The intramuscular fat content (IMF) is an important indicator of the eating quality of meat and its visible part, known as marbling, is an important visual characteristic. IMF, therefore, is currently determined in the pig performance tests of the Swiss pig breeding program using a NIRS method which requires homogenization of the meat. The aim of this investigation was to examine the ability of a NIR hyperspectral imaging method to predict IMF by just scanning the surface of a meat slice, which would speed up the analysis and reduce the expenditure of work. For this purpose slices of the loin muscle from 76 pigs with an IMF ranging from 0.77 to 5.24 % IMF were scanned with a SWIR (Shortwave Infrared) hyperspectral camera (Specim). The calibration set consisted of 60 samples; 16 samples served as independent validation set (1.9±0.8 %). With the Calibration an $R^2=0.92$ and RMSE=0.21 % was obtained. The validation gave an $R^2V=0.95$ and RMSEP=0.24 %, indicating that hyperspectral imaging can be used as a fast and accurate method to determine the average IMF in pork. Ongoing work aims to determine coarseness and spatial distribution of the IMF based on the hyperspectral images.

KEYWORDS: hyperspectral imaging, intramuscular fat, marbling, pork
MATERIALS AND METHODS

For this study a SWIR (Shortwave Infrared) hyperspectral camera (Specim) was used, spectral range 1000 –
2500 nm, 320 spatial pixels and 256 spectral bands. A field of view of 200 mm was used giving an image with a
pixel size of 0.625 mm/pixel. Both sides of 3 cm thick slices of the loin muscle (m. long. dorsi) from 76 pigs with
an IMF ranging from 0.77 to 5.24 % IMF were scanned. The images were analysed and a calibration model was
developed using the mean spectra of each side. Mean centering and SNV (Standard Normal Variate) transforma-
tion were applied as pre-treatment followed by PLS. All data analysis was done using the Evince Image and
Breeze software (Prediktera). The training (calibration) set consisted of 60 samples with IMF values covering
the range from 0.77 to 5.24 % (mean ± standard deviation: 2.1±0.8 % IMF). To validate the calibration, the IMF of
16 independent samples ranging from 0.82 to 3.71 % IMF (1.9±0.8 %) was predicted using the calibration. The
predicted results were compared to the actual reference values, which were measured using an existing NIRS
method (NIRFlex N-500, Büchi, Flawil, Switzerland) based on homogenized pork and Soxtec extraction with
petroleumether (R²V=0.98 and RMSEP=0.12 %).

RESULTS AND DISCUSSION

A calibration model for IMF with an R²=0.92, Q²=0.91 and RMSE=0.21 % was obtained (Fig. 1). The validation
gave an R²V=0.95 and RMSEP=0.24 %, indicating that hyperspectral imaging can be used to accurately deter-
mine the average content of IMF in an intact slice of pork respectively at the surface of a meat cut. The precision
of this method seems to be slightly lower compared to the measurement in homogenized meat (R²V: 0.95 vs.
0.98, RMSEP: 0.24 vs. 0.12 %) but it is faster as well as far less laborious and destructive. Thus, this method has
the potential to be applied under industrial conditions e.g. in a meat cutting plant. Regarding its use for breeding
purposes, where high precision of the determination of the individual phenotypic characteristics is required, the
benefit of a fast determination (and thus the possibility to measure more samples) has to be balanced against
a slightly lower precision, possibly resulting in slightly lower heritability and accuracy of the breeding values
derived. However, it may be speculated that a higher precision of the imaging method could be achieved when
more samples with an IMF>4 % would be included in a calibration data set.

A further advantage of the imaging method is the potential to provide information about the visual appearance of
the IMF, which is an important factor influencing the purchase decision of consumers at the point of sale. For this
purpose, the calibration based on the mean spectra was used to predict the IMF for each pixel. Applying image
analysis algorithms on the recorded hyperspectral data gave an indication of coarseness and spatial distribu-
tion of the IMF (Fig. 2). This information, combined with the determined level of IMF, would provide an objective,
fast and easy method for grading the marbling in meat cuts. As an even distribution of small IMF inclusions is
probably most desirable, it would be interesting to define appropriate characteristics and to examine genetic pa-
rameters of such traits as well as the potential to improve those by means of animal breeding. For this purpose,
however, samples of a couple of hundred animals have to be measured in future projects.

Figure 1. Correlation of the IMF prediction in the calibration (●) and validation (●) data sets.

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CONCLUSION

Hyperspectral imaging (Near infrared camera) has the potential of being used as a new and fast, easy and objective method for grading the marbling in meat. This method would be of interest for the meat industry which then could use this for quality control and optimizing the breeding process. Further work is needed to establish a method to determine coarseness and spatial distribution of IMF, its relevance for consumers purchase decisions, and the genetic parameters of these traits in order to judge possibility and usefulness of breeding pigs for an optimal marbling.

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References