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Study of the between-goat variation in feed efficiency with a high-concentrate diet

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Abstract. Feed efficiency in ruminants is largely linked to rumen digestive efficiency. Moreover, some recent research pointed out that feeding behaviour influences rumen pH. This work showed that twelve dairy goats (six Alpine and six Saanen) characterized by very different intake rates with a standard diet increased their intake rate when the diet was changed to a high concentrate one. The between-goat ranking for intake rates was not modified ($P = 0.70$) by the shift in diet composition. Organic matter digestibility of the high concentrate diet decreased as level of intake increased, with a 2.2 points difference between the Alpine and Saanen breeds. This difference is mainly due to a difference in cell wall digestibility and can be explained neither by the rate of intake, nor by the sorting behaviour or by the fat corrected milk yield. Feed efficiency was, in this trial, linked to metabolic efficiency. Both items were explained by the fat-corrected milk yield. Feed efficiency was not correlated with digestibility and there was no difference ($P = 0.72$) between breeds. Differences between animals in feed efficiency were explained by differences in metabolic efficiency.

Keywords. Dairy goat – Feeding behaviour – Between-animal variation – Feed efficiency.

Etude de la variation inter-chèvres de l'efficacité alimentaire avec un régime riche en aliments concentrés

Résumé. L'efficacité alimentaire est essentiellement liée à l'efficacité du rumen. Des études récentes ont montré que le comportement alimentaire influence le pH du rumen. Ce travail a mis en évidence que douze chèvres (six Alpine et six Saanen) présentant une grande variabilité inter-animaux de leur vitesse d'ingestion avec un régime standard gardaient la même hiérarchie avec un régime riche en concentré, même si leur vitesse d'ingestion augmentait. La digestibilité de la matière organique du régime riche en concentré a été influencée négativement par le niveau d'ingestion. Les chèvres de race Alpine ont présenté, à ingestion égale, une digestibilité plus élevée que les chèvres Saanen. Cette différence est principalement due à une différence de digestibilité de la paroi végétale. Elle n'est pas liée à la vitesse d'ingestion, au tri effectué par les animaux ou à la production laitière. Dans cet essai, l'efficacité alimentaire était liée à l'efficacité métabolique. Ces deux paramètres étaient liés à la production laitière standard. L'efficacité alimentaire n'a pas été corrélée à l'efficacité digestive et il n'y a pas eu de différence entre races. Les différences entre animaux pour l'efficacité alimentaire étaient liées aux différences d'efficacité métabolique.

Mots-clés. Chèvre laitière – Comportement alimentaire – Variabilité individuelle – Efficacité alimentaire.

I – Introduction

In ruminants, feed efficiency is largely related to rumen digestive efficiency (Jarrige, 1978). In some recent research, feeding behaviour was shown to influence rumen pH, and thus digestive efficiency, and that dairy goats expressed a large between-animal variability on this aspect (Desnoyers *et al.*, 2011). Moreover, it seems that there is quite a good repeatability in feeding behaviour (Duvaux-Ponter *et al.*, 2013).

This work aimed to find out if dairy goats showing very different intake rates with a standard diet modify their eating behaviour and show different organic matter digestibility when receiving a high concentrate diet, and if they valorise this high-concentrate diet to the same extent.

II – Material and methods

One month after their second kidding, thirty five dairy goats were given for three weeks a total mixed diet (control): 30% dehydrated alfalfa, 20 meadow hay, 30% pressed sugar beet pulp and 20% concentrate on a dry matter (DM) basis. They were fed *ad libitum*, after milking, with 2/3 of the diet offered in the afternoon and 1/3 in the morning after milking in agreement with the intervals between milking.

Feed intake was recorded every 2 minutes in individual crates by weighing devices fitted under the feed trough. For each afternoon feeding, the quantity of diet eaten 180 min after feeding was divided by the total feed intake for this feeding (fractional intake rate, P180), because the greatest variability between animals was observed at that moment (Giger-Reverdin *et al.*, 2014). It was measured during a four day period on the control diet at the end of the 3rd week (P180c).

Two groups were formed with six Alpine goats and six Saanen. The twelve goats were chosen out of the 35 to present a wide range of variation for P180c within a group, but a similar P180c and similar DIM (days in milk) in the two groups. They were then shifted to an acidogenic diet: 15% dehydrated alfalfa, 15% meadow hay, 20% pressed sugar beet pulp and 50% concentrate on a DM basis after a transition week between control and acidogenic diets. After an adaptation period of three weeks, their fractional intake rate was measured during a four day period (P180a). The goats were then moved to digestibility crates, and a five day digestibility measurement was performed after an adaptation period of one week to digestibility crates.

Dry matter, ash, cell wall content (or NDF) and crude protein were measured on feed offered, refusals and feces according, respectively, to ISO (1983), ISO (1978), Giger *et al.* (1987) and ISO (1997) to calculate the digestibility of the corresponding constituents. Body weight (BW) was measured once a week. Milk yield was measured at each milking and fat and protein contents were measured each week on two consecutive milkings. Fat corrected milk (FCM) corresponds to a standard milk with 35 g/kg fat and 31 g/kg protein.

III – Results and discussion

1. Intake

When the diet was shifted from control to the acidogenic one, one goat exhibited an off-feed period two weeks after the beginning of the allowance of this diet. Its dry matter intake was as low as 0.337 g/kgBW, but the goat recovered its former intake in three days.

The mean value on the whole data set for P180c was 0.759 (standard deviation or SD = 0.0771) and ranged from 0.628 to 0.912 with a normal distribution. For the twelve goats chosen to be fed the acidogenic diet, the P180c had a mean value of 0.736 (SD = 0.0717) and varied from 0.628 to 0.860.

The rate of intake with the acidogenic diet (P180a) was directly proportional to the rate of intake with the control diet (P180c):

$$P180a = 1.15 \times P180c \quad (n = 12, r = 0.69, RSD = 0.066)$$

There was no interaction between breed and P180c and no breed effect ($P = 0.70$). This means that the animals exhibited the same ranking for control and acidogenic diet, and that they ate at a 15% higher rate the high concentrate diet, even for the goat which exhibited the off-feed episode with the acidogenic diet. This result is in agreement with the repeatability within goats of intake behaviour previously observed on the whole data set with a control diet fed at four different times (Giger-Reverdin *et al.*, 2014). This is also in agreement with previous data showing that when goats

shifted from a medium concentrate diet to a high concentrate diet, their rate of intake was not modified during the first weeks of allowance (Serment and Giger-Reverdin, 2012). The goat who exhibited an off-feed period had surprisingly the lowest intake rate (P180c). The large between-animals variation for P180a should also be noticed.

2. Organic matter digestibility

The organic matter digestibility (OMD) was 61.8% (SD = 1.32) and ranged from 59.9 to 63.5.

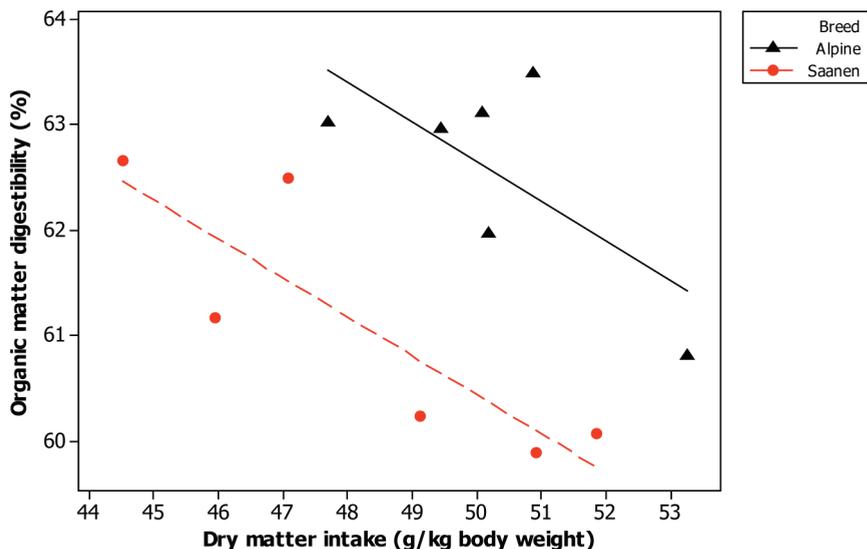


Fig. 1. Effects of dry matter intake and breed on organic matter digestibility.

OMD decreased as the dry matter intake (DMI) expressed on a body-weight basis increased, there was no interaction between breed and the covariate DMI, but a significant difference ($P < 0.001$) of 2.2 points for OMD with a digestibility higher for Alpine than for Saanen (Fig. 1).

$OMD = 80.1 (4.64) - 0.372 (0.0941) DMI/BW$ ($n = 12$, $n \text{ breed} = 2$, $r = -0.88$, $RSD = 0.718$)

The between breed difference can be explained neither by the fractional rate of intake (P180c or P180a), nor by the sorting behaviour (expressed as the ratio between the NDF composition of intake and offered) or by the milk yield. It is mainly due to a better digestibility of NDF by the Alpine goats compared to the Saanen ones, as the mean difference between the digestible NDF content was 18 g/kg DM. The remaining difference was explained by the difference in the digestible crude protein content: 5 g/kg DM.

The decrease in OMD with the level of intake was higher than the slope of 0.253 that we observed in various ruminants (Sauvant and Giger-Reverdin, 2009). This decrease is probably due to the transit time of the feeds which is negatively correlated to digestibility (Najar *et al.*, 1990).

3. Feed efficiency

Feed efficiency (FE) was calculated as the ratio of FCM yield/DMI which is the product of digestibility (DOMI/DMI) by metabolic efficiency ($ME = FCMY/DOMI$). FE was firstly linked with ME ($n = 12$, $r = 0.97$). These two items were mainly explained by FCMY ($n = 12$, $r = 0.66$ and $r = 0.72$ for FE

and ME respectively). FE was not correlated with digestibility ($n = 12$, $r = -0.38$, $P = 0.22$). This could be explained by the low range of digestibility in this trial.

Individual variation of FE were mainly explained by the level of performance. Individual variation of digestibility which were mainly linked to the levels of FCMY and DMI cannot explain individual FE. There was no breed effect ($P = 0.72$).

IV – Conclusion

This work pointed out that intake rates of dairy goats were modified by the type of diets, but that between goat ranking remained unchanged. Between animal variability for organic matter digestibility depends on the level of intake, but there was also a between-breed difference due mainly to a different ability in cell wall digestion. Differences between animals in feed efficiency were linked to the level of performance and were explained by difference in metabolic efficiency. Digestibility had no influence on feed efficiency in this trial, as it did not vary a lot.

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