Compatibility of using TiO_2 and the faecal near-infrared reflectance spectrometry for estimation of cattle intake

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Abstract

Combining titanium dioxide (TiO_2) as indigestible marker to faecal near-infrared reflectance spectrometry (F-NIRS) can be used to determine cattle feed intake and quality of ingested forage if F-NIRS spectra are not modified by the marker. This study aimed at determining the compatibility of TiO_2 with F-NIRS. Three dry cows were fed a standard hay-based diet for three weeks supplemented with a daily dose of 0.1 % (10g) TiO_2 during the last two weeks of the experiment. Faeces samples were collected every day and analysed for TiO_2 and F-NIRS. Results suggest that TiO_2 did not interfere with F-NIRS analyses. The calculations of crude protein, NDF, ADL contents, as well as dry matter intake did not change over time with increasing TiO_2 in the faeces ($P > 0.05$). Slight differences observed for other predicted parameters seemed to be independent from TiO_2. The higher Mahalanobis distance (H) for chemical composition ($H = 7.2$) independent from TiO_2 inclusion could indicate that faecal spectra did not correspond exactly to the prediction database. Although 0.1% incorporation of TiO_2 seem not to interfere with F-NIRS measurements, caution must be taken with higher levels of TiO_2 as nothing indicates that interference could not appear.

Keywords: Ruminant, titanium dioxide, faecal near-infrared spectrometry, intake, diet chemical composition.

Introduction

Methods used to determine feed intake and quality of consumed forage in grazing cattle are time-consuming, expensive and sometimes controversial in respect to animal welfare as they include different techniques such as sward clipping techniques or oesophageal fistulated animals (Decruyenaere *et al*., 2009). A combination of an indigestible marker to faecal near-infrared reflectance spectrometry (F-NIRS) can provide a useful alternative providing that the marker fed daily to the animal does not interfere with F-NIRS spectra (Titgemeyer *et al.*, 2001; Decruyenaere *et al.*, 2012). As previous studies report that Cr_2O_3 is likely to interfere with NIRS calibration data (Decruyenaere *et al.*, 2012), this study investigates if titanium dioxide (TiO_2) used as indigestible marker was compatible with F-NIRS analysis.

Materials and methods

A three-weeks experiment was performed on three dry red-pied cows housed in free stalls in the Animal Science Unit of GxABT (Gembloux, Belgium). All cows received 7kg d^{-1} of

standard temperate hay and 2kg d^{-1} of a mixed concentrate and had a free access to water. After an adaptation period of one week, 10g of TiO_2 mixed with 50ml of molasses was distributed every day to each cow until the end of the experiment. The faeces were collected every day, dried at 60°C, and ground to pass a 1mm screen prior to TiO_2 and F-NIRS analyses. TiO_2 dosage in faeces was performed according Myers *et al.* (2004). The F-NIRS analyses were achieved as described by Decruyenaere *et al.* (2012). The chemical composition, dry matter intake (DMI) and *in vivo* organic matter digestibility (OMD) predicted from the F-NIRS database were compared daily along the entire experiment using the MIXED procedure of SAS 9.2. with the 'cow×day' as experimental unit. The correlation between these parameters and TiO_2 content in the faeces was calculated with the CORR procedure of SAS 9.2.

Results and discussion

Figure 1 shows the evolution of TiO_2 contents in the faeces before and during the daily incorporation of 10g of TiO_2 in the diet (day 6 being the first day of TiO_2 distribution). During the adaptation period without TiO_2, its faecal content was equal or close to zero before increasing and then reaching a plateau towards the end of the experiment; so the TiO_2 dosage did not face interference problems. Dietary TiO_2 did not interfere with the F-NIRS analysis. Prediction of crude protein (CP), neutral detergent fibre (NDF) and acid detergent lignin (ADL) contents as well as the DMI (Figure 2) did not change over time ($P > 0.05$; $P = 0.0723$ for NDF content as the lowest P-value). Despite some changes along days for the acid detergent fibre (ADF, $P = 0.0381$) content and the *in vivo* OMD ($P = 0.0009$) (Figure 2), the slightly different values seemed to appear independently before or after ingestion of titanium dioxide. The DMI ($P = 0.4613$; Figure 2) which seemed more fluctuating along the experiment could be explained by individual differences of intake; for example, the 13th day of the experiment, the DMI of one cow reached 85.3 *vs* 47.5g kg^{-1} metabolic weight (MW) for another one. The standardized Mahalanobis distance (H) which evaluates the correspondence between the faeces spectra and the F-NIRS database should ideally be lower than 3 for an accurate prediction (Shenk and Westerhaus, 1991). For OMD and DMI, the average distance H was below 3 for the DMI and the OMD (H = 2.8 and 2.87 respectively; two thirds of the samples being lower than 3) while it reached 7.2 for the chemical composition. This should probably not be due to TiO_2 inclusion in the diet, but rather to a discrepancy between the samples and the calibration dataset.

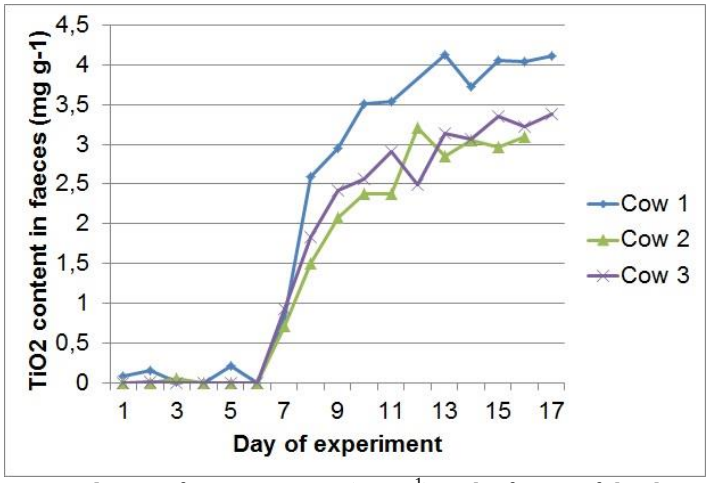

Figure 1: Evolution of TiO_2 contents (mg g^{-1}) in the faeces of the three cows

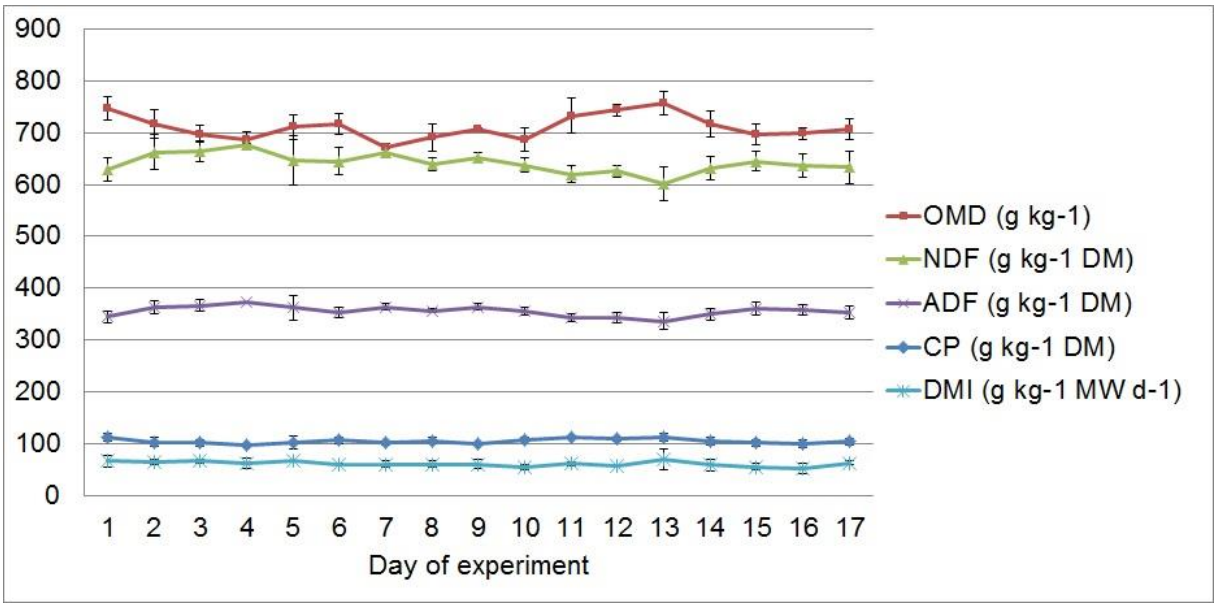

Figure 2: Means and standard deviation of CP, NDF and ADF contents (g kg^{-1} of DM) of the diet and the DMI (g kg-1 MW d-1) and *in vivo* OMD (g kg^{-1}) predicted by F-NIRS along the experiment

The results of correlation between the titanium dioxide content in the faeces and the parameters predicted by F-NIRS should be considered with caution. Indeed most of parameters, as DMI or OMD, wasn't significatively correlated to the TiO_2 content ($P > 0.05$; $P = 0.1086$ and $r = 0.23206$ for CP as the highest P-value and correlation coefficient (r)) but other parameters were significatively correlated to TiO_2 content as total ashes (TA), NDF and ADF content ($P < 0.0001$ and $r = 0.58651$ for TA).

Conclusion

Feeding 10g d^{-1} TiO_2 as indigestible marker in cattle (0.1% incorporation level) did not interfere with F-NIRS prediction. The use of these results should be done with caution as nothing indicates that interference could not appear when higher levels of TiO_2 are incorporated in the diets.

Acknowledgments

The authors are grateful to Walloon Agricultural Research Centre for the near-infrared reflectance spectrometry analyses. Sophie Vandermeulen, as a research fellow, acknowledges the support of the National Fund for Scientific Research (Brussels, Belgium).

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