How to feed high yielding dairy cows to maintain milk yield and fertility

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Outline

• Feed Intake, Energy Balance and Body Condition Score
• Diet, Metabolic Hormones and Reproduction
• Optimal Nutrition for Fertility

High yielding cows can have good fertility
Is high milk yield a problem?

High milk yield can be associated with:

• Poor fertility
• Increased disease incidence
• More lameness

**THESE ARE NOT INEVITABLE**

• The challenge is to meet the nutritional needs of the cow!
Nutritional needs of the high-yielding cow

• High energy and nutrient intake
• A high energy diet fed *ad libitum*
• Managed body condition
  – Not too fat, avoid excessive loss
• Balanced diet
  – Avoid excesses as well as deficiencies
  – Maybe adjust to cow’s physiological state?
How much does a cow eat?

- Animal factors e.g. live weight, milk yield, condition score etc.
- Diet factors e.g.
- Dry Matter, Digestibility
- Forage Palatability
- Acid Loading of Forages
- Long fibre (saliva buffering)
- Total Mixed Rations
How much does a cow eat?

- Feed access (trough space 0.5-0.75 m/cow)
- Feed availability (ad-libitum is 110%)
- Ad-lib fresh clean water
- Number of feeds per day
- Remove old feed
- Comfortable bed for rumination
How much grass does a cow eat?
Cows prefer to stay indoors!

**Potential Milk Yield from Grass**

<table>
<thead>
<tr>
<th>Milk (kg/d)</th>
<th>DMI (kg/d)</th>
<th>Grazing time (h/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>early</td>
</tr>
<tr>
<td>5</td>
<td>10.6</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>13.5</td>
<td>8</td>
</tr>
<tr>
<td>25</td>
<td>16.4</td>
<td>9</td>
</tr>
<tr>
<td>35</td>
<td>19.6</td>
<td>11</td>
</tr>
</tbody>
</table>

Cows will not graze for longer than 9 hours per day.
Negative Energy Balance

- Milk
- Body Condition
- Feed Intake
- Negative energy balance
Thinner cows lose less body condition and can even gain body condition

Body condition scores converge to a genetic target

Garnsworthy and Topps, 1982
Fat cows reduce appetite to get thinner. Their Negative Energy Balance is worse.
Change in Condition Score with Genetic Merit

(Holmes, 1988)
Effect of BCS at Calving on change in BCS (0-10 wks)

1980-1993
\[ y = -0.62x + 1.55 \]
\[ R^2 = 0.82 \]

2000-2006
\[ y = -0.55x + 1.15 \]
\[ R^2 = 0.79 \]

23 studies, 81 treatment groups, >5,000 cows
Garnsworthy, 2006
Negative Energy Balance and Resumption of Oestrous Cycles

Butler, 2004

Days to Ovulation

Body Condition Loss (units)

< 0.5  38  44

0.5 - 1.0

> 1.0

Butler, 2004
Effect of BCS change on Pregnancy Rate to 1\textsuperscript{st} service

Bourchier & Garnsworthy 1987
Ferguson 1996
Humblot 2008
# BCS and ketosis

<table>
<thead>
<tr>
<th>BCS at calving</th>
<th>Odds ratio for ketosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=3.25</td>
<td>1.0</td>
</tr>
<tr>
<td>3.5-3.75</td>
<td>2.4</td>
</tr>
<tr>
<td>4.0-4.25</td>
<td>2.3</td>
</tr>
<tr>
<td>&gt;=4.5</td>
<td>2.8</td>
</tr>
</tbody>
</table>

732 cows; P<0.01

Gillund et al. 2001
# BCS and Fatty Liver

<table>
<thead>
<tr>
<th></th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCS at calving (1-5 scale)</td>
<td>2.82</td>
<td>3.93</td>
</tr>
<tr>
<td>BCS change 0-8 weeks</td>
<td>-0.52</td>
<td>-1.20</td>
</tr>
<tr>
<td>Liver fat week 1 (% liver volume)</td>
<td>15.2</td>
<td>30.8</td>
</tr>
<tr>
<td>Liver fat week 4 (% liver volume)</td>
<td>5.2</td>
<td>23.9</td>
</tr>
<tr>
<td>Dry matter intake (kg/d)</td>
<td>17.2</td>
<td>15.8</td>
</tr>
<tr>
<td>Milk yield (kg/d)</td>
<td>30.9</td>
<td>26.5</td>
</tr>
<tr>
<td>Mastitis</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Lameness</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Other disease incidents</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

Treacher et al. (1986); Reid et al. (1986)
BCS and oxidative stress

Cows calving with BCS >3.0 had:

Higher:
- Lipid mobilization
- NEFA, BHBA
- Reactive oxygen metabolites (ROM)
- Thiobarbituric acid-reactive substances (TBARS)
- Plasma thiol groups (SH)

Lower:
- Superoxide dismutase

Conclusion: BCS >3 = greater oxidative stress

Bernabucci et al. (2005)
Modern Holsteins do not have to lose BCS

Yan, Mayne, Keady, and Agnew (2006)
Concentrates
HC 60 – 50 – 40%
LC 30 – 20 – 10%
change at 100 & 200d
Energy Balance Summary

- Prolonged periods of severe negative energy balance must be avoided.
- The main factor affecting loss of body condition is Body Condition Score at calving NOT nutrition.
- Modern Holsteins are genetically thinner, so cows with BCS >3.0 at calving will lose ≥1.0 BCS units and be at risk from poor health and fertility.
Outline

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High and Low genetic merit dairy cows
Days to first ovulation,
Growth Hormone and Insulin

<table>
<thead>
<tr>
<th>Merit</th>
<th>First ovulation</th>
<th>Growth Hormone (GH)</th>
<th>Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>High merit</td>
<td>28.2 days</td>
<td>14.2 ng/ml</td>
<td>0.35 ng/ml</td>
</tr>
<tr>
<td>Low merit</td>
<td>20.1 days</td>
<td>10.0 ng/ml</td>
<td>0.46 ng/ml</td>
</tr>
</tbody>
</table>

(Gutierrez et al., 1999; 2006)

Can we increase insulin by nutrition?
Fat and Starch

Can a high fat or high starch diet overcome the problems of negative energy balance?
Energy Status: Effect of high dietary starch or fat on body tissue energy balance

Week of Lactation

High Fat:
- ↑ Milk Yield
- ↓ Insulin
- ↑ NEBAL

Beever, 2004
Effect of dietary fat content on plasma insulin

Effect of dietary starch content on plasma insulin

Effect of dietary starch content on ovarian follicles

Number of follicles

Dietary starch content (g/kg DM)
High starch increases plasma insulin and ovulation rate

Insulin Conclusions

• Improving insulin status of dairy cows encourages resumption of oestrous cycles

• Insulin status can be improved by high starch / low fat diets – but not too high starch or too low fat

• A note of caution …

  … beware oocyte quality!
Ultrasound-guided ovum pickup (OPU)
Day 8 blastocysts used for differential staining

- Apoptotic
- Trophoderm (TE)
- Inner cell mass (ICM)
High Insulin reduces oocyte quality in dairy cows

Blastocysts / Cleaved (%)
P<0.01

ICM / TE Ratio
P<0.01

56 OPU, 243 oocytes
Fouladi et al. (2005)
High Fat produces better oocytes in dairy cows

Fouladi-Nashta et al. 2007

144 OPU, 1051 oocytes

No effect on ICM/TE ratio
Another Insulin Conclusion

For good oocyte quality and blastocyst development we need low starch and/or high fat

i.e. a LOW insulin diet !!
Progesterone and embryo development

![Graph showing progesterone levels over the day of the cycle for large and small embryos.]

- **Large embryo**
- **Small embryo**

Key points:
- **Low progesterone concentration**
- **Delayed rise in progesterone**
Effect of dietary fat concentration on Progesterone at Day 5 of the Oestrous Cycle

\[ y = -0.008x^2 + 0.92x - 20.5 \]

\[ R^2 = 0.97 \]

Garnsworthy et al. 2008
Summary: Fertility and Insulin

- Early resumption of oestrous cycles
  - High insulin
- Good follicular development
  - High insulin
- Good quality oocyte
  - Low insulin – High fat
- Establishment of pregnancy (High Day-5 P4)
  - Low insulin – High fat

A conundrum!
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Nottingham Pregnancy study

High insulin cycling diet (18% starch, 3.9% fat)
Low insulin mating diet (10% starch, 5.3% fat)
4 dietary treatments, 60 cows (n = 15)
Diets changed after cows started to cycle (≈50 d)
Days 0 to 120 of lactation

1. Worst for reproduction (LH)
2. Intermediate A (H)
3. Intermediate B (L)
4. Best for reproduction (HL)

Garnsworthy et al. (2009) Reproduction 137, 759-768
No treatment effect on:

- Milk yield, energy balance, BCS
- Days to first progesterone rise (29 +/- 5.4)
- Days to first insemination (74 +/- 7.6)
- Proportion of cows served (87%)
- Days to conception (78 +/- 12.2)  
  (for cows pregnant at 120 DIM)
Pregnancy rate at 120 days with diets designed to improve cycling (High Starch) or oocytes (High Fat)

Garnsworthy et al. (2009) *Reproduction* 137, 759-768
Overall Fertility Conclusions

A high insulin diet improves follicular development in early lactation

A low insulin diet improves oocyte quality

For best results, feed the right diet at the right time

(Or MAYBE avoid extremes?)
Conclusions

• Nutrition can have profound effects on all aspects of production, health and reproduction
• Negative energy balance must be minimised by controlling body condition in late lactation
• Avoid extremes of fat, starch [and protein] – an excess can be as bad as a deficiency
• Resumption of oestrous cycles is encouraged by high insulin, oocyte quality by low insulin
• Optimum nutrition at each stage of the lactation cycle significantly improves health and fertility

Thank you for your attention