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Using near infrared spectroscopy to predict the physical traits of *Bos grunniens* meat

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A B S T R A C T

The purpose of the current study was to evaluate the use of near infrared spectroscopy to predict the physical traits of yak (*Bos grunniens*) meat. Near infrared spectra data of *M. longissimus thoracis* from 162 yaks were collected, as well as physical traits data. Prediction models of physical traits using near infrared spectroscopy were established through partial least squares regression (PLSR) combined with mathematical pretreatments such as orthogonal signal corrections (OSC) and detrending corrections (DT). The coefficients of determination of calibration (R^2_C) of prediction models were higher than 0.6 except WBSF. The ratio performance deviation for a* and b* values and their derived values SI and HA exceeded 2.0, which are suitable for screening. Through modeling separately for steers and heifers, we found that prediction ability for cooking loss would be increased but for b* would be decreased. Conclusively, near infrared spectroscopy is useful for predicting physical traits of yak meat and could be a potential tool for monitoring beef quality of the yak.

1. Introduction

China has a population of more than 16 million yak (*Bos grunniens*). They are distributed throughout Tibet, Sichuan, Yunnan, Guangxi, Qinghai and Gansu and account for approximately 95% of the world's yak population. Yak meat is a potential new resource for the meat industry in China. It is high in protein, low in fat and has a unique flavor. However, the commercial potential of yak meat is limited due to a lack of data regarding meat quality. The physical traits of meat are closely related to consumer preferences (Hoffman, 2006; Hoffman, Kroucamp, & Manley, 2007; Hoffman, Mostert, Kidd, & Laubscher, 2009; Hoffman, Muller, Cloete, & Brand, 2008). Physical traits, such as tenderness, water holding capacity (WHC) and chromatic features are major factors that influence the purchasing decisions of consumers (Kuchtík, Zapletal, & Šustová, 2012; Mora, Curti, Vittadini, & Barbanti, 2011; Oliete et al., 2006; Polidori, Cavallucci, Beghelli, & Vincenzetti, 2009; Sekar, Dushyanthan, Radhakrishnan, & Babu, 2006) and are widely used for evaluation of meat quality. It is helpful for collecting data regarding yak meat quality in China to establish a rapid method of the physical traits.

Conventional methods for measuring the physical traits of meat such as Warner-Bratzler shear force (WBSF) and cooking loss are destructive and time-consuming making them impractical for large-scale use. Near infrared spectroscopy (NIR) could be a potential tool for analyzing yak meat quality on a large scale since it is quick, non-destructive and inexpensive. NIR has been previously proven to be useful for predicting the chemical composition (Alomar, Gallo, Castañeda, & Fuchslocher, 2003; Prieto, Andrés, Giráldez, Mantecón, & Lavín, 2006; Viljoen, Hoffman, & Brand, 2007) and physical traits (De Marchi, 2013; De Marchi, Berzaghi, Boukha, Mirisola, & Gallo, 2007; De Marchi, Penasa, Cecchinato, & Bittante, 2013) of meat. In fact, predicting models have been previously established for many meat quality characteristics. However, the NIR predicting model, based on data from other cattle breeds, may not apply to the yak. Therefore, an NIR predicting model for the physical traits of yak meat is needed.

The purpose of present study was to evaluate the use of NIR for predicting the physical traits of yak meat, including WBSF, cooking loss, press loss, chromaticity coordinates (L*, a*, b*), hue angle and saturation index of meat from the *longissimus thoracis* of yaks, in order to provide experimental evidence and a basis for the application of NIR in quality assurance related to yak meat.

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2. Materials and methods

2.1. Animals and sampling method

One hundred and sixty two yak (*B. grunniens*) from Gansu, Sichuan and Tibet regions of China, including 85 steers and 77 heifers, were used in this study. The animals were raised on local native pasture and slaughtered in 9 batches between July 2012 and October 2013. The average live weight of animals was 296.2 ± 58.1 (SD) kg, the average carcass weight was 161.2 ± 45.6 (SD) kg and the average age was 4 ± 0.5 (SD) years. Animal transport and slaughtering was approved by the National Administration of Cattle Slaughtering and Quarantine regulations.

The *M. longissimus thoracis* was removed from the left sides of all carcasses which were quartered at the 11th rib, 24 h postmortem. Near infrared spectra were collected 2 min after the samples were cut; 50 g of *M. longissimus thoracis* was used from each carcass. The rest of the samples from each carcass were vacuum packed and aged to 7 days at 0 °C for measurement of WBSF, cooking loss, press loss, L*, a*, b*, hue angle and saturation index.

2.2. Near infrared spectra collection

Each 50 g sample of *M. longissimus thoracis* was homogenized by a variable speed blender (LB20ES blender, Waring Conair Corporation, Stamford, Connecticut, USA) 2 min after collection, prior to NIR. Near infrared spectra were collected on homogenized samples using an NIR spectrophotometer (SupNIR-1500, Focused Photonics Inc., Hangzhou, Zhejiang, China), equipped with a scanning head. The detection waveband ranged from 1000 to 1800 nm and measurements were taken in one nm increments. Twenty spectra were collected for each sample. Inconsistent spectra were removed and the remaining spectra were averaged. A total of 801 NIR spectra data points were stored as log (1/R) with R indicating the reflectance. Data collection and analysis were done using CM 2000 software (Version 1.0, Focused Photonics Inc.).

2.3. Physical traits measurements

Physical traits of the 162 meat samples were evaluated after the meat had aged for 7 days at 0 °C. A 100-g section of meat from each sample was used to measure WBSF and cooking loss. Meat was cooked in a retort pouch, in a heated water bath, to a center temperature of 70 °C. The temperature was monitored continuously via a stabbing temperature probe. Cooking loss was calculated using the difference in weight before and after cooking. Three cores (1.27 cm in diameter), parallel to the longitudinal orientation of the muscle fibers, were removed from each cooked sample using a portable coring device. A shear machine (C-LM, Northeast Agricultural University, Harbin, Heilongjiang, China) was used to shear the center of each core, perpendicular to the longitudinal orientation of the muscle fibers, for determination of WBSF. Particular care was taken to avoid fat or connective tissue at the point of shearing. The average of the three measurements of shear force was taken as the reference value for WBSF.

A 50-g section of raw meat from each sample was used to measure meat color and press loss. Meat color defined as L* (lightness), a* (redness) and b* (yellowness) was measured after exposure to air for 45 min using a portable colorimeter (CR-13, Konica-Minolta Sensing Inc., Japan), as described by Cecchinato, De Marchi, Penasa, Albera, and Bittante (2011). Saturation index (SI) was calculated using the formula $SI = (a^{*2} + b^{*2})^{1/2}$ and the hue angle (HA) was calculated from the formula $HA = \tan^{-1}(b^*/a^*)$. The variables L*, a*, b*, SI and HA were measured 5 times each and the measures were averaged before statistical analysis. After measurement of meat color, the same meat samples were used for measurement of press loss as described by Prieto, Andrés, Giráldez, Mantecón, and Lavín (2008).

2.4. Data analysis

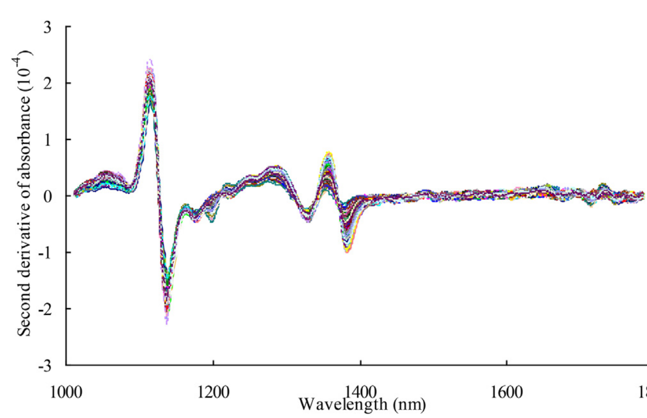
The descriptive statistics of measured value of physical traits include range, mean, standard deviations (SD) and coefficients of variation (CV). SD can be calculated by dividing sum of squares of deviations by degree of freedom and then extracting the root.

Calibration and validation procedures were performed using the software CM 2000 (version 1.0, Focused Photonics Inc). Samples with Mahalanobis distances higher than 3.0 standardized units from the mean spectrum were excluded as these were considered to be global H outliers. Data pre-treatments, such as first-order derivatives (D1), orthogonal signal corrections (OSC) (Khanmohammadi et al., 2014) and detrending corrections (DT) (Rivero, Valderrama, Haines, & Alomar, 2012), were used to improve the accuracy of calibration. Partial least square regression type I (PLSR1) was used to build the NIR spectra prediction model for the physical traits of yak meat. The samples are randomly divided into calibration set (85%) and test set (15%). Prediction models are built by using calibration set and then validated by using test set. The accuracy of prediction was evaluated via coefficient of determination of calibration (R^2_C), standard error of calibration (SE_C), coefficient of determination of validation (R^2_V), standard error of validation (SE_V) and RPD, ratio performance deviation (RPD). SE_C and SE_V can be calculated by dividing sum of squares of deviations between reference and predicted value by degree of freedom and then extracting the root for calibration set and test set, respectively. RPD is calculated as SD/SE_C. Meanwhile, in order to evaluate the effect of gender on prediction performance, we also carry out the calibration and validation for heifers and steers, respectively.

3. Results

3.1. NIR spectra information

The NIR spectra information from *M. longissimus thoracis* meat of 162 yak is shown in Fig. 1. The screening wavelength used in present study ranged from 1000 to 1800 nm. There are minimum and maximum of second derivative of absorbance in the waveband



[a] The 162 *bos grunniens* used in present study included 85steers and 77 heifers.

Fig. 1. Average, maximums and minimums of absorbance of NIR spectra obtained from meat of *M. longissimus thoracis* of yak (n = 162[a]).