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Accuracy of the ytterbium-faecal index method for estimating intake of pasture-fed dairy goats

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Abstract

There is no validated method for estimating pasture intake of dairy goats receiving concentrates and grazing on multispecies swards. The objective of this study was to determine the accuracy of a method based on estimates of faecal output (from ytterbium (Yb) oxide dilution), and of diet digestibility (from faecal N concentration). Four indoor experiments with six goats each were carried out between 2014 and 2016, comparing several feeding management factors: concentrate supplementation level, diet feeding level and pasture regrowth age. Actual daily intake, faecal output, *in vivo* diet digestibility, faecal N concentration and faecal recovery rate of Yb were determined individually over five days at the end of each period. Pasture intake was also estimated from faecal N and Yb concentrations. The relative mean prediction error between actual and estimated pasture intake was low (7%), with no line or mean biases, and a faecal Yb recovery close to 1.0. Random error came equally from the estimates of faecal output and of indigestibility. It is concluded that the Yb-faecal index method is accurate and suitable for estimating pasture intake of dairy goats grazing on multispecies swards whether or not supplemented with concentrate.

Keywords: goat, pasture, intake, methodology, ytterbium

Introduction

Grazing systems may be used to increase self-sufficiency and sustainability of dairy goat farms in the oceanic regions of France (Bossis, 2012). The lack of knowledge in relation to grazing dairy goat nutrition, however, precludes greater grazing utilisation. A reliable method for estimating daily pasture intake is needed for predicting variations of nutrient intake in grazing dairy goats under varying grazing and supplementation management practices. Two main generic methods for estimating individual pasture intake exist, one called the 'faecal output/digestibility' method (Penning, 2004) and the other the '*n*-alkanes' method (Mayes *et al.*, 1986). Grazing goats are generally offered multispecies swards, for which the *n*-alkanes method may be inaccurate due to the difficulty for estimating *n*-alkanes profile of the selected pasture. In the 'faecal output/digestibility' method, total intake (I) is calculated from the ratio between daily faecal output (F) and the indigestible fraction of the diet (1 - OMD), according to $I = F \times (1 / (1 - OMD))$. Pasture intake is then calculated by subtracting known supplement intake from total intake. Ytterbium (Yb) oxide may be considered as a good indigestible external marker for estimating faecal output (Pérez-Ramírez *et al.*, 2012). Recently, specific equations were developed for estimating diet OM digestibility from faecal N concentration in dairy goats fed on fresh forage (Charpentier *et al.*, 2017). The objective of this work was to determine the accuracy of the Yb-faecal index method for estimating forage intake of dairy goats fed indoors with conserved or fresh forage, across a large range of feeding strategies.

Materials and methods

Four trials were carried out in which forage distribution level (130 vs 80% of *ad libitum* intake level, determined before the start of each trial), concentrate supplementation level (no supplement vs 600 g day⁻¹ of a pelleted concentrate), and age of regrowth of the pasture (from young and leafy pasture to aged and stemmy pasture) were the factors tested, with three or four treatments compared per trial. Trials were

carried out at the INRA farm of Méjusseume (Le Rheu, France), with six Alpine dairy goats per trial. Experimental designs were latin squares repeated two to three times, with three to four successive periods of 14 days, with measurements made the last week of each period. The basal forage fed was grass hay in trial 1 (Spring 2014), fresh multispecies pasture including grasses, clovers, chicory and dandelion in trial 2 (Autumn 2015) and fresh grass-based pasture in trials 3 and 4 (Spring 2016). Fresh pasture was cut once daily before feeding in four meals offered daily to goats. Goats were dry in trial 1, in late lactation and milked once a day in trial 2, and in mid-lactation and milked twice a day in trials 3 and 4. Goats were maintained in digestibility boxes allowing individual measurement of actual DM intake, faecal output and diet *in vivo* OM digestibility during five day total faecal collection periods (Charpentier *et al.*, 2017). Each goat received 0.13 g d⁻¹ of Yb₂O₃, at each milking, mixed in a specific Yb-concentrate (15 g d⁻¹). Total and forage (hay or pasture) intake were estimated from faecal output assuming an Yb faecal recovery of 1.0, and from diet digestibility, estimated from faecal and diet CP concentrations according to specific goat predictive equations (Charpentier *et al.*, 2017). The ability of the Yb-faecal index method to accurately predict the actual values of forage and total intake, faecal output, as well as diet digestibility and indigestible fraction, was estimated on the entire database (n = 72 goat × period data), through the calculation of the mean prediction error (MPE) and its decomposition into three components: mean bias, line bias and random variation (Bibby and Toutenburg, 1977).

Results and discussion

In the entire database, actual forage intake, faecal output and diet OM digestibility ranged from 0.56 to 2.56 kg DM d⁻¹, from 0.18 to 0.60 kg OM d⁻¹, and from 0.636 to 0.832, respectively. The average and standard deviation of actual and estimated forage intake, total intake, faecal output, diet digestibility and diet indigestible fraction were very close, showing no overall bias of the method for estimating intake (Table 1).

Moreover, the regressions of estimated versus actual forage intake and their components (faecal output and diet digestibility) show high correlations (R^2 from 0.88 to 0.96) and low mean prediction errors (relative MPE from 0.02 to 0.07) (Table 1 and Figure 1). A relative MPE of only 0.07 clearly indicates a very accurate method. The similar relative MPE for faecal output and for the inverse of the diet indigestible fraction, both close to 7%, suggest that the error in estimating forage intake came equally from the two parts of the equation. Whatever the variable, the main source of error is random, with no overall mean or line bias (Table 1). For faecal output, this result should be directly related to the Yb faecal recovery rate that averaged 1.01 ± 0.069 , meaning no bias and low variability of the faecal output estimation. This variability in Yb faecal recovery is similar to that already observed in dairy cows (Pérez-Ramírez *et al.*, 2012). The good ability of the faecal index equation to predict actual diet OM digestibility is due to the fact that the equation was calibrated from the same database, from data averaged per treatment and period (Charpentier and Delagarde, 2017). A lower accuracy of the intake prediction with other types

Table 1. Accuracy of the Yb-faecal index method for estimating actual DM intake (g d⁻¹), faecal OM output (g d⁻¹), diet OM digestibility (OMD), and the inverse of the indigestible fraction of the diet (1/(1 - OMD)) in dairy goats fed hay or fresh forage-based diets (n = 72).¹

Variable	Actual	Estimated	R^2	MPE	MPEr	Percentage of MSPE		
						Mean	Line	Random
Forage DM intake	1,515 ± 548	1,518 ± 584	0.96	111	7.4	0	17	83
Total DM intake	1,823 ± 553	1,826 ± 580	0.96	111	6.1	0	11	89
Faecal OM output	378 ± 93	374 ± 90	0.92	27	7.1	2	0	98
OMD	0.762 ± 0.055	0.762 ± 0.052	0.89	0.018	2.4	0	0	100
1/(1 - OMD)	4.41 ± 0.91	4.37 ± 0.83	0.88	0.32	7.3	1	1	98

¹ MPE: mean prediction error, same unit as the corresponding variable; MPEr: relative MPE, in % of actual mean; MSPE: mean square prediction error (Bibby and Toutenburg, 1977).

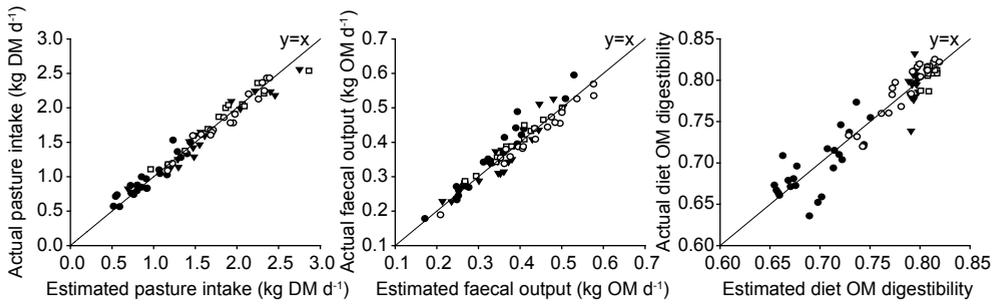


Figure 1. Relationship between actual and estimated values for (a) forage DM intake, (b) faecal output, and (c) $1/(1-OMD)$, when measured in dairy goats fed indoors on hay or fresh pasture-based diets (● trial 1, ▼ trial 2, □ trial 3, ○ trial 4) (n = 72).

of fresh forages or supplements could be expected but the digestibility predictive equations may always be improved from new calibration indoor experiments.

Conclusion

The complete faecal recovery of Yb independent of feeding regime and the suitability of the equation predicting diet OM digestibility make the Yb-faecal index method accurate for estimating pasture intake variations of dairy goats fed on forage-based diets. This method may be used for estimating intake of dairy goats grazing on multispecies swards and supplemented or not with concentrate.

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