Behavioural strategies of dairy goats fed an acidogenic diet

Giger-Reverdin S., Desnoyers M., Rigalma K., Morand-Fehr P., Sauvant D., Tessier J., Dhumez O., Duvaux-Ponter C.

in

Papachristou T.G. (ed.), Parissi Z.M. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.). Nutritional and foraging ecology of sheep and goats

Zaragoza : CIHEAM / FAO / NAGREF
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 85

2009
pages 85-90

Behavioural strategies of dairy goats fed an acidogenic diet

S. Giger-Reverdin, M. Desnoyers, K. Rigalma, P. Morand-Fehr, D. Sauvant, J. Tessier, O. Dhumez and C. Duvaux-Ponter

UMR Physiologie de la Nutrition et Alimentation, INRA-AgroParisTech,
16 rue Claude Bernard, 75231 Paris Cedex 05 (France)

Abstract. The aim of this study was to compare daily evolution in dry matter intake (DMI), composition of refusals and the relationships between diet composition, feeding behaviour and rumen pH in eight mid-lactation goats fed *ad libitum* a control (concentrate 30% DM or D30) or an acidogenic diet (60% concentrate or D60) in a cross-over design. With D30, daily DMI was more constant than with D60 and the cell wall content of the refusals was higher than that of the offered diet. With D60, NDF content of the refusals was similar to that of the offered diet. A principal component analysis showed the relationships between rumen pH and feeding behaviour, such as the between-animal variability within a diet. This might explain the fact that some animals suffered from acidosis more than others, presumably because they were less able to adapt their feeding behaviour to the acidogenic diet.

Keywords. Feeding behaviour – Refusals – Fibre – Acidosis – Dairy goats.

Stratégies comportementales des chèvres laitières soumises à des régimes acidogéniques

Résumé. *Cette étude concerne la comparaison, sur 8 chèvres en milieu de lactation, de l'évolution de l'ingestion, de la nature des refus et des relations entre la composition de la ration ingérée, le comportement alimentaire et le pH ruminal avec deux régimes différant par leur pourcentage de concentré : témoin (30% sur MS)* vs *acidogène (60%). Avec le régime témoin, la variation journalière de matière sèche ingérée était plus faible qu'avec le régime acidogène, et les refus étaient plus fibreux que la ration distribuée. Avec le régime acidogène, le NDF des refus était similaire à celui de la ration. Une analyse en composantes principales a montré les relations entre le pH ruminal et le comportement alimentaire ainsi que les variations inter-individus dans chaque régime. Ceci peut expliquer pourquoi certains animaux sont plus sensibles à l'acidose que d'autres, car ils sont moins aptes à modifier leur comportement alimentaire avec un régime acidogène.*

Mots-clés. *Comportement alimentaire – Refus – Fibre – Acidose – Chèvres laitières.*

I – Introduction

Goats fed a diet with a high proportion of concentrates may develop subclinical acidosis: a decrease in ruminal pH below a threshold value of 6.0 (Sauvant *et al.*, 2006). In a previous paper (Giger-Reverdin *et al.*, 2007) we compared two diets differing in their concentrate percentage: control (30% DM basis or D30) *vs* acidogenic (60% or D60) in the same eight mid-lactation goats. When fed the acidogenic diet, feeding behaviour of goats was modified in comparison with the control ones: dry matter intake was increased and the animals spent less time eating and ruminating. However, there was a high individual variability in the response to the diet, which is a key-point in understanding the occurrence of subclinical acidosis.

It has often been pointed out that goats have a high ability to select their feed (Morand-Fehr *et al.*, 1980). The aim of this paper was to compare the day-to-day evolution of dry matter intake, type of refusals and the relationships between these variables and rumen pH in goats receiving the two diets (D30 and D60).

II – Materials and methods

Two total mixed diets (control, 30% concentrate on a DM basis or D30 and acidogenic, 60% concentrate or D60) were fed to eight fistulated dairy goats in mid-lactation for four weeks after adaptation in a cross-over design. The four goats receiving D30 and then D60 constitute the "D30-D60" group (animals 1 to 4), and the four others the "D60-D30" group (goats 5 to 8). Forage was a mixture of Gramineae hay (2/3) and pressed sugar beet pulp silage (1/3) on a dry matter basis. The concentrate was a mixture of wheat (20%), barley (20%), oats (20%), soybean meal (35%) and a vitamin and mineral premix (5%). Goats were fed *ad libitum*, after milking, with two thirds of the daily allowance offered in the afternoon (16:00 h) and one third in the morning (08:00 h) according to the interval between daily milkings.

Diets offered and refusals were weighed individually every day, and the animals, every week (LW). Dry matter intake level (DMI/LW) was expressed in g DMI/kg LW. Its standard deviation (SdDMI/LW) was computed weekly during the experimental periods. Rumination behaviour was measured with a portable device (APEC, INRA, Theix, France) as described by Béchet *et al.* (1989) over a 24 hour period. The duration of rumination was expressed in hours per kg DMI (rumin/DMI). At the end of each 4-week experimental period, a kinetic was performed twice, at a one-week interval, during the 8 hours following the morning distribution. Intake rates were characterised by the level of intake and the percentage of the diet ingested during the first hour following the morning distribution (respectively, Intake1h/LW and %Intake1h). Samples of diets and individual refusals were analysed according to the original van Soest procedures (van Soest, 1963; van Soest and Wine, 1967) adapted in our laboratory for a sequential approach with ADF determination on the NDF residue (Giger *et al.*, 1987). The composition of the diet ingested (NDFi in % DM) was calculated from the quantities and composition of diets offered and refusals. The modification in cell wall composition (NDFmod) was computed by dividing the value for the diet ingested by that of the diet offered. A NDFmod value lower than 1 corresponds to feed ingested with a lower cell wall composition than the diet offered. Rumen pH was the mean value of the records taken 2, 4 and 6 hours after feed distribution.

A principal component analysis was carried out (Lebart and Fenelon, 1971) on eight variables characterising the feeding behaviour of the goats and rumen pH: Intake1h/LW, %Intake1h, NDFi, NDFmod, DMI/LW, SdDMI/LW, rumin/DMI and pH.

III – Results

1. Dry matter intake

Mean value of the four experimental weeks for dry matter intake (expressed as g/kg live-weight) was higher with D60 than with D30 (respectively 45.0 *vs* 41.8 g DMI/kg LW, $P < 0.001$). There was also a significant goat effect ($P < 0.001$), but the interaction between goat and diet was not significant (Fig. 1). When fed the acidogenic diet, all the goats which began with D60 suffered from acute acidosis, but only the two goats which had a high level of intake with D30 (>45.0 g DMI/kg LW) suffered from acidosis when they were changed from D30 to D60 (goats 2 and 3). Goat 7 decreased greatly its intake after the first bout of acidosis and never recovered its previous level. Daily fluctuations of dry matter intake are a sign of chronic acidosis in dairy cattle (Owens *et al.*, 1998). Standard deviation of dry matter intake was higher for D60 than for D30 (respectively 4.77 *vs* 2.71 g DM/kg LW; $P < 0.01$). There was also a goat effect ($P < 0.05$). It is noticeable that two goats of the "D60-D30" group (5 and 7) had a different behaviour from the other goats (Fig. 2). Goat 7 had a high standard deviation linked to acidosis and goat 5 had a low intake level with D60 after an acute acidosis.

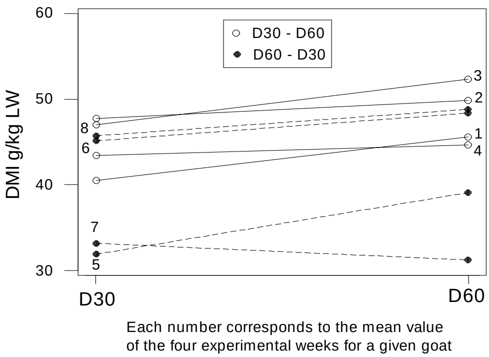

Fig. 1. Individual variations in dry matter intake in goats receiving either 30% (D30) or 60% (D60) concentrate in the diet.

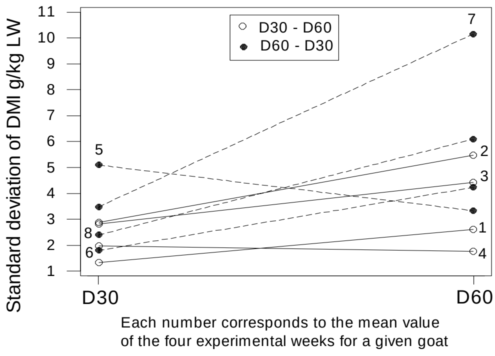

Fig. 2. Individual variations in dry matter intake standard deviation in goats receiving either 30% (D30) or 60% (D60) concentrate in the diet.

It is well known that goats are able to select their feeds. The diets offered differed in their cell wall composition, as D30 was more fibrous than D60: NDF – 48.2 *vs* 37.9%/DM, ($P < 0.001$); ADF – 24.0 *vs* 16.7%/DM, ($P < 0.001$); and ADL – 2.4 *vs* 1.3%/DM, ($P < 0.001$). The cell wall content of the refusals for the goats fed D30 was higher ($P < 0.001$) than that of the diet offered: NDF 54.0, ADF 29.2 and ADL 3.3%/DM. The opposite was observed for D60, cell wall content of refusals was similar to that of the diet: NDF 36.7, ADF 17.3 and ADL 1.6%/DM. This means that the feed ingested by the goats had a better nutritive value than the feed offered with D30 and was of similar value for D60.

When fed D30, goats improved ($P < 0.03$) the nutritive value of the diet, as the NDFmod was equal to 0.984 (±0.012). With D60, the NDFmod was equal to 1.012 (±0.026) and did not statistically differ from 1 ($P < 0.09$). The standard deviation was twice as high for D60 than for D30. It was mainly due to one goat, which experienced a very acute bout of acidosis (goat 7). Nevertheless, all the goats changed their feeding behaviour, except goat 5 (Fig. 3). The same trends were observed for the lignocellulosic fraction (ADF): ADFmod = 0.97 (±0.015) and 0.99 (±0.048) respectively for D30 and D60.

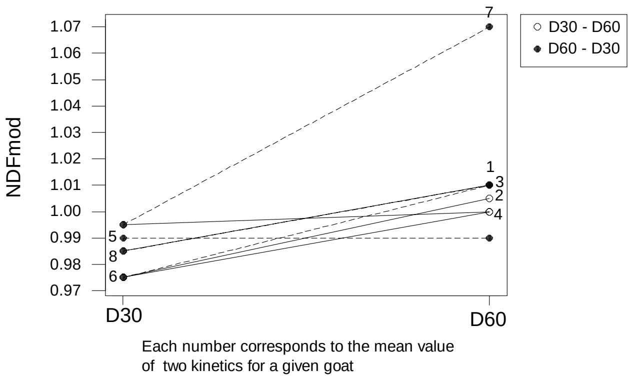

Fig. 3. Individual variations in NDFmod in goats receiving either 30% (D30) or 60% (D60) concentrate in the diet.

2. Relationships between feed composition, intake and ruminal acidosis

In a previous paper, we found that goats can modify their feeding behaviour according to the acidogenicity of the diet (Giger-Reverdin *et al.*, 2007). Therefore, it appears important to estimate the impact of feeding behaviour on rumen pH. The first two components accounted for around 71% of the total variance of the data (Fig. 4). The first eigenvector shows the opposition between the rumen pH, the intensity of rumination (rumin/DMI) and the cell wall composition of the ingested diet on one hand, and the level and rate of intake, as well as the NDFmod, on the other hand. While the second eigenvector effected mainly the separation of the standard deviation of the dry matter intake from the rates of intake (Intake 1h/LW and %intake1h). The two dimensional score plot PC1 *vs* PC2 showed the opposition between NDFmod and the standard deviation of the dry matter intake, on one hand, and pH, NDFi and rumin/DMI, on the other hand. This can represent an "acidosis axis" because a low pH is associated with a low NDFi and low rumination expressed per kg DM and corresponds to a high NDF modification and a high standard deviation in dry matter intake. There was also another axis that showed the opposition between pH and level of intake during the hour following feeding.

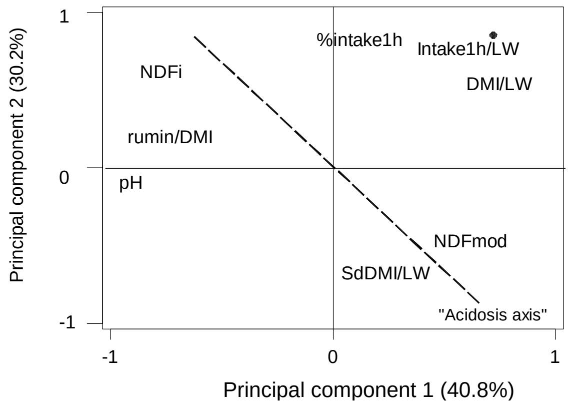

Fig. 4. Plot of the first two components of a principal component analysis (variables).

The positions of the goats on the two dimensional score plot PC1 *vs* PC2 highlighted differences between animals as diets are quite well separated on the "acidosis axis" with D30 in the upper left quarter and D60 in the lower right one. The perpendicular axis to the "acidosis axis" showed the between-goat variations within a diet: goats 5 and 7 did not eat a lot of feed and ate it at a slow rate (Fig. 5). Goat 7 showed a high decrease in feed intake after acidosis, which occurred before the kinetics and searched for fibre (NDFmod = 1.06). Goat 6 coped well with acidosis by decreasing its rate of intake and goat 4 ate quite slowly. The opposite was observed for goats 3 and 8 which ate a large amount of a feed which was quite similar in composition to the diet offered. They suffered from acidosis during the kinetics. This score plot explains the degree of acidosis experienced by the goats and enables a distinction to be made between the diet effect and the individual responses of the goats.

IV – Discussion

As shown for other ruminants, goats suffer from acidosis when their diet contains excessive amounts of readily fermentable carbohydrates (Owens *et al.*, 1998), their feed intake decreases a lot after a bout of acidosis (Fulton *et al.*, 1979) and they show a cyclic pattern of intake (Huber, 1976). In our experiment, this pattern was outlined by the higher standard deviation of dry matter intake with D60 compared to D30. The feeding behaviour is a means of helping maintaining the rumen environment within a certain physiological range (James and Kyriazakis, 2002) and thus returning to the physiological equilibrium according to the well-known concept of homeostasis (Ruckebusch, 1961). Indeed, the maintenance in pH values higher than 6.0 within the rumen is of great importance to both the resident micro-organisms (Russell *et al.*, 1979) and to the host (Owens *et al.*, 1998).

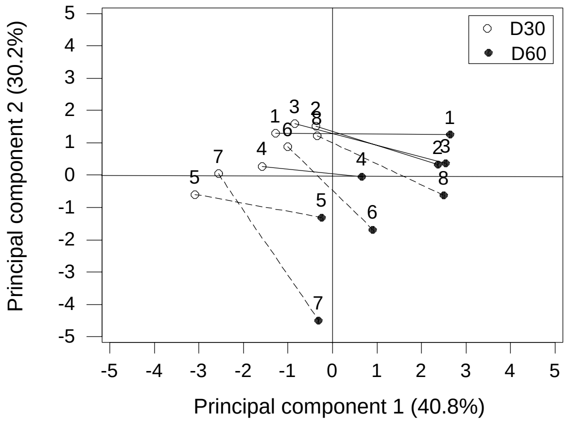

Fig. 5. Plot of the two first components of principal component analysis (observations).

Generally, goats select their feeds in order to increase the nutritive value of their intake when the offered feed quality is poor and does not meet their needs especially on poor rangelands (Morand-Fehr *et al.*, 1991; Narjisse, 1991; Morand-Fehr, 2003). In our experiment, the feed ingested was of a better nutritive value than the offered one with D30. However, with D60, which induced acidosis, some goats searched for fibre as it has been observed in cows experiencing subclinical acidosis (Keunen *et al.*, 2002) or in goats offered free-choice (Fedele *et al.*, 2002).

V – Conclusion

It seems that some goats support quite well an acidogenic diet, as they were able to decrease their rate of intake and modify their feed choice. This selective behaviour is an essential component of goat behaviour because it enables them to cope in difficult areas as well as to deal more effectively with toxic plants (Morand-Fehr, 2003). Thus, according to Provenza (1996), goats possess some nutritional wisdom and are able to reject feeds that cause toxicity, assuming that acidosis can be considered as a kind of toxicity.

References

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

Fedele V., Claps S., Rubino R., Calandrelli M. and Pilla A.M., 2002. Effect of free-choice and traditional feeding systems on goat feeding behaviour and intake. In: *Livest. Prod. Sci.*, 74. p. 19-31.

Fulton W.R., Klopfenstein T.J. and Britton R.A., 1979. Adaptation of high concentrate diets by beef cattle. 1. Adaptation to corn and wheat diets. In: *J. Anim. Sci.*, 49. p. 775-784.

Giger S., Thivend P., Sauvant D., Dorléans M. and Journaix P., 1987. Etude de l'influence préalable de différents traitements amylolytiques sur la teneur en résidu NDF d'aliments du bétail. (Effect of different amylolytic pretreatments on NDF content in feedstuffs for cattle). In: *Ann. Zootech.*, 36. p. 39-48.

Giger-Reverdin S., Rigalma K., Martin O. and Duvaux-Ponter C., 2007. Effects of an acidogenic diet on nycthemeral kinetics of feed intake, feeding behaviour and ruminal pH in dairy goats. In: *Options Méditerranéennes, Series A*, 74. p. 337-342.

Huber T.L., 1976. Physiological effects of acidosis on feedlot cattle. In: *J. Anim. Sci.*, 43. p. 902-909.

James S.M. and Kyriazakis I., 2002. The effect of consumption of foods that differ in energy density and/or sodium bicarbonate supplementation on subsequent diet selection in sheep. In: *Br. J. Nutr.*, 88. p. 81-90.

Keunen J.E., Plaizier J.C., Kyriazakis L., Duffield T.F., Widowski T.M., Lindinger M.I. and McBride B.W., 2002. Effects of a subacute ruminal acidosis model on the diet selection of dairy cows. In: *J. Dairy Sci.*, 85. p. 3304-3313.

Lebart L. and Fenelon J.P., 1971. *Statistique et Informatique Appliquées*. Paris, France: Dunod.

Morand-Fehr P., 2003. Dietary choices of goats at the trough. In: *Small Ruminant Res.*, 49. p. 231-239.

Morand-Fehr P., Hervieu J. and Sauvant D., 1980. Contribution à la description de la prise alimentaire de la chèvre. (Feed intake by goats). In: *Reprod. Nutr. Develop.*, 20. p. 1641-1644.

Morand-Fehr P., Owen E. and Giger-Reverdin S., 1991. Feeding behaviour of goats at the trough. In: Morand-Fehr P. (ed.). *Goat Nutrition*. Wageningen, Netherlands: Pudoc. p. 3-12.

Narjisse H., 1991. Feeding behaviour of goats on rangelands. In: Morand-Fehr P. (ed.). *Goat Nutrition*. Wageningen, Netherlands: Pudoc. p. 13-24.

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

Provenza F.D., 1996. Acquired aversions as the basis for varied diets of ruminants foraging on rangelands. In: *J. Anim. Sci.*, 74. p. 2010-2020.

Ruckebusch Y., 1961. Les bases physiologiques du comportement alimentaire. In: *Rev. Med. Vet.*, 112. p. 121-148.

Russell J.B., Sharp W.M. and Baldwin R.L., 1979. The effect of pH on maximum bacterial growth rate and its possible role as a determinant of bacterial competition in the rumen. In: *J. Anim. Sci.*, 48. p. 251-255.

Sauvant D., Giger-Reverdin S. and Meschy F., 2006. Le contrôle de l'acidose ruminale latente. (The control of latent ruminal acidosis). In: *Prod. Anim.*, 19. p. 69-78.

van Soest P.J., 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. In: *J. Assoc. Agric. Chem.*, 46. p. 829-835.

van Soest P.J. and Wine R.H., 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell-wall constituents. In: *J. Assoc. Anal. Chem.*, 50. p. 50-55.