Feed Efficiency in Beef Finishing Systems

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Feed costs

- "Conversion of feed to product"

- Providing feed - particularly during the indoor winter period - is the LARGEST variable cost in BEEF production:

  ![Pie chart showing feed and other costs]

  - Feed: 65%
  - Other: 35%

  \[ \text{Feed costs:} \; 70\%+ \]
Annual Feed Budgets (/cow unit)

Suckler calf-to-Beef: 24 mth steer

Optimising the contribution of grazed grass to the lifetime intake of feed and provide silage & concentrates as efficiently and at as low as cost as feasible.
Improvement in feed efficiency is worth **4-8 times more** than an equivalent increase in growth rate (Gibb and McAllister, 1999; Okine et al., 2004).
High maternal cost to Suckler beef production

Cow Feed Requirements

In beef production
Maintenance Reqs. = ~70% of total feed energy requirements
Feed efficiency

• Traditionally, expressed
  
  \[
  FCR = \text{feed intake} : \text{weight gain}
  \]

Selection for FCR

- Similar to selection for growth rate
- Improves FCR in growing animal

BUT

Increase in cow size
Increase in maintenance requirements
Increase costs € & Environment

Improve the efficiency of growth / finishing phase

BUT not necessarily the entire production system
Increasing cow size?

• France:
  – “Frame size of beef cows increased during the last 25 years – genetics + feeding”
    • e.g. carcass weight of cull cows increased from 357 to 408 kg (Lherm et al., 2004).

• UK:
  – “Avg. cow live weight….considerably higher than 20 years ago, probably as a result of genetic selection for higher body weight”
    • 680 kg vs. 434 – 560 kg (Hyslop, 2006)
Residual Feed Intake (RFI)

Alternative measure of feed efficiency independent of growth & body size

RFI = animals actual intake - predicted intake

Assume:
- 2 steers: LW = 600 kg; ADG = 1.0 kg
  - EXPECT them to eat 10 kg DM/day
  - BUT one eats 11 kg DM & one eats 9 kg DM

Steer eating 1 kg more than expected = RFI (+1) = High = less efficient
Steer eating 1 kg less than expected = RFI (-1) = Low = more efficient

Therefore, negative or lower RFI values are better
Residual Feed Intake

Live weight

Feed Intake (UFV/day)

High RFI = inefficient

Low RFI = efficient
In any population of cattle, within breed, = >LARGE variation in Feed Efficiency

Table 1: Intake and performance of beef cattle with high (Inefficient), medium and low (efficient) RFI

<table>
<thead>
<tr>
<th></th>
<th>RFI&lt;sup&gt;1&lt;/sup&gt;</th>
<th></th>
<th>RFI&lt;sup&gt;2&lt;/sup&gt;</th>
<th></th>
<th>RFI&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Med.</td>
<td>Low</td>
<td>Sig.</td>
<td>High</td>
</tr>
<tr>
<td>DMI (kg/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>5.9</td>
<td>5.5</td>
<td>***</td>
<td></td>
<td>10.2</td>
</tr>
<tr>
<td>Live weight (kg)</td>
<td>316</td>
<td>327</td>
<td>330</td>
<td>NS</td>
<td>522</td>
</tr>
<tr>
<td>ADG (kg)</td>
<td>0.60</td>
<td>0.61</td>
<td>0.60</td>
<td>NS</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Source: <sup>1</sup>Lawrence et al., 2012; <sup>2</sup>Fitzsimons et al., 2014; <sup>3</sup>Kelly et al., 2010

Top 1/3 vs Bottom 1/3

15% 13% 18%

Scope: Breeding more feed efficient cattle!!
Factors affecting Feed Efficiency
# Live weight & live weight gain

**Table 2:** Theoretical energy requirements of finishing bulls (UFV/day) at different weights and growth rates

<table>
<thead>
<tr>
<th>Average daily gain (kg)</th>
<th>450</th>
<th>500</th>
<th>550</th>
<th>600</th>
<th>650</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>4.4</td>
<td>4.8</td>
<td>5.1</td>
<td>5.5</td>
<td>5.8</td>
</tr>
<tr>
<td>1.0</td>
<td>6.0</td>
<td>6.5</td>
<td>6.9</td>
<td>7.4</td>
<td>7.9</td>
</tr>
<tr>
<td>1.2</td>
<td>6.5</td>
<td>7.0</td>
<td>7.5</td>
<td>8.0</td>
<td>8.6</td>
</tr>
<tr>
<td>1.4</td>
<td>7.0</td>
<td>7.6</td>
<td>8.1</td>
<td>8.7</td>
<td>9.4</td>
</tr>
<tr>
<td>1.2 vs. 1.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Source: INRA

*Feed efficiency is better with light, fast growing animals*
Duration of finishing
## Daily gain (kg) by finishing Interval

<table>
<thead>
<tr>
<th>Interval (d)</th>
<th>Silage</th>
<th>+ 6 kg Conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 147</td>
<td>0.65</td>
<td>1.10</td>
</tr>
<tr>
<td>0 – 56</td>
<td>0.80</td>
<td>1.43</td>
</tr>
<tr>
<td>56 – 98</td>
<td>0.59</td>
<td>1.02</td>
</tr>
<tr>
<td>98 – 147</td>
<td>0.54 (-33%)</td>
<td>0.79 (-45%)</td>
</tr>
</tbody>
</table>

Rate of live weight gain is **NOT** constant over the finishing period

- Initial increase in gut fill,
- Fixed/declining DMI relative to increased weight (& Reqs)
- Increased fat deposition (much less efficient)
Effect of Feeding Period on live/carcass weight gain & FCR

Charolais xbred steers: **High concentrate diet**

<table>
<thead>
<tr>
<th>Finishing period</th>
<th>0-12 wks</th>
<th>12-23 wks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight gain (kg/d)</td>
<td>1.42</td>
<td>1.16</td>
</tr>
<tr>
<td>Carcass gain (kg/d)</td>
<td>1.04</td>
<td>0.84</td>
</tr>
<tr>
<td>Concentrate intake (kg DM/d)</td>
<td><strong>10.2</strong></td>
<td><strong>11.4</strong></td>
</tr>
<tr>
<td>Feed efficiency (Conc DMI:gain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live weight</td>
<td>7.2</td>
<td>9.9</td>
</tr>
<tr>
<td>Carcass</td>
<td><strong>9.9</strong></td>
<td><strong>13.6</strong></td>
</tr>
</tbody>
</table>
### Guidelines for duration of Finishing Period on ad libitum concentrate

<table>
<thead>
<tr>
<th>Animal</th>
<th>Days</th>
<th>ADG (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers</td>
<td>60-80</td>
<td>1.10-1.30</td>
</tr>
<tr>
<td>Steers</td>
<td>70-90</td>
<td>1.25-1.45</td>
</tr>
<tr>
<td>Bulls</td>
<td>&lt;180 (80-120)</td>
<td>1.70-1.90</td>
</tr>
</tbody>
</table>
Duration of Finishing Period

Avoiding excessively long finishing periods & minimising carcass fatness at slaughter (without impairing carcass value) are ways to reduce feed requirements & feed costs associated with finishing cattle.
Compared to dairy breeds, beef breeds had:

- **+23% LWG** per unit of energy consumed
- **+51% meat** per unit of energy consumed

BUT with higher KO% & greater proportion of meat in carcass

Source: Crowley et al. 2010

Source: Clarke et al. 2009
GENDER:
Bulls vs. comparable steers

• Grange data:
  ~ +8% ADG
  ~ +9% carcass wt
  ~ +20% lean meat yield

• NI data: (/kg feed eaten)
  ~ +10% ADG
  ~ +14% carcass wt
  ~ +20% lean meat
  ~ +17% saleable meat

• USA data:
  ~ +17% ADG
  ~ -35% fat
  ~ +13% feed efficiency

• Europe data:
  ~ +1% higher intake
  ~ +20% ADG
  ~ -20% fat
  ~ +17% feed efficiency
Indoor Finishing
Grass silage

- Grass silage - primary forage for feeding cattle over winter.

- **Digestibility (DMD):** primary factor influencing the nutritive value of grass silage & consequently,
  - the performance of cattle offered grass silage-based diets.

- Both intake & animal performance increases with increasing digestibility.
Silage Digestibility - what difference does it make?

<table>
<thead>
<tr>
<th>DMD %</th>
<th>75</th>
<th>70</th>
<th>65</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest Date</td>
<td>20 May</td>
<td>2 June</td>
<td>15 June</td>
<td>30 June</td>
</tr>
<tr>
<td>Silage DMI Kg/day</td>
<td>9.0</td>
<td>8.3</td>
<td>7.6</td>
<td>7.0</td>
</tr>
<tr>
<td>Animal gain (kg/day)</td>
<td>0.83</td>
<td>0.66</td>
<td>0.49</td>
<td>0.31</td>
</tr>
<tr>
<td>Live weight</td>
<td>0.51</td>
<td>0.39</td>
<td>0.27</td>
<td>0.15</td>
</tr>
<tr>
<td>Carcass</td>
<td>Source: Teagasc, Grange</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Effect of silage digestibility on carcass gain

Daily carcass gain (g) / 10 g/kg increase in silage DOM

- GS: 0.2-0.37 (Steen, 1988)
- GS + CO: 0.2-0.4 (Steen et al. 2002)
Response in carcass gain to a 1% unit change in grass silage digestibility at various forage:concentrate ratios

Keady et al. 2013
Effect of silage digestibility & concentrate level on carcass gain

Daily carcass gain (g) / 10 g/kg increase in silage DOM

Steen, 1998
Silage Digestibility

• Implication

• Low DMD grass silage means that higher levels of supplementation are needed to maintain performance
  
  - Each 1-unit decline in digestibility requires an additional ~0.4 kg concentrate daily to sustain performance in finishing cattle (Keady et al., 2013)

• At high levels of concentrate feeding, silage digestibility had no effect on carcass gain
Silage Intake & Substitution rate
Supplementation increases total DMI, although at a progressively decreasing rate.

Source: Teagasc, Grange
Substitution Rate - High Digestibility Silage

Kg silage DM / kg Conc. DM

Dietary concentrate proportion

Steen; 1998; Agnew & Carson, 2000; Steen & Kilpatrick, 2000; Patterson et al., 2000; Dawson et al., 2002; Caplis et al. 2005
Substitution Rate - High Digestibility Silage

Steen, 1998; Caplis, 2004
Effect of silage digestibility on substitution rate

Drennan & Keane, 1987
Steen, 1998
Effect of energy supplement type on substitution rate

• **Finishing Cattle**
  
  – Starch = Fibre = Sugar *(Moloney et al. 1993)*
  – Starch = Fibre *(Steen, 1995; O’Kiely & Moloney, 1994)*
  – Starch < Fibre *(Moloney, 1996)*
  – Starch < Fat *(Steen, 1995; Moloney, 1996)*
Effect of dietary concentrate proportion on diet digestibility

Implication: Dietary energy intake often mirrors DMI

Steen & Robson, 1995; Steen & Kilpatrick, 2000; Patterson et al., 2000; Caplis, 2004
Effect of dietary concentrate proportion on fibre digestibility

Steen & Robson, 1995; Steen & Kilpatrick, 2000; Patterson et al., 2000; Steen et al. 2002
Production response to concentrate supplementation
Concentrate supplementation - finishing cattle

Days to finish

Dietary concentrate proportion

0 0.3 0.7

Scollan et al. 2003
Effect of concentrate supplementation on growth response - steers

Liveweight gain (kg/day)

Concentrates (kg/day)

Incremental growth response declines as concentrate level increases.

Higher response in animals with high growth potential e.g. gender, breed, compensatory growth.

Source: Teagasc, Grange
Effect of silage digestibility on carcass growth response to supplementation

Carcass gain (kg/day)

Concentrates (kg/day)

Steen, 1998
Concentrate supplementation & Growth response

Patterson et al. 2000

O = 0.95
### Optimum level of concentrate feeding?

#### Table 4: Cost (c/kg) of carcass gain for steers

<table>
<thead>
<tr>
<th>Feeding level (kg/day concentrate)</th>
<th>Concentrate costs (€/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>175</td>
</tr>
<tr>
<td>3</td>
<td>117</td>
</tr>
<tr>
<td>4</td>
<td>119</td>
</tr>
<tr>
<td>5</td>
<td>124</td>
</tr>
<tr>
<td>6</td>
<td>159</td>
</tr>
<tr>
<td>7</td>
<td>172</td>
</tr>
<tr>
<td>8</td>
<td>180</td>
</tr>
</tbody>
</table>

Silage substituted valued at 15.0 cents/kg DM
Ad libitum feeding of concentrates for finishing cattle

• Considered when
  - Silage digestibility is low
  - Animal growth potential is high
  - Especially where silage supplies are in deficit

• Critical to ensure:
  1. gradual adaptation to the concentrates,
  2. minimum roughage inclusion (~10% of total DM intake) in the diet for rumen function,
  3. that meal supply never runs out
  4. that a constant supply of fresh water is provided.
Ingredient Composition
Concentrate **Energy** source &
Growth response

Supplements to grass silage

- **Wheat = Barley** *(Steen, 1993; Drennan et al. 2006)*

- **Sugar-based = Starch-based @~0.2 DMI**
  *(Drennan, 1985; Moloney et al. 1993; Chapple et al. 1996)*

- **Starch-based > or < Fibre-based**
  *(Moloney et al. 1993; O’Kiely & Moloney, 1994; Steen, 1995; Moloney, 1996; Moloney et al. 2001)*

- **Fat-based < Starch or Fibre-based**
  *(Steen, 1995; Moloney, 1996)*
Concentrate type

- 4 rations x 2 feeding levels

  Ration
  
  A. Rapidly fermentable starch - RFS (Barley-based)
  B. Slowly fermentable starch - SFS (Maize-based)
  C. RFS + digestible fibre - RFS+F
  D. Digestible fibre-based - Fibre (Pulp)

- Concentrate feeding level
  
  Ad libitum
  5 kg per head/day

- Formulated: ~ same Energy & Protein concentration
### Concentrate type

<table>
<thead>
<tr>
<th>Ration Type</th>
<th>RFS</th>
<th>SFS</th>
<th>RFS+F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake (kg DM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silage</td>
<td>3.8</td>
<td>4.0</td>
<td>3.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Conc.</td>
<td>6.5</td>
<td>6.5</td>
<td>6.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td>10.2</td>
<td>10.5</td>
<td>10.7</td>
<td>10.1</td>
</tr>
<tr>
<td>Daily gain (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live weight</td>
<td>1043</td>
<td>985</td>
<td>1032</td>
<td>911</td>
</tr>
<tr>
<td>Carcass</td>
<td>582</td>
<td>570</td>
<td>584</td>
<td>520</td>
</tr>
<tr>
<td>KO (g/kg)</td>
<td>537</td>
<td>541</td>
<td>540</td>
<td>539</td>
</tr>
<tr>
<td>Fat</td>
<td>3.5</td>
<td>3.4</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>FCE</td>
<td>56.8</td>
<td>54.6</td>
<td>55.6</td>
<td>52.0</td>
</tr>
</tbody>
</table>

McGee et al. 2006, 2009
Concentrate type: Maize meal

Dairy bulls 170 days

<table>
<thead>
<tr>
<th>Ration Type</th>
<th>Barley-based</th>
<th>Barley/Maize-based</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake (kg DM)</td>
<td>9.21</td>
<td>9.54</td>
<td>*</td>
</tr>
<tr>
<td>Live weight gain (g/day)</td>
<td>1697</td>
<td>1745</td>
<td>ns</td>
</tr>
<tr>
<td>Carcass wt (kg)</td>
<td>275</td>
<td>279</td>
<td>ns</td>
</tr>
<tr>
<td>Carcass Fat (1-5)</td>
<td>2.98</td>
<td>3.09</td>
<td>ns</td>
</tr>
</tbody>
</table>

Keane, 2008
## Response to protein in Finishing Cattle

*High concentrate diet*

<table>
<thead>
<tr>
<th>Gender</th>
<th>protein</th>
<th>Bulls</th>
<th>Heifers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Start wt (kg)</td>
<td>331</td>
<td>332</td>
<td>288</td>
</tr>
<tr>
<td>LWG (kg)</td>
<td>1.58</td>
<td>1.55</td>
<td>1.25</td>
</tr>
<tr>
<td>Slaughter wt (kg)</td>
<td>572</td>
<td>568</td>
<td>470</td>
</tr>
<tr>
<td>Carcass wt (kg)</td>
<td>319</td>
<td>315</td>
<td>255</td>
</tr>
<tr>
<td>Kill-out (g/kg)</td>
<td>558</td>
<td>555</td>
<td>542</td>
</tr>
<tr>
<td>Intake (kg DM/d)</td>
<td>9.4</td>
<td>9.1</td>
<td>8.0</td>
</tr>
</tbody>
</table>
### Composition (g/kg) of diets for bulls & heifers

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled barley</td>
<td>875</td>
<td>945</td>
</tr>
<tr>
<td>Soya-bean meal</td>
<td>70</td>
<td>-</td>
</tr>
<tr>
<td>Molasses</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Mins/vits</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>CP (g/kg DM)</td>
<td>143</td>
<td>116</td>
</tr>
</tbody>
</table>
Response to protein in Finishing Cattle

Grass silage + concentrates

• Finishing steers / heifers / bulls
  - Barley-based conc. + Protein:
    • High DMD silage = X
    • Low DMD silage = ✓
  - Low crude protein grass silage = ✓

Implications

- With low DMD & low CP grass silage
  • Higher CP % required in concentrate [~11-12% to ~14-20%, depending]
Thank you