ANALYSIS OF PALM KERNEL CAKE BY NEAR INFRARED REFLECTANCE TECHNOLOGY

NORLINDAWATI A.P.*, SHARIFF S., NOORMAH MIW A., SABARIAH B., OMAR R., SAMIJAH A., SUPIE J. AND JAMNAH O.

Institut Veterinar Malaysia, KM 13 Jalan Batu Pahat, Beg Berkunci 520, 86009 Kluang, Johor, Malaysia

* Corresponding author: nor_linda83@yahoo.com

ABSTRACT. The rapid method for predicting palm kernel cake quality with near infrared reflectance spectroscopy was investigated. Chemical tests for moisture, ash, crude protein, crude fat, crude fibre, total digestible nutrients (TDN), nitrogen free extract (NFE), metabolisable energy (ME), calcium and phosphorous were time consuming and involve high cost. This technology can save considerable time by testing all the parameters simultaneously; however accurate calibration of the equipment is essential. Near infrared (NIR) partial least square (PLS) regression models for determination of several palm kernel cake quality parameters were developed from NIRFlex Model N-500 (Buchi). In general, reliable prediction results were obtained for the TDN (SEP = 0.85 r^2 = 0.99), NFE (SEP = 0.42 r^2 = 0.97) and crude protein (SEP = 0.57 r^2 = 0.98) PLS regression models.

Keywords: Palm Kernel Cake, Near Infrared Reflectance Technology

INTRODUCTION

In 2000, Malaysia produced 1.64 tons of palm kernel cake (PKC) as a by-product in the milling of palm kernel oil (Hishamuddin, 2002). This by-product is considered as medium grade protein feed containing approximately 14.6% to 16% of crude protein. Other then protein, PKC also contains approximately 10.6% of crude fat and 16% of crude fibre (Mustaffa *et al.*, 1987 and Chin, 1991). It is often considered suitable for feeding of ruminants (Hishamuddin, 2002). PKC is useful for fattening cattle either as a single feed, with only minerals and vitamins supplement, or mixed with other feedstuffs such as ground maize and soybean meal (Chin, 2001). Since 1999, Institut Veterinar Malaysia (IVM) received a total number of 641 PKC samples. Other than PKC, IVM also received approximately 1,297 varieties of feed samples a year with an average of 9,803 tests carried out per year.

Conventional proximate analysis, routinely conducted on feed samples, is time consuming and expensive compared to near infrared technology which is inexpensive, quick and provide useful information on the composition of feed ingredient (Edney *et al.,* 1994). The near infrared (NIR) instrument works on the principle that each of the major chemical components of a sample has near infrared absorption properties that can be used to differentiate one component with another. The NIR technology definitely provides a solution to reduce the laboratory workload in carrying out proximate analyses. This technology also has been approved by the Association of Official Analytical Chemists (AOAC) for use in determining moisture, Kjeldahl nitrogen and acid detergent fiber for feed and forage analysis (Undersander, 2006).

The objective of the present study is to develop NIR calibrations for predicting nutrient composition in PKC. Parameters studied were moisture, ash, crude protein, crude fat, crude fibre, total digestible nutrients (TDN), nitrogen free extract (NFE), metabolisable energy (ME), calcium and phosphorous.

MATERIALS AND METHODS

Palm kernel cake samples

A total of 312 samples were submitted to Animal Feed Laboratory, IVM from 2006 to 2010. Samples received were considered different due to environmental conditions and consequent variability in PKC quality. Variability is essential for development of meaningful calibrations for NIR equipment (Edney *et al.*, 1994).

Chemical analyses

Crude protein content (*N x 6.25*) was determined by the Kjeldahl method. Crude fibre was determined using Fibertec method using FOSS equipment. Crude fat was determined using Soxtec method (FOSS). Other parameters in proximate analyses were determined according to the methods established by AOAC (2000). Metabolisable energy for ruminant was determined by Menke gas test. Total Digestible Nutrient (TDN) was calculated using the formula according to Devendra (1979). Concentrations of minerals were determined using atomic absorption spectrophotometer.

Spectroscopic analysis

The Near Infra Red equipment used was a NIRFlex Model N-500 (Buchi), in conjunction with NIRCal® software version 5.1 and NIRWare® Management software (Buchi). Reflectance NIR spectra were recorded over the range 4000-10000 cm^{-1} (400-1000 nm) at 4 cm^{-1} interval. Approximately 25.0 g of ground PKC samples was placed into a glass Petri dish and spread evenly to cover the surface of the Petri dish.

Data analysis

Calibration was carried out by using NIRCal® software version 5.1. Partial least squares (PLS) regression was used to build the calibration models. Two-thirds of the samples were randomly selected as the calibration set and the rest one-third of the samples were used as the validation set.

RESULTS AND DISCUSSION

Reference data

The descriptive statistics of the sample sets for each respective parameter used for PLS regression model development are summarized in Table 1.

Evaluation of regression models

In developing calibrations for moisture, ash, crude protein, crude fat, crude fibre, total digestible nutrients, nitrogen free extract, metabolisable energy, calcium and phosphorous, PLS regression was employed. The results of PLS regression

Table 1. Summary of descriptive statistics for the reference values

	Calibration set				Validation set			
Parameter	*n*	Range	Mean	*SD*	*n*	Range	Mean	*SD*
Moisture (%)	183	4.11 – 8.75	6.67	0.99	62	4.02 – 10.59	6.69	1.15
Total Ash (%)	229	2.77 – 16.3	8.32	3.81	72	3.36 – 16.1	8.22	3.76
Crude Protein (%)	238	8.49 – 18.26	14.39	2.94	80	8.72 – 18.18	14.39	2.99
Crude Fat (%)	221	1.49 – 9.63	4.01	1.89	73	1.48 – 9.45	3.79	1.69
Crude Fibre (%)	172	11.34 – 27.59	19.59	3.65	54	11.43 – 25.99	19.82	3.37
TDN (%)	94	48.76 – 78.32	62.04	8.10	32	49.00 – 77.80	61.78	7.89
NFE (%)	125	41.92 – 61.91	51.51	5.36	41	42.11 – 61.74	51.93	5.28
ME (MJ/kg)	182	5.21 – 12.17	9.56	1.71	61	5.57 – 12.13	9.58	1.68
P (%)	178	0.15 – 0.77	0.43	0.14	60	0.15 – 0.72	0.43	0.14
Ca (%)	163	0.09 – 2.47	0.85	0.57	55	0.24 – 2.29	0.89	0.61

SD = Standard deviation

Table 2. Prediction results for the optimised PLS regression models

Parameter	*SEP*	r^2	*Bias*	*RPD*
Moisture (%)	0.57	0.89	0.0627	2.01
Total Ash (%)	0.84	0.96	0.0274	4.48
Crude Protein (%)	0.57	0.98	0.0369	5.23
Crude Fat (%)	0.51	0.95	0.0326	3.31
Crude Fibre (%)	0.99	0.96	0.0923	3.40
TDN (%)	0.85	0.99	0.0502	9.28
NFE (%)	0.72	0.99	-0.0231	7.33
ME (MJ/kg)	0.42	0.97	0.0125	4.00
P (%)	0.05	0.93	-0.0043	2.80
Ca (%)	0.20	0.95	0.01	3.00

SEP (Standard error of prediction); RPD (Ratio Performance Deviation) = $SD_{validation}\ SEP^{-1}$

model prediction are shown in Table 2. The prediction results of this study included extremely low and high reference values. The calibration should be improved further if all the extreme reference values are excluded.

According to the *Ratio Performance Deviation (RPD)* values ($SD_{validation}$ SEP^{-1}), the models for the TDN and NFE are quite excellent and would be applicable for any applications; crude protein value model is good and suitable for quality control purposes. However, *RPD* values for total ash, crude fibre, metabolism energy and crude fat can be classified as fair and applicable for screening only. The moisture, calcium and phosphorus value models performed poorly with this instruments and it is questionable whether these parameter will be applicable for NIR regression models.

CONCLUSION

Prediction data has been successfully developed for predicting the nutrient composition of PKC. However, to maintain the quality of the data, calibration had to be altered each year in order to predict the nutritional values of the new PKC batches. Calibrations of the other feedstuff are also recommended, because this technology has been proven as a rapid, reliable and low-cost method to analyze feed quality.

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