Effect of linseed supplementation on fatty acid composition and lipid oxidation of Maremmana beef

Conte G.*, Serra A., Casarosa L., Cappucci A., Mele M.

* e-mail: gconte@agr.unipi.it

25th to 29th August 2014
The fatty acid composition of meat is of interests because of its implications for human health.

Nutritionists now recommend:

- limiting fat intake
- Increasing consume of PUFA in substitution of SFA
- n-6/n-3 < 4
- α-linolenic acid intake in adults at least 2 g/d

Linseed supplementation in the diet of beef cattle has resulted in an increase in α-linolenic and conjugated linoleic acid (CLA) content in intramuscular fat (Bas et al., 2007; Jeronimo et al., 2009; Berthelot et al., 2010)
Meat oxidation and shelf-life

High level of PUFA

Reduction of:
- stability to oxygen;
- resistance to rancidity;
- optimal sensory quality;
- colour;

shelf life
The aim of this work was to evaluate the oxidative stability of intramuscular fat of beef obtained from Maremmana young bulls fed a diet supplemented with extruded linseed.
The experiment was carried out on 20 young bulls of the Maremmana breed.

The animals were weaned (6-8 month of age) and randomly assigned to groups of 10 animals each:

**Control (C)**
- Grass hay + Control concentrate (no added fat)
- 3.5 Kg/animal/day

**Experimental (E)**
- Grass hay + Concentrate 20% linseed
- 3 Kg/animal/day
- Grass hay + Control concentrate (no added fat)
- 4.5 Kg/animal/day
- Pasture
- Pasture + hay

**December**
- hay + cereals and horse bean grains
  (daily weight gain = 1 Kg)

**April**
- Pasture

**July**
- Pasture + hay

**September**
- Grass hay + Control concentrate (no added fat)
  3.5 Kg/animal/day

**November**
- Grass hay + Concentrate 20% linseed
  4 Kg/animal/day
Free Fatty Acid
TBARs
COPs
Colour
Vitamins and Carotenoids

\[ y_{ijz} = \mu + T_i + A_j + T_i \times A_j + I_z (T) + \epsilon_{ijz} \]

\( T \) = Treatment (C and E)
\( A \) = Aging (0, 2, 6 days)
\( I \) = Animal (1-20) as random factor
Result

Weight

Kg


Control
Experimental

Daily Weight Gain

Kg/d


Control
Experimental
## Results: Meat composition

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>E</th>
<th>SE</th>
<th>P&lt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM g/100 g meat</td>
<td>24.34</td>
<td>25.10</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>Protein g/100 g meat</td>
<td>22.01</td>
<td>21.89</td>
<td>0.32</td>
<td>0.12</td>
</tr>
<tr>
<td>Ash g/100 g meat</td>
<td>1.11</td>
<td>1.10</td>
<td>0.01</td>
<td>0.71</td>
</tr>
<tr>
<td>Lipids g/100 g meat</td>
<td>1.53</td>
<td>1.72</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Cholesterol mg/100 g meat</td>
<td>34.02</td>
<td>34.10</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>Iron mg/100 g meat</td>
<td>1.47</td>
<td>1.50</td>
<td>0.13</td>
<td>0.65</td>
</tr>
<tr>
<td>Organic Iron %</td>
<td>86</td>
<td>86</td>
<td>1.12</td>
<td>0.99</td>
</tr>
</tbody>
</table>

---

**Bruciapaglia et al. 2013** | **Mele et al., 2008**

<table>
<thead>
<tr>
<th></th>
<th>Piedmontese</th>
<th>Limousine</th>
<th>Holstein</th>
<th>Chianina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipids g/100 g meat</td>
<td>1.1</td>
<td>1.7</td>
<td>2.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Cholesterol mg/100 g meat</td>
<td>51</td>
<td>50.8</td>
<td>51</td>
<td>30</td>
</tr>
</tbody>
</table>
## Results: Fatty acid composition

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>E</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATURED g/100 g meat</td>
<td>26.31</td>
<td>24.93</td>
<td>1.07</td>
</tr>
<tr>
<td>MONOUNSATURED g/100 g meat</td>
<td>24.51</td>
<td>26.27</td>
<td>1.12</td>
</tr>
<tr>
<td>POLYUNSATURED g/100 g meat</td>
<td>8.76</td>
<td>8.67</td>
<td>0.60</td>
</tr>
<tr>
<td><strong>ω-6</strong> g/100 g meat</td>
<td>7.48</td>
<td>6.64</td>
<td>0.49</td>
</tr>
</tbody>
</table>
| **ω-3** g/100 g meat | 1.28   | 2.41   | 0.10  | **+ 88%**
| α-linolenic acid g/100 g meat | 0.50   | 1.06   | 0.04  | **+ 112%**
| **ω-6/ω-3** | 5.89   | 2.76   | 0.23  | **- 53%**
| CLA g/100 g meat | 0.31   | 0.45   | 0.04  | **+ 45%**
| TRANS ISOMERS g/100 g meat | 2.33   | 3.24   | 0.15  | **+ 39%**
| Thrombogenic Index | 1.21   | 0.96   | 0.06  | **- 21%**
| Atherogenic Index | 0.56   | 0.54   | 0.03  |
Free Fatty Acids

Hydrolysis of triglycerides is the first step of fatty acids oxidation.

FFA level increase significantly after 6 days of aging.

Hydrolysis of triglycerides:

\[ \text{Lipase} \rightarrow R^1\text{-COO} \text{H} + \text{HO-CH}_2 \]

A and B = aging differences
α and β = diet differences
TBARs level increase significantly in the experimental group after 2 days of aging, overcoming the rancidity threshold.

Relating the level of TBARS to PUFA content, the increase is similar for both groups.

A and B = aging differences
α and β = diet differences

CONTROL
EXPERIMENTAL
COPs

7-KETO CHOLESTEROL

Days

µg/100 g meat

0 2 6

B B + 51% Bβ

TRIOL

Days

µg/100 g meat

0 2 6

B B + 212% Bβ

A and B = aging differences

α and β = diet differences

COPs/ Cholesterol %

Days

0 2 6

CONTROL EXPERIMENTAL

Aα

B B B B B Bβ

A and B = aging differences

α and β = diet differences
Meat Colour

Lightness “L*”: reflectance of colour

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Experimental</th>
<th>SE</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>L*</td>
<td>49.5A</td>
<td>50.0A</td>
<td>1.4</td>
<td>***</td>
</tr>
<tr>
<td>a*</td>
<td>13.0A</td>
<td>12.2A</td>
<td>1.1</td>
<td>***</td>
</tr>
<tr>
<td>b*</td>
<td>12.9A</td>
<td>12.1A</td>
<td>1.2</td>
<td>***</td>
</tr>
<tr>
<td>H</td>
<td>44.1C</td>
<td>44.8C</td>
<td>1.9</td>
<td>***</td>
</tr>
<tr>
<td>C</td>
<td>18.4A</td>
<td>17.3A</td>
<td>1.4</td>
<td>***</td>
</tr>
</tbody>
</table>

Meat colour exhibited the expected pattern for satisfactory appearance and demonstrated that including 20% linseed in concentrate did not significantly alter meat colour.
Vitamins

**Vitamin A**

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>6</td>
<td>0.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Minimum threshold to increase the shelf life (Liu et al., 1995)

**Carotenoids**

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>0.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Although tocopherol level is higher in the experimental group, no more antioxidant effect was observed.

**α-tocopherol**

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>6</td>
<td>0.8</td>
<td>0.7</td>
</tr>
</tbody>
</table>

A and B = aging differences
α and β = diet differences
Conclusions

Linseed supplementation improve meat quality by increasing PUFAω-3 content.

The results confirmed the strictly relationship between the high level of PUFAω-3 and lipid oxidation of meat.

Finally, higher levels of antioxidants than those normally present in the intramuscular fat are needed in order to control the oxidation during the storage and increase shelf life of meat.

Thank you for your attention.