Improving Dairy Farm Sustainability through Strategic Alternatives to Corn Grain Feeding

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Introduction

• The dairy industry is struggling to remain economically viable because of skyrocketing corn grain feed prices and uncertain milk price fluctuations

• Dairy farmers and extension faculty have indicated a need to improve dairy cattle feed efficiency in order for the dairy industry to remain economically sustainable
Hypothesis

- Effective feeding strategies that include corn grain substitution will improve economic net return in many farm and market situations in Wisconsin. These substitutions will additionally decrease dairy farm environmental impacts and promote more ecologically sustainable production systems.
Materials and Methods

• Integration of four major components into a bio-economic decision support system, the corn-replacer:

1. Compilation and analyses of data from extensive field research of corn/forage substitution, Tessmann et al. (1991);

2. Development of corn/forage substitution production models, Earleywine (2001);
3. Integration of grazing concentrate supplementation, Soder and Rotz (2001); Bargo et al. (2003); and

4. Development of a Markov-chain, stochastic, dynamic herd simulation model to portray real-life dairy cattle conditions, (Cabrera et al., 2006; 2008)
## Milk Production to Different Diets

<table>
<thead>
<tr>
<th>Diet (TRT)</th>
<th>Alfalfa hay</th>
<th>Corn grain (HMEC)</th>
<th>Soybean meal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lactation Stage</strong></td>
<td>Early-Mid-Late</td>
<td>Early-Mid-Late</td>
<td>Early-Mid-Late</td>
</tr>
<tr>
<td><strong>Week</strong></td>
<td>(0-12)-(13-26)-(27-44)</td>
<td>(0-12)-(13-26)-(27-44)</td>
<td>(0-12)-(13-26)-(27-44)</td>
</tr>
<tr>
<td>1</td>
<td>38-48-68%</td>
<td>42-40-25%</td>
<td>18-10-05%</td>
</tr>
<tr>
<td>2</td>
<td>48-58-78%</td>
<td>34-33-17%</td>
<td>16-07-03%</td>
</tr>
<tr>
<td>3</td>
<td>58-68-88%</td>
<td>27-25-09%</td>
<td>13-05-01%</td>
</tr>
<tr>
<td>4</td>
<td>68-88-98%</td>
<td>19-09-00%</td>
<td>11-01-00%</td>
</tr>
<tr>
<td>5</td>
<td>98-98-98%</td>
<td>00-00-00%</td>
<td>00-00-00%</td>
</tr>
</tbody>
</table>

Source: Tessmann et al. (1991)
Corn in diet

Week of Lactation

Lb/cow/day

TRT 1
TRT 2
TRT 3
TRT 4
TRT 5
Dry Matter Intake (actual)
Dry Matter Intake (Predicted)

\[ DMI_{1-12} = 24.035 - 7.84 \times AA\% + 0.3577 \times WK - 3.83 \times WK^{-1} \]

\[ DMI_{13-44} = 21.88 - 5.86 \times AA\% - 0.065 \times WK + 0.0087 \times WK^{-1} \]

Source: Earleywine (2001)
Milk Production to Different Diets (actual)

Week of Lactation

Lb/cow/day

TRT 1
TRT 2
TRT 3
TRT 4
TRT 5

UW Extension
Wisconsin Madison
Milk Production to Different Diets (Pred.)

\[ MILK_{1-12} = 14.56 + 4.77 \sqrt{AA} - 16.42 \sqrt{AA} \sqrt{Corn} + 10.63 WK^{-1} - 5.04 \sqrt{AA} WK^{-1} - 32.35 \sqrt{Corn} WK^{-1} - 0.86 WK - 99.41 \sqrt{SBM} + 22.21 \sqrt{AA} \sqrt{SBM} + 36.72 \sqrt{SBM} WK^{-1} \]

\[ MILK_{13-44} = 24.92 - 0.91 \sqrt{Corn} + 3.42 \sqrt{SBM} - 0.27 WK + 3.26 - 0.091 WK \sqrt{AA} - 97.36 WK^{-1} + 49.76 \sqrt{Corn} WK^{-1} \]

Source: Earleywine (2001)
Feed Efficiency (actual)
Feed Efficiency (Predicted)
<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price (June 08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$177/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$6/bs</td>
</tr>
<tr>
<td>SBM</td>
<td>$358/ton</td>
</tr>
<tr>
<td>Milk</td>
<td>$18/cwt</td>
</tr>
</tbody>
</table>
Feed Cost

Week of Lactation

Feed Cost ($/day)
Milk Revenue

Week of Lactation

Milk Revenue ($/day)
Income Over Feed Cost

<table>
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**Graph: Income Over Feed Cost**

- **Week of Lactation:**
  - Wk 13-44
  - TRT 1: $4.18/d
  - TRT 2: $3.98/d
  - TRT 3: $3.77/d
  - TRT 4: $3.12/d
  - TRT 5: $2.64/d
Income Over Feed Cost

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$172/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$4/bu</td>
</tr>
<tr>
<td>SBM</td>
<td>$265/ton</td>
</tr>
<tr>
<td>Milk</td>
<td>$15.5/cwt</td>
</tr>
</tbody>
</table>

The graph shows the income over feed cost (IOFC) in dollars per day over the weeks of lactation. The data points indicate that the IOFC decreases as the week of lactation increases, with specific values noted for Wk 13-44:

- TRT 1: $3.71/d
- TRT 2: $3.39/d
- TRT 3: $3.08/d
- TRT 4: $2.33/d
- TRT 5: $1.85/d
Income Over Feed Cost

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price (Oct 08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$172/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$8/bu</td>
</tr>
<tr>
<td>SBM</td>
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<td>Milk</td>
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### Graph

- **IOFC ($/day)** vs **Week of Lactation**
- **Wk 13-44**:
  - TRT 1: $2.61/d
  - TRT 2: $2.57/d
  - TRT 3: $2.54/d
  - TRT 4: $2.19/d
  - TRT 5: $1.85/d
Income Over Feed Cost

<table>
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<tr>
<th>Feed Ingredient</th>
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</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$100/ton</td>
</tr>
<tr>
<td>Corn grain</td>
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</tr>
<tr>
<td>SBM</td>
<td>$265/ton</td>
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Week of Lactation

- **Wk 13-44**
  - TRT 1: $3.64/d
  - TRT 2: $3.78/d
  - TRT 3: $3.84/d
  - TRT 4: $3.68/d
  - TRT 5: $3.39/d
Optimal Corn Usage (Diminishing returns)

Quantity of output per period of time

Q=f(X₁,X₂,X₃)

Units of variable inputs per period of time

Stage 1  Stage 2  Stage 3

Marginal Milk/Corn (lb milk/lb corn)

Quantity of Milk (lb)

Corn in Diet (lb)
Optimal Corn Usage (Break-even)
Milk Production Because of Corn

\[ MP\text{MILK} / \text{Corn} = (-0.46 \times \text{Corn}^{-0.5} + 24.88 \times WK^{-1} \times \text{Corn}^{-0.5}) / 0.454 \]

Corn in Diet
- 42%
- 34%
- 27%
- 19%
- 17%
- 9%

Marginal Milk/Corn (lb milk/lb corn)

Week of Lactation

13 15 17 19 21 23 25 27 29 31 33 35
Optimal Corn Usage

Corn in Diet
- 42%
- 34%
- 27%
- 19%
- 17%
- 9%

Marginal Value Milk/Corn ($)

Week of Lactation

Feed | Price
---|---
Corn grain | $6/bu
Milk | $18/cwt
Optimal Corn Usage

Week of Lactation

Feed | Price
--- | ---
Corn grain | $6/bu
Milk | $18/cwt
Optimal Corn Usage

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### Marginal Value Milk/Corn ($)

- **Week of Lactation**
  - 13
  - 15
  - 17
  - 19
  - 21
  - 23
  - 25
  - 27
  - 29
  - 31
  - 33
  - 35

- **Corn in Diet**
  - 42%
  - 34%
  - 27%
  - 19%
  - 17%
  - 9%
Optimal Corn Usage

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Week of Lactation

Marginal Value Milk/Corn ($)

Corn in Diet (lb)
Optimal Corn Usage

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<tbody>
<tr>
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</tr>
<tr>
<td>17</td>
<td>27%</td>
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</tr>
<tr>
<td>21</td>
<td>17%</td>
</tr>
<tr>
<td>23</td>
<td>9%</td>
</tr>
</tbody>
</table>

### Marginal Value Milk/Corn ($)

- **Feed** | **Price**
- Corn grain | $8/bu
- Milk | $15.5/cwt
Optimal Corn Usage

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</tbody>
</table>

Week of Lactation

Marginal Value Milk/Corn ($)

Corn in Diet (lb)
Optimal Corn Usage

Strategic Alternatives to Corn Grain Feeding

Victor E. Cabrera, vcabrera@wisc.edu, 608-265-8506
http://www.uwex.edu/ces/dairymgt/

Milk Price ($/cwt)  19
Corn Price ($/bu)   6

Week of Lactation
- 13
- 18
- 24
- 28
- 32
- 36

Corn in Diet
- 42%
- 34%
- 27%
- 19%
- 17%
- 9%

Marginal Value Milk/Corn ($)
- Week of Lactation
- Corn in Diet (lb)
Markov-Chains

- **Stage** = Time
- **State** = Characteristics of cow or group of cows
- **Transition** = Probabilities that determine the flow from one state to another state
Markov-Chains

• All potential **states** a cow (or group of cows) can be in a specific **stage**

• Example: (5,400 states)
  - 9 parities
  - 20 month in milk
  - 10 pregnancy (0-non-preg., 1-9 preg.)
  - 3 production levels
  - 12 months in a year
Markov-Chains

Some Biological Data Needs
Markov-Chains

Forecast of a dairy herd using Markov Chains

par mim 0 1 2 3 4 5 6 7 8 9
1 1 303
1 2 291
1 3 201
1 4 143
1 5 103
1 6 75
1 7 55
1 8 41
1 9 31
1 10 23
1 11 18
1 12 14
1 13 4
1 14 4
1 15 3
1 16 3
1 17 3
1 18 3
1 19 3
1 20
### Optimal IOFC Using Herd Structure

<table>
<thead>
<tr>
<th>Diet</th>
<th>Lactation Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2-20</td>
</tr>
<tr>
<td>3</td>
<td>21-26</td>
</tr>
<tr>
<td>1</td>
<td>27-44</td>
</tr>
<tr>
<td>Total IOFC</td>
<td>$35,463/wk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diet</th>
<th>Lactation Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1-44</td>
</tr>
<tr>
<td>Total IOFC</td>
<td>$24,642/wk</td>
</tr>
</tbody>
</table>

| Alfalfa hay   | $177/ton        |
| Corn grain    | $7/bu           |
| SBM           | $350/ton        |
| Milk          | $18/cwt         |
| Milking cows  | 1000            |
| Culling rate  | 30%             |
The Corn-replacer DSS

http://www.uwex.edu/ces/dairymgt/

Improving dairy farm sustainability through strategic alternatives to corn grain feeding

Feeding Strategies (3 pages, 740 KB)

This spreadsheet application calculates the income over feed cost (IOFC), the marginal value of milk to corn, and the optimal level of corn usage for defined milk price, feed costs, and stage of lactation.

Optimal Alternative Corn Grain Feeding (6 pages, 300 KB)

This PDF document describes the analyses of replacing corn grain by alternative feed strategies.

Optimal Feeding Strategies (SWF file, 782 KB)

This Macromedia Flash application performs analyses in real time directly in the web browser.

Income Over Feed Costs Analyses (SWF file, 918 KB)

This Macromedia Flash application performs analyses in real time directly in the web browser.

Improving Feeding Sustainability (Poster, 320 KB)

This PDF document gives a background of more efficient feeding practices for economic and environmental sustainability.

Victor E. Cabrera, PhD, Assistant Professor and Extension Specialist in Dairy Management, is available to contact for more information.
Limitations and Continued Work

1) Incorporate milk fat and protein,
2) Study and integrate grazing field observations,
3) Incorporate other forages, especially corn silage,
4) Incorporate herd and group feed analyses,
5) Distinction of cow's parity,
6) Incorporate high producing herds, and
7) Account for unintended impacts
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Jim Leverich

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