Molasses as the Primary Source of Energy for Grazing Dairy Cows

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USDA-ARS Pasture Systems & Watershed Mgmt. Research Unit

eOrganic webinar, Dec 2018
Why look at alternative energy sources for dairy cows?

• Organic corn prices/availability
  – Farmers seeking alternative (energy) supplement

• Farmer questions
  – How much- does it work?
  – Claims (3:1 molasses/corn)
  – No research on grazing dairy cows in temperate pastures

• Other benefits (i.e., milk FA)?
Grassfed milk

• Growing consumer market
  – Commercially available milk in some regions
  – Premium milk price (~$4/cwt over organic price)

• No concentrates (grains), corn silage or small grains with seedheads allowed

• Potential Drawbacks:
  – ↓ Milk yield
  – ↓ BCS
  – Breeding efficiency

• No-grain ‘train wrecks’ have happened
How Much Milk Can We Expect if We Feed Only Pasture and No Grain?

Results from recent research trials
Does it Make Sense to Feed Some Energy to Cows on Pasture?

- High-quality pasture is high in protein, high in rumen degradable protein and low in non-fiber carbohydrates (energy)
How Excess Degradable Protein Wastes Energy

Degradable Protein

- Used by microbes
  - microbial protein - used by cows
- Not used
  - converted to ammonia
    - energy
  - ammonia in blood to liver
    - energy
  - liver converts to urea
  - urea excretion

Energy flow diagram:

1. Degradable Protein
2. Used by microbes
   - microbial protein - used by cows
3. Not used
   - converted to ammonia
     - energy
   - ammonia in blood to liver
     - energy
   - liver converts to urea
   - urea excretion
Nitrogen (N) Efficiency in Dairy Cows

- N intake
- 25-35% milk N
- 30-40% fecal N
- 35-45% urinary N
Molasses

Primary source of energy on some grassfed and/or organic dairies
Why Molasses?

• High energy feed
  – 14 different sugars

• Less expensive per pound fed
  – Depends on organic grain prices
  – $0.39 vs. $0.45 or more

• Farmer testimonials
  – Feed at 1/3rd substitution rate to corn meal – 3 to 7 lbs/cow/day
Hypothesis

Molasses

Increase milk N

Reduce fecal N

Reduce urine N
But.....

• Some farms have little or no success
• No research to confirm 3:1 ratio
  – NRC – same energy value as corn
  – Sucrose vs. starch
• Prior molasses research
  – Not fed at high rates
  – Not fed to grazing dairy cows
  – Fed in combination with grain
  – 1950’s to 1970’s
Nutrition Issues

• High sugar levels
• Low starch levels
• High protein from pasture
• Ammonia & Milk Urea Nitrogen (MUN)

= loss of body condition, low breeding performance, low milk production, acidosis and laminitis, nutrient management issues, etc.
Effects of Molasses or Corn Meal Supplemented to an Herbage Diet on Ruminal Fermentation in Continuous Culture

✅ Kathy Soder, USDA-ARS
✅ Karen Hoffman, USDA-NRCS
✅ André Brito, UNH

Prof. Anim. Scientist. 26:167-174. 2010
Dual Flow Continuous Culture Fermenters
MOL vs. CM

- Compared molasses with corn meal
- Treatments
  - Orchardgrass pasture only (CON)
  - Molasses (5%) + pasture (MOL)
  - Corn meal (7%) + pasture (CM)
  - MOL + CM + pasture
MOL vs. CM

- Measured
  - Ruminal pH
  - Volatile fatty acid (VFA)
  - Bacterial nitrogen efficiency
  - Nutrient digestibility
  - Nitrogen utilization
MOL vs. CM
Nutrient Digestibility

- No change in DMd or NDFd
- CPd > MOL, < PAST
MOL vs. CM
NH₃-N Concentration

mg/dL

- PAST
- MOL
- CM
- MOL+CM

• < MOL+CM
• Decreased N intake due to greater supplementation level
• 5 mg/dL minimum to stimulate microbial growth (Satter and Slyter, 1974)
MOL vs. CM

- No impact on VFA or efficiency of bacterial N synthesis
Application to Pasture Diets

• Variability in on-farm response to molasses supplementation
  – Forage quality
  – Molasses source/nutrient content
  – Other supplements

• Greater supplementation rates may be warranted, but have been shown to depress nutrient digestibility (Broderick and Radloff, 2004)

• Cost must be evaluated
Implications

• MOL responded similarly to CM in improving *in vitro* N utilization
• Both only minimal improvements over PAST diet
• Needs to be evaluated at the cow level
  – Milk production/composition
  – Body condition
  – Reproduction
Molasses Level x Forage Quality

• Forage quality (FQ) may influence response to molasses (Heldt et al., 1999; Titgemeyer et al., 2004)
• There may be an interaction between FQ and level of molasses supplementation
• This interaction has not been investigated with temperate pastures
MOL vs. FQ

• Evaluate interaction between molasses and forage quality

• Treatments
  – 5% Molasses + Good Quality Pasture (G5)
  – 10% Molasses + Good Quality Pasture (G10)
  – 5% Molasses + Lower Quality Pasture (L5)
  – 10% Molasses + Lower Quality Pasture (L10)
## MOL vs. FQ
### Forage quality

<table>
<thead>
<tr>
<th></th>
<th>Good quality</th>
<th>Lower quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, % DM</td>
<td>26.8</td>
<td>20.4</td>
</tr>
<tr>
<td>RDP, % CP</td>
<td>65.0</td>
<td>61.0</td>
</tr>
<tr>
<td>NDF, % DM</td>
<td>35.9</td>
<td>45.3</td>
</tr>
<tr>
<td>Starch, % DM</td>
<td>3.8</td>
<td>2.4</td>
</tr>
<tr>
<td>WSC, % DM</td>
<td>11.3</td>
<td>10.8</td>
</tr>
<tr>
<td>NE\textsubscript{L}, Mcal/lb</td>
<td>0.74</td>
<td>0.65</td>
</tr>
</tbody>
</table>

- Typical range of forage quality for NE dairy pastures
MOL vs. FQ
Nutrient Digestibility

%

Diet

G10  G5  L10  L5

DM  NDF  CP

\( \text{DMd} = \text{FQ effect} \)
MOL vs. FQ

**NH₃-N Concentration**

- Tendency ($P = 0.07$) for lower NH₃-N with lower FQ
- Due to lower N intake

**Diet**

- mg/dL

**Bacterial Efficiency**

- g N/kg OM digested

**Total VFA**

- mmol/L

- FQ effect
Implications

• No significant interactions between FQ and MOL
• FQ not as extreme in original studies
  – Winter range in Intermountain West
• Disparity in animal production on farms may be due to a number of factors
  – Timing of supplementation
  – Molasses source
  – Level of molasses
  – Adaptation of cows
  – Forage quality
Conclusions

• Molasses did not significantly impact ruminal fermentation, either alone or in combination
• No interaction with forage quality differences found in NE temperate pastures
• Farms using molasses successfully must consider other management factors that may be cause for ‘success’
• Cost must be evaluated
• Ease of handling (summer flies, cold weather)
MOLASSES SUPPLEMENT TO GRAZING DAIRY COWS

On-Farm Case Study


Karen Hoffman[1], Larry E. Chase[2], and Kathy J. Soder[3]

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[2] Cornell University, 272 Morrison Hall, Ithaca, NY, 607-255-2196, lec7@cornell.edu
2008-09 Observational Study

• Central NY organic dairy farm feeding molasses successfully
  – 2008 - 3 lbs molasses with 1 lb corn meal/barley grain mix
  – 2009
    • April – May - 2 lbs molasses w/3 lbs grain
    • June - 3 lbs molasses w/2 lbs grain
    • July – 2.5 lbs molasses w/2 lbs grain
    • August – October - 2 lbs molasses w/2 lbs grain
2008-09 Observational Study

- Data collected monthly during grazing season
  - 80 acres of orchardgrass, red and white clover, forbs, etc. pasture

- The herd:
  - 2008 - 56 cross-bred cows, 1000 lbs
    - 2009 – 66 cows
  - Seasonal calving starts in March
Molasses

Data collected:
- body condition scores
- milk production, SCC, components, MUN
- pasture quality

Cornell Net Carbohydrate and Protein System (CNCPS) model used to analyze diets

Molasses is poured over corn meal to slow intake
Dry period BCS unknown in 2008 – in 2009 avg. dry cow BCS = 2.34

Lowest BCS is well after peak production
6 month persistency rate = 12% per month

Late May to late June = 25% per month – low pasture quality

Typical PR is 3-9% per month
Butterfat trends higher later in lactation

- dry hay and baleage fed beginning in September 2008, & October 1st, 2009
Protein 2008 vs. 2009

- 2008 may be statistically significant vs. 2009
- 3.39% average vs. 4.32% over season
✓ Recommended range is 8 to 12 mg/dl
✓ Herd averaged 16.15 in 2008 vs. 14.46 in 2009
✓ May and June lowest due to pasture quality in 2008
✓ Supplementation in 2009?
## Pasture Quality Analysis Results

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>May</td>
<td>21.5</td>
<td>21.6</td>
<td>46.7</td>
<td>47.0</td>
<td>18.7</td>
<td>29.7</td>
<td>40</td>
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<td>June</td>
<td>21.2</td>
<td>21.3</td>
<td>47.7</td>
<td>51.4</td>
<td>19.7</td>
<td>25.6</td>
<td>30</td>
<td>28</td>
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<td>July</td>
<td>17.6</td>
<td>16.9</td>
<td>46.5</td>
<td>42.7</td>
<td>25.3</td>
<td>23.7</td>
<td>42</td>
<td>28</td>
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<tr>
<td>August</td>
<td>19.3</td>
<td>22.7</td>
<td>46.5</td>
<td>51.7</td>
<td>23.7</td>
<td>20.4</td>
<td>31</td>
<td>30</td>
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<tr>
<td>September</td>
<td>20.1</td>
<td>17.2</td>
<td>43.6</td>
<td>48.9</td>
<td>22.7</td>
<td>27.2</td>
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<td>37</td>
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<td>October</td>
<td>14.4</td>
<td>20.9</td>
<td>51.4</td>
<td>45.9</td>
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<td>27.4</td>
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# Pasture Quality Analysis Results

<table>
<thead>
<tr>
<th>Date</th>
<th>% NFC 2008</th>
<th>% NFC 2009</th>
<th>% Starch 2008</th>
<th>% Starch 2009</th>
<th>% ESC 2008</th>
<th>% ESC 2009</th>
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<td>May</td>
<td>28.2</td>
<td>27.3</td>
<td>2.9</td>
<td>2.1</td>
<td>13.4</td>
<td>12.8</td>
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<tr>
<td>June</td>
<td>27.7</td>
<td>24.2</td>
<td>2.8</td>
<td>2.1</td>
<td>10.3</td>
<td>13.3</td>
</tr>
<tr>
<td>July</td>
<td>20.2</td>
<td>28.3</td>
<td>1.9</td>
<td>3.4</td>
<td>3.4</td>
<td>7.7</td>
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<tr>
<td>August</td>
<td>23.6</td>
<td>23.0</td>
<td>5.4</td>
<td>3.8</td>
<td>9.5</td>
<td>9.1</td>
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<td>September</td>
<td>27.9</td>
<td>22.0</td>
<td>2.4</td>
<td>5.6</td>
<td>7.8</td>
<td>3.6</td>
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<tr>
<td>October</td>
<td>22.2</td>
<td>25.2</td>
<td>0.5</td>
<td>4.2</td>
<td>5.8</td>
<td>11.1</td>
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## Milk Production Results vs. CNCPS Model Predictions

<table>
<thead>
<tr>
<th>Date</th>
<th>Year</th>
<th>Actual milk lb/day</th>
<th>ME milk lb/day</th>
<th>MP milk lb/day</th>
<th>MET milk lb/day</th>
<th>LYS milk lb/day</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- 4.94 Mcal/day</td>
<td></td>
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<tr>
<td>May</td>
<td>2008</td>
<td>50.0</td>
<td>40.8</td>
<td>50.8</td>
<td>57.6</td>
<td>59.9</td>
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<tr>
<td></td>
<td>2009</td>
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<td>91.7</td>
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<td>67.7</td>
<td>73.2</td>
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<tr>
<td></td>
<td>2009</td>
<td>42.8</td>
<td>43.5</td>
<td>66.1</td>
<td>61.7</td>
<td>69.4</td>
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<td>2008</td>
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<td>40.7</td>
<td>62.5</td>
<td>58.1</td>
<td>66.2</td>
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<tr>
<td></td>
<td>2009</td>
<td>36.8</td>
<td>43.9</td>
<td>67.0</td>
<td>66.5</td>
<td>72.8</td>
</tr>
</tbody>
</table>

Cows were probably using BCS for additional energy
## Milk Production Results vs. CNCPS Model Predictions

<table>
<thead>
<tr>
<th>Date</th>
<th>Year</th>
<th>Actual milk lb/day</th>
<th>ME milk lb/day</th>
<th>MP milk lb/day</th>
<th>MET milk lb/day</th>
<th>LYS milk lb/day</th>
</tr>
</thead>
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<tr>
<td>August</td>
<td>2008</td>
<td>36.2</td>
<td>36.8</td>
<td>54.1</td>
<td>54.0</td>
<td>59.4</td>
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<tr>
<td></td>
<td>2009</td>
<td>33.1 (-highlighted)</td>
<td>15.7</td>
<td>29.4</td>
<td>25.1</td>
<td>31.2</td>
</tr>
<tr>
<td>September</td>
<td>2008</td>
<td>31.9</td>
<td>37.3</td>
<td>57.1</td>
<td>57.4</td>
<td>62.8</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>32.5</td>
<td>34.9</td>
<td>49.9</td>
<td>43.1</td>
<td>50.8</td>
</tr>
<tr>
<td>October</td>
<td>2008</td>
<td>30.0</td>
<td>24.8</td>
<td>25.0</td>
<td>31.2</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>29.0</td>
<td>30.5</td>
<td>40.5</td>
<td>39.4</td>
<td>43.4</td>
</tr>
</tbody>
</table>

- 9.24 Mcal/day

hay and/or baleage fed
## Actual MUN Values vs. Predicted MUN, N excretion, and Urea Cost

<table>
<thead>
<tr>
<th>Date</th>
<th>Year</th>
<th>Actual MUN, mg/dl</th>
<th>Predicted MUN, mg/dl</th>
<th>Predicted N excreted, g/day</th>
<th>Urea cost, Mcal/day</th>
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</thead>
<tbody>
<tr>
<td>May</td>
<td>2008</td>
<td>15.5</td>
<td>11</td>
<td>36</td>
<td>0.02</td>
</tr>
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<td></td>
<td>2009</td>
<td>11.5</td>
<td>33</td>
<td>451</td>
<td>1.64</td>
</tr>
<tr>
<td>June</td>
<td>2008</td>
<td>17.6</td>
<td>11</td>
<td>100</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>11.9</td>
<td>25</td>
<td>302</td>
<td>1.48</td>
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<tr>
<td>July</td>
<td>2008</td>
<td>20.9</td>
<td>24</td>
<td>306</td>
<td>1.47</td>
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<td></td>
<td>2009</td>
<td>16.7</td>
<td>16</td>
<td>197</td>
<td>0.89</td>
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</tbody>
</table>

Molasses = 3x corn?  
CNCPS value for molasses?

Nutrient management issue
Conclusions

• Sugar from molasses may not compensate for lack of starch

• Higher starch appears to improve BCS, milk protein, and MUN
  – ‘09 – cows reached + energy balance sooner
  – ‘09 pasture quality higher

• Cost of organic starch sources a concern

• Research on-going
  – Rumen dynamics - fermenter
  – Animal trial w/treatment groups
Effects of Cornmeal or Molasses on Milk Production of Grazing Organic Dairy Cows

✓ André F. Brito, UNH
✓ Kathy J. Soder, USDA-ARS
✓ Shara Ross, UNH
✓ Kristen Greene, UNH
✓ Ashley Green, UNH
✓ Melissa Rubano, USDA-ARS
Objectives

✓ Compare the effects of cornmeal or molasses on:

- Milk production
- Milk composition
- Nitrogen metabolism
Methods

✓ Molasses or corn meal fed at 12% of DMI (May-Sept)
  ✓ Topdressed on alfalfa baleage (18% DMI)

✓ Data collected
  ✓ Milk yield
  ✓ Milk Composition
    ✓ Fat (FA), protein, SCC, MUN
  ✓ Blood metabolites
  ✓ Urine (N efficiency)
  ✓ BW, BCS
  ✓ Grazing behavior
  ✓ Pasture sampling
    ✓ Quality
    ✓ Biomass
    ✓ Botanical composition
Cows Grazing on Assigned Paddocks
Calan Gates: Individual Intake
Milk Production in Organic Grazing Cows Fed Cornmeal (CM) or Molasses (MOL)

Milk production, lbs/d

$P = 0.54$

$\text{SED} = 3.38 \text{ lb/day}$

CM  MOL
# Pasture and Supplement Dry Matter Intake (DMI) in Organic Grazing Cows Fed Corn meal (CM) or Molasses (MOL)

<table>
<thead>
<tr>
<th>Item</th>
<th>CM</th>
<th>MOL</th>
<th>SED(^1)</th>
<th>P &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture, lbs/day(^2)</td>
<td>22.1</td>
<td>25.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Supplement, lbs/day(^3)</td>
<td>8.10</td>
<td>9.43</td>
<td>0.29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Total DMI, lbs/day</td>
<td>31.1</td>
<td>34.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pasture, % of total</td>
<td>71.1</td>
<td>72.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Supplement, % total</td>
<td>26.0</td>
<td>27.1</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\)SED = standard error of the least square means difference  
\(^2\)Group pasture intake estimated using pre- and post-grazing pasture height measurements  
\(^3\)Supplement = CM or MOL plus a grass-legume baleage
### Milk Yield and Composition, and Body Weight (BW) Gain in Grazing Cows Fed Cornmeal (CM) or Molasses (MOL)

<table>
<thead>
<tr>
<th>Item</th>
<th>CM</th>
<th>MOL</th>
<th>SED</th>
<th>P &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield, kg/d</td>
<td>11.9</td>
<td>12.6</td>
<td>0.54</td>
<td>NS</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>4.81</td>
<td>4.82</td>
<td>0.22</td>
<td>NS</td>
</tr>
<tr>
<td>Milk fat, lbs/d</td>
<td>1.24</td>
<td>1.35</td>
<td>0.31</td>
<td>NS</td>
</tr>
<tr>
<td>Milk protein, %</td>
<td>3.46</td>
<td>3.45</td>
<td>0.15</td>
<td>NS</td>
</tr>
<tr>
<td>Milk protein, lbs/day</td>
<td>0.88</td>
<td>0.95</td>
<td>0.20</td>
<td>NS</td>
</tr>
<tr>
<td>Milk lactose, %</td>
<td>4.64</td>
<td>4.70</td>
<td>0.04</td>
<td>NS</td>
</tr>
<tr>
<td>Milk lactose, lbs/d</td>
<td>2.67</td>
<td>2.91</td>
<td>0.33</td>
<td>NS</td>
</tr>
<tr>
<td>BW gain, lbs/day</td>
<td>0.49</td>
<td>0.79</td>
<td>0.37</td>
<td>NS</td>
</tr>
</tbody>
</table>

SED = standard error of the least square means difference
NS = not significant (P > 0.05)
Concentration of Milk Urea Nitrogen (MUN) and Plasma Urea Nitrogen (PUN) in Grazing Cows Fed Cornmeal (CM) or Molasses (MOL)

- **MUN**:
  - Value: 15 mg/dL
  - Significance: P = 0.03
  - Standard Error of the Difference (SED): 0.59 mg/dL

- **PUN**:
  - Value: 17 mg/dL
  - Significance: P < 0.01
  - Standard Error of the Difference (SED): 0.56 mg/dL
Fatty Acid Profile [conjugated linoleic acid (CLA), n:6:n-3 ratio] in Grazing Cows Fed Cornmeal (CM) or Molasses (MOL)

15% < n6:n3
$P = 0.02$
SED = 0.02

5% > CLA
$P = 0.04$
SED = 0.041
Conclusions

• Liquid molasses fed at 3.5 lb. can replace same amount of corn when fed as only NSC source.
  – Not 3:1 per anecdotal claims
  – No effect on milk yield, components
  – Decreased MUN (↑ N utilization)
  – Slight positive effect on CLA and n6:n3 fatty acids

• Must be economically competitive or for specific milk market.
Questions??