

NIR Spectroscopy for determining soy contents in processed meat products

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Introduction

Soy protein products such as soy concentrate, soy protein and soy grits are widely used in processed meat, poultry and seafood products to perform specific functions such as texture forming, gelation, fat and water binding and emulsification.¹ However, soy protein allergy is one of the common food allergies, especially in infants and young children, and can be mild to life-threatening.² The United States Department of Agricultural (USDA)-Food Safety Inspection Service (FSIS) has been routinely requested to determine soy contents in further-processed meat products, such as ground meat, meat patties and frankfurters. Currently the analytical method used to determine soy contents is time-consuming (about 4 hrs) and lacks in accuracy. This study was conducted to develop a rapid NIR spectroscopic method to predict soy contents in meat products.

Materials and Methods

Sample preparation

Ground beef (93%–87% lean meat) was purchased in a retail store. Four different soy products powder including Toasted Soy Grits, Arcon T U-172 Soy Protein Concentrate, Pro-Fam H200 Hydrolyzed soy protein and Textured vegetable protein (TVP U-218 Minced 180) were prepared. Ground beef samples were reground using a grinder and mixed with soy products in plastic bags, providing a range of soy contents from 0 to 30%. A total of 68 mixture samples were prepared for this study.

NIR spectroscopy

Samples were packed in a round cell having a quartz window (38 mm diameter, 10 mm depth) and scanned on a NIR spectrometer (NIRSystems 6500, FOSS NIRSystems, Inc., Laurel, MD). Spectral data were collected in a diffuse reflection mode over a range of 400 to 2498 nm at 2 nm

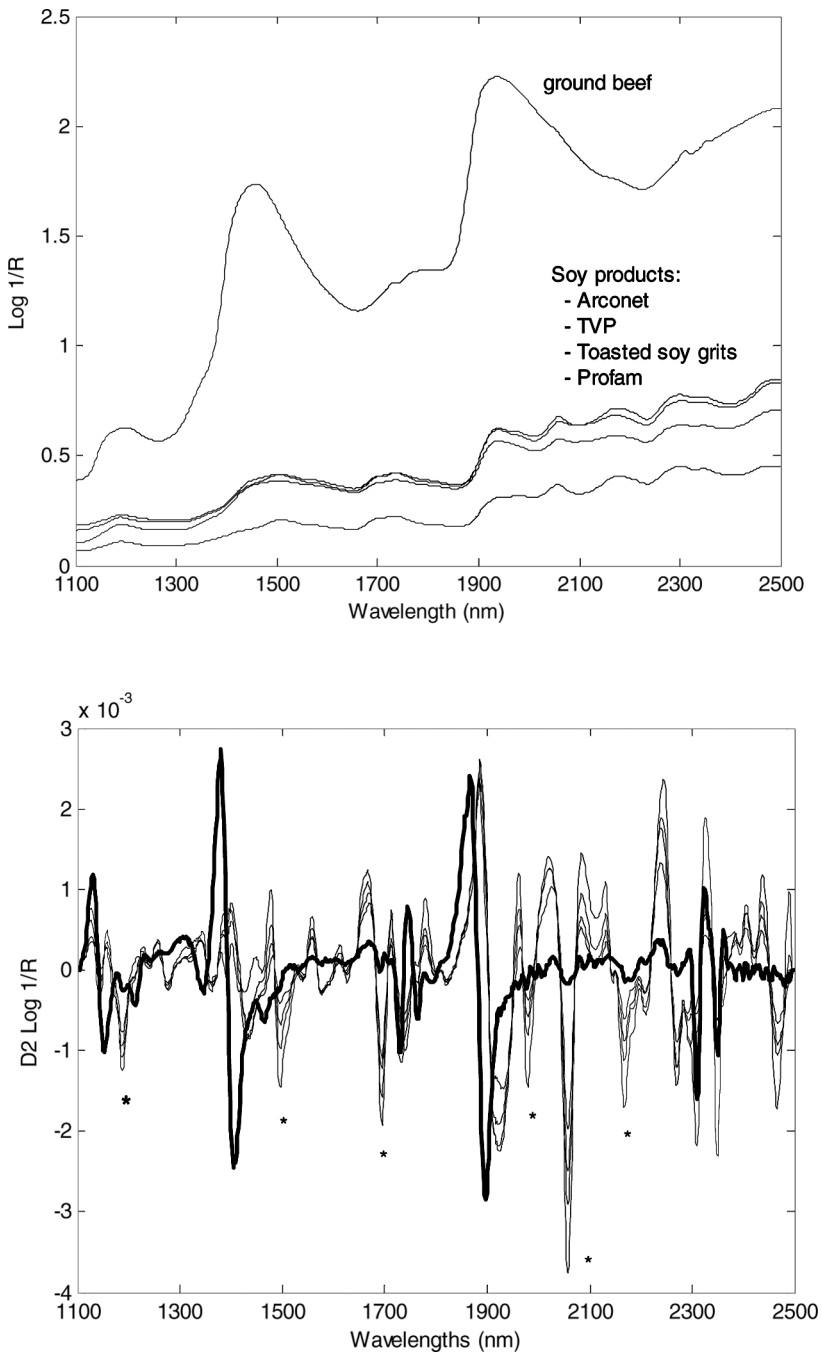


Figure 1. NIR raw spectra (upper) and second derivative spectra (lower) of pure ground beef and pure soy products. The soy products have sharper peaks at 1187, 1496, 1694, 1978, 2056, 2166 nm.

Table 1. PLS models for predicting soy contents in beef-soy product mixtures.

Model	Soy products used	Number of samples	LV	R ²	RMSEC	RMSECV
I	Arconet	17	3	0.99	0.38	0.72
II	Toasted soy grits	17	4	0.99	0.24	0.66
III	Profam	17	3	0.99	0.42	0.73
IV	TVP	17	3	0.99	0.50	0.90
V	Total	68	3	0.99	0.75	0.89

intervals using WinISI software (ver. 2.01, Infrasoft International Inc., Port Matilda, PA) and truncated to 1100 to 2498 nm for analysis. Triplicate spectra were collected from separately packed cells on each sample and then averaged.

Data processing and chemometrics

All spectral data collected were imported into Matlab (ver. 7.3, Mathworks, Inc., Natick, MA, USA) and analyzed using PLS_Toolbox software (ver. 4.0, Eigenvector Research, Inc., Manson, WA, USA). Partial least squares regression (PLSR) with full leave-one-out cross-validation was used for model development. Performance of each PLS model was reported as a multiple coefficient for determination (R²), root mean squared error of calibration (RMSEC) and root mean square error of cross-validation (RMSECV).

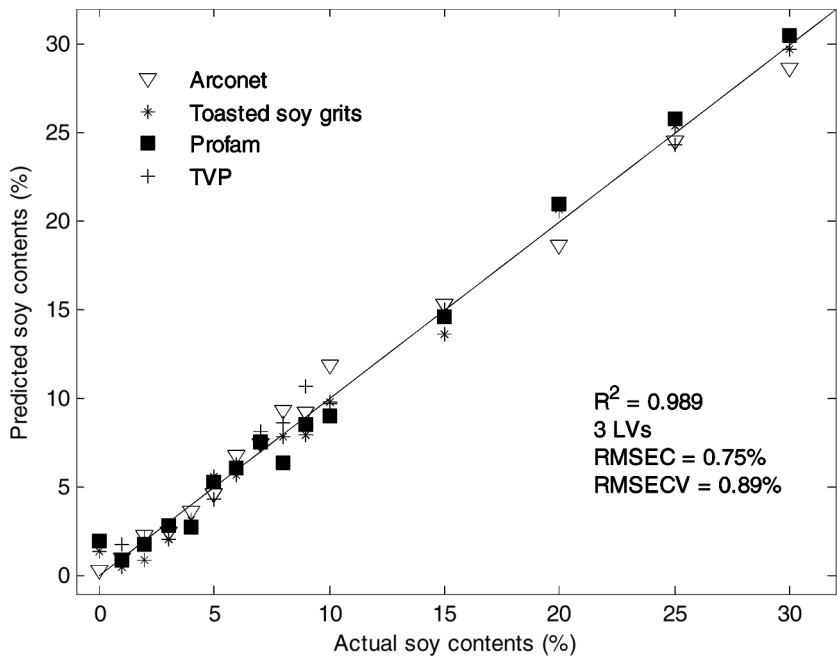


Figure 2. NIR predicted vs. actual contents of soy product in ground beef by PLS model V.

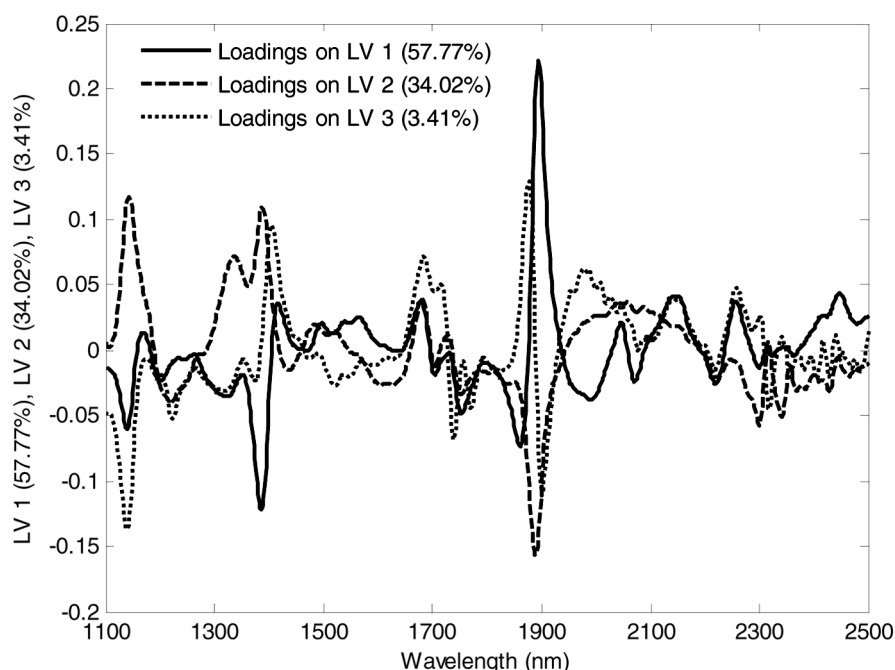


Figure 3. Loading plots for the PLS model V.

Results and discussion

Figure 1 shows the NIR raw spectra and second derivative spectra of the ground beef and four soy products used in this study. The soy products had sharper peaks at 1187, 1496, 1694, 1978, 2056 and 2166 nm, which are assigned to the N-H stretching mode and amide of protein.³ Table 1 summarizes the PLS regression results of the models for the individual soy product set and total set, respectively. All PLS models were developed using the spectral data pretreated with Savitzky-Golay first derivative (3rd order polynomial and 11-point convolution intervals) followed by MSC and mean centering, which provided the best performance for the models. For each soy product set ($n=17$), the PLS models (I-IV) resulted in an R^2 over 0.99 and RMSECV of 0.66 to 0.90% using 3–4 LVs. For the total sample set ($n=68$), the model (V) gave an R^2 of 0.99 and a RMSECV of 0.89% using 3 LVs, showing a good precision. The scatter plots of NIR predicted versus actual soy contents in beef-soy product mixtures by the model V were presented in Figure 2. The accuracy of the model could be improved by preparing homogeneous samples. Loading plots (Figure 3) show that the most highly correlated wavelengths for the model were around 1180, 1700, 2050 nm (1400 and 1900 nm are water bands), which correspond with the peaks in Figure 1.

When the second derivative spectra of the samples with varying soy product contents (0 to 30%) are compared, systematic changes in absorbance were clearly observed at 1694, 2056 and 1187 nm (Figure 4). From the results, it was indicated that NIR spectroscopy could be used to predict soy contents in further-processed meat products with less than 1% error.

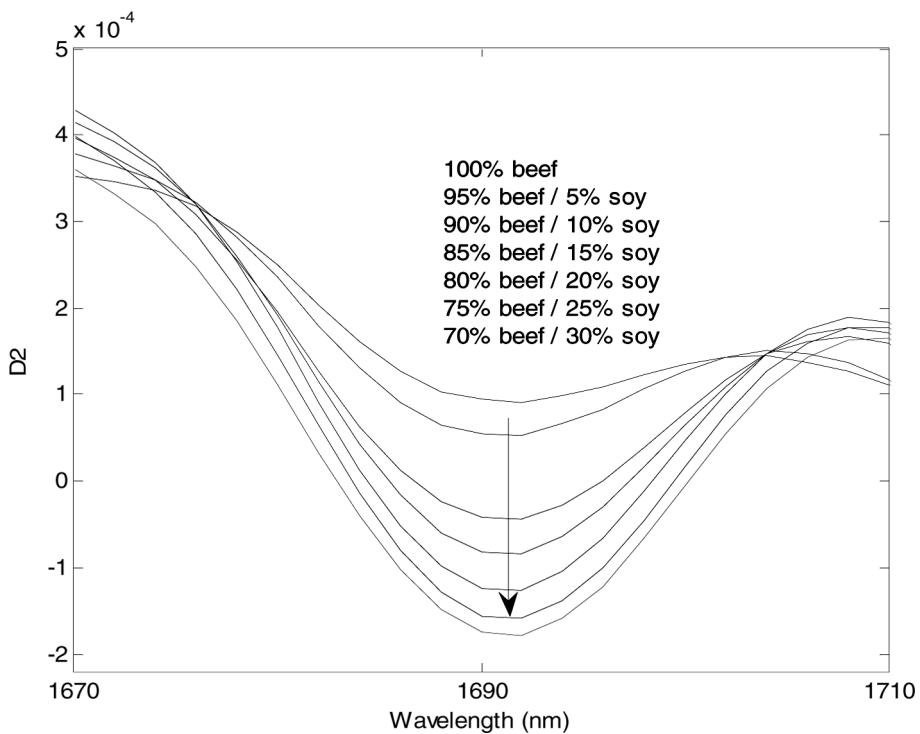


Figure 4. Second derivative NIR spectra at 1694 nm of ground beef samples containing a broad range in soy product contents (0, 5, 10, 15, 20, 25, 30%). This pattern was shown at 1187 and 2056 nm as well.

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