Prediction Of Intramuscular Fat In Live Pigs Using Ultrasound Technology And Potential Use In Selection

L. Maignel[1], J.P. Daigle[2], C. Gariépy[3], D. Wilson[4], B. Sullivan[1]

Introduction

Selection of pigs for leaner carcasses has been very efficient in the past decades, but as total body fat decreased, intramuscular fat might also have been affected. Nowadays, an increasing number of export and domestic markets require minimum levels of visible fat, or marbling, in pork loins. Pork marbling is related to eating quality and consumer preference (Ngapo et *al.,* 2007). There is a need to routinely evaluate, and possibly select on marbling. However, this trait is expensive to measure and requires sacrificing the animals, which can be done only on a limited number of animals in breeding populations. A new technology based on ultrasound scanning and image analysis was developed at Iowa State University and could potentially help predicting intramuscular fat (IMF) content in the loin of live pigs (Schwab and Bass, 2006). This technology was tested on a thousand Canadian Duroc pigs, in order to check its accuracy, compute genetic parameters for live IMF and study its potential application in the Canadian Swine Improvement Program.

Material and methods

Live measurements. A total of 1,000 Duroc pigs from 16 farms across Canada, including 499 females, 456 males and 45 castrates were scanned using an Aloka 500 SSD with a 12.5 cm, 3.5 MHz probe. Between 8 and 10 longitudinal images covering the area of 10^{th} to 13^{th} ribs were saved for each pig.

Image analysis. Ultrasound scans were analyzed by one technician using the Biosoft Swine Toolbox developed by Biotronics, and validated by an expert at Biotronics. Only good quality images in terms of site and contrast were kept for analysis, by moving a square Region Of Interest (ROI) of either 80×80 or 100×100 pixels where the analysis was performed. For each pig analyzed, *in vivo* IMF (IV-IMF) was computed as the average value of at least 5 good images. An example of image analysis is shown on Figure 1.

Carcass measurements. A group of 150 pigs including 82 females, 37 males and 31 castrates from one participating farm were slaughtered 3 to 4 days after IMF scanning. Loin sections from ribs 10 to 13 were extracted from the right loin of each carcass and visually scored for marbling using NPPC marbling standards (NPPC, 1999), ranging from 1 (no marbling) to 10 (highly marbled).

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[1] Canadian Centre for Swine Improvement inc, Central Experimental Farm, Bldg 54, 960 Carling avenue, Ottawa (Ontario) K1A 0C6 Canada
[2] Centre de développement du porc du Québec inc, 2795 boul. Laurier, bureau 340, Québec (Québec) G1V 4M7 Canada
[3] Food Research and Development Centre, Agriculture and Agri-Food Canada, 3600 boulevard Casavant Ouest, Saint-Hyacinthe (Québec) J2S8E3 Canada
[4] Biotronics inc, Aspen Business Park, 1606 Golden Aspen Drive Suite 104, Ames, Iowa 50010-8011, USA

Loin samples at the 11th and 12th ribs were analyzed for chemical IMF according Chandrasekar *et al*. (2001). Intramuscular collagen content was also determined following the colorimetric determination of hydroxyproline (Kolar, 1990). Fatty acid profile assessment was carried out following the procedure of Park and Goins (1994).

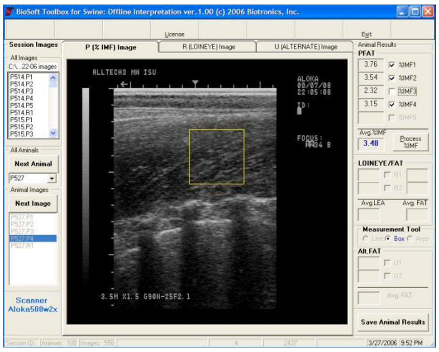

Figure 1: Analysis of an ultrasound scan using Biosoft Toolbox for Swine.

Statistical analyses. Analyses were performed using GLM and CORR procedures from SAS software. (Co)variance components for IV-IMF, age, backfat and lean depth adjusted to 100kg were analyzed using restricted maximum likelihood (REML) methodology applied to a multiple trait animal model from VCE software (Kovacs and Groenveld, 2003).

Results and discussion

Accuracy of IMF prediction. Figures 2 and 3 show the joint distribution of IV-IMF with chemical IMF and visual marbling score, respectively. The correlation with IV-IMF was 0.69 for chemical IMF and 0.55 for average NPPC marbling score. The standard error of prediction of chemical IMF using IV-IMF was 0.71% in this sample.

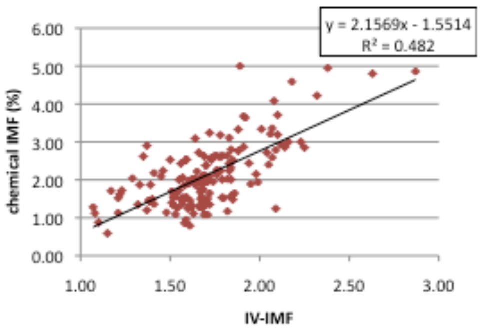

Figure 2: Joint distribution of IV-IMF and chemical IMF.

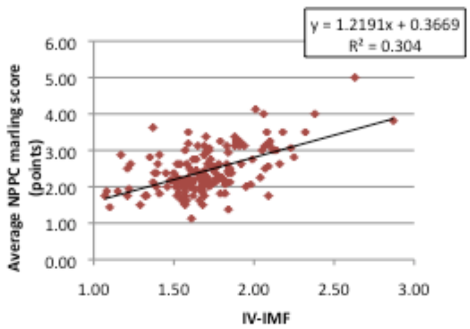

Figure 3: Joint distribution of IV-IMF and visual marbling score

Effect of intramuscular collagen content and fatty acid profile on loin IMF prediction. Collagen is one of the muscle components that has been suggested in the past to create potential 'noise' in ultrasound scans, which might influence the quality of IMF prediction. Fatty acid profiles have an impact on fat tissue texture and might also impact the propagation of ultrasound and hence the quality of scan images. Both aspects were analyzed by focusing on subgroups of 50 pigs with either low or high levels of total loin collagen and degree of unsaturation of loin fatty acids, to see potential differences on the quality of the IMF prediction. For total collagen content, no difference was found between high and low collagen content groups, suggesting that intramuscular collagen does not have an impact on the ultrasound image quality or the subsequent signal analysis. In the subset of 50 pigs with lower degree of unsaturation, the correlation between chemical and *in vivo* IMF was 0.72, vs. 0.60 in the group of 50 pigs with the highest degree of unsaturation. This suggests that the loin fatty acid profile might affect the accuracy of the *in vivo* prediction of loin IMF. This will have to be confirmed on a higher number of animals, and if confirmed, would require some adaptation in the algorithm used in the image analysis software package.

Genetic parameters. A total of 5,312 pigs scanned for fat and lean depths between January and June 2008 on the Canadian Swine Improvement Program were used in the genetic parameters estimation, including 1,000 pigs also scanned for IMF. Table 1 shows the estimates of genetic parameters for IV-IMF and other traits which are routinely measured around 100 kg live weight on selection candidates. In this study, IV-IMF was found to be highly heritable (h^2=0.69±0.07) and negatively correlated with lean depth (r_g=-0.46). This is consistent with estimations published by Newcom *et al*. (2005).

Table 1: Estimates of genetic parameters for IV-IMF, backfat thickness (BF100), lean depth (LD100) and age (AGE100) adjusted to 100kg live weight.

Traits	IV-IMF	BF100	LD100	AGE100
IV-IMF	0.69 ± 0.07	0.13 ± 0.11	-0.46 ± 0.11	-0.10 ± 0.19
BFT100	0.17	0.49 ± 0.04	0.37 ± 0.07	-0.27 ± 0.09
LD100	-0.14	0.18	0.38 ± 0.04	-0.14 ± 0.09
AGE100	0.05	-0.22	-0.08	0.28 ± 0.05

Heritabilities (±s.e.) on the diagonal, phenotypic correlations below and genetic correlations above the diagonal.

Predicted genetic gains. In order to predict the impact of including IV-IMF in a selection program, simulations were performed using a deterministic, step-by-step model. The Canadian Duroc population was simulated with various proportions of pigs scanned for IMF and different relative weights of IMF in the sire line index. Other traits in the index included growth, feed conversion ratio, lean depth and loin eye area, for which absolute weights were kept constant. Variance components estimated in this study were used as input parameters. Figure 4 shows the main results for scenarios where 25, 50, 75 or 100% of candidates are scanned for IMF. The potential gains are high, as expected from the high heritability of the trait. For instance, with a relative weight of 50% for IMF in the selection index and all pigs scanned for IMF, the expected gain would be 0.27% per year. These results provide information on selection strategies to put in place on this new trait. However, gains on other traits should also be included in the analysis, since their respective potential gains could be reduced with the inclusion of a new trait, but also because of genetic correlations among all traits. For instance, when 100% of pigs are scanned for IMF, switching the relative weight of

IMF in the index from 10 to 50% leads to doubling the progress on IMF (+0.27% vs. 0,14%) but would also decrease the progress on lean depth.

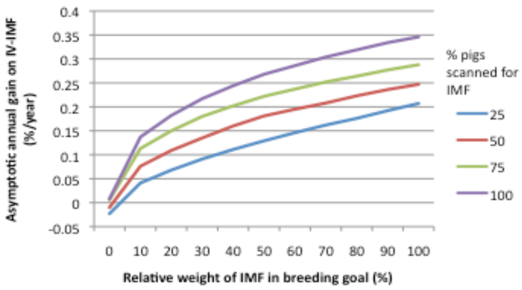

Figure 4: Predicted annual genetic gains on IMF in the Canadian Duroc population, based on the proportion of pigs scanned for IMF and the relative weight of the trait

Conclusion

This study has shown the potential to use ultrasound technology to predict intramuscular fat in the loin of live pigs. This development provides opportunities to select on meat quality without requiring carcass information to be collected routinely. IMF scanning has been added to the Canadian technician accreditation program for swine technicians in 2009 to ensure accurate and consistent application across the country. Pilot multi-trait genetic evaluations including IMF predicted *in vivo* have been developed, and provide tools for Canadian breeders to integrate selection for meat quality along with other economically important traits currently under selection.

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