Near infrared spectroscopy analysis of fat and moisture contents of Thai coconut milk

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Introduction

The determination of the principal milk constituents is a key issue for different products in the coconut milk industry and marketing. The standard methods for determination of total fat and moisture content involve detailed sample preparation, and dangerous reagents. Also they are expensive and time-consuming. NIR spectroscopy was examined as a possible replacement for the standard methods. NIR spectroscopy has been shown to be effective in determination of organic compounds in food and natural products, as well as in other agricultural products.[1] In emulsion products, especially in the dairy industry, NIRS had been widely used to determine the composition of major constituents in milk, skim milk, fermented milk, cheese and butter.[2,3] Furthermore, NIRS was an effective tool for monitoring cheese coagulation[4] and has been used for measuring casein in oil/water emulsion systems.[5] The objective of the present study was to develop models to predict quality parameters (fat content and moisture content) of coconut milk, by visible and NIR spectroscopy.

Materials and methods

Samples

One hundred and fifty samples of coconut milk were purchased from local markets and hypermarkets around Kasetsart University, Bangkok, Thailand. In this research, every type of coconut milk was purchased three times. All samples were purchased during 2008 and stored at –18 °C before measuring the properties. Before measurement of the NIRS and chemical properties, the coconut milk samples were heated to 45 °C and homogenized at 2500 rpm for 90 s.

Chemical measurements

The total fat content was determined by the standard method (AOAC 989.05 for milk) and the moisture content was determined by AOAC method 990.20 for milk. All physicochemical

measurements were determined in triplicate and the mean values of the triplicate measurements were calculated, and used as reference data in calibration model development.

Spectral acquisition

The coconut milk samples were scanned in reflectance mode from 400–2500 nm at 0.5 nm intervals, using a single beam monochromator (rapid content TM Analyzer XDS near infrared, FOSS, USA.) and a 0.5 mm path-length smart probe. The spectral data were exported into Vision software version 3.1.1, and Unscrambler software version 8.0: CAMO AS, Trondheim, Norway.

Model analysis

Data from both NIR spectra and chemical analysis were used to develop the quantitative models. PLS regression was used to construct the models, using Vision software and the Unscrambler software. NIR reflectance spectra from one hundred and fifty coconut milk samples were divided into two sets for model development. The calibration set and validation set consisted of 105 samples and 45 samples, respectively. Because of significant noise in the range 2301–2500 nm for all the spectra, only the spectral range of 400–2300 nm were used for analysis. The original spectra were pretreated with S.Golay smoothing, standard normal variance (SNV) and second derivatives before the calibration equation was developed, using partial least square (PLS) regression. Model performance statistics reported included the correlation coefficient (R^2), standard error of calibration (*SEC*), standard error of prediction (*SEP*) and ratio between SEP and standard deviation of reference data in the validation set (*RPD*).

Results and discussion

The chemical composition of the coconut milk samples ranged from 5.35 – 32.00 % in fat content, and from 60.41 – 92.67 in moisture content (Table 1).

The spectra of coconut milk are shown in Figure 1.

In the visible range, the PLS model for fat content was good enough for prediction, but not so good as the NIR range (Table 2).

In the NIR region, the PLS models had excellent statistics for the prediction of fat content. The model showed an r^2 value of 0.929, *SEC* of 0.712, and a *SEP* of 1.404, in the wavelength range of 701–2300 nm, using nine PLS factors. Results for the prediction of moisture content showed a similar pattern. Prediction of moisture content was good in the visible range (400–700 nm) with a

Table 1. Composition characteristics of coconut milk samples in visible and NIR calibration and validation sets.

Item	Calibration set ($n = 105$)			Prediction set ($n = 45$)		
	Mean	*SD*	Range	Mean	*SD*	Range
Fat content	18.68	13.32	5.35– 32.00	19.56	10.98	8.58 – 30.53
Moisture content	76.54	16.13	60.41 – 92.67	75.34	13.29	62.05 – 88.64

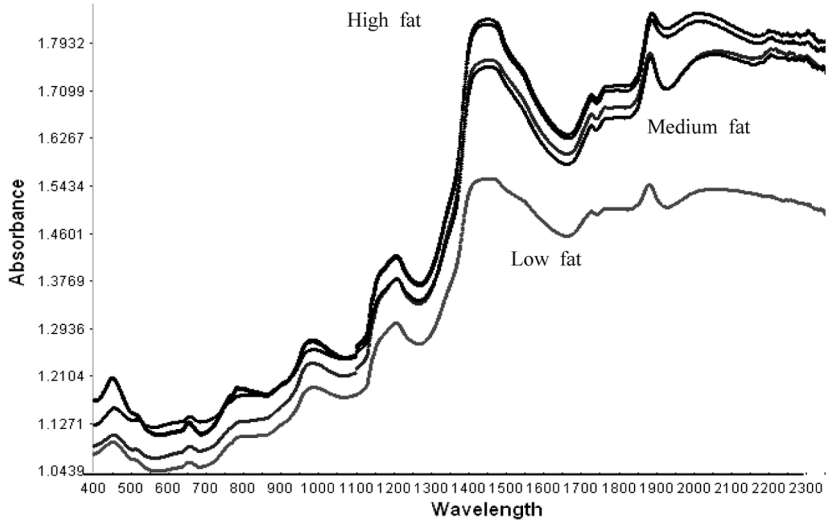

Figure 1. Reflection spectra of coconut milk samples in visible and NIR ranges.

value for r^2 of 0.985, but results were better in the wavelength range of 701–2300 nm, where the correlation coefficient was 0.993 and the *SEP* was 1.358, using eight PLS factors. These results showed that fat content and moisture content could be determined by NIR spectroscopy well enough for use in the coconut milk industry.

Conclusion

In our experiments the NIR spectroscopic technique has a very short time per test, requires minimum to no sample preparation, and was able to predict fat and moisture contents accurately, using PLS regression calibration models. The technique is considered to be satisfactory for the

Table 2. Chemical properties and PLS model performance for fat content and moisture content of coconut milk.

Parameter	Regression	Wavelength (nm)	*F*	R^2	*SEC*	*SEP*	*RPD*
Fat content (%)	PLS	400– 700 nm	9	0.896	1.230	2.348	4.67
		701–2300 nm	9	0.929	0.712	1.404	7.81
Moisture content (%)	PLS	400–700 nm	8	0.985	0.489	1.618	8.21
		701–2300 nm	8	0.993	0.387	1.358	9.78

F: The number of factors, R^2: Correlation Coefficient, *SEC*: Standard error of calibration, *SEP*: Standard error of prediction, bias and *RPD*: The ratio of standard deviation of reference data in the validation set to *SEP*.

prediction of fat and moisture content in coconut milk, two measurements that are important in the quality of the milk, and could become a valuable analytical tool for the industry.

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