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Prediction of *in vivo* digestibility of pasture-based diets in dairy goats from faecal indicators

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Abstract

For estimating quality and intake of pasture herbage by grazing goats, estimation of herbage digestibility is often required. The aim of this work was to predict *in vivo* organic matter digestibility (OMD) of diets based on temperate pasture forage from faecal composition (CP mainly). A series of indoor experiments was carried out with goats fed on grass hay or with fresh herbage cut daily and given either *ad libitum* or in restricted amounts, to mimic the effect of pasture herbage availability. Concentrate supplementation level and regrowth age of the herbage were also studied in order to achieve a wide range of diets composition and quality. Intake of each feed, and of faecal output (total collection), were measured precisely during 5 consecutive days in each experimental period. For each dataset (fresh pasture herbage only or fresh pasture herbage + hay), there was a strong and inverse relationship between OMD and faecal crude protein (CP) concentration. Including dietary CP concentration in the regression allowed increased accuracy of the prediction. The proposed equations, relevant for good quality pastures, show a good continuum with previous published equations on goats fed on much less digestible tropical, Mediterranean or Sahelian forages.

Keywords: goat, digestibility, pasture, faecal nitrogen, prediction

Introduction

Reliable methods for determining individual daily intake of herbage from pasture are needed for predicting variations of nutrient intake in grazing dairy goats. One of the main techniques is the 'faecal output/digestibility' method (Penning, 2004), intake being calculated from the ratio between daily faecal output and the indigestible fraction of the diet. Faecal output is often estimated from the dilution of an indigestible external marker, while digestibility is often determined *in vitro* or from faecal composition, mainly from faecal nitrogen concentration (Penning, 2004). Several predictive equations of *in vivo* digestibility exist for cattle (Penning, 2004; Ribeiro Filho *et al.*, 2005) and sheep (Chenost *et al.*, 1985) fed on good quality forages, for meat goats fed on tropical (Boval *et al.*, 2003) or sahelian (Schlecht and Susenbeth, 2006) forages, but not for dairy goats fed on good-quality pastures. The objective of this work was to develop an accurate predictive equation of *in vivo* diet digestibility based on faecal indicators in dairy goats fed on good-quality forages, including fresh pasture.

Materials and methods

A series of 4 trials was carried out at the INRA-PEGASE experimental farm of Méjusseume (Le Rheu, Brittany, France) between spring 2014 and spring 2016 to determine voluntary intake, *in vivo* digestibility and faecal composition of Alpine goats fed under a large range of diet quality, diet composition, and intake level, which mimic what could happen under grazing conditions. The forage fed was grass hay of medium quality in trial 1 (Spring 2014), fresh herbage from a multi-species pasture including grasses, clovers, chicory and dandelion in trial 2 (Autumn 2015) and fresh grass-based pasture herbage in trials 3 and 4 (Spring 2016). Fresh herbage was cut once daily before feeding as 4 meals per day to goats. Three to four nutritional treatments were compared within each experiment, varying by the level of allocation of the forage (130 to 80% of *ad libitum* intake level determined before the start of the experiment), by the level of supplementation (no supplement to 600 g/day of a pelleted concentrate containing 220 g of crude protein (CP) kg⁻¹ dry matter (DM)), and by the regrowth age of the freshly cut pasture herbage (from

young and leafy to aged and stemmy). Experimental designs were Latin squares repeated 2 to 3 times, with 3 to 4 successive periods of 14 days, and six Alpine goats per trial. Goats were dry in trial 1, milked once-a-day in trial 2, and milked twice-a-day in trials 3 and 4. Goats were maintained in digestibility boxes allowing individual measurement of intake and total faecal collection. The amount of forage and concentrate DM offered and refused, and the amount of faecal DM output were measured during the last 5 days of each period. Amount of DM, organic matter (OM), N, neutral detergent fibre (NDF) and average daily gain (ADG) eaten (offered minus refused) and excreted in faeces were determined, allowing to calculate *in vivo* diet OM digestibility (OMD) and faecal and diet nutrients concentrations. Multiple regressions were performed on data averaged per trial \times treatment \times period to find the best equations predicting OMD from faecal and diet indicators. Two datasets were considered: hay + fresh pasture herbage (HP dataset, n=39), or fresh pasture herbage only (P dataset, n=23). Specific effects of concentrate supplementation (with or without) or intake level (*ad libitum* or restricted) were tested through covariance analyses.

Results and discussion

The OMD averaged 0.694 for hay-based diets and 0.796 for fresh pasture-based diets. Large ranges in OMD, intake, faecal output, and diet and faeces CP concentrations were observed (Table 1). There was a strong and inverse relationship between OMD and faecal CP concentration (Table 2 and Figure 1), with 0.021 and 0.013 of residual standard error of the regression when this variable is considered alone, in the HP and P databases, respectively. Taking also into account in the regression of the ratio diet/faecal CP concentrations (Penning, 2004; Ribeiro Filho *et al.*, 2005) allowed increased the accuracy of the prediction in both databases. These regressions established with temperate forages showed a good continuum with existing regressions on goats fed on tropical (Boval *et al.*, 2003), Mediterranean or Sahelian forages (Schlecht and Susenbeth, 2006); nonetheless these forages are much less digestible than those of this study (Figure 2). Faecal ADF concentration had no significant effect on OMD provided that diet CP concentration is taken into account, contrary to previous studies with cattle (Penning, 2004; Ribeiro Filho *et al.*, 2005), but in good agreement with studies on meat goats (Boval *et al.*, 2003; Schlecht and Susenbeth, 2006). The effects of concentrate supplementation level or of intake level were never significant. This suggests that the predictive equations are sufficiently generic to be used in grazing

Table 1. Description of the dataset relating diet and faecal characteristics to *in vivo* diet organic matter (OM) digestibility in dairy goats fed on pasture-based diets (n=39).¹

Variable	Unit	Mean	Min	Max	SD	CV
Total intake	g DM d ⁻¹	1712	808	2597	518	30%
Diet OM digestibility	g g ⁻¹	0.754	0.636	0.826	0.057	8%
Diet CP concentration	g kg ⁻¹ OM	166	94	235	41	25%
Faecal CP concentration	g kg ⁻¹ OM	199	127	262	47	24%

¹ CP = crude protein; SD = standard deviation; CV = coefficient of variation.

Table 2. Parameters of main equations predicting *in vivo* diet OM digestibility from faecal and diet characteristics in dairy goats fed on pasture-based diets.¹

Dataset		Intercept	1/FCP	DCP/FCP	R ²	RSD
Hay + fresh pasture (n=39)	Eq. 1	0.959	-3.83		0.86	0.021
	Eq. 2	1.012	-3.65	-0.074	0.88	0.019
Fresh pasture (n=23)	Eq. 3	0.895	-2.24		0.61	0.013
	Eq. 4	0.939	-2.44	-0.0445	0.69	0.012

¹ FCP and DCP are the faecal and diet crude protein concentration, in g 100 g⁻¹ organic matter, respectively). RSD = relative standard deviation.

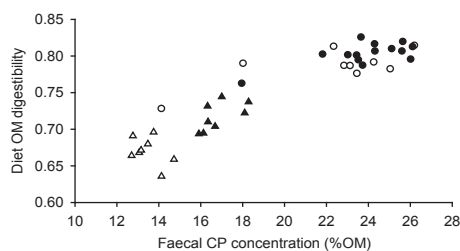


Figure 1. Relationship between faecal crude protein (CP) concentration and organic matter (OM) digestibility on dairy goats fed on pasture (triangles: hay; circles: fresh pasture herbage) with (black symbols) or without (white symbol) concentrate supplementation.

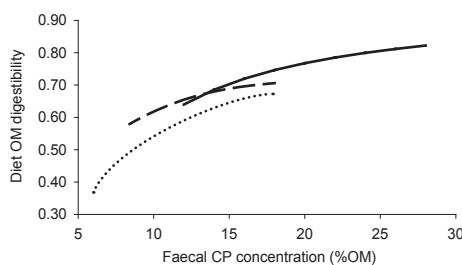


Figure 2. Relationship between faecal crude protein (CP) concentration and organic matter (OM) digestibility on goats fed on forages (—: this study, Eq. 1; ---: tropical pastures, Boval *et al.*, 2003;: sahelian forages, Schlecht and Susenbeth, 2006).

situations with various concentrate supplementation levels and various grazing pressure. The fact that concentrate supplementation does not affect the relationship between faecal CP concentration and digestibility has been already observed by Chenost *et al.* (1985) on sheep fed on diets based on fresh pasture herbage.

Conclusions

The inverse relationship observed between OMD and faecal CP concentration seem generic enough to be used under a large range of grazing situations, but larger databases are needed to achieve more precision, particularly considering the large range of pasture type and supplement type used. The proposed equations, developed and relevant for temperate pastures, show a good continuum with previous published equations on goats fed on tropical, Mediterranean or Sahelian forages, nonetheless much less digestible.

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