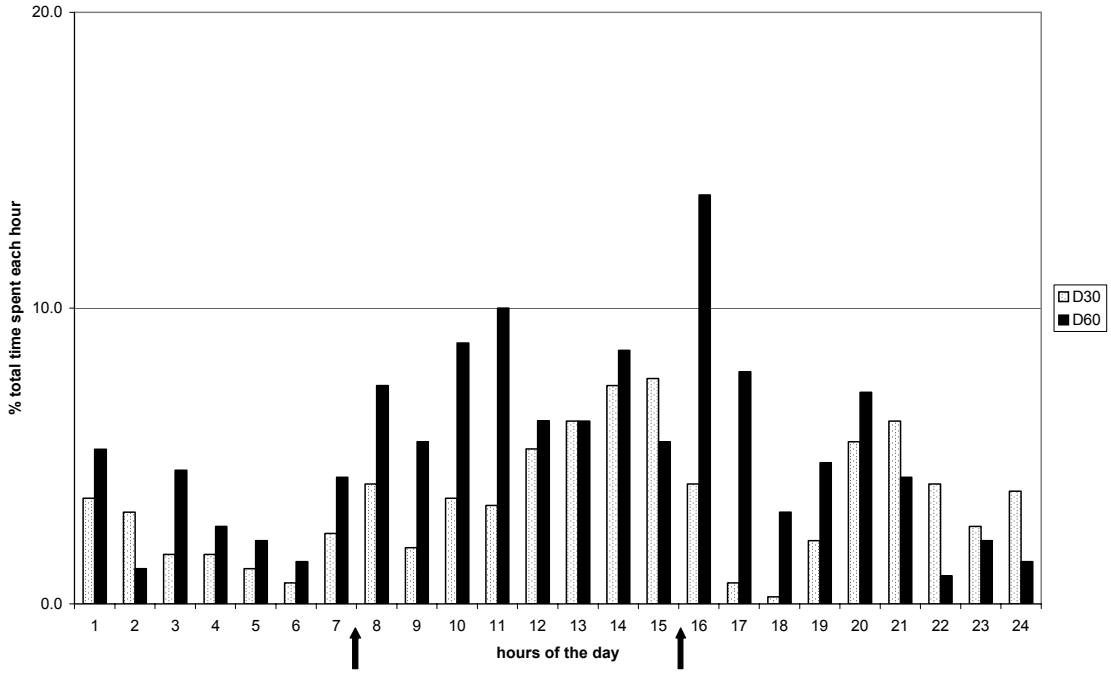

Fig. 2. Nycthemeral kinetic of idling intake periods in seven mid-lactation goats (arrows indicate feed distribution) receiving total mixed rations: control, 30% concentrate on a DM basis (D30) and acidogenic, 60% concentrate (D60).

With D60, goats spent less time ruminating (1h 20 min per day) than with D30. The difference in mastication time was greater than 3 hours between diets: D30 (13 h 12 min) *vs* D60 (10 h 3 min). The

goats rested more with the acidogenic diet compared to the control diet. As observed by Beauchemin *et al.* (2003), higher dry matter intake was associated with shorter eating time.

The pattern of diurnal fluctuation of ruminal pH averaged per diet was similar between treatments, but the ruminal pH was on average lower with D60 than with D30 (Fig. 3).

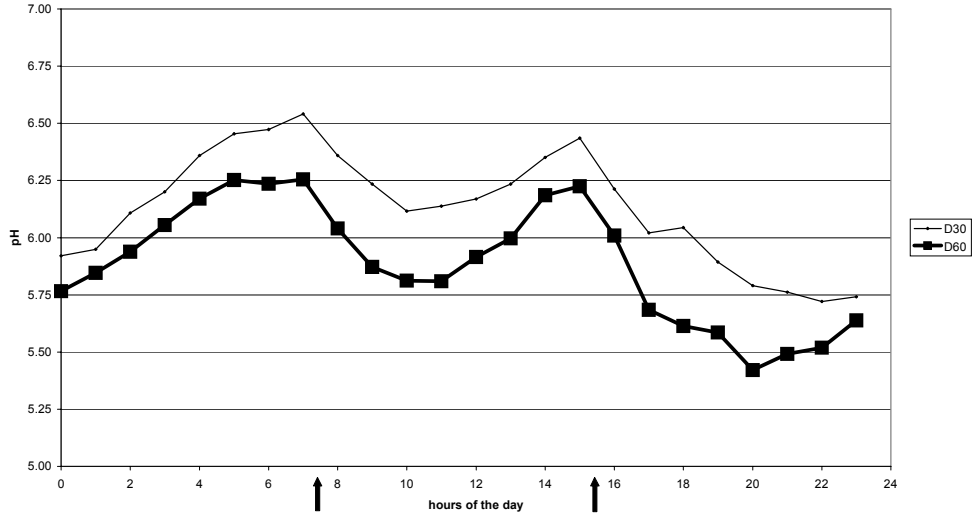

Fig. 3. Nycthemeral kinetic of ruminal pH in seven mid-lactation goats (arrows indicate feed distribution) receiving total mixed rations: control, 30% concentrate on a DM basis (D30) and acidogenic, 60% concentrate (D60).

The minimum pH values were observed after the afternoon feed distribution with the highest feeding allowance. The pH curve can be explained by the percentage of time spent ruminating divided by total time spent chewing (Fig. 4).

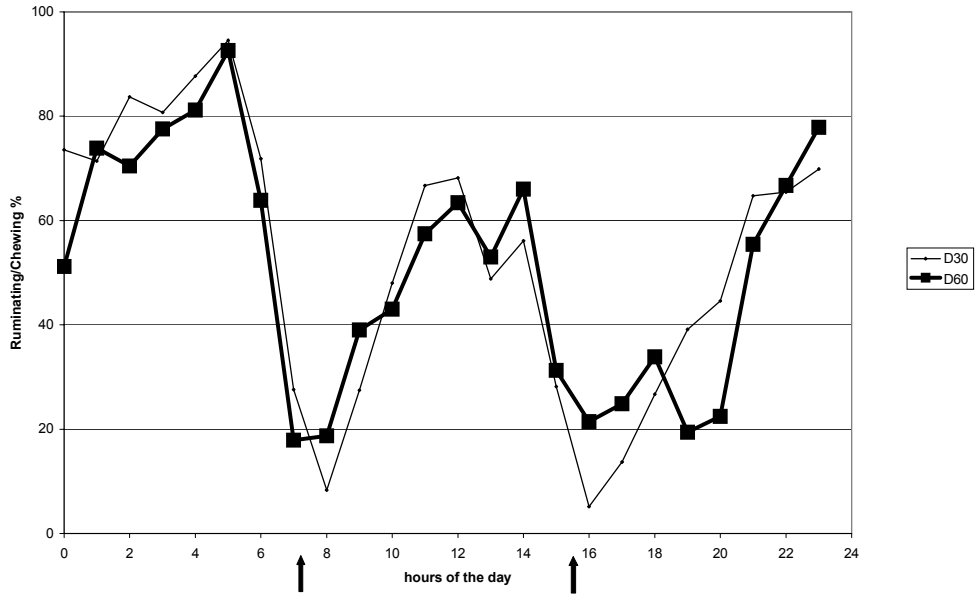

Fig. 4. Nycthemeral kinetic of percentage of time spent ruminating divided by total time spent chewing in seven mid-lactation goats (arrows indicated feed distribution) receiving total mixed rations: control, 30% concentrate on a DM basis (D30) and acidogenic, 60% concentrate (D60).

There was a 3-4 hour delay between changes in feeding behaviour and pH modifications. It must be stressed that for D60, there were two peaks of intake after the evening feed distribution and thus two nadirs in pH due to intensive fermentation. Moreover, after the ruminating phases, the pH increased because of the arrival of buffers via the saliva.

Between goat variability

In this study, the goat effect was significant in almost all the analyses. This means that the response of goats to diet varies between animals. This might explain why only some animals in a herd are sensitive to an acidogenic diet: these animals are probably not capable of modifying their feeding behaviour and of replacing intensive intake periods by idling ones.

The mean pH value observed during the kinetics and averaged per diet and per goat was estimated using several parameters related to feeding behaviour. The best estimation parameters were the duration of mastication (min per kg DMI) and the level of intake (g/kg LW):

$pH = 6.53 + 2.02\ 10^{-3}$ min. chewing/kg DMI - $20.7\ 10^{-3}$ g DMI /kg LW
($r^2 = 0.74$, n = 14, RSD = 0.16)

Neither diet nor goat affected the residual of this equation.

Therefore, with a diet rich in concentrate, the decrease in pH results from a combination of lower chewing activity and higher feed intake.

Conclusion

The originality of this first approach lies in the fact that data have been integrated from different research areas. This is seldom performed in experiments with goats. It highlights the fact that feeding behaviour of goats can explain variations in pH since when animals ruminate less, less buffers enter the rumen and therefore the ruminal pH is lower. Moreover, when feed intake is increased, more fermentable material enters the rumen which contributes to the decrease in pH. Further research is needed to explain the differences in behaviour between animals and the aptitude of animals to modify their feeding behaviour in accordance to the diet. This aspect is important in order to explain differences in sensitivity between goats receiving acidogenic diets.

Acknowledgements

The authors are indebted to their colleagues from the Theix INRA centre who helped them with the use of the APEC system (G. Béchet and T. Vimal) and the indwelling probes (L. Brossard, C. Martin and M. Fabre) and to their colleagues of the Grignon experimental farm (J. Tessier and A. Eymard) who took care of the animals.

References

Beauchemin, K.A., Yang, W.Z. and Rode, L.M. (2003). Effects of particle size of alfalfa-based dairy cow diets on chewing activity, ruminal fermentation, and milk production. *J. Dairy Sci.,* 86: 630-643.

Béchet, G., Thériez, M. and Prache, S. (1989). Feeding behaviour of milk-fed lambs at pasture. *Small Ruminant Res.,* 2: 119-132.

Brossard, L., Fabre, M., Martin, C. and Michalet-Doreau, B. (2003). Validation of continuous ruminal pH measurements by indwelling probes. In: *Conference on gastrointestinal function*, Chicago, Illinois (USA), 10-12 March 2003, Cotta, M.A. (ed.). 25

Giger-Reverdin, S., Duvaux-Ponter, C., Sauvant, D., Martin, O., Nunes do Prado, I. and Muller, R. (2002). Intrinsic buffering capacity of feedstuffs. *Anim. Feed Sci. Technol.,* 96: 83-102.

Jarrige, R., Dulphy, J.-P., Faverdin, P., Baumont, R. and Demarquilly, C. (1995). Activités d'ingestion et de rumination. In*: Nutrition des ruminants domestiques. Ingestion et digestion. (Nutrition of domestic ruminants. Ingestion and digestion),* Jarrige, R., Ruckebusch, Y., Demarquilly, C., Farce, M.H. and Journet, M. (eds). Institut National de la Recherche Agronomique (INRA), Paris, France. pp. 123-181.

Owens, F.N., Secrist, D.S., Hill, W.J. and Gill, D.R. (1998). Acidosis in cattle: A review. *J. anim. Sci.,* 76: 275-286.

Rigalma, K. (2004). *Effets de l'acidose sub-clinique sur le comportement alimentaire et le pH du rumen de chèvres laitières*. Mémoire de fin d'études ENITA, Clermont-Ferrand, France. 33 p.