# Use of near infrared spectroscopy for the prediction of nutrient digestibility in poultry

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## Introduction

Digestibility of nutrients is an essential parameter in animal nutrition for the characterisation of raw materials and complete feeds. It represents the proportion of feed actually utilised by animals, and is calculated as the difference between feed intake and fecal output. It is classically assessed by animal trials, or sometimes by prediction equations based on the composition of feeds. Animal trials require measuring the chemical composition of feces, and some authors showed that this heavy analytical work can be done with help of near-infrared (NIR) spectroscopy.[1]

Another approach is the prediction of digestibility directly from the feces NIR spectrum, without reference to feed analysis. This has been tested with some success in ruminants,[2,3] but never in poultry although some intake parameters have been estimated with success in ostriches.[4] This rapid analysis could be useful for research as well as for practical use. The present work aimed at evaluating the potential precision of digestibility prediction by fecal NIRS analysis.

## Materials and methods

The faeces samples originated from experiment on genetic digestion capacity in broilers.[5] These experiments used animals with a high variability in digestion coefficients, including low values out of the classical range. The trials were digestibility studies on individual animals fed with a standardised diet based on wheat, soybean meal and rapeseed oil. Feces samples were freeze dried and ground in a coffee grinder (particle size <1mm) for chemical and NIR analysis.

The parameters studied included digestibility of energy (dEn), starch (dSt) and protein (dProt). They were calculated by difference between feed intake (quantity and composition) and excretion (quantity and composition). Gross energy was determined by combustion with an isoperibol bomb calorimeter (C7000, IKA, 79423 Heitersheim, Germany). Starch was determined enzymatically

as described by Carré *et al*.[6] Protein in feeds was determined by the Kjeldahl procedure, while protein in feces was estimated from the determination of precipitable proteins by lead acetate precipitation described by Terpstra and de Hart.[7]

A total of about 400 samples was used, with 200–350 reference values depending on the parameter. Samples were scanned on a monochromator instrument (Foss Nirsystem model 6500, Silver spring, MD, USA) in reflectance mode between 400 and 2500 nm. Spectra were measured in duplicate (two different cup fillings) and averaged. They were pretreated with second derivative, smoothing and normalisation.

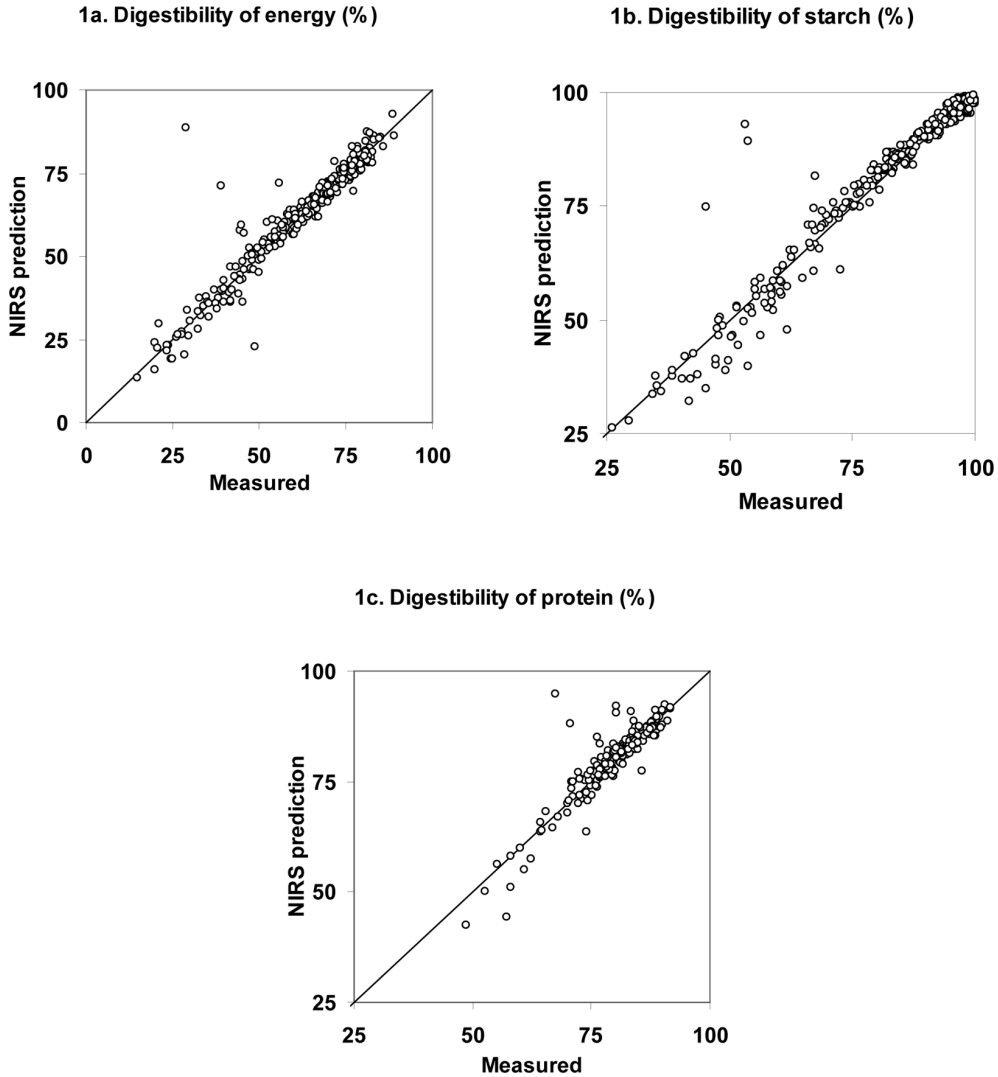


**Figure 1.** Predicted *vs* measured values for digestibility coefficients. (a) Digestibility of energy, (b) digestibility of starch and (c) digestibility of protein.

Calibration equations were developed on WinISI software (Infrasoft Int., Port Matilda, PA, USA) with partial least squares regression (mPLS procedure). Two passes of outlier elimination were used, since the dataset contained values with obvious measurement errors (see Figure 1).

At this stage the equations were evaluated though cross-validation on 4 subgroups.

## Results and discussion

Thanks to the extreme points brought by genetic studies, the population studied was very variable, compared to the usual range of values, and contained some extremely low values (25 % digestibility of starch and energy). This was favourable for NIR calibration. The calibration equations obtained are presented in Table 1.

Equation for digestibility of energy had a coefficient of determination ($R^2$) of 0.98 and *RPD* of 5.4. The comparison between measured and predicted values presented in figure 1a shows the quality of the agreement, but also some outlier values probably due to experimental or analytical errors. Nevertheless the accuracy is not so high as illustrated by the *SECV* of 2.8 %, which is greater than some values published in ruminants (for example, 1.9 to 2.3 % in Decruyenaere *et al*., 2009[3]).

The calibration for digestibility of starch had high $R^2$ and *RPD* values (0.98 and 7.5 respectively). *SECV* was lower than for digestibility of energy. Moreover figure 1b shows that the lowest values have a much higher error than the highest values. Indeed, the restriction of database to values above 70 % (data not shown) reduced the *SECV* to 1.1 %, which is a very precise estimation for an individual digestibility parameter. Digestibility of protein was less well predicted, perhaps because of the smaller dataset (206 samples) and the lower variability of the database. Also nitrogen determination in poultry excreta is complicated because fecal protein is mixed with uric acid of urinary origin. Therefore the calibration of protein digestibility can be biased by spectral confusion between various forms of organic nitrogen.

## Perspectives

This study showed that NIR spectroscopy shows an interesting potential for the estimation of digestibility in poultry. The evaluation of digestibility through faeces spectra does not require the total collection of excreta or measurement of feed consumption. This can lead to simplified protocols in digestibility experiments, as well as reduction of chemical analyses required, and associated costs.

**Table 1.** Calibration parameters for digestibility coefficients.

| Parameter | *N* | Mean | *SD* | *SEC* | $R^2$ | *SECV* | *RPD* |
|---|---|---|---|---|---|---|---|
| Digestibility of energy | 342 | 63.4 | 15.4 | 2.3 | 0.98 | 2.8 | 5.4 |
| Digestibility of starch | 362 | 84.9 | 17.0 | 2.1 | 0.98 | 2.3 | 7.5 |
| Digestibility of protein | 206 | 80.0 | 7.1 | 1.8 | 0.94 | 2.1 | 3.4 |

*N*, Mean, *SD*: description of calibration population.
*SEC*, *SECV*: standard error of calibration, of cross-validation. *RPD* = *SD*/*SECV*.

In the future, the method could be adapted to fresh samples. It could also be a useful tool for early diagnostic of digestibility problems in farms.

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