MID-INFRARED TRANSMISSION SPECTROSCOPY TO QUANTIFY INTRAMUSCULAR FAT, PROTEIN AND DRY MATTER CONTENT IN PIG MEAT

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Introduction

Protein and intramuscular fat (IMF) contents are closely associated with meat quality and nutritional value and largely affects tenderness of meat. Pork with high content of IMF is expected to produce more desirable meat for consumption. Several methods have been developed to analyse IMF, the simplest of which is visual evaluation to obtain fat content. This method is often used to evaluate marbling (Stoller *et al.*, 2003). However, the method is subjective and the accuracy depends on the individual ability of the surveyor to describe the samples. In contrast, IMF determined by chemical methods is an objective measurement that quantifies the total fat content within the muscle. One important indicator of nutritional value of meat is its protein content, and total protein is widely determined by Kjeldahl digestion. Mid-infrared spectroscopy plays an important role in food analysis, and the applications of this technique have considerably increased (Wilson and Tapp, 1999). The objective of this study was to evaluate the capability of mid-infrared transmission (MIR) technique to analyse the contents of IMF, protein and dry matter.

Materials and Methods

Muscle samples from *M. longissimus dorsi* (LD) and *M. semimembranosus et aductor* (SMA) were obtained from female pigs at a live weight of approximately 107 kg. Muscle samples, approximately 10 g in duplicate, were diluted with LOSsolver MEAT (LOSAB, Uppsala, Sweden) and homogenized with LOSmixer (LOSAB, Uppsala, Sweden) for 3 min. Then, 500 µl of antifoam solution was added into each tube and mixed for another 2-3 sec. The homogenates were kept in a water bath at 45° C, for 60 min to remove foam followed by filtration through a 60-µm sieve. The samples were analyzed for fat, protein and dry matter with a mid-infrared instrument (FMA2001 Farm Milk analyzer). To evaluate extraction repeatability, two samples with low (0.82 ± 0.15) and high (1.53 ± 0.12) fat content were extracted 8 times, and analysed for fat, protein and dry matter. The MIR performance was evaluated by repeated measurement of the same extract.

Reference methods included the following. IMF was measured by an established reference method of Schmid, Bondzynski, and Ratzlaff (SBR), which uses hydrolysis with HCl and extraction with petroleum ether: diethyl ether (1:1 v/v). Nitrogen was determined by the Kjeldahl digestion by a Kjeltec Auto System (Tecator AB, Höganäs, Sweden) and a factor of 6.25 was used to convert the nitrogen content to total protein content. To determine dry matter content, the samples were dried in 105°C for 16 h and heated in an ash oven at 550°C for 4 h.

Results and Discussion

The repeatability of the extraction, calculated as the relative standard deviation (R.S.D.) of the repeated analysis of two samples, was sufficient for analysing fat, protein and dry matter contents (Table 1). The repeated measurements of the same extract demonstrated a good repeatability of the MIR technique. Variations (R.S.D.) in the measurements were 10.1 – 11.6% for IMF, 0.7 – 2.3% for protein, and 1.4 – 2.8% for dry matter contents.

Table 1: Intra-assay variations.

	Sample 1			Sample 2		
	Mean	SD	RSD, %	Mean	SD	RSD
Fat	0.82	0.15	18.4	1.53	0.12	7.76
Protein	21.92	0.29	1.33	22.80	0.33	1.44
Dry matter	24.43	0.55	2.27	25.47	0.59	2.30

The relationship between IMF contents obtained by MIR spectroscopy and reference method is presented in Figure 1a. Comparison of individual mean values demonstrated that MIR technique often underestimated the corresponding value detected by reference method. This should be taken into consideration if MIR is to be used for routine analysis of IMF content. The measurements of dry matter obtained using the two methods were moderately correlated (r=0.55). Equation of regression was y=0.334x + 16.89, where x is the dry matter content obtained by MIR.

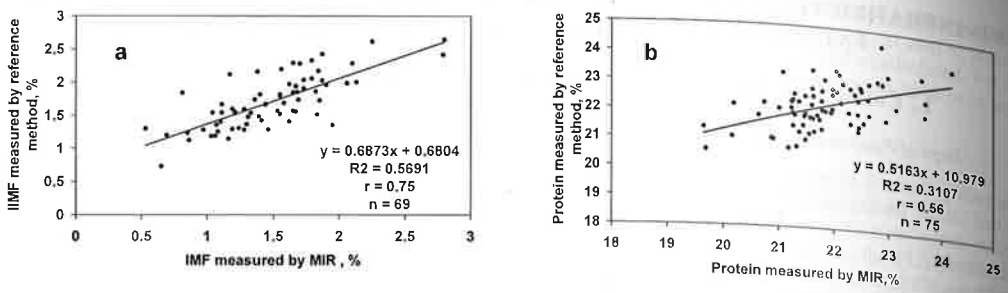

Figure 1: Comparison of IMF (a) and protein (b) content determined by MIR technique and reference method.

The relationship between protein content obtained by the two methods, was quite poor (Figure 1b). It should be noted, however, that in the present study the range of the measured protein was limited and therefore it was problematic to find a good statistical agreement between these two methods. Additionally, the Kjeldahl method is based on the measurements of nitrogen; such measurements likely contribute to uncertainty when converting the nitrogen content to total protein.

Various methods were developed to measure meat composition. Near-infrared spectroscopy (NIR) was shown to be an attractive technique to determine IMF with sufficient accuracy (Monin, 1998; Savenije *et al.*, 2006). Recently, Altmann and Pliquett (2006) described a method to predict IMF in beef and pork using impedance spectroscopy. The MIR method described here is a new attempt to develop a simple, rapid method to evaluate meat composition. Originally, the infrared instrument used in the present study (FMA2001 farm milk analyzer) was designed to analyse milk composition. Elvingson and Sjaunja (1992) successfully adapted a commercial milk analyzer (Milko-Scan, Multispec) to determine fat, protein and dry matter content in fish muscles. The present study demonstrated that this technique can also be used to evaluate those components in pig muscles. Compared with the reference methods, the MIR method has several advantages that make it attractive for routine purposes. Simplicity and rapidity of this method can considerably reduce the amount of time and labour needed to obtain the data. Three important components of muscle chemical composition are measured simultaneously, and the same extraction procedure is involved. Additionally, the procedure is comparatively cheap and does not involve the use of toxic extraction solvents. However, full validation of the proposed method is needed before it can be used for research purposes.

Conclusion

In the present study, the contents of IMF, protein and dry matter in pig muscle were analysed using MIR technique. This preliminary study demonstrated that the method is simple and repeatable, and can potentially be used to routinely analyse meat composition. Prior to this, more complete investigations are needed.

References

Altmann, M. and Pliquett, U. (2006). Prediction of intramuscular fat by impedance spectroscopy. Meat Science, 72: 666-671.

Elvingson, P. and Sjaunja, L.O. (1992). Determination of fat, protein and dry matter content of fish by mid-infrared transmission spectroscopy. Aquaculture and Fisheries Management, 23: 453-460.

Monin, G. (1998). Recent methods for predicting quality of whole meat, Meat Science, 48: S231–S243.

Savenije, B., Geesink, G.H., van der Palen, J.G.P. and Hemke, G. (2006). Prediction of pork quality using visible/near-infrared reflectance spectroscopy. Meat Science, 73: 181-184.

Stoller, G.M., Zerby, H.N., Moeller, S.J., Baas, T.J., Johnson, C. and Watkins, L.E. (2003). The effect of feeding ractopamine (Paylean) on muscle quality and sensory characteristics in three diverse genetic lines of swine. Journal of Animal Science, 81:1508-1516.

Wilson, R.H. and Tapp H. S. (1999). Mid-infrared spectroscopy for food analysis: recent new applications and relevant developments in sample presentation methods. TrAC Trends in Analytical Chemistry, 18: 85-93.