Near-infrared optical characteristics for estimating the pork loin freshness

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Abstract

NIRS (Near-infrared spectroscopy) was applied on meats to characterize properties without chopping in pieces, boiling, dissolving in solvents. Analysis of optical, especially near-infrared data from meats is a promising technique for large-scale meat quality evaluation. Meat freshness is an important parameter for consumers to purchase the meat in terms of quality. In this study, near-infrared (NIR) spectra ranges of 950~1650nm were used for the freshness measurement of pork loin. Volatile basic nitrogen (VBN), thiobarbituric acid (TBA) and total microbes (TM) were used as indicators to estimate the freshness. Fifty loin muscles from ten independent batches were stored at 5±1°C. NIR spectra and the freshness parameters were measured during 18 days of storage at 4 days interval. Pre-processing of NIR spectra was conducted before the statistical analysis. Principal component regression (PCR) and partial least square regression (PLSR) were used as calibration and validation for models to predict the parameters from the near-infrared spectra. Concerning number of variables used for model development, models by PLSR were reasonable for estimating VBN, TBA, and TM of pork. The coefficient of determination between spectra and each parameter by PLSR showed 0.8212, 0.5895, and 0.7804 with standard error of cross validation (SECV) of 2.11, 0.13, and 0.79, respectively on VBN, TBA, and TM. Therefore, the freshness of pork loin can be predicted most closely by estimating VBN using near-infrared spectroscopy.

Introduction

Since introduction of NIRS (near-infrared spectroscopy) for measuring moisture in grains, in the 1960s, the number of NIRS-aided analytical applications has been greatly expanded. The technology relies on the differential absorption of energy in certain segments of the spectral range between 900 and 2500nm, by various chemical bonds.

Rapid screening techniques to determine quality characteristics of meat are in great interest. Estimating freshness of meats has problems to be executed out side of laboratory. However, if optical sensor system such as near-infrared spectroscopy was used, nondestructive and real-time analysis could be conducted.

The system developed in this study is a quantitative analysis method for predicting freshness index such as volatile basic nitrogen (VBN), thiobarbituric acid (TBA) and total microbes (TM) of pork loin using near infrared spectra.

Materials and methods

Fifty pork loin muscles from ten independent batches of pigs were acquired from a local slaughterhouse to get fresh ones. The samples were sliced to 1.5±0.1cm thick, air-packed into LDPE packaging material separately, and stored at 5±1°C in the air. Ten samples from each independent batch were taken out for each experiment. The NIR spectra were measured by SNIR106 (Control Development, Inc) wavelength of 892-1692nm. Optic fiber was used for transfer the optical signals from the source to sample and reflectance NIR spectra from sample to spectrometer. Probe holder was manufactured to correct the contact angle of optic fiber probe on sample, to minimize pressure variation and also to prevent optical noise mixed in reflectance signal from sample during the measurement. Figure 1 is the image of the experiment apparatus.

For reflectance spectra have error factors caused by instrumental reason, sampling time and fixing reference, pre-process was conducted to reduce the effects. Spectra were cut off and 950-1650nm range was used for analysis. Reflectance spectra were transferred to absorbance, smoothing and averaging in 5nm. Analysis spectra were transferred to first order derivative and calibration model was developed using Matlab 6.1 and PLS_Toolbox 2.1.

Figure 1. System of measuring NIR reflectance spectrum on pork loin.

Each experiment was conducted at four-day intervals over eighteen days. Chemical and microbial properties such as VBN (Bae et al., 2006), TBA (Witte et al., 1970) and TM were measured at the same samples which spectra were taken. These indicators were monitored and evaluated to find relations on storage days of pork loin by the mean of freshness.

Results and discussion

Freshness indicators have shown that TM, VBN and TBA values increased with storage days. By the results of indicators transition by storage it was reasonable to develop freshness sensor based on those factors.

Figure 2(a) is the absorbance spectra which were transferred from reflectance spectra. 140 samples on wavelength from 950 to 1650nm were used for analysis. The absorption peaks at 1000 and 1400nm rely on third and second overtone bands of the OH group and peak around 1200nm rely on the second overtone of the CH group which is related to constituents such as fat, fatty acid, proteins, and amino acids (Bae et al., 2006). It shows uniform tendency and proved from first derivative spectra on figure 2(b). It gave significant peaks at 1140nm, 1330nm and 1370nm.

Table 1 summarizes the results of model predicting VBN, TBA and TM by PCR and PLSR. PCR results showed a high correlation on model validation but it had less correlation on calibration and also

needed more variables to develop high correlated model than PLSR. On the side of standard error, PLSR showed less error in calibration but more in validation. As a result, PCR model was relevant to predict each freshness indicators especially on VBN and TM.

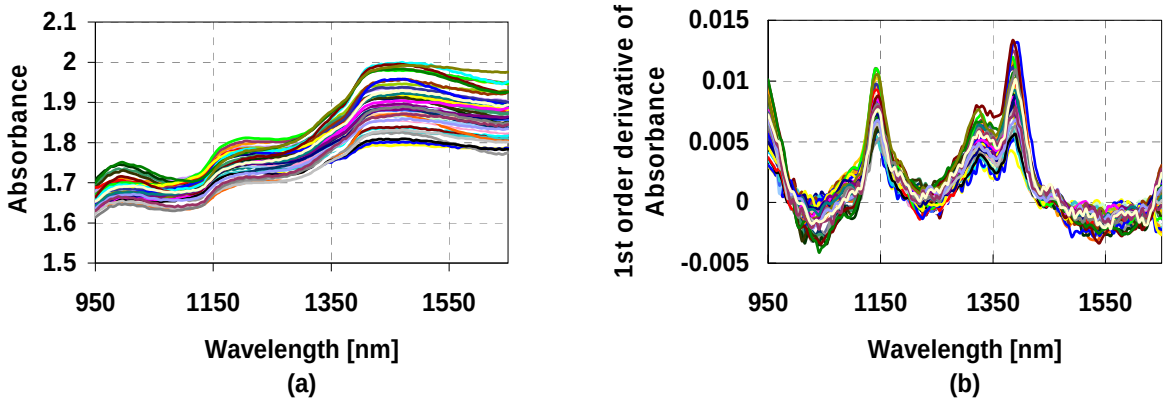

Figure 2. Absorbance spectra transferred from reflectance(a) and 1st derivative of absorbance(b).

Table 1. Comparison of prediction performance between PCR and PLSR analysis

	VBN		TBA		TM	
	PCR	PLSR	PCR	PLSR	PCR	PLSR
Calibration R^2	0.9198	0.9503	0.6659	0.8531	0.9238	0.9140
Validation R^2	0.8335	0.8212	0.6566	0.5895	0.7927	0.7804
SEC	2.04	1.26	0.14	0.08	0.69	0.53
SEP	2.03	2.11	0.11	0.13	0.76	0.79

Conclusions

Three freshness indicators (VBN, TBA and TM) were based to build model estimating freshness of pork loin. They showed the correlation with storage days. NIR reflectance spectra wavelength of 950-1650nm were measured from samples and transferred to absorbance; smoothing and first derivative were conducted. PCR and PLSR were used to develop model to predict freshness and validated. PCR had more relevant result on predicting VBN and TBA. VBN had 0.8335, 2.03 and TM had 0.7927, 0.76 as validation correlation and SEP, respectively.

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