Pork carcass classification and grading in Canada

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## Introduction

### Some definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition and usages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>The ranking of carcasses according to given parameters <strong>describing attributes</strong> (e.g., lean yield) of the carcass that are useful to those involved in their utilization (i.e., selection, trade, etc.)</td>
</tr>
<tr>
<td></td>
<td><strong>Usage:</strong> to establish carcasses evaluation systems based on given carcass quality criteria</td>
</tr>
<tr>
<td>Grading</td>
<td>The placing of different values (e.g., indexes) on carcasses <strong>for pricing purposes</strong>, depending on the market and requirements of traders</td>
</tr>
<tr>
<td></td>
<td><strong>Usage:</strong> to establish a <strong>payment</strong> system based on carcass quality</td>
</tr>
</tbody>
</table>
However, why are we interested in carcass classification and grading?
Carcass grading systems have been developed across domestic animals species and countries to:

- **Facilitate the trade** of carcasses by providing a common and unambiguous language for describing the commercially important attributes of carcasses (Allen and Oka, 2004).

- **Pay** producers according to the quality of their product. In Canada, the pork carcass grading system was developed "to ensure that producers receive a fair, impartial and equitable return based on the lean yield of their carcasses" (Fredeen et al. 1964; Price 1995; Daumas 1999).
Introduction

When carcass attributes have a real value to trade and the classification is accurate and meaningful to all industry sectors, carcass grading could be effective,

➢ **To send a clear signal to the production sector**
  - reflecting consumer demands
  - maintaining the profitability of the overall sector

(Allen and Oka, 2004; Marcoux et al., 2007; Andersen, Oksbjerg et al., 2005).
Accurate carcass quality assessment and meaningful carcass classification and grading systems are essential to,

- Define common carcass quality objectives across industry sectors
- Improve production effectiveness by allowing the production sector to identify optimal production methods in terms of genetics, feeding and management
- Facilitate the link between specific market demands (niche markets) and specialized production systems
In integrated pig production systems, accurate and meaningful carcass quality assessment systems can contribute to,

- Identify the best genetics, feeding programs and management strategies (e.g., slaughter weight) for optimal production profitability
- Allow easy development and management of several production schemas each responding to specific market demands
- Continuous evaluation of production effectiveness
Introduction

In this presentation we will address the following topics

- Pork carcass quality assessment
  - Current reference methods
  - On-line measuring methods
  - Prediction methods
  - Quality of the predictions
- Limits of current methods
- Future perspectives
In most pig producing countries, pork carcass quality is estimated based on carcass weight and lean yield.

Carcass lean yield is defined as the proportion of tissues of interest of a carcass obtained according to a reference method in which carcass preparation and the number and extent of dissected tissues is precisely described.
Pork carcass quality assessment

- The tissues of interest are mainly dissected lean but they can also include some fat and bones.

Canada

Saleable lean yield (%) = \frac{X}{100}
Current reference methods

Today the Canadian pork carcass classification system


- Today pigs are much heavier in relation to those sampled in the 1992 National cut-out

<table>
<thead>
<tr>
<th>1992 cut-out carcass characteristics</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>n</td>
<td>mean</td>
<td>STD</td>
<td>Min</td>
</tr>
<tr>
<td>Hot carcass weight, kg</td>
<td>1527</td>
<td>81,2</td>
<td>6,3</td>
<td>65,2</td>
</tr>
<tr>
<td>Lean yield, %</td>
<td>1445</td>
<td>59,8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backfat, Hennessy, mm</td>
<td>1660</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle depth, Hennessy, mm</td>
<td>1660</td>
<td>48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Average warm carcass weights, kg](image-url)
On-line measuring methods

✓ Optical probes

- Destron (Anitech Identification System Inc., ON)
- Fat-O-Meat’er (FOM) (Carometec A/S, Herdev, Denmark. Former SFK Ltd)
- Hennessy Grading Probe (HGP) (Hennessy Grading Systems Ltd., Auckland, New Zealand)
- Capteur Gras-Maigre (CGM) (Sydel, Lorient, France)
- Danish Classification Center (Carometec A/S, Herdev, Denmark)
On-line measuring methods

- Ultrasound probes

- Ultraform (UFOM) (Carometec A/S, Herdev Denmark)
- Carcass Value Technology (CVT) (Animal Ultrasound Services (AUS), Inc, Ithaca, NY, USA)
On-line measuring methods

✓ Ultrasound probes

- AUTOFOM (Carometec A/S, Herdev Denmark)
✓ Artificial vision

- VCS (e+V Technology GmbH, Oranienburg, Germany)
- CSB-Image-Meater®, Germany)
Different statistical methods for creating prediction formulae are available.

The choice for a particular prediction method depends mostly on the instrument which is used to measure the predictors.

When the number of predictors is reduced and uncorrelated, traditional least square regression methods can be used.

Prediction methods:

Canada

\[
Saleable\ lean\ yield\ (\%) = \frac{CLY\ (\%)}{X\ 100}
\]

\[
CLY\ (\%) = 68.1863 - 0.7833f + 0.0689m + 0.0080f^2 - 0.0002m^2 + 0.0006fm
\]
Prediction methods

When instruments extract many measurements, partial least squares or principal component regression methods are recommended.

\[
\hat{Y} = 122.458 + 0.05805 \times X_1 + 0.01449 \times X_2 - 0.02996 \times X_3 - 0.001585 \times X_4 - 39.297 \times X_5 - 47.553 \times X_6 + 38.877 \times X_7 - 0.1013 \times X_8 + 0.00004308 \times X_9 - 817.242 \times X_{10} + 10.135 \times X_{11} + 15.277 \times X_{12} - 25.777 \times X_{13} - 90.738 \times X_{14} + 0.0005792 \times X_{15} + 2.743 \times X_{16} - 0.06866 \times X_{17} + 3.511 \times X_{18} - 0.1681 \times X_{19} - 0.007867 \times X_{20} - 0.1082 \times X_{21} - 0.01290 \times X_{22} + 0.02957 \times X_{23} + 0.03856 \times X_{24} - 0.003353 \times X_{25} - 0.03378 \times X_{26} - 0.01661 \times X_{27} + 2.368 \times X_{28} - 0.3133 \times X_{29} - 0.01386 \times X_{30} - 0.02100 \times X_{31} - 0.01908 \times X_{32} - 0.02442 \times X_{33} + 0.06009 \times X_{34} - 0.007792 \times X_{35} - 2.598 \times X_{36} - 7.632 \times X_{37} - 0.004848 \times X_{38} - 0.9099 \times X_{39} - 20.514 \times X_{40}
\]

Limits of current on-line technologies

- Limited measurement accuracy
Limited measurement accuracy

Pomar and Marcoux, 2005
Limits of current on-line technologies

- Limited prediction accuracy

RSD or RMSEP between 1.5 and 2.5%

Pomar et al., 2008
Limits of current classification methods

✔ Actual method weakness

➤ Perforation of some tissues which may reduce its value and increase the risk of contamination (optical probes)

➤ Complex algorithms for data cleaning and analysis (automatic systems)

➤ Limited possibilities for quality control of measurements and predictions (automatic systems)

➤ Limited capability for measuring carcass cut weights and composition (all systems)
Limits of current reference methods

✓ But the primary limit of actual systems to assess pork carcass quality does not originate from the technologies themselves, but from the conception of actual carcass evaluation systems

✓ In actual systems, carcass lean yield *is believed* to be associated to its commercial value

✓ *Is carcass weight and lean yield the carcass attribute that better describe its commercial value?*
Carcass market value ($/kg) has only a weak link with the various definitions of lean yield and grid indices

<table>
<thead>
<tr>
<th>Lean yield definition and indices</th>
<th>Correlation coefficient (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian lean yield predicted by Destron</td>
<td>0.14</td>
</tr>
<tr>
<td>European dissected lean content</td>
<td>0.23</td>
</tr>
<tr>
<td>Commercial cut weight (e.g., ham, loin, etc.)</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Marcoux et al. 2007
The low correlations between carcass market value and lean yield are explained by the proportion of the weight of the various cuts relative to total carcass weight.
The optical probes are unable to evaluate the morphological difference between carcasses other than fat and muscle depths.

Ex: Proportion of cut weight relative to the carcass weight for the same best classification result on 2 carcasses

<table>
<thead>
<tr>
<th>No</th>
<th>Destron fat depth (mm)</th>
<th>Predicted lean yield (%)</th>
<th>Grid index</th>
<th>Ham (%)</th>
<th>Loin (%)</th>
<th>Belly (%)</th>
<th>Shoulder (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>126</td>
<td>20,0</td>
<td>60,3</td>
<td>115</td>
<td>26,5</td>
<td>28,9</td>
<td>17,6</td>
<td>26,9</td>
</tr>
<tr>
<td>129</td>
<td>20,5</td>
<td>60,3</td>
<td>115</td>
<td>28,7</td>
<td>25,2</td>
<td>16,8</td>
<td>29,2</td>
</tr>
</tbody>
</table>
The 22 years old Canadian pork carcass classification system is not adapted to today carcasses

Carcass market value is not adequately correlated with carcass lean yield

Therefore, why are we classifying and grading pork carcasses?
Carcass grading systems have been developed across domestic animals species and countries to,

- Facilitate the trade of carcasses by providing a common and unambiguous language for describing the commercially important attributes of carcasses (Allen and Oka, 2004).

- Pay producers according to the quality of their product...

- To send a clear signal to the production sector that...
Limits of current reference methods

In integrated pig production systems, accurate and meaningful carcass quality assessment systems can contribute to,

- **Identify** the best genetics, feeding programs and management strategies (e.g., *slaughter weight*) for optimal production profitability

- Allow **easy development and management** of several production schemas each responding to specific market demands

- **Continuous evaluation of production effectiveness**
New pork carcass quality assessment approaches are needed

The conformation and compositional information should be obtained on-line for each carcass
The new pork carcass quality assessment methods should determine precisely the weight, composition and value of each carcass cut.

Ex: Proportion of ham weight in relation to visual conformation classes.
Carcasses should be virtually cut and the weight and composition of each cut estimated using measurements taken on the 3D modeled carcasses.
The new carcass evaluation systems have de potential to estimate retail cuts’ weight and composition.
New carcass quality assessment methods

✓ The new carcass evaluation systems will be used to,

- Optimize carcass cutting and market utilization
- Evaluate the genetic merit of individual carcasses
- Establish more faithful carcass payment systems
- Provide the right signal for carcass quality to production

✓ Carcass information will be stored and used for further analysis
Thank you
Merci beaucoup

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Some clarifications

For classification and grading, these carcass attributes which normally only includes carcass measurements (e.g., fat and muscle depths, lean yield) should not exclude meat quality measurements (e.g., pH, color, intramuscular fat)
Introduction

➢ The need to place an objective value on pork carcasses has been recognized by the pig industry for more than 80 years.

➢ It was not until the 60's that an effective value-based systems were introduced in many countries following the capacity to measure fat depths with automatic probes in slaughter plants.

➢ Frequently, pork carcass grading systems use carcass weight and lean yield to determine the commercial value of carcasses.

<table>
<thead>
<tr>
<th>CATÉGORIE DE RENDEMENT</th>
<th>RENDEMENT APPRoximatIF EN VIANDE</th>
<th>CATEGORIE DE POIDS (EN KILOGRAMMES)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64,3 et plus</td>
<td>80 88 102 110 116 116 112 102 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>61,5-64,3</td>
<td>80 86 98 108 114 114 110 100 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>59,5-61,8</td>
<td>80 86 94 104 110 110 106 98 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>57,7-59,8</td>
<td>80 82 92 102 108 108 104 94 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>55,9-57,7</td>
<td>80 82 88 98 106 106 102 90 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>54,7-56,1</td>
<td>80 82 88 98 100 100 98 88 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>54,7 et moins</td>
<td>80 82 84 92 96 96 94 84 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Different definitions of meat yield are used for carcass quality assessment.

**Canada**

\[
\text{Saleable lean yield (\%)} = \frac{X}{X} \times 100
\]

**Europe**

\[
\text{Lean yield (\%)} = \frac{X}{X} \times 100
\]

**USA**

\[
\text{Fat free lean yield (\%)} = \frac{X}{X} \times 100
\]

Since 2006 the EU has changed the definition of lean yield (TVM) to LMP (Lean Meat Percentage).
# Pork carcass quality assessment

<table>
<thead>
<tr>
<th>Method</th>
<th>The determination of the carcass quality should be,</th>
</tr>
</thead>
</table>
| **Reference**      | ✓ Measuring the desired attributes of carcasses  
|                     | ✓ Unbiased (true)  
|                     | ✓ Precise  
|                     | ✓ Maybe laborious  
|                     | ✓ Used in lab conditions  |
| **Usage**:         | accurate measurement of the desired carcass attributes which are meanly used to calibrate the indirect and on-line methods |
| **Indirect reference** | ✓ Accurate (normally less precise and true than the reference method)  
|                     | ✓ The desired attributes are estimated from indirect measurements  
|                     | ✓ Maybe laborious (less than the reference)  
|                     | ✓ Used in lab conditions  |
| **Usage**:         | replaces the reference method when cost and speed is a concern |
| **On-line**        | ✓ The desired attributes are estimated from indirect measurements taken in commercial conditions  
|                     | ✓ The level of accuracy should be estimated and periodically verified |
| **Usage**:         | speed and cost are major concerns |
Current reference methods

✔ Canadian cutout and dissection by butchers

Ex: Loin

Ex: Picnic
Current reference methods

✓ European cutout and dissection by butchers

Ex: Loin

Ex: Belly
Current reference methods

- USA cutout and dissection by butchers
Indirect reference methods are used to reduce the disadvantages (e.g., time consuming, cost, operator effect, etc.) brought about by the reference method.

- Dual Energy X-Ray Absorptiometry (DEXA)
- X-Ray Computed Tomography (CT-scan)
- Magnetic Resonance Imaging (MRI)
On-line measuring methods

Electrical properties

- BIA (Bio electrical impedance analysis, RJL Systems, Detroit, MI, USA)
- TOBEC (Total Body Electrical Conductivity, Meat Quality Inc., Springfield, USA)
On-line measuring methods

✓ Artificial vision


Fig. 1. The two components of the Lacombe Computer Vision System for grading pig carcasses are a computer vision system to provide 2- and 3-dimensional measurements on a carcass and an ultrasound system to provide fat thickness, depth and area of the loin (or longissimus dorsi).
RMSE and RMSEP should be used.

In Europe, grading methods should be authorized only if the root mean squared error of prediction (RMSEP), computed by a full cross-validation or by a test set validation on a representative sample of at least 60 carcasses, is less than 2.5 (EU Regulation 1249/2008).

\[
RMSEP = \sqrt{\frac{(y_i - \hat{y}_i)^2}{n}}
\]
The value of the meat and fat is related to its location in the carcass rather than to its total weight.

<table>
<thead>
<tr>
<th>Cuts</th>
<th>Market value ($/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial ham</td>
<td>1.48</td>
</tr>
<tr>
<td>Commercial loin</td>
<td>2.95</td>
</tr>
<tr>
<td>Commercial belly</td>
<td>3.40</td>
</tr>
<tr>
<td>Spare-ribs</td>
<td>3.45</td>
</tr>
<tr>
<td>Picnic</td>
<td>1.30</td>
</tr>
<tr>
<td>Butt</td>
<td>1.73</td>
</tr>
</tbody>
</table>

Marcoux et al. 2007
New carcass quality assessment methods

The concept has been validated using 61 carcasses from which 3D images were taken before cut and dissected.

Carcasses were selected according to:

- gender (barrows and gilts),
- fat depth (< 14.9, 15.0 to 18.9 and > 19.0 mm)
- carcass weight (< 85, 90 to 100 and > 105 kg)
- Conformation (AA, A, B and C)
Cuts’ weight are precisely estimated (CVe < 0.6%)

<table>
<thead>
<tr>
<th>Primal cuts</th>
<th>Average weight (kg)</th>
<th>R²adj</th>
<th>Estimation error (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ham</td>
<td>11.776</td>
<td>0.999</td>
<td>0.024</td>
</tr>
<tr>
<td>Shoulder</td>
<td>12.188</td>
<td>0.999</td>
<td>0.024</td>
</tr>
<tr>
<td>Loin</td>
<td>11.600</td>
<td>0.998</td>
<td>0.048</td>
</tr>
<tr>
<td>Belly</td>
<td>7.811</td>
<td>0.998</td>
<td>0.046</td>
</tr>
</tbody>
</table>
Cuts’ composition are precisely estimated
For ham, shoulder and loin: CVe < 4.3%

<table>
<thead>
<tr>
<th>Primal cuts</th>
<th>Average lean weight (kg)</th>
<th>$R^2_{adj}$</th>
<th>Estimation error (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ham</td>
<td>7.588</td>
<td>0.935</td>
<td>0.260</td>
</tr>
<tr>
<td>Shoulder</td>
<td>6.759</td>
<td>0.868</td>
<td>0.281</td>
</tr>
<tr>
<td>Loin</td>
<td>6.854</td>
<td>0.901</td>
<td>0.272</td>
</tr>
<tr>
<td>Belly</td>
<td>4.078</td>
<td>0.691</td>
<td>0.330</td>
</tr>
</tbody>
</table>
For each carcass, the weight and composition of primal and sub-primal cuts should be estimated.