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QUICK DETERMINATION OF FAT CONTENT IN LONGISSIMUS AT THE SECTION OF BEEF CARCASS AND NUTRIENT COMPOSITION OF BEEF CUTS BY NEAR-INFRARED SPECTROSCOPY WITH A FIBER OPTIC PROBE

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Background:
Marbling score of longissimus thoracis at the 6th to 7th rib section of beef carcass is the most important characteristic for grading in Japan. Fat content in longissimus muscle closely relates (r=0.93) with marbling score. Nutrient composition of retail beef cuts such as moisture, fat, protein and energy contents are also very important information for consumers. Since conventional methods for determining these contents are time consuming and destructive, a more rapid, accurate and nondestructive technical tool is desired. Mitsumoto et al. (1991) found that an NIR spectroscope fitted with a fiber optic probe was almost as efficient as using direct transmittance or reflectance for objectively measuring beef quality.

Objectives:
The objective of this work was to evaluate NIR spectroscopy using a fiber optic probe as a means of determining fat content in longissimus muscle at the section of beef carcass and nutrient composition of beef cuts.

Methods:
A specially designed fiber optic probe was made to be able to insert between the 6th and 7th rib section of carcass and to put on longissimus thoracis at the section. The fiber optic probe was 8 cm height and easy to grip, and had a black disk to prevent interference from outside light. A white ceramic disk was used as reference. Fiber optic spectra measurements (400 – 1100 nm) were performed by a NIRSystems Model 5500 Spectrophotometer.
Carcass Thirty–eight Japanese Black steers were used. Scannings were performed at three different locations on longissimus muscle at the section of each left side carcass to obtain the average value (Mitsumoto et al., 1997).
Beef cuts Six muscles (semitendinosus, semimembranosus, psoas major, longissimus thoracis, serratus ventralis cervicis, supraspinatus) from each left carcass of sixteen Japanese Black steers were used. Scanning was performed once on cut section of each muscle.

Data were recorded at 2 nm intervals and 10 scans / 10 sec were averaged for every sample. Data obtained were saved as log 1/*R*, where *R* is the reflectance energy, and then mathematically transformed to second derivatives to reduce effects of differences in particle size and sample composition.

Fat content was determined by ether extraction and moisture content was measured by oven drying at 100° C for 16 hours. Protein content was estimated from nitrogen content using the Kjeldahl technique. Energy was calculated using energy conversion factors as follows: Energy (kcal/100g meat) = 4.22 x protein (g/100g meat) + 9.41 x fat (g/100g meat) (Resources Council, Science and Technology Agency, 1982). As the carbohydrate content of beef is very low (0.3 – 0.7 g/100g meat; Resources Council, Science and Technology Agency, 1982) compared to protein and fat, carbohydrate content was not used in calculation of energy content.

The following multiple linear regression model was used to find the equation which would best fit the data. In this study, three wavelengths were selected for each composition by means of external or internal validation and chemical assignments of absorption bands, and also to prevent overfitting.

$$Y=K_0 + K_1(X_1) + K_2(X_2) + K_3(X_3)$$

where, Y is the composition value and K_0 – K_3 are the constants of the regression equation. X_1 – X_3 are the second derivatives of log 1/*R* at different wavelengths.

Results and discussions:
Selected wavelengths and statistical summary of calibration and prediction for fat content in longissimus at the section of beef carcass and nutrient composition of beef cuts by fiber optic scans are presented in Table 1.
Carcass The multiple correlation coefficient of a selected regression model for fat content in longissimus at the section was 0.9414 (SE=2.33%).
Beef cuts The multiple correlation coefficients of selected regression models for moisture, fat, protein and energy contents of beef cuts were 0.9370 (SE=2.30%), 0.9403 (SE=2.92%), 0.9127 (SE=0.87%) and 0.9400 (SE=24.3 kcal/100g), respectively.

Ben–Gera and Norris (1968) reported correlation coefficients of 0.977 between moisture and ΔO.D. (1800 nm – 1725 nm) and 0.974 between fat and ΔO.D. (1725 nm – 1650 nm) in 2 mm–thick emulsions of meat products using NIR absorbance.

Iwamoto et al. (1981) reported multiple correlation coefficients of 0.972 for moisture and 0.996 for fat in ground pork using NIR reflectance. Kruggel et al. (1981) reported that multiple correlation coefficients were 0.92 for moisture and fat in emulsified beef, 0.70 for moisture and 0.81 for fat, respectively, in ground lamb using NIR reflectance. Lanza (1983) reported that multiple correlation coefficients were 0.987 for moisture, 0.998 for fat, 0.885 for protein and 0.991 for energy in emulsified pork and beef by NIR reflectance, respectively. Clark and Short (1994) reported multiple correlation coefficients of 0.97 for dry matter and 0.98 for fat in ground beef using NIR reflectance. Although our samples were not emulsified or ground, high correlation coefficients for composition of longissimus muscle at the section of beef carcass and/or beef cuts were obtained.

The conventional methods of determination are time consuming and destructive; for example, that of fat content takes at least 3 days for grinding, freezing, freeze–drying, ether extraction and weighing. On the other hand, NIR determination of the above composition can be nondestructively done within ten seconds. A NIR spectroscope fitted with a fiber optic probe should enable quick determination of fat content in longissimus at the rib section during beef carcass grading and nutrient composition of beef cuts.

Conclusions:

Fat content in longissimus at the section of carcass and nutrient composition of beef cuts can be quickly determined by the near–infrared spectroscopy with a fiber optic probe. This will lead objective grading of beef carcasses, and also provide useful information for consumers, such as nutrition facts label on retail packaged beef.

Pertinent literature:

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Table 1. Selected wavelengths and statistical summary of calibration and prediction for fat content in longissimus at the section of beef carcass and nutrient composition of beef cuts by fiber optic scans

Composition	Selected wavelengths X_1	X_2	X_3	Calibration R	SE	Prediction R	SE	Bias
Longissimus at the section of beef carcass								
Fat	928nm	886nm	730nm	0.9414	2.33	0.934	3.04	1.10
Nutrient composition of beef cuts								
Moisture	960nm	880nm	1046nm	0.9370	2.30	0.966	1.31	0.76
Fat	924nm	1026nm	898nm	0.9403	2.92	0.925	2.54	−1.29
Protein	894nm	928nm	910nm	0.9127	0.87	0.911	0.89	−0.05
Energy	892nm	1044nm	726nm	0.9400	24.3	0.937	26.9	−4.23

X_1, X_2, X_3 refer to selected wavelengths for the linear calibration model.
R: multiple correlation coefficient, SE: standard error.