Associative effects of feeds

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Associative effects

DEFINITION: Interaction between nutrients in different ingredients in a ration which result in performance that is greater or less than expected from the individual ingredients

E.g. the NE of a mixed diet may not reflect the NE calculated from the ME intakes of the ingredients

Reflect non-additivity of nutrients in feeds

May be positive, negative or absent
Associative effect illustration

\[ 0.50 \text{A} + 0.50 \text{B} \]
Positive associative effects

1. Increased fiber utilization after N supplementation in N deficient forages
2. Increased fiber utilization after supplementation of roughages with small quantities of sugars
3. Increased intake when more than one forage is fed
4. Increased microbial protein production due to synchronized / balanced diets
Effect of supplementation with urea or alfalfa hay on straw intake

- Fiber digestibility is often increased by N supplementation if feed CP content is < 62 g/kg DM (Minson, 1990)
Effect of suppl. with urea or alfalfa hay on rumen degradation

<table>
<thead>
<tr>
<th>Rate (%/h)</th>
<th>Extent (g/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw (S)</td>
<td>0.5</td>
</tr>
<tr>
<td>S + 1% Urea</td>
<td>0.7</td>
</tr>
<tr>
<td>S + 150g</td>
<td>0.9</td>
</tr>
<tr>
<td>S + 300g</td>
<td>1.1</td>
</tr>
<tr>
<td>S + 450g</td>
<td>1.3</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>1.5</td>
</tr>
<tr>
<td>S + 150g</td>
<td>1.7</td>
</tr>
<tr>
<td>S + 300g</td>
<td>1.9</td>
</tr>
<tr>
<td>S + 450g</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Mixed forage diets

Grass silage
Other forage

(Phipps '92)
Effect of cereal silage inclusion on DM intake (kg/d)

- WS
- MS

(Phipps '92)
Effect of cereal silage inclusion on milk yield (kg/d)

- WS
- MS

(Phipps '92)
Effect of replacing corn in dairy cow diets with barley on performance

(Overton et al., 1995)

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>Lin</th>
<th>Quad</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI (kg/d)</td>
<td>22.8</td>
<td>22.1</td>
<td>21.3</td>
<td>19.5</td>
<td>19.6</td>
<td>.01</td>
<td>NS</td>
</tr>
<tr>
<td>Milk (kg/d)</td>
<td>26.9</td>
<td>27.8</td>
<td>26.6</td>
<td>25.2</td>
<td>22.6</td>
<td>.002</td>
<td>.05</td>
</tr>
<tr>
<td>3.5% FCM (kg/d)</td>
<td>27.3</td>
<td>27.4</td>
<td>26.4</td>
<td>24.7</td>
<td>23.7</td>
<td>.003</td>
<td>NS</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>3.58</td>
<td>3.37</td>
<td>3.50</td>
<td>3.41</td>
<td>3.91</td>
<td>NS</td>
<td>.03</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>3.36</td>
<td>3.36</td>
<td>3.44</td>
<td>3.45</td>
<td>3.69</td>
<td>.003</td>
<td>NS</td>
</tr>
<tr>
<td>Microbial N (%NAN)</td>
<td>46</td>
<td>46.4</td>
<td>46.7</td>
<td>50.2</td>
<td>56.0</td>
<td>0.02</td>
<td>NS</td>
</tr>
</tbody>
</table>
Effect of replacing grass silage with WCW on starch digestibility (%)

(Phipps ‘92)
Effect of processing maize on performance of dairy cows

<table>
<thead>
<tr>
<th></th>
<th>Rolling</th>
<th>Steam flaking</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI (kg/d)</td>
<td>26.5</td>
<td>26.5</td>
<td>0</td>
</tr>
<tr>
<td>Milk (kg/d)</td>
<td>35.8&lt;sup&gt;e&lt;/sup&gt;</td>
<td>38.0&lt;sup&gt;f&lt;/sup&gt;</td>
<td>6</td>
</tr>
<tr>
<td>Prot (%)</td>
<td>2.99&lt;sup&gt;g&lt;/sup&gt;</td>
<td>3.06&lt;sup&gt;h&lt;/sup&gt;</td>
<td>2</td>
</tr>
<tr>
<td>Prot (kg/d)</td>
<td>1.07&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.16&lt;sup&gt;f&lt;/sup&gt;</td>
<td>8</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>3.11&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.98&lt;sup&gt;f&lt;/sup&gt;</td>
<td>-4</td>
</tr>
<tr>
<td>Fat (kg/d)</td>
<td>1.12</td>
<td>1.13</td>
<td>1</td>
</tr>
<tr>
<td>Total starch dig (%)</td>
<td>87.4&lt;sup&gt;i&lt;/sup&gt;</td>
<td>95.7&lt;sup&gt;j&lt;/sup&gt;</td>
<td>9</td>
</tr>
</tbody>
</table>

(Theurer et al., 1999)
Positive associative effects

- High NSC and High RDP forages
- Simultaneously offered cereal and legume forages that respectively may enhance microbial protein production and hence, animal performance.
Effect of replacing grass silage + 8kg conc with pea-wheat silage + 4kg conc

<table>
<thead>
<tr>
<th>Forage</th>
<th>Conc. level (kg/d)*</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass silage</td>
<td>4</td>
<td>GS4</td>
</tr>
<tr>
<td>Grass silage</td>
<td>8</td>
<td>GS8</td>
</tr>
<tr>
<td>Magnus bi-crop</td>
<td>4</td>
<td>MW4</td>
</tr>
<tr>
<td>Setchey bi-crop</td>
<td>4</td>
<td>SW4</td>
</tr>
</tbody>
</table>
Feed intake and Milk yield (kg/day)

- GS8
- GS4
- MW4
- SW4

- Forage DMI
- Milk yield

Conc. Level
Total DMI
Fat-corrected milk yield
Negative associative effects

1. Concentrate supplementation of forage diets in excess of 600 g/kg DM **depresses** fiber utilization

2. Fat supplementation of diets in excess of 60g/kg DM depresses fiber digestion
   - Coats particles thereby preventing fermentation,
   - Reduced intake due to chemostatic feedback from high energy diets
   - Certain PUFAs are toxic to ruminal microbes

3. Presence of antinutritive factors which hinder nutrient utilization
Supplementation of grazing ruminants with NDF / NSC

Anderson et al., 1988
### Effect of rumen pH & starch supplementation on NDF digestion

<table>
<thead>
<tr>
<th>pH</th>
<th>5.8</th>
<th>602</th>
<th>6.8</th>
<th>5.8</th>
<th>6.2</th>
<th>6.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Alfalfa hay INDF</td>
<td>24.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>19.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bromegrass hay INDF</td>
<td>31.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

◎ INDF = indigestible NDF

(Grant and Mertens, 1992)
Effect of rapeseed oil supplementation on digestibility

Control
Infused fat
Single dose

Fat content (%)
NDF digestibility (g/10g)
DM digestibility (g/10g)
Factors determining associative effects

- Ingredient palatability
- Nutrient content of dietary ingredients
- Nutrient ratios e.g. energy:protein NSC vs NDF; NSC vs RDP
- Energy:protein ratio
- Physical form of feed (due to conservation / processing method)
- Microbial activity
- Substitution rate
- Level of feeding and outflow rates
Measuring associative effects

- Feeding supplements at different ratios to a basal diet (Van Soest, 1994).

- Statistical methods
  - Continuous analysis
  - Response Surface Methodology
Estimation of associative effect

(Van Soest, 1994)
Associative effect of fermenting two forages together

- Expected data – obtained from fermentation of individual components
  I.e. half of (100:0 and 0:100)

- Observed data (50:50)

(Rosales et al., 1998)
Associative effects – implications

- Not built into most current feeding systems yet they:
  - Over or undervalue nutrients / ingredients
  - Prevent determination of digestibility of components of a mixed ration by difference.
  - Limit the usefulness of nutritive value indices measured on individual foods.
Conclusion

- Associative effects are real and nutritionists should complement the science of feeding, with the “art” of feeding, by utilizing positive associative interactions..... to increase flexibility of diets as typical grain and roughage prices fluctuate. (Erasmus 2002)

- Negative interactions must also be avoided.
References

Erasmus (2002) Associative effects in dairy feeds – are they real?  
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