Prediction of nutrient value on forage paddy rice by near infrared spectroscopy

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Introduction

Efficiency in dairy farm management involves ensuring the most efficient and reliable milk production. To achieve this a feeding strategy is necessary that satisfies the nutritive demands for body growth and maintenance, as well as achieving maximum and stable milk production. Reduction by the dairy farm management of feed costs, which are responsible for more than 45% of the milk production cost, is an important issue. In recent times when the price of feed materials has increased significantly, and high prices have been sustained, it is particularly important to achieve effective feeding. To increase the self-sufficiency rate of food and animal products in Japan, the extension of Japanese forage production is necessary. It is anticipated that the production of forage paddy rice, a cattle feed with nutritive value equivalent to that of imported hay, will increase in the near future. To support the use of forage paddy rice, it is important to establish a rapid and accurate method for determining its feed constituents and nutritive value. It is believed that near infrared (NIR) spectroscopy is able to analyze precisely the constituents of forage paddy rice.[1]

In this study, we examined prediction of digestible dry matter (DDM) and total digestible nutrients (TDN) of paddy rice by NIR spectroscopy in reflectance mode.

Materials and methods

Samples

This study was carried out using a total of 149 samples of forage paddy rice collected from all regions in Japan. Of the TDN sample set 29 samples included 10 varieties: Hamasari, kusahonami, Hoshiaoba, Kusayutaka, Momiroman, Yumetoiro, Hokuriku 184, Fukuhibiki, Saikai No.203 and Supuraisu. These varieties were of known TDN values (*in vivo* TDN)[2,3] and had been used in a digestion trial using dairy cattle. The other samples (DDM sample set) included 54 varieties that represented most of the varieties cultivated in Japan. These samples were dried, and ground to a fine particle size through 1 mm mesh by a cutting-mill, and then submitted for chemical analysis, and the digestion trial. The chemical analysis included moisture and crude ash contents by proximate method.[4]

The digestion trial

Samples (about 0.5 g) of the DDM sample set ($n = 120$) were weighed into filter bags, and inserted into the rumens of dairy cattle (body weight: 530 kg) for 48 hours. Fistulæ had been installed in the cattle during the *in situ* digestion trial. The filter bags were of the F57, 25 µm type (Ankom Technology Corp.). The *in situ* digestion trial was replicated three times, and the the digestion rates of dry matter were measured.

NIR analysis

Of the TDN sample set twenty samples were selected for calibration, and nine samples were used for validation. Of the DDM sample set, eighty samples were used for calibration, while forty samples were used for validation.

Spectra of samples were scanned in the wavelength range of between 400 nm and 2500 nm, by an NIRS instrument model 6500 (Foss NIRSystems, Laurel, USA). The second derivative spectra (gap = 0 nm, segment = 20 nm) and were used to develop calibration equations by partial least square (PLS) regression. The prediction efficiency was evaluated in term of standard error of prediction (*SEP*) values.

Results and discussion

The ranges and averages in values of DDM and *in vivo* TDN of forage paddy rice are given in Table 1.

The values of DDM and *in vivo* TDN in forage paddy rice were 53.2–75.6%, 63.8% and 45.1–57.7%, 51.8%, respectively. The *in vivo* TDN values in forage paddy rice were lower in comparison to the TDN values of corn silage.

In the calibration equation for the DDM value, the multiple correlation coefficient (R) and standard error of calibration (*SEC*) were 0.83 and 2.86%, respectively. As a result of validation, the correlation coefficient (r) and *SEP* values were 0.69 and 2.80%, respectively (Figure 1).

On the other hand, the TDN calibration equation produced results where $R = 0.94$, and the $SEC = 1.17\%$ for calibration set, and $r = 0.97$ and $SEP = 0.87\%$ for validation set (Figure 2, Table 2). The estimated accuracy of TDN in the forage paddy rice by NIR spectroscopy was better than

Table 1. *In vivo* TDN values and DDM values in forage paddy rice.

	Total			Calibration set			Validation set		
	n	Min–Max	Ave	*n*	Min–Max	Ave	*n*	Min–Max	Ave
DDM	114	53.2–75.6	63.8	66	53.2–72.3	62.9	48	56.0–75.6	65.0
In vivo TDN	27	45.1–57.7	51.8	19	45.1–55.0	51.4	8	47.6–57.7	52.8

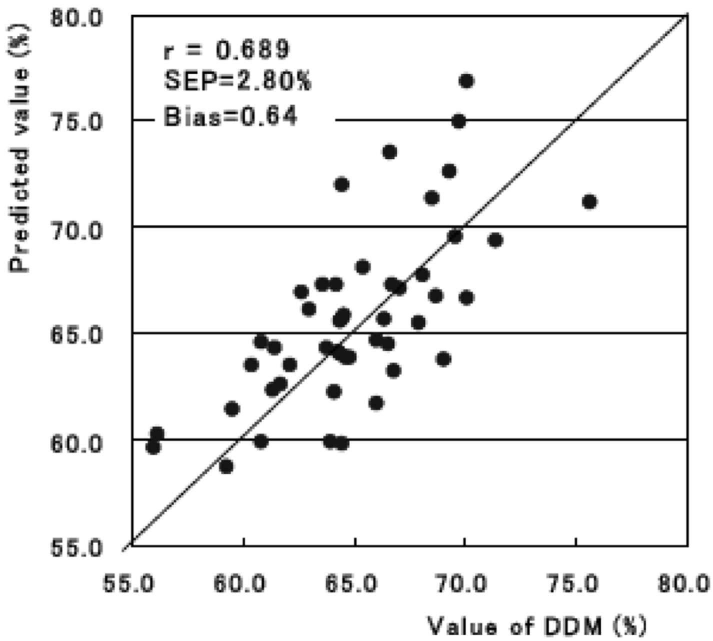

Figure 1. Relationship between digestible dry matter value by *in situ* and NIR predicted value in forage paddy rice.

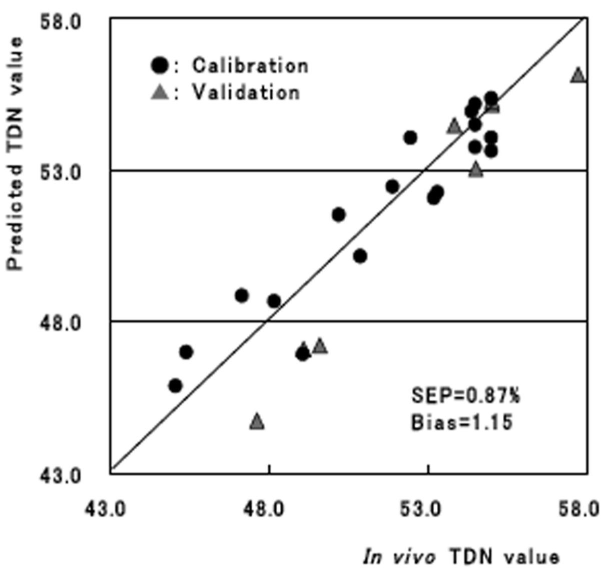

Figure 2. Relationship between *in vivo* TDN value by digestion trial and NIR predicted value in forage paddy rice.

Table 2. Results of calibrations for determining in vivo TDN and DDM values in forage paddy rice.

	Calibration			Validation			
	Factor	*r*	*SEC*	*r*	*SEP*	Bias	*RPD*
DDM	8	0.830	2.86	0.689	2.80	0.64	1.2
In vivo TDN	6	0.944	1.17	0.974	0.87	1.15	4.1

the results obtained for hay and grass silage,[5] and these results showed that the *in vivo* TDN could be analysed by NIR with high accuracy. The results of DDM analysis suggested that NIR spectroscopy had potential for measuring the DDM value of forage paddy rice, but further study on the prediction of DDM is necessary in order to improve the accuracy of the calibration equations.

References

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