VISUALIZATION OF MARBLING AND PREDICTION OF INTRAMUSCULAR FAT OF PORK LOINS WITH COMPUTED TOMOGRAPHY

Maria Font-i-Furnols¹, Albert Brun¹, Núria Tous²,³, Marina Gispert¹

¹IRTA-Product Quality, Monells, Girona, Spain
²IRTA-Monogastric Nutrition, El Morell, Tarragona, Spain
³URV, Reus, Tarragona, Spain

COST Action FAIM is acknowledged for their financial support. We would like to thank INIA for the financial support to the project “Evaluación in vivo del crecimiento alométrico de los tejidos muscular y adiposo de los cerdos según la genética y el sexo mediante tomografía computerizada”. INIA-RTA2010-00014-00-00.
Intramuscular fat content (IMF) and marbling varied across breed, sex, diet, muscle and slaughter weight.

IMF and marbling are moderately related (Font-i-Furnols et al., 2012; Faucitano et al., 2004).

→ Not all the IMF can be seen visually

Marbling standards
IMF – SENSORY TRAITS

IMF has been positively related with acceptability and tenderness (Bejerholm & Barton-Gade, 1986; Berge et al., 1993; Cannata et al., 2010; Font-i-Furnols et al., 2012; Fortin et al., 2005)

→ lubrication during chewing

However, in other works IMF had few (Johnson et al., 1988) or even negative (Andrieghetto et al., 1999) effect on acceptability and tenderness

The same discrepancy between studies has been found in preferences of marbled loins by consumers.
Introduction

Images: http://www.carniceriapedorivas.com

What do consumers like?
55% “lean loin lovers” (preferred mainly loins from G1 and G2)

45% “marbling loin lovers” (preferred mainly loins from G3 and G4)

Both “marbling loin lovers” and “lean loin lovers” gave higher scores in acceptability, tenderness and juiciness of loins with higher marbling and IMF (G3 and G4).

IMF is a parameter that could produce an added value to the product.
The aim of the present work was to use computed tomography (CT) to visualize marbling and quantify IMF in loin pork.
EXPERIMENTAL DESIGN

365 pork loins

CT scanned (3rd-4th last rib)
. Axial 120 (to visualize marbling)
. Axial 140 (to predict carcass composition)

GE HiSpeed Zx/I

Materials & Methods

Axial full 3s
1mm thick
120 kV
200 mA
EDGE

Axial full 1s
10mm thick
140 kV
145 mA
STND
EXPERIMENTAL DESIGN

365 pork loins

CT scanned (3rd-4th last rib)
  . Axial 120 (to visualize marbling)
  . Axial 140 (to predict carcass composition)

Histograms generation and checking for data analysis
EXPERIMENTAL DESIGN

Materials & Methods

CT scanned (3rd-4th last rib)
- Axial 120 (to visualize marbling)
- Axial 140 (to predict carcass composition)

Histograms generation and checking for data analysis

Calibration data set (2/3)
Validation data set (1/3)

Ordinary Linear Regression
Independent variables:
partial relative volumes every 10 or 20 HU values
maximum value

365 pork loins

Axial 120: HU 0 to HU 120
Axial 140: HU 0 to HU 120
*: HU 40 to HU 80
MARBLING

Materials & Methods

Axial 120

SF: 18.8mm
C40
W400

GE MEDICAL SYSTEMS
Results & Discussion

**Axial 120**

- less equal 1
- less equal 2
- less equal 3
- less equal 4
- less equal 5
- higher than 5

**Axial 140**

- less equal 1
- less equal 2
- less equal 3
- less equal 4
- less equal 5
- higher than 5

### Results

<table>
<thead>
<tr>
<th></th>
<th>Axial 140</th>
<th>Axial 140</th>
<th>Axial 140*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>-0.06</td>
<td>-0.79</td>
<td>-0.79</td>
</tr>
<tr>
<td>HU 0 to 20</td>
<td>0.87</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>HU 21 to 40</td>
<td>0.67</td>
<td>0.69</td>
<td>0.69</td>
</tr>
<tr>
<td>HU 41 to 60</td>
<td>0.18</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>HU 61 to 80</td>
<td>-0.20</td>
<td>-0.78</td>
<td>-0.78</td>
</tr>
<tr>
<td>HU 81 to 100</td>
<td>-0.31</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>HU 101 to 120</td>
<td>-0.26</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>HU 40 to 50</td>
<td></td>
<td></td>
<td>0.79</td>
</tr>
<tr>
<td>HU 51 to 60</td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>HU 61 to 70</td>
<td></td>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td>HU 71 to 80</td>
<td></td>
<td></td>
<td>-0.34</td>
</tr>
</tbody>
</table>
Linear regression

<table>
<thead>
<tr>
<th>Scanning protocol</th>
<th>Calibration</th>
<th>Validation</th>
<th>Variables included in the model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2$</td>
<td>RMSEPCV</td>
<td>$R^2$</td>
</tr>
<tr>
<td>A Axial 120</td>
<td>0.79</td>
<td>0.54</td>
<td>0.76</td>
</tr>
<tr>
<td>B Axial 140</td>
<td>0.76</td>
<td>0.56</td>
<td>0.76</td>
</tr>
<tr>
<td>C Axial 140$^1$</td>
<td>0.75</td>
<td>0.56</td>
<td>0.76</td>
</tr>
</tbody>
</table>

RMSEPCV: Root Mean Squared Error of Prediction obtained by cross-validation; RMSEP: Root Mean Square Error of Prediction; $R^2$: coefficient of determination; $^1$: proportion from 40 to 80 Hounsfield values.
Linear regression

<table>
<thead>
<tr>
<th>Scanning protocol</th>
<th>Calibration</th>
<th>Validation</th>
<th>Variables included in the model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2$</td>
<td>RMSEPCV</td>
<td>$R^2$</td>
</tr>
<tr>
<td>A Axial 120</td>
<td>0.79</td>
<td>0.54</td>
<td>0.76</td>
</tr>
<tr>
<td>B Axial 140</td>
<td>0.76</td>
<td>0.56</td>
<td>0.76</td>
</tr>
<tr>
<td>C Axial 140$^1$</td>
<td>0.75</td>
<td>0.56</td>
<td>0.76</td>
</tr>
<tr>
<td>A and B$^2$</td>
<td>0.83</td>
<td>0.46</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RMSEPCV: Root Mean Squared Error of Prediction obtained by cross-validation; RMSEP: Root Mean Square Error of Prediction; $R^2$: coefficient of determination; $^1$: proportion from 40 to 80 Hounsfield values. $^2$: n=222 for calibration and n=116 for validation.
# MARBLING

## Results & Discussion

<table>
<thead>
<tr>
<th>NPPC-CT</th>
<th>%</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>&gt;3</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPPC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>19</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>11</td>
<td>5</td>
<td>1</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>&gt;3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>54</td>
<td>34</td>
<td>11</td>
<td>1</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

8% MARBLING

55%
It would be of interest to determine IMF in live pigs. We have a national project (INIA-RTA2010-00014-00-00) in which we will try to estimate IMF in growing pigs from 30 to 120 kg.

By the moment:
- The determination of IMF in small pigs (70 kg) or less is difficult because of the lower amount of this tissue.
- It is possible to determine IMF in 100-120 kg pigs. Results are better if pigs have higher IMF content.
CONCLUSIONS

• Combination of data from images taken using two different acquisition conditions improves the estimation of intramuscular fat.

• Intramuscular fat can be predicted from loins using computed tomography images with a RMSEP of 0.45%.

• Evaluation of marbling from CT images using a scale for fresh meat produces an lower marbling scores.

• It is necessary to create a new marbling scale based on CT images for its evaluation.

• The determination of IMF in live pigs would produce an added value useful for meat industry.
Thank you for your attention

maria.font@irta.cat