Factors affecting milk fat

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FMMO milk component values, 1/08 to 1/15
Sources of milk fat

- “De novo” – made by the mammary cells
  - Short- and medium-chain fatty acids
- “Pre-formed” – extracted from the blood by the mammary gland
  - Long-chain fatty acids from diet and body fat (esp. in early lactation)
- “Mixed” – both made in the mammary gland and extracted from the blood

- ~ 50% of milk fatty acids made in mammary gland and about 50% extracted from the blood

Many factors can affect milk fat

**Nutritional Factors**
- Dietary CHO
- Unsaturated fats
- Feeding strategy
- Ionophores

**Non-nutritional Factors**
- Genetics
- Stage of lactation
- Season
- Parity
- Ambient temperature
Many non-nutritional factors affect milk fat

- Genetics/breed
- Days in milk
- Season
- Heat stress
- Feeding patterns/stocking density
- Sampling strategy/analytical methods

Source: Heinrichs et al., 2005

<table>
<thead>
<tr>
<th>Trait</th>
<th>Holstein h²</th>
<th>Holstein SD¹</th>
<th>Jersey h²</th>
<th>Jersey SD¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat, %</td>
<td>0.58</td>
<td>0.23</td>
<td>0.55</td>
<td>0.28</td>
</tr>
<tr>
<td>Protein, %</td>
<td>0.51</td>
<td>0.14</td>
<td>0.55</td>
<td>0.20</td>
</tr>
<tr>
<td>Fat, lb</td>
<td>0.30</td>
<td>52</td>
<td>0.35</td>
<td>50</td>
</tr>
<tr>
<td>Protein, lb</td>
<td>0.30</td>
<td>37</td>
<td>0.35</td>
<td>36</td>
</tr>
<tr>
<td>Milk, lb</td>
<td>0.30</td>
<td>1444</td>
<td>0.35</td>
<td>1204</td>
</tr>
</tbody>
</table>

¹ Estimate of genetic standard deviation.
Source: USDA-AIPL yield traits definition (May 2005) and trend estimates for cows born in 2000.
Milk fat percentage by days in milk (test day snapshot from Cornell T&R Center)

Source: http://future.aae.wisc.edu/data/monthly_values/by_area/450?area=US&tab=production&yoy=true
Possible explanations for seasonality in milk fat percentage

- Changes in silage quality/characteristics?
- Photoperiod?
  - Prepartum day length negatively correlated with milk yield and milk fat and protein percentage (Aharoni et al., 2000)
- Changes in feeding behavior?
- Heat stress

Many non-nutritional factors affect milk fat

- Genetics/breed
- Days in milk
- Season
- Heat stress
- Feeding patterns/stocking density
- Sampling strategy/analytical methods
Intake, Milk Yield, and Milk Composition by Stocking Rate (Miner Institute)

<table>
<thead>
<tr>
<th>Item</th>
<th>Stocking Rate, %</th>
<th></th>
<th></th>
<th></th>
<th>SE</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI&lt;sup&gt;1&lt;/sup&gt;, kg/d</td>
<td>100</td>
<td>113</td>
<td>131</td>
<td>142</td>
<td>0.65</td>
<td>0.69</td>
</tr>
<tr>
<td>Milk, kg/d</td>
<td>24.4</td>
<td>24.8</td>
<td>25.0</td>
<td>25.3</td>
<td>0.32</td>
<td>0.39</td>
</tr>
<tr>
<td>Fat, %</td>
<td>41.4</td>
<td>40.7</td>
<td>41.5</td>
<td>41.1</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.77&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.77&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.02</td>
<td>0.66</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>3.05</td>
<td>3.03</td>
<td>3.03</td>
<td>3.03</td>
<td>0.01</td>
<td>0.42</td>
</tr>
<tr>
<td>SCS&lt;sup&gt;2&lt;/sup&gt;</td>
<td>4.89</td>
<td>4.88</td>
<td>4.90</td>
<td>4.90</td>
<td>0.39</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>3.1</td>
<td>3.4</td>
<td>3.6</td>
<td>0.39</td>
<td>0.62</td>
</tr>
</tbody>
</table>

<sup>1</sup> DMI = Dry matter intake
<sup>2</sup> SCS = Somatic cell score
<sup>a,b</sup> Means within rows with different superscripts differ (P < 0.05)

Many non-nutritional factors affect milk fat

- Genetics/breed
- Days in milk
- Season
- Heat stress
- Feeding patterns/stocking density
- Sampling strategy/analytical methods
Quist et al., 2008. J. Dairy Sci. 91:3412–3423

Variation in milk yield and milk fat and protein content by milking for herds milking 2X

Quist et al., 2008. J. Dairy Sci. 91:3412–3423

Variation in milk yield and milk fat and protein content by milking for herds milking 3X

Quist et al., 2008. J. Dairy Sci. 91:3412–3423
Many non-nutritional factors affect milk fat

- Genetics/breed
- Days in milk
- Season
- Heat stress
- Feeding patterns/stocking density
- Sampling strategy/analytical methods

Summary opinion – these are responsible for variation in milk fat within a herd over time and among herds, but rarely, if ever are they the cause for low milk fat on farms
Many factors can affect milk fat

**Nutritional Factors**
- Dietary CHO
- Unsaturated fats
- Feeding strategy
- Ionophores

**Non-nutritional Factors**
- Genetics
- Stage of lactation
- Season
- Parity
- Ambient temperature

“Old” understanding of low milk fat

- Most commonly observed when grain overload/low forage diets
- Must relate to not enough fiber fermentation
  - Acetate produced from fiber fermentation is major building block for milk fat
  - If not enough fiber fermented, may not have enough acetate to make milk fat
  - Not well-supported by research
- Must relate to increased insulin in cows fed high energy diets promoting BCS accumulation
  - Not well-supported by research
“New” understanding of low milk fat

- Not actually new
  - First advanced as a theory during 1970s

- Specific fats (fatty acids) produced during microbial metabolism of dietary fats in the rumen are responsible for low milk fat

- Very potent – 2 to 3 grams of these fatty acids flowing out of the rumen can decrease milk fat by 0.5% or more

- Mechanism for all situations of low milk fat appears to be the same, but get there in different ways

Low milk fat

Requires two conditions:

1) Dietary presence of PUFA

2) Altered rumen fermentation
### Fatty Acid Composition of Typical Feedstuffs

<table>
<thead>
<tr>
<th>Feed Name</th>
<th>C14:0</th>
<th>C16:0</th>
<th>C16:1</th>
<th>C18:0</th>
<th>C18:1C</th>
<th>C18:2</th>
<th>C18:3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CrsSil6Cp60Nd11LNdf</td>
<td>0.46</td>
<td>17.83</td>
<td>0.36</td>
<td>2.42</td>
<td>19.24</td>
<td>47.74</td>
<td>8.25</td>
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<tr>
<td>AlHly17Cp43Nd20LNdf</td>
<td>0.66</td>
<td>18.81</td>
<td>1.91</td>
<td>3.35</td>
<td>2.05</td>
<td>15.91</td>
<td>38.71</td>
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<tr>
<td>AlHly17Cp46Nd20LNdf</td>
<td>0.85</td>
<td>25.01</td>
<td>2.23</td>
<td>4.01</td>
<td>2.43</td>
<td>18.49</td>
<td>36.79</td>
</tr>
<tr>
<td>BakeryByProd</td>
<td>3.16</td>
<td>15.82</td>
<td>0.18</td>
<td>9.29</td>
<td>26.41</td>
<td>33.51</td>
<td>0.85</td>
</tr>
<tr>
<td>CornGrainCrkd</td>
<td>2.33</td>
<td>13.21</td>
<td>0.12</td>
<td>1.99</td>
<td>24.09</td>
<td>55.70</td>
<td>1.62</td>
</tr>
<tr>
<td>CornGrainGrndFine</td>
<td>2.33</td>
<td>13.21</td>
<td>0.12</td>
<td>1.99</td>
<td>24.09</td>
<td>55.70</td>
<td>1.62</td>
</tr>
<tr>
<td>CornHM22%Med</td>
<td>0.26</td>
<td>13.57</td>
<td>0.19</td>
<td>1.83</td>
<td>25.99</td>
<td>55.08</td>
<td>1.64</td>
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<td>FatTallowBeef</td>
<td>3.00</td>
<td>24.43</td>
<td>3.79</td>
<td>17.92</td>
<td>41.62</td>
<td>1.09</td>
<td>0.53</td>
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<tr>
<td>FatCurtatOil</td>
<td>0.00</td>
<td>11.08</td>
<td>0.00</td>
<td>1.55</td>
<td>26.95</td>
<td>58.95</td>
<td>1.10</td>
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<td>FatSoybeanOil</td>
<td>0.11</td>
<td>10.83</td>
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<td>3.89</td>
<td>22.82</td>
<td>53.75</td>
<td>8.23</td>
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<td>Megalac</td>
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<td>50.80</td>
<td>0.00</td>
<td>4.10</td>
<td>35.70</td>
<td>7.00</td>
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<td>EnergyBooster</td>
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<td>40.00</td>
<td>0.62</td>
<td>40.70</td>
<td>10.40</td>
<td>1.80</td>
<td>0.00</td>
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<td>CornDistEthanol</td>
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<td>14.05</td>
<td>0.13</td>
<td>2.39</td>
<td>24.57</td>
<td>56.11</td>
<td>1.68</td>
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<tr>
<td>CottonseedWhtsLint</td>
<td>0.09</td>
<td>23.91</td>
<td>0.55</td>
<td>2.33</td>
<td>15.24</td>
<td>56.48</td>
<td>0.19</td>
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<tr>
<td>SoybeanMealExtrd</td>
<td>0.07</td>
<td>11.55</td>
<td>0.09</td>
<td>3.71</td>
<td>18.13</td>
<td>54.77</td>
<td>9.52</td>
</tr>
<tr>
<td>ClvrSil17Cp53Nd15LNdf</td>
<td>0.33</td>
<td>15.22</td>
<td>1.52</td>
<td>2.38</td>
<td>2.62</td>
<td>18.19</td>
<td>53.84</td>
</tr>
<tr>
<td>GrssSil7Cp72Nd13Lndf</td>
<td>0.54</td>
<td>16.76</td>
<td>1.67</td>
<td>1.94</td>
<td>3.80</td>
<td>19.96</td>
<td>44.30</td>
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<tr>
<td>GrssHy16Cp55Nd16Lndf</td>
<td>0.43</td>
<td>16.44</td>
<td>0.48</td>
<td>1.33</td>
<td>2.53</td>
<td>23.38</td>
<td>49.99</td>
</tr>
</tbody>
</table>

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### Pathways for Rumen Biohydrogenation

- **Linolenic Acid**
  - cis-9, cis-12, cis-15 \( C_{18:3} \)
  - cis-9, trans-11, cis-15 \( C_{18:3} \)
  - trans-11, cis-15 \( C_{18:2} \)
  - trans-15 or cis-15 \( C_{18:1} \)

- **Linoleic Acid**
  - cis-9, cis-12 \( C_{18:2} \)
  - cis-9, trans-11 CLA

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- **Stearic Acid** \( C_{18:0} \)

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**Harfoot and Hazlewood, 1997**

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- Process extensive, but not complete
- All intermediates formed potentially pass to the small intestine

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Harfoot and Hazlewood, 1997
Rumen Biohydrogenation

Linolenic Acid
\( cis-9, \, cis-12, \, cis-15 \, C_{18:3} \)
\[ \rightarrow \]
\( cis-9, \, trans-11, \, cis-15 \, C_{18:3} \)
\[ \rightarrow \]
\( trans-11, \, cis-15 \, C_{18:2} \)
\[ \rightarrow \]
\( trans-15 \, or \, cis-15 \, C_{18:1} \)
\[ \rightarrow \]
Stearic Acid \( C_{18:0} \)

Linoleic Acid
\( cis-9, \, cis-12 \, C_{18:2} \)
\[ \rightarrow \]
\( cis-9, \, trans-11 \, CLA \)
\[ \rightarrow \]
\( trans-10, \, cis-12 \, CLA \)

Altered fermentation

Effect of CLA Isomers on Milk Fat

Infusion

Milk Fat (percentage)

-2 -1 1 2 3 4 5 6 7 8
Day

Milk Fat

- 1.5 2 2.5 3 3.5

- Control
- \( cis-9, \, trans-11 \, CLA \)
- \( trans-10, \, cis-12 \, CLA \)

Baumgard et al., 2000
How do we find and troubleshoot ruminal outflow of 1 to 2 grams of a specific MFD-causing fatty acid???
Dietary components can impact the risk of MFD in 3 ways

1. Increase C18 PUFA Precursors

- Linoleic acid (cis-9, cis-12 18:2)
- Rumenic acid (cis-9, trans-11 CLA)
- Vaccenic acid (trans-11 18:1)
- Stearic acid (18:0)

2. Alter BH pathways/rumen environment

- trans-10, cis-12 CLA
- trans-10 18:1

3. Inhibit final step/alter rates of BH

- Stearic acid (18:0)

Increase C18 PUFA precursor supply and rumen availability

- Linoleic acid (C18:2) supply and availability in the rumen
- CNCPS predictions of linoleic acid intake from high corn silage-based lactating diets can approach or exceed 400 to 500 g/d
- Ready availability of low-cost byproducts from corn (distillers) or other sources
  - Variation in fat content within and among production plants
- Any processing method that will increase ruminal availability of unsaturated FA (e.g. finely ground or extruded full-fat soybeans)
- Despite high content of C18:2, whole cottonseed not frequently associated with low milk fat
  - Effect of hull on release of fatty acids into rumen environment
Factors that result in an altered ruminal environment

- Dynamics of rumen pH as a balance of
  - Acid production from ruminally fermentable CHO
    - Dietary CHO profile and Kd of fractions as affected by source, processing, and moisture
  - Buffer production from salivary and dietary sources
    - peNDF supply and source
  - Rate of removal of acids through absorption or passage
- Feeding management and environmental/facility effects
  - Mixing, DM changes, feeding frequency, stocking density, heat stress, stall usage, etc.

Proceedings from Cornell Nut Conf 49-60 (2005)

Intake, Milk Yield, and Milk Composition by Stocking Rate (Miner Institute)

<table>
<thead>
<tr>
<th>Item</th>
<th>Stocking Rate, %</th>
<th></th>
<th></th>
<th></th>
<th>SE</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>113</td>
<td>131</td>
<td>142</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI(^1), kg/d</td>
<td>24.4</td>
<td>24.8</td>
<td>25.0</td>
<td>25.3</td>
<td>0.65</td>
<td>0.69</td>
</tr>
<tr>
<td>Milk, kg/d</td>
<td>41.4</td>
<td>40.7</td>
<td>41.5</td>
<td>41.1</td>
<td>0.32</td>
<td>0.39</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.84(^a)</td>
<td>3.77(^ab)</td>
<td>3.77(^ab)</td>
<td>3.67(^b)</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.05</td>
<td>3.03</td>
<td>3.03</td>
<td>3.03</td>
<td>0.02</td>
<td>0.66</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>4.89</td>
<td>4.88</td>
<td>4.90</td>
<td>4.90</td>
<td>0.01</td>
<td>0.42</td>
</tr>
<tr>
<td>SCS(^2)</td>
<td>3.2</td>
<td>3.1</td>
<td>3.4</td>
<td>3.6</td>
<td>0.39</td>
<td>0.62</td>
</tr>
</tbody>
</table>

\(^1\) DIM = Dry matter intake
\(^2\) SCS = Somatic cell score
\(^a\)^\(^b\) Means within rows with different superscripts differ \(P < 0.05\)
Other factors that may contribute to an “altered” ruminal environment conducive to production of MFD-causing FA

- High mold and yeast counts on ensiled forages or high-moisture cereals??
- Mycotoxins??
- Off-fermented feeds, particularly high acetic corn silage??
- Oxidized lipids in feeds??

Effect of Time of Storage in Silo on Digestion of Starch in Corn Silage

Newbold et al., 2006
### Changes in silage microbiology

- Denmark study of 20 corn silage piles (Storm et al., 2010)
  - Samples collected about 3 feed in from face every 2 months
  - Counts of various yeast species increased over time
  - Peaked at 5 to 7 months post-ensiling

- Protection against yeasts
  - Good silage management (pack, moisture, chop, etc.)
  - Good face management (defacer helps)
  - Low oxygen permeability plastics
  - Silage inoculants based upon Lactobacillus Buchneri or acid-based preservatives

### Factors that influence biohydrogenation rate

- Anything that slows rates of biohydrogenation at different steps may result in more passage of FA intermediates that cause MFD from the rumen

- These do not cause milk fat problems, but will amplify the effect of an existing ruminal condition on milk fat

- Monensin
- Fish fatty acids (last step of biohydrogenation)
- High load of unsaturated FA (C18:1?)
Factors that influence rate of passage

- DMI (higher producing, higher intake herds more risk)
- Ration particle size (especially middle screen and pan if using 3-part Penn State Particle Separator)

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Univariable Categorical Analysis of TMR Particle Size and herd milk fat %

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cut-Point</th>
<th>Mean MF% Bottom 75%</th>
<th>Mean MF% Top 25%</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSPS(^1) Top, %</td>
<td>8.7</td>
<td>3.40</td>
<td>3.45</td>
<td>0.46</td>
</tr>
<tr>
<td>PSPS(^1) Middle, %</td>
<td>49.8</td>
<td>3.37</td>
<td>3.54</td>
<td>0.02</td>
</tr>
<tr>
<td>PSPS(^1) Bottom, %</td>
<td>54</td>
<td>3.49</td>
<td>3.26</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

\(^1\)Penn State Particle Separator

Overton et al., 2008 CNC
Time courses during induction and recovery from milk fat depression


Dr. Dave Barbano research
(2014 ADSA-ASAS JAM)

- Large field study (430 farms in Northern VT and Northern NY)
  - Sampled multiple times per month for 14 mo
  - Tested for fat, protein, lactose, and FA composition by mid-infrared analysis
- Key results
  - Wide variation in FA composition among herds
  - De novo FA content strongly and positively correlated with overall milk fat and protein percentages
    - Mixed and preformed also correlated positively with components, but not as strongly as de novo FA content
  - Total unsaturation negatively correlated with both overall fat and protein content of milk

Barbano et al., 2014. J. Dairy Sci. 97(E. Suppl. 1):320
Summary -- common observations for low milk fat

• Factors that cause altered ruminal biohydrogenation
  – NDF and NFC interrelationships
  – Altered corn silage fermentation profiles?
  – Mycotoxins in forages or high moisture corn?
  – Elevated mold/yeast counts in high-moisture corn or silages?
  – Oxidized components of feedstuffs?

• Factors that result in high availability of linoleic acid
  – Unsaturated fat source, amount, and processing

• Factors that slow rates of biohydrogenation
  – Fish fatty acids
  – Ionophores
  – High C18:1 intake?

• Factors that result in high rates of passage
  – High production/DMI

• Most often not one factor, but an INTERACTION AMONG SEVERAL FACTORS, responsible for milk fat problems

What might we do nutritionally to increase milk fat percentage and yield when milk fat content is “normal”??
Specific nutritional supplements and additives that may increase milk fat percentage and yield

• Many nutritional supplements and feed additives exert their effects on milk fat yield through effects on milk yield rather than on milk fat percentage per se
• Some additives can have effects on milk fat percentage and yield
  – Buffers
  – DCAD
  – Yeast/yeast culture
  – AA analogs
  – Certain added fat sources (especially those high in palmitate C16:0)

Rumen buffers

• Maintain more stable rumen pH
• May increase liquid passage rate
• Examples
  – Sodium bicarbonate
  – Sodium sesquicarbonate (SQ-810)
  – Magnesium oxide
Meta analysis (40 publications)

- Rumen buffer supplementation (per % unit)
  - Increased DMI (0.5 kg/d)
  - Increased milk yield (0.5 kg/d)
  - Increased milk fat % (0.15%)
  - Increased ruminal pH (0.07 units)
  - Responses strongly linked to initial conditions
    - Greater in subacute acidosis situations

Meschy et al., 2004

Rumen buffers and biohydrogenation (Cabrita et al., 2009)

- Diets
  - 45% corn silage
  - 5% wheat straw
  - 50% wheat- or corn-based concentration
  - With and without buffer (0.15 kg bicarb and 0.11 kg MgOx)

- Buffer addition decreased milk fat content of BH intermediates
Dietary DCAD and milk fat

- Focus has been on *increasing* dietary DCAD for lactating cows (instead of *decreasing* DCAD as we do for dry cows)
- Hu and Murphy (2004) meta analysis
  - 17 trials, 69 dietary treatments
  - DCAD (Na + K – Cl)
  - Quadratic increases in yields of milk, fat, and protein with increasing DCAD
  - No relationship with milk fat or protein percentages

Performance of cows fed diets containing either 1.2% K or 2.0%K from potassium carbonate

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>DCAD+</th>
<th>SEM</th>
<th>P, treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg/d</td>
<td>26.0</td>
<td>26.7</td>
<td>0.9</td>
<td>0.35</td>
</tr>
<tr>
<td>Milk, kg/d</td>
<td>39.5</td>
<td>41.6</td>
<td>1.6</td>
<td>0.20</td>
</tr>
<tr>
<td>Fat, kg/d</td>
<td>1.58</td>
<td>1.77</td>
<td>0.8</td>
<td>0.10</td>
</tr>
<tr>
<td>Protein, kg/d</td>
<td>1.16</td>
<td>1.15</td>
<td>0.42</td>
<td>0.94</td>
</tr>
<tr>
<td>Fat, %</td>
<td>4.01</td>
<td>4.38</td>
<td>0.10</td>
<td>0.01</td>
</tr>
<tr>
<td>Protein, %</td>
<td>2.95</td>
<td>2.78</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Harrison et al., 2012. J. Dairy Sci. 95:3919-3925
Yeast/yeast culture

• Many different types/strains available in the marketplace
• Most have data showing positive effects on milk composition, at least in some situations
• Very difficult to decipher interactions of individual products with dietary factors on milk components

Saccharomyces cerevisiae meta analysis

• 110 papers, 157 experiments, and 376 treatments
• SC supplementation
  – Increased ruminal pH (0.03 units)
  – Decreased lactic acid concentration (-0.9 mM)
  – Increased total tract OM digestibility (0.8%)
  – Increased DMI (0.44 g/kg BW)
  – Increased milk yield (1.2 g/kg BW)
  – Tended to increase milk fat content (0.05%)
  – No influence on milk protein content
• Positive effect on pH increased with concentrate level and DMI

Desnoyers et al., 2009
Weighted average responses of cows to additional Met provided by experimental infusion or feeding protected forms or a Met analog

<table>
<thead>
<tr>
<th>Item</th>
<th>DL-Met</th>
<th>HMTBa (Alimet)</th>
<th>Mepron</th>
<th>Smartamine</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg/d</td>
<td>+0.12ab</td>
<td>+0.15a</td>
<td>-0.25b</td>
<td>+0.31a</td>
<td>0.012</td>
</tr>
<tr>
<td>Milk, kg/d</td>
<td>-0.34</td>
<td>+0.28</td>
<td>+0.31</td>
<td>-0.13</td>
<td>0.055</td>
</tr>
<tr>
<td>Milk protein, g/d</td>
<td>+19ab</td>
<td>+13b</td>
<td>+35a</td>
<td>+19ab</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Milk protein, %</td>
<td>+0.08a</td>
<td>0.00b</td>
<td>+0.07a</td>
<td>+0.07a</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Milk fat, g/d</td>
<td>+12ab</td>
<td>+45a</td>
<td>+35ab</td>
<td>+6b</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>+0.08ab</td>
<td>+0.13a</td>
<td>+0.05b</td>
<td>+0.04b</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(Protein+fat)/DMI</td>
<td>+0.78b</td>
<td>+1.70ab</td>
<td>+3.88a</td>
<td>-0.42b</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Zanton et al., 2014. J. Dairy Sci. 97:7085-7101

Effect of feeding high palmitic acid fat supplements (> 85% C16:0) on DMI, milk yield, and milk composition

<table>
<thead>
<tr>
<th>Study</th>
<th>DMI, kg/d</th>
<th>Suppl. C16:0</th>
<th>Milk, kg/d</th>
<th>Fat, %</th>
<th>Protein, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosley et al. 2007</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Control</td>
<td>23.3 a</td>
<td>0</td>
<td>30.9 a</td>
<td>3.44 a</td>
<td>2.98</td>
</tr>
<tr>
<td>Treatment</td>
<td>26.4 b</td>
<td>412</td>
<td>34.0 b</td>
<td>3.93 b</td>
<td>2.97</td>
</tr>
<tr>
<td>Warntjes et al. 2008</td>
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<td></td>
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</tr>
<tr>
<td>Control</td>
<td>26.2</td>
<td>0</td>
<td>36.7</td>
<td>3.75 a</td>
<td>2.96</td>
</tr>
<tr>
<td>Treatment</td>
<td>26.4</td>
<td>384</td>
<td>38.0</td>
<td>3.60 b</td>
<td>2.99</td>
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<tr>
<td>Rico and Harvatine, 2011</td>
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<td></td>
</tr>
<tr>
<td>Control</td>
<td>25.3 a</td>
<td>0</td>
<td>28.8</td>
<td>3.86</td>
<td>3.19</td>
</tr>
<tr>
<td>Treatment</td>
<td>23.0 b</td>
<td>394</td>
<td>29.0</td>
<td>3.92</td>
<td>3.14</td>
</tr>
<tr>
<td>Rico and Harvatine, 2011</td>
<td></td>
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</tr>
<tr>
<td>Control</td>
<td>28.3 a</td>
<td>0</td>
<td>41.5</td>
<td>3.14</td>
<td>3.14</td>
</tr>
<tr>
<td>Treatment</td>
<td>26.4 b</td>
<td>449</td>
<td>42.0</td>
<td>3.22</td>
<td>3.17</td>
</tr>
<tr>
<td>Lock et al., 2013</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Control</td>
<td>24.7 a</td>
<td>0</td>
<td>32.0</td>
<td>3.88 a</td>
<td>3.33 a</td>
</tr>
<tr>
<td>Treatment</td>
<td>23.3 b</td>
<td>361</td>
<td>32.0</td>
<td>4.18 b</td>
<td>3.28 b</td>
</tr>
<tr>
<td>Piantoni et al., 2013</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Control</td>
<td>27.8</td>
<td>0</td>
<td>44.9 b</td>
<td>3.29 a</td>
<td>3.11</td>
</tr>
<tr>
<td>Treatment</td>
<td>27.8</td>
<td>545</td>
<td>46.0 b</td>
<td>3.40 b</td>
<td>3.09</td>
</tr>
</tbody>
</table>

Adapted and updated from Loften et al., 2014. J. Dairy Sci. 97:4661-4674
Specific nutritional supplements and additives that may increase milk fat percentage and yield

• Many nutritional supplements and feed additives exert their effects on milk fat yield through effects on milk yield rather than on milk fat percentage per se

• Some additives can have effects on milk fat percentage and yield
  – Buffers
  – DCAD
  – Yeast/yeast culture
  – AA analogs
  – Certain added fat sources (especially those high in palmitate C16:0)