The use of visible and near infrared reflectance spectroscopy for prediction and improvement of meat quality characteristics in beef

R. Roehe¹, N. Prieto¹, D.W. Ross¹, E.A. Navajas¹, G.R. Nute², R.I. Richardson², J. Hyslop¹ & G. Simm¹

¹Scottish Agricultural College, Edinburgh, UK
²University of Bristol, Bristol, UK

Importance of Meat Quality

• Technological quality
  – Shelf-life (lipid oxidation)
  – Colour (myoglobin oxidation)
  – Water holding capacity (pH values)

• Sensory quality
  – Tenderness
  – Juiciness
  – Flavour

• Nutritional quality
  – Protein
  – Fatty acid profiles
Near-infrared (NIR) spectroscopy & meat quality characteristics

- Fatty acid profiles
- Sensory characteristics
- Colour & cooking loss
- Physical tenderness measurements

Data description and analysis

- 106 crossbred steers and heifers sired by Limousin
- 88 crossbred steers and heifers sired by Aberdeen Angus
- Vis-NIR measurements *M. longissimus thoracis*
  - 13th rib region (caudal end) 48 hours post mortem
  - Scanning 1 nm over spectral range (350 to 1,800 nm)
- Absorbance data (log 1/R)
- Calibrations using partial least squares regression
- Cross-validation
  - Best model selection
  - Criteria: Minimisation of the standard error of cross-validation
What is NIR measuring?

- O-H bonds: water
- N-H bonds: Protein
- C-H bonds: fatty acids

Correlation coefficient between groups of fatty acid content and absorbance
Near-infrared (NIR) spectroscopy & groups of fatty acids in beef

Vis-NIR measures & individual fatty acids:
- $r=0.78$ Palmitic acid (C16:0)
- $r=0.68$ Stearic acid (C18:0)
- $r=0.79$ Oleic acid (C18:1)

Vis-NIR measures & groups of fatty acids:
- $r=0.74$ saturated fatty acids (SFA)
- $r=0.80$ monounsaturated fatty acids (MUFA)
- $r=0.49$ polyunsaturated fatty acids (PUFA)

Correlations: fatty acids & sensory characteristics

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavour</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFA</td>
<td>0.33***</td>
<td>0.52***</td>
<td>0.38***</td>
</tr>
<tr>
<td>MUFA</td>
<td>0.29**</td>
<td>0.49***</td>
<td>0.37***</td>
</tr>
<tr>
<td>PUFA</td>
<td>0.36***</td>
<td>0.68***</td>
<td>0.40***</td>
</tr>
</tbody>
</table>

*** $P < 0.001$, ** $P < 0.01$
Correlations between Vis-NIR measurements & meat quality traits

Vis-NIR & water holding capacity:
- \( r=0.60 \) Cooking loss

Vis-NIR & taste panel traits:
- \( r=0.53 \) tenderness
- \( r=0.45 \) juiciness
- \( r=0.77 \) flavour

Vis-NIR & colour:
- \( r=0.93 \) \( L^* \) colour
- \( r=0.93 \) \( a^* \) colour
- \( r=0.95 \) \( b^* \) colour

Vis-NIR & physical tenderness measurements:
- \( r=0.61 \) Volodkevitch shear force
- \( r=0.74 \) Slice shear force (3 days)
- \( r=0.56 \) Slice shear force (14 days)

Conclusions

- Vis-NIR simultaneous measurements of numerous:
  - technological meat quality characteristics
  - and sensory meat quality traits
- Vis-NIR is able to predict fatty acids composition (human health)
- Vis-NIR used on-line:
  - Early (in the abattoir)
  - Fast
  - Non-invasive
  - Cost-effective
- Implementation
  - Value-based marketing system
  - Genetic improvement programmes
Genome-wide selection for meat quality

- SNP-Chip identifies >54,000 genomic markers
- Used to predict all gene effects attributing to meat quality

Acknowledgements

The research on beef meat quality is funded by the Rural & Environment Research & Analysis Directorate of the Scottish Government

Aligned research is sponsored through DEFRA Link

Other collaborators are shown below