ANALYZING INTRAMUSCULAR FAT CONTENT IN PORK LONGISSIMUS LUMBORUM USING RAMAN SPECTROSCOPY

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I. INTRODUCTION

Total intramuscular fat (IMF) content is very important for overall quality and nutritional wholesomeness of meat [1]. Consequently, rapid determination of IMF is of great interest to the meat industry for optimal utilization of raw materials. Raman spectroscopy (RS) is a technique that has capability to provide information about IMF, as adipose tissue has a strong Raman signal, which also potentially can be used to analyze fatty acid composition [2, 3]. The few studies conducted to establish an association between IMF and RS have been unsuccessful for intact meat [3] or have only analyzed homogenized meat [4]. The objective of the current study was to analyze IMF content of intact and homogenized pork *longissimus lumborum (LL)* with RS, utilizing a Raman probe with a wide area illumination scheme to collect a spectrum from a large area of the sample.

II. MATERIALS AND METHODS

Commercially farmed and slaughtered pigs (n = 50) were analyzed in this study. A sample of approx. 80g was cut from the *LL* of each pig prior to vacuum packing and freezing at −20°C. Samples were thawed over night at 4°C for RS analysis. A Raman spectrum was collected from each sample using a Kaiser RamanRXN2™ Multi-channel Raman analyzer (Kaiser Optical Systems, Inc., Ann Arbor, MI, USA) equipped with a 785 nm laser and PhAT probe, measuring a spot size of 6 mm in diameter. All spectra were collected in the range of 300-1800 cm^{-1} and each acquisition lasted 1 min (4 acquisitions of 15 s). The sample surface was scanned by moving continuously under the laser for the entire acquisition time. Each sample was homogenized for approx. 5 s using a commercial food processor and a Raman spectrum was subsequently collected from the homogenate as described for intact samples. Percent concentration of IMF of homogenized samples were determined using a low field Nuclear Magnetic Resonance instrument (@nTEK, Trondheim, Norway) as described by Sørland et al. [5]. Raman spectra were base-line corrected, before sixth order extended multiplicative scattering correction was applied. Partial least squares regression (PLSR) models were calculated from the pre-processed spectra and IMF measurements. The ratio of prediction to deviation (RPD) statistic was calculated as the standard deviation of the IMF measurements divided by the root mean square error of cross validation (RMSECV) from PLSR. Guidelines for RPD values (x): x<2: very poor; 2.0<x<2.4: poor; 2.5<x<2.9: fair; 3.0<x<3.4: good; 3.5<x<3.9: very good, and 4.0<x: excellent [6].

III. RESULTS AND DISCUSSION

Measured IMF ranged from 1.4% to 13.0%, with a mean and standard deviation of 4.9% and 2.7%, respectively. The PLSR model from intact pork (Fig. 1. A) showed good correlation between RS and IMF. The error of the model for intact meat was relatively high, resulting in a RPD of 2.1, which is considered as a poor model, but it is still applicable for rough screening [6]. For comparison, Fowler et al. [3] analyzed IMF of intact lamb *LL* and achieved a cross-validated coefficient of correlation of (r_{cv}^2) of 0.02 and RPD of approx. 1.0 when collecting Raman spectra from 10 spots with 50 µm laser spot diameter directly on the muscle. The substantial improvement in r_{cv}^2 and RPD in the current study can likely be attributed to the increased laser spot size and scanning of the muscle surface. The PLSR model from homogenized pork performed better (Fig. 1. B), and resulted in an RPD value of 3.5, which is considered a very good model and is suitable for process control [6]. These results were similar to the results obtained by Nian et al. [4] in a study where they analyzed young dairy bull beef using RS on homogenized *longissimus thoracis,* and achieved an r_{cv}^2 of 0.85 and an RPD of approx. 2.5. By investigating the reference measurement versus the predicted values of IMF for both models developed in the current study, it was evident that neither could predict IMF over approx. 10% very well, and these samples seemed to contribute the most to the error in the models. However, IMF over 10% is not very common, meaning that it might be sufficient to classify these as IMF>10% in a process control scenario. Taken together, results from PLSR showed that Raman spectra from both intact and homogenized samples could be used to assess IMF of pork *LL*.

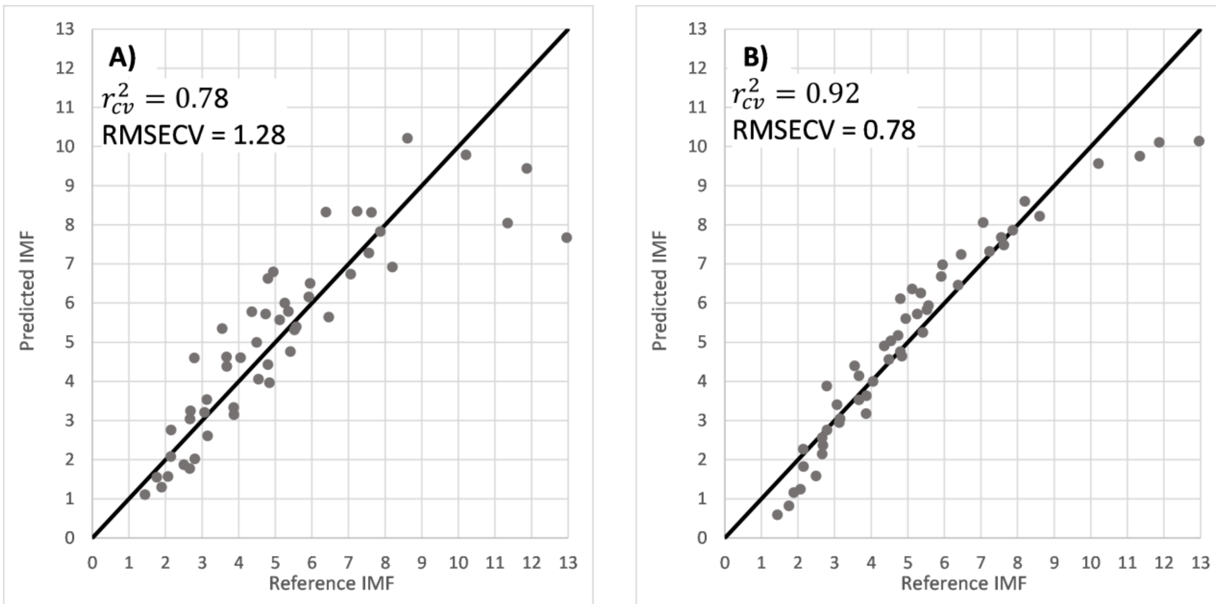

Figure 1. Performance of PLSR models from Raman spectra and IMF measurements for intact (A) and homogenized (B) samples. The r_{cv}^2 and RMSECV are stated for each model.

IV. CONCLUSION

The current study demonstrates the first successful attempt to analyze IMF of intact meat using RS for an IMF range relevant for the pork industry. In addition, the PLSR model for homogenized meat had higher RPD than previous studies. The results encourages further research and development of RS to one day implement the technique for quality and process control in the slaughterhouse.

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