Prediction of polyunsaturated fatty acid content in the bovine muscle

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Dietary fatty acids (FA) in human nutrition

**FA requirement**

- **PUFA**
  - 15% ω6
  - 60% MUFA
  - 25% SFA

\[
\frac{\omega 6}{\omega 3} \leq 5
\]

(Ansnes, 2010)

**PUFA**: polyunsaturated fatty acid

**Important PUFA needs**

- MUFA: 39%
- SFA: 44%
- PUFA: 16%

\[
\frac{\omega 6}{\omega 3} : 15 \text{ to } 30
\]

(Afssa, INCA2, 2007)

**Unbalanced ω6/ω3 ratio**

**Mean FA consumption**

We don’t consume enough ω3

**Human** can’t synthetized ω3 PUFA

- Only in plants
- in animals

Introduction
We must be able to measure the content of ω3 PUFA in the beef slaughter chain.

Feeding strategy to increase ω3 PUFA content in animal products: fresh grass, linseed,…

Results control for labels

Nutritional quality information for consumer

Positive economic impact on beef industry
### Glossary of fatty acids (FA)

<table>
<thead>
<tr>
<th>DENOMINATION</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Saturated FA</strong></td>
<td>SFA</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>-</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>-</td>
</tr>
<tr>
<td><strong>Mono-unsaturated FA</strong></td>
<td>MUFA</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>-</td>
</tr>
<tr>
<td><strong>Poly-unsaturated FA</strong></td>
<td>PUFA</td>
</tr>
<tr>
<td>ω6 Linoleic acid</td>
<td>LA</td>
</tr>
<tr>
<td>Arachidonic acid</td>
<td>ARA</td>
</tr>
<tr>
<td>α-linolenic acid</td>
<td>ALA</td>
</tr>
<tr>
<td>ω3 Eicosapentaenoic acid</td>
<td>EPA</td>
</tr>
<tr>
<td>Decosahexaenoic acid</td>
<td>DHA</td>
</tr>
</tbody>
</table>

**Context**

MOUROT BP/EAAP 2013
# Method of fatty acids measurement

## Gas-Liquid Chromatography
- Time-consuming
- Costly
- Tissue sampling
- Laboratory material
- Not adapted for systematic daily controls

## Near-Infra Red Spectroscopy
- Short analysis time (1 to 2 min)
- Cheaper (than reference method)
- No depreciation
- Slaughter chain adapted (portable)
### Original work

<table>
<thead>
<tr>
<th>Major FA</th>
<th>GLC</th>
<th>NIRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFA</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Palmitic Acid</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>MUFA</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Oleic Acid</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>PUFA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ω6) LA</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>(ω6) ARA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ω3) ALA</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>(ω3) EPA</td>
<td></td>
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PUFA are more interesting for beef industry **BUT** NIRS cannot measure them.

Is there a link between major FA and PUFA?

NIRS can’t measured PUFA. We need to establish an alternative method to measure PUFA.

**Objective**
OBJECTIVES:

To develop prediction equations in order to predict PUFA indirectly from major FA
### Materials and methods

**• Prediction database:**

W3Meat in the data-warehouse Nutriflux\(^{\text{INRA}}\) from published beef FA composition (182 references, H 32000 values, >2000)

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Diets</th>
<th>Breeds</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Longissimus Thoracis</em></td>
<td>Concentrate</td>
<td>65 breeds and crossbreeds</td>
<td>Steer</td>
</tr>
<tr>
<td><em>Rectus Abdominis</em></td>
<td>Pasture</td>
<td></td>
<td>Cull cow</td>
</tr>
<tr>
<td><em>Semimenbranosus</em></td>
<td>Silage</td>
<td></td>
<td>Heifer</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>

**• Validation database:**

from industrial individual beef samples

(595 animals H 10000 values)

**• Selected statistical method:**

Multiple linear regression (\(^{\text{R}}\) software)

Prediction equations were performed by using a bibliographic database and linear regression.
Prediction equations of total PUFA and ω6 PUFA

predictors: SFA, Palmitic Acid, Stearic Acid, MUFA, Oleic acid

Each prediction equation has been tested and validated with the validation dataset.

Total PUFA

Adjusted $R^2 = 0.86$

$n_{trt} = 283$

Measured, %

Predicted, %

ω6LA

Adjusted $R^2 = 0.79$

$n_{trt} = 301$

Measured, %

Predicted, %

ω6 ARA

Adjusted $R^2 = 0.72$

$n_{trt} = 283$

Measured, %

Predicted, %
Prediction equations of $\omega_3$ PUFA

predictors: SFA, Palmitic Acid, Stearic Acid, MUFA, Oleic acid

$\omega_3$ PUFA predictions are not satisfactory

$\omega_3$ EPA

Predicted, %  

Adjusted $R^2 = 0.43$  
n_{trt} = 270

$\omega_3$ ALA

Predicted, %  

Adjusted $R^2 = 0.48$  
n_{trt} = 299

$\omega_6$ LA / $\omega_3$ ALA

Predicted, %  

Adjusted $R^2 = 0.16$  
n_{trt} = 299
Strategy to improve the prediction of beef ω3 PUFA

**Prediction equations**

- To update the database with recent data (from bibliography and own laboratory data).
- To incorporate more variable data (extreme data).

**NIRS calibrations**

- To find new tissue samples more variable in ω3 PUFA.
- To refine FA spectra treatments.
Conclusion

NIRS data used with prediction equations of PUFA

Well adapted for Total PUFA and ω6 PUFA determinations

More studies are in progress for ω3 PUFA determinations

Information on nutritional quality of beef

Could have a positive impact for producers, industries, and consumers
Thank you for your attention!
NIRS – method (1)

(De Marchi et al., 2013)

- Infrared scanning
- Reflected beam
- Meat
- Captor
NIRS – method (2)

(De Marchi et al., 2013)
NIRS – calibration

For a component

**Method:** Partial least square (PLS) regression

Model with $R^2 > 0.82$

= well calibrate (Guy et al., 2011)
Nutriflux Database
Prediction equation – Validation

- New dataset
- ≈ 600 FA composition from industrial animal production
- 3 different laboratories analysis

VALIDATED

But

laboratory effect to take care
What is a PUFA?

18:3 n-3 \( \alpha \)-linolenic acid (ALA)

PRECURSOR

18:2 n-6 Linoleic acid (LA)

Positive effects on health:
- Reduces risk of heart diseases
- Role in nervous system development

\( \omega 3 \) consumption: 0.8 g/d
\( \omega 3 \) requirement: 2.2 g/d

\( \Delta 5 \) \& \( \Delta 6 \) désaturase

18:3 n-3 \rightarrow 18:2 n-6

18:2 n-6 \rightarrow 20:4 n-6

20:4 n-6 \rightarrow 20:5 n-3 \rightarrow 22:5 n-3

20:5 n-3 \rightarrow 22:5 n-3

Elongase 5

Only find in plants (grass, oilseed)

Only find in animals which already have synthetized them

\( \omega 3 \) PUFA class have a great health benefic but we don’t enough consume them

INRA

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Context

26/08/2013