Effect of feeding regime on the fatty acid composition of South African beef

Dr Nicolette Hall & Prof Hettie Schönfeldt
Livestock under the spotlight

- Particular concerns for livestock, esp. red meat:
  1. *Environmental concerns* - Reported high carbon footprint & GHG emissions emitted through animal husbandry
  2. *Ethical concerns* – e.g. grass-fed vs. feedlot cattle
  3. *Health & nutrition implications* related to the consumption of certain fats, cholesterol and red meat in general
Uninformed consumer perception

**GRASS FED vs GRAIN FED**

**Healthiness**
- **Grass Fed**: Strong stress management in open pastures, no added hormones, growth hormones not used.
- **Grain Fed**: Poor stress management in cramped conditions, added hormones, antibiotics.

**Meat Quality**
- **Grass Fed**: Healthy, lean, no chemicals, tender, high marbling.
- **Grain Fed**: Unhealthy, high fat, high marbling, less tender.
**Good Fats**
- Polyunsaturates
- Monounsaturates

**Bad Fats**
- Saturated
- Trans

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**Is Saturated Fat Healthy?**

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**Natural trans fats from dairy and beef are good.**

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**Diagram:**
- Omega-3 fatty acids
- Omega-6 fatty acids
- Natural Diet: Desirable under 5:1, Intermediate, Undesirable over 10:1
- Modern Diet
Global findings for grass-fed beef:

✓ Less total fat
✓ Higher nutrient density
✓ More essential omega-3 fatty acids
✓ More heart-healthy CLA
✓ Higher SFA per 100g fat
✓ But lower SFA per 100g edible product as less total fat
Global findings for grass-fed beef:

- Less total fat
- Higher nutrient density
- More essential omega-3 fatty acids
- More heart-healthy CLA
- Higher SFA per 100g fat
- But lower SFA per 100g edible product as less total fat

What is true for South African beef?

4x more Vitamin E
10x more Vitamin A

Contains high levels of conjugated linolenic acid, which may enhance muscle growth, reduce heart disease, and lower cancer risk.
Updating the nutritional profile of South African beef

• Many studies reflecting the **substantial changes over time** in the composition of meat
• Especially reduction in the amount of fat
  ▪ On the carcass
    ▪ Changes in breed selection
    ▪ Changes in feeding regimes
  ▪ Changes in butchery technique (seam trimming)
  ▪ At home removal of visible fat
  ▪ Changes in preparation methods
Review: Changes in fat content of red meat over time
Review: Changes in fat content of red meat over time

2015?
Meat available in South Africa

Market variety - influences nutrient content

- **Production system**
  - Grass fed
  - Grain fed
  - Mixed

- **Classification system**
  - Age
  - Level of fatness

- **Local breeds**

Other... e.g. 26 current brand schemes such as Tender & Tasty
US production & classification system

- Based on marbling
  - Fat content between muscles
  - More marbling = higher price incentive

- Grain fed beef specifically fed a diet to induce more marbling & higher fat
South African carcass classification system

- Legislation since 1992
- Classifies carcasses according to:
  - age (by dentition),
  - and outer fatness (visually)
- Edible ink stamped on carcass (roller mark)
- Price margin for retailers
### South African carcass classification system

<table>
<thead>
<tr>
<th>Fat class</th>
<th>Description</th>
<th>Subcutaneous fat (%)</th>
<th>Fat thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No fat</td>
<td>.</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Very lean</td>
<td>3.3</td>
<td>&lt;1</td>
</tr>
<tr>
<td>2</td>
<td>Lean</td>
<td>4.1</td>
<td>1 to 3</td>
</tr>
<tr>
<td>3</td>
<td>Medium</td>
<td>5.2</td>
<td>&gt;3 and ≤5</td>
</tr>
<tr>
<td>4</td>
<td>Fat</td>
<td>6.3</td>
<td>&gt;5 and ≤7</td>
</tr>
<tr>
<td>5</td>
<td>Overfat</td>
<td>7.3</td>
<td>&gt;7 and ≤10</td>
</tr>
<tr>
<td>6</td>
<td>Excessively fat</td>
<td>7.8</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>

- ✔ Price incentive for lean carcasses
South African carcass classification system – age (by dentition)
Study: Determining the composition of South African beef

Objective:

– To determine the fatty acid profile of beef from all 4 age groups (incl. all production systems)

Supported by Red Meat Research & Development South Africa (RMRDSA), the National Research Foundation (NRF), and the Institute of Food, Nutrition & Well-being (IFNuw) at UP
All age groups included in current study
Sampling

• 216 carcass cuts were selected from all 4 age groups
• Fatcode 2
• Obtained from ARC Meat Industry & University of Pretoria Experimental Farm
• Same breed: Bonsmara
• Slaughtered at the ARC abattoir
Sampling

Retail cuts were removed from each side by an experienced dissection team

1. Rump
2. Prime-rib
3. Shoulder
Sampling

- Whole cuts were weighed

- Cuts from left sides (raw):
  - Physically dissected into meat, sub-fat, inter-fat and bone
  - Weighed to determine physical composition of each cut

- Cuts from right sides (to be cooked):
  - Vacuum sealed whole
  - Frozen at -20°C until cooking
Sampling - cooked

- Primary cuts were cooked under standardized conditions
- Internal temp (73-75°C), cooking time, thawing loss, cooking loss, drip loss were determined

Primary cuts

Cooked in calibrated ovens – internal temp of 75°C

Drip loss measured & cuts cooled before dissection
Nutrient analyses

- Double-blind basis
- Standardized & AOAC official methods of analyses
- University of Pretoria NutriLab laboratory:
  - Moisture & dry matter
  - Crude protein (N x Jones Factors 6.25)
  - Ash
  - Minerals
  - Fat (ether extraction)

- University of the Freestate Department of Microbial, Biochemical & Food Biotechnology:
  - Total lipid (gravimetrically)
  - Fatty acids & CLA (GC)
Results

1st: Visual

USA  Local study
Results
Trimming makes a difference
Physical composition main findings

✓ For all cuts muscle content *decreased* with age and fat content *increased*

✓ Trimming of visible fat had the least effect on lipid content in age C cuts – confirming depositing of lipid between & within muscle cells as animals age
## Red meats in comparison to other animal source foods

<table>
<thead>
<tr>
<th>Food (100g, raw)</th>
<th>Fat (g)</th>
<th>Untrimmed</th>
<th>Trimmed of sub fat</th>
<th>Trimmed of all fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (age A), prime rib</td>
<td>13.3</td>
<td>10.0</td>
<td>3.37</td>
<td></td>
</tr>
<tr>
<td>Beef (age A), rump</td>
<td>10.7</td>
<td>7.15</td>
<td>1.84</td>
<td></td>
</tr>
<tr>
<td>Beef (age A), shoulder</td>
<td>7.56</td>
<td>5.72</td>
<td>2.55</td>
<td></td>
</tr>
<tr>
<td>Beef (age AB) prime rib</td>
<td>19.6</td>
<td>15.4</td>
<td>3.82</td>
<td></td>
</tr>
<tr>
<td>Beef (age AB), rump</td>
<td>16.1</td>
<td>10.4</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td>Beef (age AB), shoulder</td>
<td>12.7</td>
<td>9.28</td>
<td>2.98</td>
<td></td>
</tr>
<tr>
<td>Lamb (age A), leg^</td>
<td>10.2</td>
<td>6.15</td>
<td>3.84</td>
<td></td>
</tr>
<tr>
<td>Lamb (age A), loin^</td>
<td>16.7</td>
<td>11.3</td>
<td>4.96</td>
<td></td>
</tr>
<tr>
<td>Lamb (age A), shoulder^</td>
<td>13.0</td>
<td>9.63</td>
<td>5.80</td>
<td></td>
</tr>
<tr>
<td>Mutton (age C), leg^</td>
<td>11.0</td>
<td>6.77</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mutton (age C), loin^</td>
<td>18.8</td>
<td>11.4</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mutton (age C), shoulder^</td>
<td>13.4</td>
<td>9.46</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chicken, dark meat#</td>
<td>17.8</td>
<td>-</td>
<td>7.62</td>
<td></td>
</tr>
<tr>
<td>Chicken, white meat#</td>
<td>9.63</td>
<td>-</td>
<td>2.70</td>
<td></td>
</tr>
<tr>
<td>Pork, shoulder*&amp;</td>
<td>13.1</td>
<td>-</td>
<td>7.5</td>
<td></td>
</tr>
</tbody>
</table>

Untrimmed & trimmed SA beef & lamb compare well with other similar animal source foods, e.g. pork and chicken

^ Schönfeldt et al., 2012
# Schönfeldt et al., 1998
* Van Heerden & Smith, 2013
& Van Heerden et al., 2008
Effect of feeding regime on fatty acids

- Different fatty acids elicit different responses in the human body

It is the current position statement of the American Dietetic Association (ADA) and the Dietitians of Canada that dietary fat for the adult population should provide 20% to 35% of energy and emphasize a reduction in saturated fatty acids and trans fatty acids, and an increase in the omega 3 polyunsaturated fatty acids.

The South African guidelines state that total fat should provide 20% to 30% of daily energy intake and that polyunsaturated fatty acids should contribute 6% to 10% of energy. Omega 6 fatty acids should provide 5% to 8% of energy and omega 3 should provide 1% to 2% of energy. The remainder of the energy from total fat should be from monounsaturated fatty acids, with trans fatty acid intake being less than 1% (Smuts & Wolmarans, 2013).

- Red meat often considered high in unhealthy fatty acids
- Many studies reflect variability in red meat produced on different production systems, age groups, breeds etc.
Fatty acid composition per 100g fat from prime rib

<table>
<thead>
<tr>
<th>Age</th>
<th>Total FA</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
<th>n-6</th>
<th>n-3</th>
<th>CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>52.7</td>
<td>30.5</td>
<td>20.9</td>
<td>1.35a</td>
<td>1.29a</td>
<td>0.05a</td>
<td>0.11a</td>
</tr>
<tr>
<td>AB</td>
<td>54.3</td>
<td>33.6</td>
<td>20.0</td>
<td>0.73b</td>
<td>0.48b</td>
<td>0.25b</td>
<td>0.29b</td>
</tr>
<tr>
<td>B</td>
<td>57.0</td>
<td>34.8</td>
<td>21.4</td>
<td>0.78b</td>
<td>0.54b</td>
<td>0.23b</td>
<td>0.30b</td>
</tr>
<tr>
<td>C</td>
<td>50.4</td>
<td>31.0</td>
<td>18.5</td>
<td>0.89b</td>
<td>0.78b</td>
<td>0.11a</td>
<td>0.19a</td>
</tr>
</tbody>
</table>

P-VALUE: 0.445 0.437 0.420 0.015 0.007 <0.001 <0.001

- No significant difference in total FA
- No significant difference in SFA between age groups / feeding regimes
Fatty acid composition per 100g fat from prime rib

<table>
<thead>
<tr>
<th>Age</th>
<th>Total FA</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
<th>n-6</th>
<th>n-3</th>
<th>CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>52.7</td>
<td>30.5</td>
<td>20.9</td>
<td>1.35\textsuperscript{a}</td>
<td>1.29\textsuperscript{a}</td>
<td>0.05\textsuperscript{a}</td>
<td>0.11\textsuperscript{a}</td>
</tr>
<tr>
<td>AB</td>
<td>54.3</td>
<td>33.6</td>
<td>20.0</td>
<td>0.73\textsuperscript{b}</td>
<td>0.48\textsuperscript{b}</td>
<td>0.25\textsuperscript{b}</td>
<td>0.29\textsuperscript{b}</td>
</tr>
<tr>
<td>B</td>
<td>57.0</td>
<td>34.8</td>
<td>21.4</td>
<td>0.78\textsuperscript{b}</td>
<td>0.54\textsuperscript{b}</td>
<td>0.23\textsuperscript{b}</td>
<td>0.30\textsuperscript{b}</td>
</tr>
<tr>
<td>C</td>
<td>50.4</td>
<td>31.0</td>
<td>18.5</td>
<td>0.89\textsuperscript{b}</td>
<td>0.78\textsuperscript{b}</td>
<td>0.11\textsuperscript{a}</td>
<td>0.19\textsuperscript{a}</td>
</tr>
<tr>
<td>P-VALUE</td>
<td>0.445</td>
<td>0.437</td>
<td>0.420</td>
<td>0.015</td>
<td>0.007</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

- No significant difference in total MUFAs
- More PUFAs & n-6 in young animals from grain
- More n-3 & CLA in grass fed animals
From a nutrition perspective:
We eat meat – not fat!

As slaughtered
Meat + inside fat +
outside fat

Trimmed
Meat + inside fat
(trimmed of outside fat)

Muscle only
Meat
(trimmed of all visible fat)
# Fatty acid profile

100g cooked edible meat, *untrimmed*

<table>
<thead>
<tr>
<th></th>
<th>Total fat</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
<th>N-6</th>
<th>N-3</th>
<th>CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>unit</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
</tr>
<tr>
<td>A</td>
<td>17.5</td>
<td>5.31</td>
<td>3.66</td>
<td>0.23</td>
<td>0.23</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>AB</td>
<td>20.4</td>
<td>6.88</td>
<td>4.12</td>
<td>0.15</td>
<td>0.10</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>B</td>
<td>20.6</td>
<td>7.24</td>
<td>4.42</td>
<td>0.16</td>
<td>0.11</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>C</td>
<td>21.6</td>
<td>6.66</td>
<td>3.99</td>
<td>0.19</td>
<td>0.17</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>P-value</td>
<td>0.06</td>
<td>0.20</td>
<td>0.67</td>
<td>0.20</td>
<td>0.05</td>
<td>0.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

- No *statistically significant* difference in total fat & SFA, although young animals from grain had **less**
- No *statistically significant* difference in PUFAs & n-6’s, although young animals from grain had **more**
- **Statistically more** n-3 & CLA in *grass fed beef* (age AB & B)
### Fatty acid profile

100g cooked edible meat, *trimmed of outside fat* (subcutaneous fat)

<table>
<thead>
<tr>
<th></th>
<th>FAT</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
<th>N6</th>
<th>N3</th>
<th>CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.39</td>
<td>3.02</td>
<td>0.19</td>
<td>0.19</td>
<td>0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.02&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>AB</td>
<td>16.3&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.51</td>
<td>3.31</td>
<td>0.12</td>
<td>0.08</td>
<td>0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>19.6&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.16</td>
<td>3.77</td>
<td>0.14</td>
<td>0.10</td>
<td>0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>19.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.07</td>
<td>3.65</td>
<td>0.18</td>
<td>0.16</td>
<td>0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.04&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

| P-value | 0.019 | 0.103 | 0.518 | 0.173 | 0.055 | 0.002 | 0.005 |

- Remaining fat after trimming – inter- & intramuscular fat (between and within muscles)
- **Total fat increases with age**
- No *statistically significant* difference in SFA, MUFA & PUFA
- Statistically **more n-6** in *grass fed beef* (age AB & B)
- Statistically **more CLA** in *grass fed beef* (age AB & B) AND in *age C (grain finished)* than in age A
  - Possibly due to CLA settling in fat during lifetime of animal prior to grain-finishing
### Fatty acid profile

100g cooked edible meat portion

*(Trimmed of all visible fat)*

<table>
<thead>
<tr>
<th>Unit</th>
<th>FAT</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
<th>N-6</th>
<th>N-3</th>
<th>CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.45</td>
<td>0.09</td>
<td>0.09</td>
<td>0.003&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.007&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>AB</td>
<td>9.77&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.97</td>
<td>0.07</td>
<td>0.05</td>
<td>0.024&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.029&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>10.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.18</td>
<td>0.08</td>
<td>0.05</td>
<td>0.024&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.031&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>10.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.94</td>
<td>0.09</td>
<td>0.08</td>
<td>0.012&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.020&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

| P-value | 0.007 | 0.003 | 0.108 | 0.474 | 0.134 | <0.001 | <0.001 |

- Trimmed of all visible fat – remaining fat is found within muscles
- More n-3 & CLA in grass fed beef (age AB & B)
- Young animals (age A), fed on grains, had significantly less Total Fat
- Young animals (age A), fed on grains, had significantly less SFA
  - incl. Lauric (C12), Mysteric (C14), Palmitic (C16) & Stearic acid (C18)
Fatty acid profile
100g cooked edible meat portion
*(Trimmed of all visible fat)*

<table>
<thead>
<tr>
<th></th>
<th>FAT</th>
<th>SFA</th>
<th>MUFA</th>
<th>PUFA</th>
<th>N-6</th>
<th>N-3</th>
<th>CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
<td>g</td>
</tr>
<tr>
<td>A</td>
<td>6.96a</td>
<td>2.16a</td>
<td>1.45</td>
<td>0.09</td>
<td>0.09</td>
<td>0.003a</td>
<td>0.007a</td>
</tr>
<tr>
<td>AB</td>
<td>9.77b</td>
<td>3.30b</td>
<td>1.97</td>
<td>0.07</td>
<td>0.05</td>
<td>0.024b</td>
<td>0.029c</td>
</tr>
<tr>
<td>B</td>
<td>10.3b</td>
<td>3.52b</td>
<td>2.18</td>
<td>0.08</td>
<td>0.05</td>
<td>0.024b</td>
<td>0.031c</td>
</tr>
<tr>
<td>C</td>
<td>10.4b</td>
<td>3.22b</td>
<td>1.94</td>
<td>0.09</td>
<td>0.08</td>
<td>0.012a</td>
<td>0.020b</td>
</tr>
<tr>
<td>P-value</td>
<td>0.007</td>
<td>0.003</td>
<td>0.108</td>
<td>0.474</td>
<td>0.134</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note: Although statistical difference, need to consider difference in terms of volume per edible portion before making dietary recommendations...
In summary

- As slaughtered: Meat + inside fat + outside fat
- Trimmed: Meat + inside fat (trimmed of outside fat)
- Muscle only: Meat (trimmed of all visible fat)

- More CLA & n-3 in grass fed meat
- Slightly less total fat & SFA in young, grain fed animals
- More CLA & n-3 in grass fed meat
- Total fat increases with age – lowest in young grain fed animals
- More CLA & n-3 in grass fed meat
- Less total (intra-muscle) fat in young, grain fed, animals
- Lower SFA in young, grain fed, animals
1. Less total fat
2. More essential omega-3 fatty acids
3. More heart-healthy CLA
4. Higher SFA per 100g fat
5. Lower SFA per 100g edible product as less total fat

Global findings for grass-fed beef:

1. More total fat (especially when trimmed)
2. More essential omega-3 fatty acids
3. More heart-healthy CLA
4. No sign diff in SFA per 100g fat
5. Higher SFA per 100g edible product as more total fat (especially when trimmed)

Local findings for grass-fed beef:
Conclusions

• Beef in SA from different production systems contain different proportions of nutrients – especially total fat & proportions of fatty acids
• Any type of SA beef can be consumed as part of a healthy, balanced diet
• Preference should be given to meat which contains the most beneficial characteristics according to individual dietary recommendations
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