Remote transfer of alfalfa hay calibration models

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Introduction

Some feed companies are achieving high levels of customer loyalty by supplying without charge to their clients nutrition advice and quality control services. For these companies, near infrared (NIR) spectroscopy is contributing to provide reliable information on the nutritive value of feedstuffs much faster and at a lower cost than traditional wet chemical analyses and / or enzymatic techniques. In some cases, the customers of these feed companies are interested in acquiring their own NIR instruments and using the calibration equations developed by their feed suppliers. Because NIR calibration may be very expensive, calibration transfer by feed suppliers is becoming a successful strategy to reinforce customer loyalty. For this reason, the feed companies adopting these strategies are very interested in validating and simplifying the transfer of calibration models.

Materials and methods

The master instrument was a NIRSystems 5000 located at the NUTEGA laboratory in Madrid. The slave instruments were: a NIRSystems 5000 (slave instrument 1) placed at the NIR laboratory of the Animal Production Department of the Polytechnic University of Madrid, and a NIRSystems 6500 (slave instrument 2) at the SERIDA laboratory in Northern Spain. For these instruments, optical values recorded as log $1/R$ were taken at 2 nm intervals over the wavelength range 400-2500 nm and 1100–2500 nm for the NIRSystems 6500 and the NIRSystems 5000, respectively. The NIRSystem 6500 spectra were subsequently trimmed to 1100–2500 nm to allow comparability between the two systems. The chemical and biological parameters selected in this study because of their interest for ration formulation were: dry matter, crude protein, neutral detergent fibre, acid detergent fibre and enzymatic organic matter digestibility. The WINISI software was utilised for the development of the master calibration equations, the determination of standardisation files, the transfer of the calibration equations, and the evaluation of the performance of the different

standardisation methods. Table 1 describes the calibration data set made up by 118 samples of alfalfa hay from Spanish fields collected during 2002 and 2003.

Table 1. Description of the calibration data set (n = 118).

Constituent	Mean	SD	MIN	MAX
DM	90.1	2.09	83.8	94.9
DE	65.9	4.85	49.0	76.9
Ash	11.4	1.82	8.54	18.6
CP	17.7	1.93	12.9	22.6
NDF	42.3	4.91	31.5	57.1
ADF	32.7	4.28	23.3	43.7

Table 2 describes the independent data set used for evaluating the performance of the standardisation and remote transfer processes. This data set consisted of 25 alfalfa hay samples from Spanish fields collected during 2003.

Table 2. Description of the validation data set (n = 25).

Constituent	Mean	SD	MIN	MAX
DM	90.2	1.98	85.6	93.8
DE	65.2	4.45	56.6	73.1
Ash	11.8	1.79	8.50	16.0
CP	18.1	2.11	14.7	23.1
NDF	41.9	4.73	35.0	52.0
ADF	33.6	4.53	27.0	44.0

In previous studies[1–3] it has been shown that the samples used in the standardisation process have an important influence in the quality of the equation transfer. Three standardisation methods are used to evaluate these effects: (1) a sample of alfalfa hay from the calibration set in a sealed cup; (2) the same sample of alfalfa hay in different cups and (3) the standardisation sample set, supplied by ISI,[4] included 30 sealed representative samples of raw materials and feed products used in animal nutrition.

As in Park study,[1] the different procedures used for the standardisation were evaluated and compared by means of a standard error of standardisation (*SES*) defined as the positive root square of the mean of the square of the differences between the predicted values of: (1) validation samples scanned on the master instrument and predicted by the master calibration equation; and (2) validation samples scanned on the slave instrument standardised to the master and predicted by the master calibration equation after remote transfer. The mathematical expression for this statistic can be expressed as:

$$SES = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y}_m - \hat{y}_s)_i^2}{n}} \tag{1}$$

Results and discussion

Table 3 shows the values of the standard error of cross validation (*SECV*) as well as the standard error of prediction (*SEP*) obtained in the validation of the master calibration equations.

Table 3. Evaluation of the accuracy of predictions obtained by using the master instrument.

	Cross-validation		Validation ($n = 25$)
Constituent	N	SECV	SEP
DM	104	0.29	0.38
DE	110	1.77	3.48
Ash	107	0.79	1.44
CP	108	0.65	0.69
NDF	103	1.49	2.76
ADF	109	1.49	2.98

Table 4 summarises the results of comparing the performance of each one of the three standardisation procedures for the two slave instrument.

Table 4. *SES* values obtained for each one of the three standardisation procedures when comparing slave and master predictions.

	Slave1 S1	Slave1 S2	Slave 1 S3	Slave 2 S1	Slave 2 S2	Slave 2 S3
DM	0.29	0.41	0.26	0.60	0.73	0.60
DE	2.17	2.17	2.41	1.98	2.27	2.33
Ash	1.17	0.86	1.26	0.86	0.81	1.09
CP	0.79	0.80	1.20	1.11	1.15	1.55
NDF	2.61	2.28	2.23	2.57	2.27	2.64
ADF	1.88	1.86	1.88	2.07	1.96	2.26

S1 = standardisation by using a single sealed cup
S2 = standardisation by using the same sample in different cups
S3 = standardisation by using a set of 30 sealed samples

Overall, the standardisation performance reached by using a set of 30 sealed samples seems to be lower than the ones reached by using a single sample of alfalfa hay. In the case of dry matter, as it was expected, the use of a sealed cup results in a better performance of the process of standardisation. However, a better performance of the second procedure, the same sample in different cups, was observed for NDF, ADF and ash.

Conclusions

This preliminary study suggests that the simplified standardisation procedure based in scanning the same alfalfa hay sample in different could be a feasible alternative to more expensive and complex procedures. Further research is needed for a better understanding of the cost of the lower accuracy in the prediction of dry matter contents that this procedure provides.

References

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