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Differentiation tender and tough beef using raman spectrum (#467)

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Introduction

Tenderness is the most important edible quality of beef. It ranks higher than price among the factors that influence consumers' buying intention. However, most of the methods to determine tenderness require long time to prepare the samples. Therefore, real-time and nondestructive identification of meat quality and grading products according to tenderness is a key problem need to be solved. Raman spectroscopy is a spectral analysis technology developed based on Raman scattering effect, which is characterized by rapid in-situ non-damage detection, and less time consuming. This technology provides the possibility of online meat quality analysis and becomes a promising technology in meat industry. Therefore, the aim of this study was to explore the possibility of using portable Raman spectrometer to predict shear force of *M. longissimus lumborum* (LL) of beef.

Methods

Ninety two Chinese yellow crossbred cattle (Simmental×Luxi) aged 18 months old were slaughtered in commercial abattoir according to standard procedure, and the LL from left carcasses were collected, were vacuum-packed and transported to the laboratory within 24h at 0 – 4 ℃. Then each loin was cut into 2.5cm-thick steaks, and was assigned to 5 storage time (1 d, 3 d, 7 d, 14 d and 21 d). Raman spectrum and shear force data were collected at each time interval. The Raman spectrometer (Raman Pro, B&W Tek, LLC) used in this study was equipped with a 785 nm laser, with a maximum power output of 100 mW. The spectra were recorded in the range of 150 - 1800 cm^{-1}, with an integration time of 12 s. Fresh cuts have been made before spectral collection and bloomed for 30 minutes at room temperature. Additionally, the muscle fibers were perpendicular to the laser during the capture of spectra.

The data of the shear force of all samples were regressed against Raman spectra using nonlinear iterative partial least squares algorithm (BWIQ, B&WTek, LLC). The samples of the calibration sets and the validation sets were divided by the extended kennard-stone algorithm (SPXY, 60% for calibration, 40% for validation). The Raman shift range was restricted to a range of 500 - 1800 cm^{-1}. The average spectra of the 6 steaks with the highest shear force (SF > 10.5 kg) and the 6 steaks with the lowest (SF < 5.3 kg) at 7 d post-mortem were obtained, respectively. And the difference spectrum is made by subtracting the spectrum of tender beef from that of tough beef (BWIQ, B&WTek, LLC).

Results

The squared correlation between share force values and Raman spectra (R^2_{cal}) was 0.10 - 0.71, and the RMSEC was 0.11-2.19, which indicated that Raman spectrum had ability to predict the shear force value of postmortem beef. In Fig.1, the relative strength of the Raman signal of the steak with high shear force is stronger than that of the steak with low shear force. And the largest difference in intensities between spectra from tough and tender LL appeared in the tyrosine doublet (Raman shift 827 cm^{-1} and 853 cm^{-1}), the α-helix peak (Raman shift 904, 934, 1316, 1449 and 1654 cm^{-1}), the myoglobin and aromatic amino acid side chains (Raman shift 714, 754, 876, 1000, 1125, 1341 and 1546 cm^{-1}) and the tryptophan (Raman shift 759, 1010, 1336, 1354 and 1555 cm^{-1}). The main difference between tough and tender steaks was the intensity of the Raman pattern of the meat proteins. The intensity of tyrosine doublet of tough meat was higher compared to tender meat. The strength of tyrosine double peaks (Raman shift 827 cm^{-1} and 853 cm^{-1}) and the intensity of the α-helix (Raman shift 934 cm^{-1}) could be used to differentiate tender and tough steaks.

Conclusion

Raman spectroscopy is a potential tool to predict shear force of fresh beef steak during aging. The strength of the tyrosine bands at the Raman shift of 826 and 853 cm^{-1} and the strength of the α-helix peak at the Raman shift of 934 cm^{-1} seems to be key parameters to distinguish the tender and tough beef.

Notes

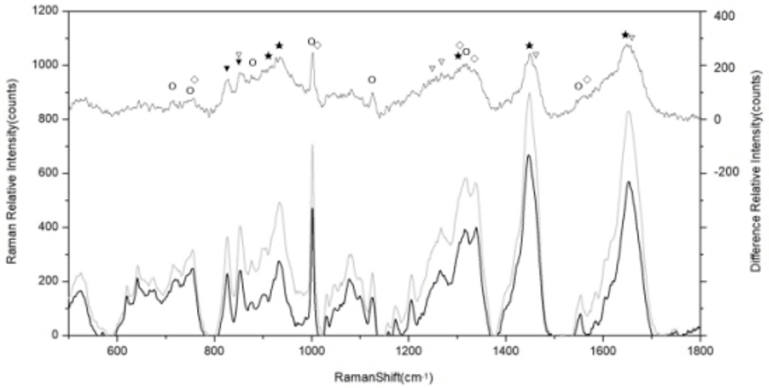

Fig. 1 Averaged Raman spectra of the most tender (SF >10.5 kg) (black line) and the toughest (SF < 5.3 kg) (gray line) beef at 7d PM(P<0.05)

Fig. 1
The thin line is the difference spectrum “tough minus tender”.Selected signals are indicated by symbols: α-helical proteins (star), myoglobin (circle), tryptophan (diamond), tyrosine doublet (gray triangle) and connective tissue (triangle)

Notes