Fast Raman screening of unsaturation of fats in pork

Benefits at a glance
- Nondestructive analysis of melted fat and intact pork fat
- Determination of IV, PUFA, MUFA, and SFA in minutes
- Fast analysis amenable to on-line quality control during meat processing

Introduction

Unsaturation of fat content in pork meat is an important measure of pork meat quality. Pork fat is comprised of the proportion of different fatty acids, and that proportion has impact on flavor, quality and storage compatibility. A high level of unsaturated fatty acids makes the meat susceptible to oxidation, a major source of off-flavoring. Determining the unsaturation level quickly during processing can also be useful in rapidly discriminating meats as suitable for cured or fresh products.

Currently, fat unsaturation is measured using time-consuming chemical methods and there is interest in rapid, non-destructive quantification of fat tissue during processing. Raman spectroscopy is a promising tool for rapid, non-destructive analysis of pork fat.

In this work, Raman spectroscopy was used to quantitate the average degree of unsaturation in pork fat tissue in order to demonstrate the viability of Raman for this application. The degree of unsaturation is expressed as the iodine value (IV). A single Raman spectrum simultaneously measured the IV, polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), and saturated fatty acids (SFA).

Methods

The average degree of unsaturation in pork back fat was determined by Raman spectroscopy on 77 samples of intact pork back fat tissue and melted fat tissue from the same carcass. Spectra were acquired using a probe coupled by optical fibers to a Raman analyzer, operating at 785 nm with a laser. Measurements were performed by placing the probe into direct contact with the sample and recording a spectrum by averaging three replicates of 20 seconds each.

Two spectra were acquired on each side of intact adipose tissue samples, providing an average fatty acid profile. An average is most relevant to meat processing applications. Intact adipose tissue samples were measured at a temperature of 20 °C, then homogenized and melted. Melted fat samples were measured in two averaged spectra at 47 to 50 °C. Reference analysis was performed by gas chromatography using standard IV, PUFA, MUFA and SFA measurement protocols.

Results

Raman spectroscopy of the fat samples gave easily identifiable and quantifiable peaks. Figure 1 shows Raman spectra of both adipose tissue (dotted line) and melted fat (solid line). Important lipid bands are in sections 1 and 2, corresponding to the 1200-1800 cm^{-1} and 2600-3100 cm^{-1} spectral regions.

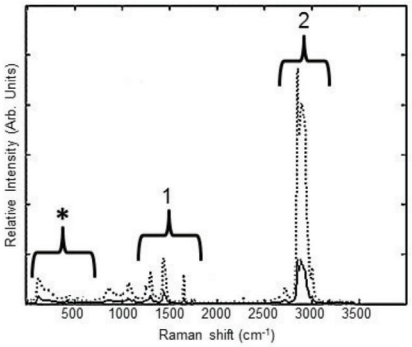

Figure 1: Raman spectra of intact pork fat tissue (dotted line) and melted pork fat (solid line) provide information on fatty acid saturation. Peaks related to lipids in pork tissue are noted in sections 1 and 2. Bands from the sapphire probe, in section *, do not interfere with collection of tissue Raman bands. Adapted from and reprinted with permission from Ref. 1. © 2007 Elsevier.

ⓘ All Raman analyzers and probes referenced in this application note are Endress+Hauser products powered by Kaiser Raman technology.

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Both intact fat tissue and melted fat were easily measured. Because spectra could be acquired in approximately 60 seconds, it is possible that Raman can be applied directly to tissue measurements on-line at the processing plant. The average degree of unsaturation is the key value for this application. The amount of unsaturated and saturated fatty acids is also measured, providing a fast and thorough characterization.

Figure 2 shows predicted versus measured values for IV, PUFA, MUFA, and SFA in adipose tissue. All parameters showed good correlation. A three-factor partial least squares (PLS) regression model resulted in correlation coefficients (R) between 0.91 (for MUFA) and 0.97 (for IV). Results for melted fat were similar and even somewhat better, ranging from R = 0.96 for MUFA to R = 0.98 for IV.

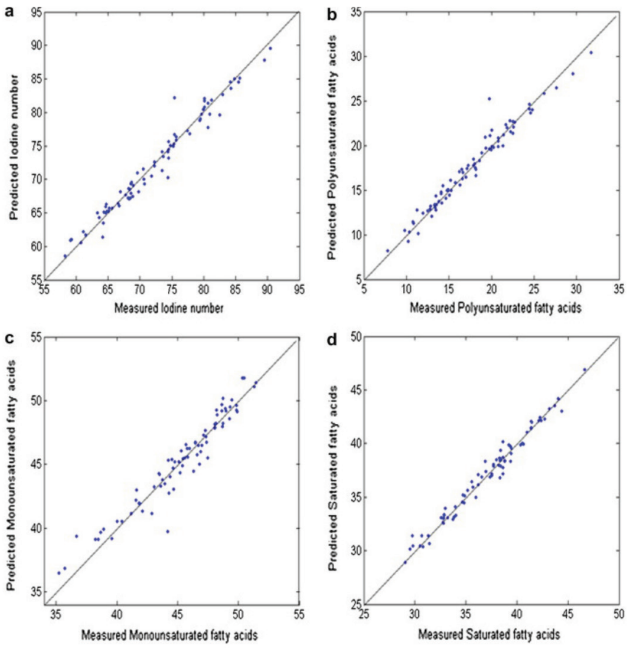

Figure 2: Predicted versus measured values of (a) iodine value, (b) polyunsaturated fatty acid content, (c) monounsaturated fatty acid content, and (d) saturated fatty acid content in adipose tissue. Reprinted with permission from Ref. 1. © 2007 Elsevier.

The low prediction errors indicate that Raman can provide data similar to established chemical methods. Importantly, Raman provides this information rapidly and without any sample preparation. Because Raman data were generated from multiple sites on each sample, Raman data matched the data generated by chemical methods on homogenized samples. The averaged degree of unsaturation provided by Raman is consistent with processing standards to treat the carcass as a whole during processing.

Conclusions

This laboratory study demonstrates that Raman spectroscopy can provide both a fast and effective analytical method for simultaneously determining IV, PUFA, MUFA, and SFA in samples of pork back fat. Raman has been reported as a robust and transferable method for IV measurements.[2] Controlling unsaturation through breeding, diet and gender can help in storage and processing. Raman has been shown to be an important tool for optimizing feeding strategies to control pork fat unsaturation.[3] The Raman analyzer has sampling capabilities of small area to large volumetric sampling for laboratory or processing plant measurements.

References

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