SEARCHING NEW PREDICTORS OF THE PIG LEAN MEAT PROPORTION BY MAGNETIC RESONANCE IMAGING (MRI)

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Background

The cost of approval of several pig classification methods has been highly reduced using the so-called statistical method "regression with surrogate predictors" (Daumas et al, 1998). This method is based on an intermediate reference method. The present French reference method, using 4 fat depths and 3 muscle depths, suffers from 2 disadvantages : the limited position and nature of the variables, the error size (RMSE = 1.7). Accuracy can be improved both by using fat and muscle areas (or volumes) and by measuring in several anatomical regions. MRI, which was known as a powerful tool for body composition studies in animal science purposes (Baulain, 1997 ; Davenel et al, 1999), seemed adapted to such.

Objectives

The main objective was to test the potential of MRI technique for searching for new predictors of the lean meat proportion. An intermediate objective consisted in checking the potential of MRI technique for estimating both the muscle weight and the lean meat proportion.

Methods

Sampling, imaging and dissection

Eighteen left sides of pig carcasses from different genotypes and two sexual types (females and castrated males) were selected in a commercial slaughterhouse. After chilling overnight they were scanned every centimetre with a 0.2T Magnetom Open Siemens equipment. For each MRI slice, two gradient-echo MRI images were simultaneously acquired, one with a large carcass/background contrast for segmenting the whole of the half-carcass (8ms echo : fig.1, image1) and the other with a large muscle/fat tissues contrast (19ms echo : fig.1, image2).

The day following imaging the sides were jointed and dissected according the EU reference dissection (Walstra and Merkus, 1996). After jointing, the 12 joints were weighed. The sum was called "carcass weight". As the head was not scanned the "carcass weight without head" was calculated. After dissection of the 4 main joints (ham, loin, shoulder and belly) muscle tissue was weighed. This sum, including tenderloin weight, multiplied by 1.3 was called "muscle weight". Dividing by carcass weight gave the lean meat proportion (LMP).

Image processing

The heterogeneousness of the apparatus was first corrected by dividing each carcass image by the corresponding image of an homogeneous oil phantom. Carcass segmentation was performed on the 8ms echo images using a different threshold for each pig and for each slice. Muscle segmentation was performed on the 19ms echo images using also a different threshold for each pig and for each slice. An attempt to segment non-muscle tissues into adipose tissue and bone tissue was done on the 19ms echo images. For each slice and each tissue was counted the number of voxels which represented the tissue volume.

Statistical analysis

Profiles of muscle tissue (fig.2) were draw in order to locate some fix anatomical points. These fix points were needed for a correspondence between slices of different pigs because of a different length. One fix point was used for each main part : front part, median part, hind part. From these points were determined 3 regions formed by continuous slices : 10 for the front part and 20 for the others. From muscle, fat and total volumes in these regions were built several predictors.

Main statistical analysis were performed by linear regression. BIC criterion was used for model selection. Some additional investigations are in progress using PLS (Partial Least Squares). All calculations were made using SAS software.

Results and discussion

Estimating muscle weight from MRI muscle volume had a RSD of 511 g ($R^2 = 0.96$). Estimating carcass weight (without head) from MRI carcass volume had a RSD of 579 g ($R^2 = 0.97$).

Images observation showed that a part of the carcass was failing on the shoulder region on 2 carcasses, probably because of a bad position in the scanning device. Removing these 2 carcasses decreased the RSD to 0.81 ($R^2 = 0.94$) when estimating LMP (without head) from MRI muscle proportion.

An anisotropic filter is still in test in order to enhance MRI contours. This pre-treatment could make easier the segmentation, especially for muscle tissue. Fat and bones segmentation could be improved by anatomical recognition. Segmentation of the subcutaneous layers could be investigated in some critical regions.

For predicting carcass volume or LMP another statistical method seems more accurate. Instead of a prior segmentation PLS could be performed directly from the grey-level frequencies.

The most predictive region of the MRI criteria was the ham. RSD was 282 cm3 for estimating MRI muscle volume and 0.78 for estimating MRI LMP. Combining 2 or 3 regions decreased the error of LMP : from 0.52 with 2 variables to 0.22 with 6 variables. In the latter case over-adjustement was expected. Additional calculations are still in progress using PLS.

Conclusions

MRI offers a number of possibilities for non-invasive carcass composition analysis of the pig. Based on side scans, muscle and fat weights as LMP were estimated with a high accuracy using a rather simple segmentation method with a specific threshold for each image. Improvements are expected with a better segmentation of non-muscle tissue (fat vs bone).

MRI is a valuable tool for searching for new predictors of LMP. Scanning one third of a side gave sufficient information. Scanning one block (approximately 20 cm) permitted accurate estimations : hind (ham) and median (trunk) regions were the most pertinent. Combination of several regions could reveal a good potential.

Some improvements are expected by a better position of the sides in the scanning tunnel, a best correspondence between the scanned and dissected parts, a more complex segmentation and the use of PLS.

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Figure 1 : Segmentation of carcass and muscle

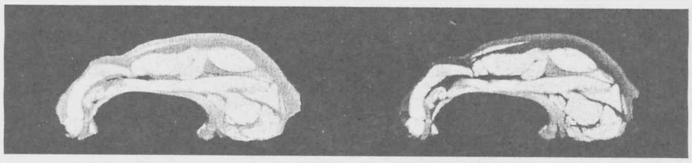

image 1: carcass segmentation image 2: muscle segmentation

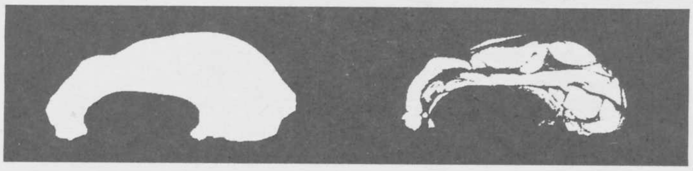

Figure 2 : Profiles of MRI muscle proportions for a fat and a lean pig from front shank (slice 1) to hind shank (slice 151)