PRIFYSGOL ABERYSTWYTH UNIVERSITY

Sefydliad y Gwyddorau Biolegol, Amgylcheddol a Gwledig
IBERS ABERYSTWYTH
Institute of Biological, Environmental and Rural Sciences

Prediction of NDF concentration and rumen degradability by Fournier Transform Infrared (FTIR) Spectroscopy

***A. Belanche*[1], G.G. Allison[1], C.J. Newbold[1], M.R. Weisbjerg[2] and J.M. Moorby[1]**

[1]*Institute of Biological, Environmental and Rural Sciences, Aberystwyth, SY23 3EE, UK.*

[2]*Animal Science, Aarhus University, Tjele P.O. Box 50, 8830, Denmark*

Corresponding author: ***aib@aber.ac.uk***

Introduction

The neutral detergent fibre (NDF) concentration of feeds, and its ruminal degradation pattern, help determine the energy supply to the rumen and therefore they are used to describe a feed's nutritional value.

The NDF degradation pattern is generally measured *in situ* as the feed disappearance from nylon bags incubated in the rumen. This is a laborious procedure which is not feasible for routine analysis of feeds used in farm conditions and an alternative (cheaper, faster) method of analysis would be useful. Near infrared spectroscopy (NIRS) has been used successfully to estimate proximate analyses, although a related method (FTIR spectrometry) for this purpose has received relatively little attention.

The aim of this study was investigate the use of FTIR spectrometry to predict feed NDF concentration and its rumen degradability in a range of feeds. We hypothesized that it is possible to develop a global calibration for most forages used for ruminants.

Material and Methods

- **Feeds:** A total of 120 feeds samples (109 forages and 11 non-forages)
- ***In situ* NDF degradability:**
  - **Nylon bags** (38µm pore size) containing 2 g DM were incubated in rumen cannulated cows for 0, 2, 4, 8, 16, 24, 48, 96, 168 and 288h
  - **Degradation profile:**
  - **NDF_{ED}**=NDF effective degradability for 2%/h outflow rate
  - ***b*** = NDF potentially degradable in the rumen
  - ***c*** = fractional degradation rate of fraction *b* (as %/h)
  - ***c*-undegraded** = degradation rate omitting 0h incubations
  - **iNDF** = indigestible NDF after 288h of incubation

FEEDS		Beet products	Barley-wheat whole crop	Maize silage	Legume forage	Grass-clove forager	Soybean hulls	Concentrates
	n	2	26	15	13	55	2	7
NDF (%)	Range	21-22	37-82	38-52	30-74	23-83	69-72	17-37
	Mean ± SD	21±0.5	45±11	43±4	41±12	41±12	71±2	29±6
NDF_{ED} (%)	Range	75-77	32-65	34-39	26-62	23-79	58-60	39-82
	Mean ± SD	76±1	42±7	38±3	40±10	59±14	59±1	58±13
b (%)	Range	93-95	57-93	95-100	43-74	59-95	100-100	48-100
	Mean ± SD	94±1	74±9	98±3	55±9	82±10	100±0	78±19
c (%/h)	Range	8.3-8.7	1.4-5.1	1.1-1.4	3.1-10.2	0.9-13	2.8-3.0	3.4-9.2
	Mean ± SD	8.5±0.2	2.8±1.0	1.2±0.2	5.4±1.9	6.2±2.9	2.9±0.1	5.9±2.3
c-und. (%/h)	Range	8.3-8.7	1.1-5.1	1-1.4	3.1-10.2	0.9-13	2.8-3.0	3.3-9.0
	Mean ± SD	8.5±0.2	2.5±1.0	1.2±0.2	5.0±1.9	6.0±2.9	2.9±0.1	4.9±1.9
iNDF (%)	Range	10-11	8-43	17-31	35-59	5-44	3-3	1.4-49
	Mean ± SD	11±0.03	25±13	23±3	45±7	19±10	3±0.2	20±16

- **FTIR spectrometry**

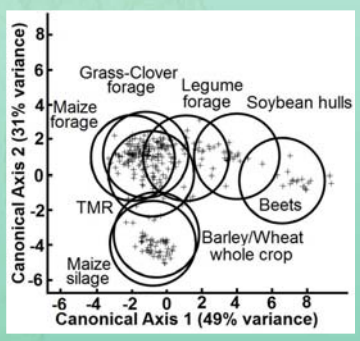
Equinox 55 FTIR spectrometer

Golden Gate ATR accessory

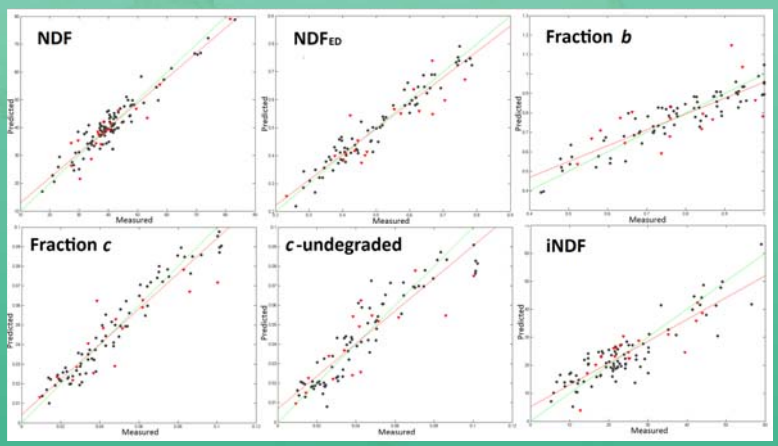
- **Partial leas square (PLS) modelling**
- **Software:** PLS tool box Matlab.
- **Pre-processing:** 2nd derivative, normalization and mean centre
- **Calibration, Cross-validation and Prediction:** independent datasets
- **Indicators of model accuracy:**
- Correlation coefficient (R^2)
- Root mean square error (RMSE)
- Ratio prediction deviation (RPD)
- **VIP scores**: to identify the most relevant wave numbers

Results and Discussion

- **Dataset:** NDF concentration and degradation pattern varied widely between feeds
- **Canonical analysis of variance** of the 10 first principal components (90% of the variance) showed differences in the FTIR spectra between forages. These differences were explored to predict the feeds nutritional value.
- **PLS models**



	Feeds			Calibration		Cross-validation		Prediction		
	Calib.	Test	LV	R^2_C	RMSEC	R^2_{CV}	RMSECV	R^2_P	RMSEP	RPD
NDF (%)	100	20	6	0.90	3.45	0.79	4.97	0.89	4.27	2.84
NDF_{ED} (%)	77	18	7	0.95	3.35	0.81	6.27	0.79	6.52	2.35
b (%)	77	18	7	0.85	5.84	0.62	9.49	0.42	12.1	1.23
c (%/h)	77	18	8	0.94	0.60	0.80	1.14	0.76	1.23	2.25
c –und. (%/h)	77	18	5	0.87	0.91	0.75	1.25	0.68	1.35	2.01
iNDF (%)	90	21	6	0.79	5.36	0.58	7.59	0.67	5.54	2.17



- **VIP scores** revealed the importance of the C-O and C-H stretching typical of carbohydrates (i.e. cellulose, lining, cutin, suberin or starch).

Conclusions

- Substantial differences in the FTIR spectra were detected among the different forage s analyzed
- PLS analysis allowed the development of an accurate universal equation to predict the NDF concentration in most ruminant feeds
- NDF_{ED} and fraction *c* were predicted with a reasonable accuracy and equations could be used for screening proposes
- Fractions *b* and iNDF were predicted with a low accuracy
- Accuracy of these models could be improved by:
  - Discarding concentrates from the model
  - Increasing the repeatability of the in situ method.

This study was supported by the Commission of the European Communities (Rednex project FP7-KBBE-2007-1) and the Welsh Government.

REDNEX