New gourmet pork products by application of the Iberian and Mangalitza breeds

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The aim of the present study is to investigate the use of alternative breeds in the production of pork gourmet products. Pigs from traditional crossings between Duroc (D) and Landrace/Yorkshire (LY) and between these traditional breeds and the alternative breeds Iberian (I) and Mangalitza (M) were produced. At slaughter, meat samples from longissimus dorsi (LD) were collected. Low-field proton nuclear magnetic resonance (LF-NMR) relaxometry was applied for characterization of water mobility and water-holding capacity (WHC) of the meat and high-field proton NMR (HF-NMR) spectroscopy was applied on meat extracts for metabolic profiling. Furthermore, sensory evaluation of fried chops was performed. By application of multivariate analysis on the LF-NMR data, some separation between the different breeds was found, which was associated with reduced drip loss in the alternative breeds compared to the DLY control. In the meat extracts of LD indications of lower levels of lactate was found in the alternative crossings compared to the control crossing by analysis of the HF-NMR spectra. The sensory analysis showed that the meat from the crossings with the alternative breeds had a more fatty flavour and was more tender. Conversely, the alternative breeds generally had less hardness at first bite, less crunchy fibres and less fibrous meat when compared to the DLY. Accordingly, the results indicate differences between the control DLY and the alternative crossings, which are of importance for meat quality. Hence, by applying these alternative breeds in the Danish pig production it may be possible to produce new unique gourmet pork products.

Keywords – Nuclear magnetic resonance, sensory profiling, meat quality

I. Introduction

It is well known that the genetic background, including breed, influence pork quality [1;2]. A long tradition for pig breeding in the Danish pig production has resulted in high-quality but uniform meat products. Consequently, a demand for new, unique high-quality meat products that differ from the standard products has emerged.

Important meat quality parameters like temperature, colour, drip loss, water distribution and variation in single metabolites like lactate, creatine and ATP can be determined by various technological measurements. More recently options for simultaneous determination of multiple metabolites have become available by application of nuclear magnetic resonance (NMR) spectroscopy.

The aim of the present study is to apply low-field proton NMR (LF-NMR) relaxometry and high-field proton NMR (HF-NMR) spectroscopy in combination with sensory analysis to investigate the use of alternative breeds to introduce new pork products with desirable properties.

II. Materials and methods

Traditional crossings were made between boars of Duroc (D) and sows of Landrace/Yorkshire (LY), and alternative crossings were made between boars of Black Footed Iberian (I) or Mangalitza (M) with sows of either D or LY. After slaughter longissimus dorsi (LD) was excised and applied for the analyses.

For drip loss measurements samples of approximately 2.2 × 2.2 cm were cut from LD, and the loss of drip was determined by weighed after 24 h [3]. Measurements were made on two meat samples for each of 20 pigs for each of the five crossings.

For LF-NMR analysis, samples of approximately 1 × 1 × 5 cm were cut from LD. Measurements were acquired on three meat samples for each of 20 pigs for each of the 5 crossings, except for the ID crossing for which 19 pigs were used. The proton NMR T_2 relaxation measurements were performed on a Maran Benchtop Pulsed NMR analyser (Resonance Instruments, Witney, UK) operating at a resonance frequency of 23.2 MHz. Transverse relaxation, T_2, was measured using the Carr–Purcell–Meiboom–Gill (CPMG) sequence. The T_2 measurements were performed with a τ-value (time between 90° pulse and 180° pulse) of 150 µs. Data from 4096 echoes were acquired as 16 scan repetitions. The repetition time between the scans was 3 s. The meat samples were stored at -20 °C until h HF-NMR analysis was performed. The obtained T_2 data were analysed using distributed exponential fitting analysis [4], which was carried out in MatLab (The Mathworks Inc., Natick, MA, USA) version 7.01 using in-house scripts. Distributed exponential fitting results in a plot of relaxation amplitude versus relaxation time over a predefined range of characteristic relaxation times. In this study we fitted 256 logarithmically distributed relaxation times from 0.5 ms to 3000 ms. Furthermore, the area of the T_{22} relaxation population was calculated.

HF-NMR measurements were performed on methanol extractions of 100 mg of thawed LD meat samples. After methanol extraction the samples were dried with N_2 and stored at -80 °C until analysis. Measurements were acquired on one meat sample for each of the 99 pigs. The samples were dissolved in 500 µl water and 100 µl D_2O containing 0.1 % (w/v) sodium trimethylsilyl[2,2,3,3-D4]-1-propionate (TSP). Proton NMR spectra were recorded at 25°C on a Bruker Avance 600 spectrometer, operating at a ^{1}H frequency of 600.13 MHz, equipped with a 5 mm ^{1}H TXI probe (Bruker BioSpin, Rheinstetten, Germany). Standard one-dimensional (1D) proton NMR spectra were acquired using a single 90° pulse experiment, and each spectrum was the sum of 64 FIDs. Water suppression was achieved by irradiating the water peak during the relaxation delay of 2 s, and 32K data points spanning a spectral width of 17.36 ppm were collected. All the spectra from the meat extraction were referenced to TSP at 0 ppm. Alignment of peaks was performed by application of MatLab (version 7.11) using the *i*coshift algorithm [5]. The proton NMR spectra were normalised to the total intensity in the spectral range 0.5-8.37 ppm, excluding the interval 4.7-5.0 ppm containing the residual water signal.

Sensory analysis was carried out on boneless pork chops from LD (2 cm thick) fried on a pan at 170 °C until 65-68 °C core temperature was reached. The attributes were assessed by nine assessors on an unstructured line scale from 0 (no intensity) to 15 (very intensive).

Principal component analysis (PCA) was performed on the obtained NMR data with SIMCA-P 12.0.1 (Umetrics, Sweden). The proton NMR T_2 relaxation decay data were mean-centred whereas the proton NMR spectra were mean-centred and Pareto scaled.

Statistical analysis was performed by using the mixed procedure of SAS (SA Institute Inc., Cary, NC). The models included the different crossbreeds as fixed effect and replicates as random effect. The drip loss, T_{22} areas and sensory intensities are calculated as least square means (LSMeans) ± standard errors (SE).

III. Results

From PCA analysis of the proton NMR T_2 relaxation curves it is apparent that there is some tendency to grouping of the different crossings (Fig. 1). Particularly the pigs from the control DLY crossing tend to be grouped at one end of the PCA plot. When comparing the areas of the proton NMR T_{22} relaxation population, significantly lower T_{22} areas were found for the alternative crossings when compared to the traditional DLY crossing (data not shown). Likewise, for the drip loss, significantly lower loss of drip was found for the alternative crossings when compared to the DLY control (data not shown). A high correlation between the T_{22} areas and the drip loss was found (Fig. 2).

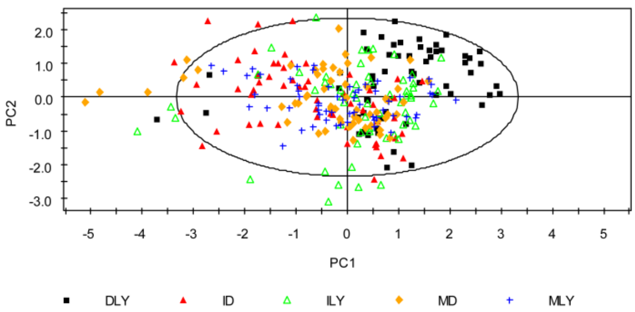

Figure 1 PCA score plot of proton NMR T_2 relaxation decays obtained on LD meat samples.

PCA analysis of the proton NMR spectra indicated a slight tendency to grouping of the pigs from the different crossings (Fig. 3a). The loading plot showed that meat from the traditional DLY crossing generally had higher levels of lactate and creatine (Fig. 3b). The alternative ID crossing was the crossing most separated from the traditional DLY crossing.

From Fig. 4 it is evident that several sensory attributes were significantly different when comparing the traditional DLY crossing with the alternative crossings. The alternative crossings generally had a more fatty flavour and the meat was more crumbly and tender as compared with the DLY crossing. Conversely, the alternative crossings generally had less acidic flavour, acidic after taste, juiciness and less hardness at first bite, less crunchy fibres and less fibrous meat.

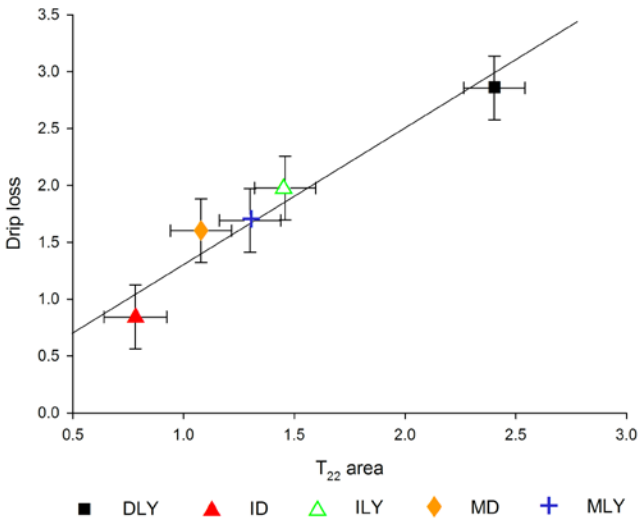

Figure 2 Correlation (R^2 = 0.95) of the LSMeans (± SE) for the T_{22} areas and the drip loss.

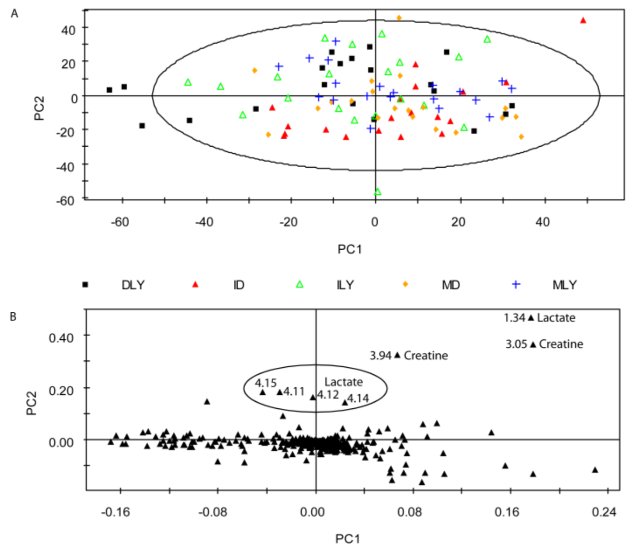

Figure 3 PCA score (a) and loading (b) plots obtained on proton NMR spectra of extractions of LD meat samples.

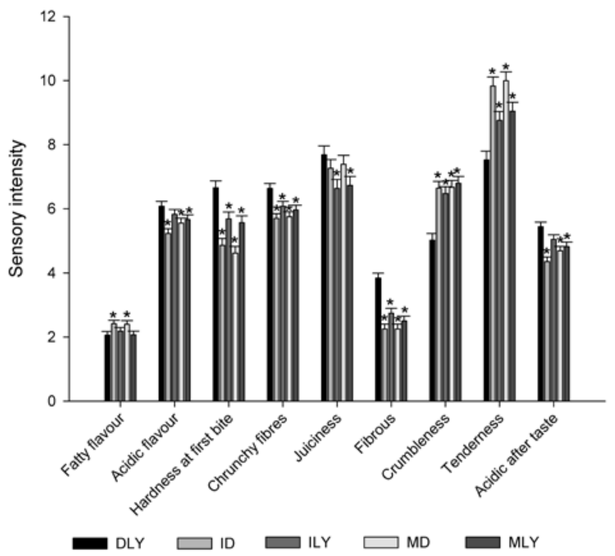

Figure 4 Sensory analysis of the fried LD meat samples (LSMeans ± SE of the sensory intensities). Significant difference ($p<0.05$) in sensory attributes between the DLY crossing and the alternative crossings is indicated with an asterisk.

IV. Discussion

Both the LF-NMR relaxation and the HF-NMR results show a tendency to grouping of the pigs from the different crossings (Fig. 1 and 3). The proton NMR relaxation data indicate a different water distribution for the different crossings, with the control DLY crossing differing the most from the other crossings (Fig. 1 and 2). This is in agreement with the findings for the drip loss, which also differed for the different crossings and was lowest for the alternative crossings (Fig. 2). A strong correlation was found between the T_{22} areas and the drip loss (Fig. 2), which is in agreement with previous studies, as the T_{22} area previously has been found to correlate with drip loss, and hence a good indicator of water holding capacity (WHC) [6-8]. The tendency to a lower level of lactate in the alternative crossings compared to the DLY crossing is also in agreement with previous studies, as lower levels of lactate and a higher pH post-slaughter has been associated with lower drip loss [9;10].

The tendency to lower levels of the metabolite lactate in the alternative breeds is in agreement with the sensory data, in which a less acidic flavour and acidic after taste were found in the alternative crossings compared to the control DLY crossing (Fig. 4). However, no relation was found between the NMR/drip loss results and the sensory attribute juiciness. A smaller T_{22} area/lower level of drip loss and a tendency to lower level of lactate was found in the alternative crossings, however, the meat from the alternative crossings was generally found to be less juicy than the meat from the DLY crossing (Fig. 4). No difference in the cooking loss was found between the five different crossings (data not shown). Thus, data indicated no relation between WHC/cooking loss and juiciness.

Several sensory properties differed significantly in the alternative crossings when compared to the traditional DLY crossing, and several of these differences contribute to an improvement of the sensory attributes for the alternative crossings. The meat from the alternative crossings was more tender and had a more fatty flavour. Conversely, the alternative crossings generally had less hardness at first bite, less crunchy fibres and less fibrous meat when compared to the DLY control crossing.

From the present study it is apparent that NMR metabolic profiling can contribute to the understanding of the knowledge acquired from the measurement of drip loss and the determination of water distribution by NMR relaxometry. Hence, proton NMR relaxometry and HF-NMR spectroscopy are useful methods, which can provide information about water distribution and metabolic profiles in pigs of different origin.

From the present study it is also apparent that there is a general improvement in the sensory attributes when applying the alterative breeds, hence, application of alternative breeds in the Danish pig production may give rise to novel gourmet pork products.

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References

1. Purslow PP, Mandell IB, Widowski TM, Brown J, Delange CFM, Robinson JAB et al. (2008) Modelling quality variations in commercial Ontario pork production. Meat Sci 80:123-131

2. Rosenvold K, Andersen HJ (2003) Factors of significance, for pork quality - a review. Meat Sci 64:219-237

3. Christensen LB (2003) Drip loss sampling in porcine m. longissimus dorsi. Meat Sci 63:469-477

4. Menon RS, Allen PS (1991) Application of Continuous Relaxation-Time Distributions to the Fitting of Data from Model Systems and Excised Tissue. Magn Reson Med 20:214-227

5. Savorani F, Tomasi G, Engelsen SB (2010) icoshift: A versatile tool for the rapid alignment of 1D NMR spectra. J Magn Reson 202:190-202

6. Bertram HC, Karlsson AH, Rasmussen M, Pedersen OD, Donstrup S, Andersen HJ (2001) Origin of multiexponential T-2 relaxation in muscle myowater. J Agric Food Chem 49:3092-3100

7. Bertram HC, Donstrup S, Karlsson AH, Andersen HJ (2002) Continuous distribution analysis of T-2 relaxation in meat - an approach in the determination of water-holding capacity. Meat Sci 60:279-285

8. Schafer A, Rosenvold K, Purslow PP, Andersen HJ, Henckel P (2002) Physiological and structural events postmortem of importance for drip loss in pork. Meat Sci 61:355-366

9. Stoier S, Aaslyng MD, Olsen EV, Henckel P (2001) The effect of stress during lairage and stunning on muscle metabolism and drip loss in Danish pork. Meat Sci 59:127-131

10. Bertram HC, Stodkilde-Jorgensen H, Karlsson AH, Andersen HJ (2002) Post mortem energy metabolism and meat quality of porcine M-longissimus dorsi as influenced by stunning method - A P-31 NMR spectroscopic study. Meat Sci 62:113-119