**INTRODUCTION**

High-fat ration ingredients, such as whole oilseeds and animal fat, can help meet the energy demands of high-producing cows. Peak energy intake lags behind peak energy output in early lactation, putting dairy cows into negative energy balance. Severe negative energy balance can result in poor persistency of lactation, metabolic disorders, and poor reproductive efficiency. Milking cows are supplemented with high-starch grains, such as corn or barley, to increase the energy density of the ration. However, the amount of grain or starch that can be fed is limited because milking cows require a minimum amount of fiber and forage in the ration for proper chewing activity and rumen function, and consequently to maintain normal milk fat test.

Fat supplementation can effectively increase the energy density of milking cow rations while providing adequate fiber and forage. Common fat sources include whole cottonseed, full-fat soybeans, tallow, and various commercial granular fat products.

Feeding fat has generally improved persistency of lactation in research trials. Body condition and reproductive efficiency have improved in some but not all trials. Dairy managers and nutritionists who feed supplemental fat report similar results.

### FAT SOURCES

Common fat sources include oilseeds such as whole cottonseed and full-fat soybeans, animal fat, and various ruminally inert fat products (Table 1). Ruminally inert fats are often called “rumen bypass,” “protected” or “escape” fats. However, ruminally inert is the proper term. These products were developed to minimize adverse effects of fat on rumen fermentation and fiber digestion. In this publication, oilseeds and animal fat will be referred to as “commodity” fats; ruminally inert fats as “specialty” fats.
Nutrient Composition

Whole cottonseed (WCS) contains 18% to 20% fat. WCS is high in neutral detergent fiber (NDF = 44%) and an excellent source of effective fiber in milking cow rations. WCS works best in rations for high-producing, early lactation cows needing a source of byproduct fiber. It is often difficult to separate fat and fiber effects when evaluating cows’ responses to WCS, since WCS generally increases NDF and acid detergent fiber (ADF) and lowers non-fiber carbohydrate, which can improve rumen fermentation. California research suggests similar effective fiber value for fuzzy and mechanically delinted WCS.\(^{15}\)

<table>
<thead>
<tr>
<th>Fat Source</th>
<th>Fat %</th>
<th>Other Nutrients Supplemented in Significant Amounts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole cottonseed</td>
<td>18-20</td>
<td>Fiber, crude protein</td>
</tr>
<tr>
<td>Full-fat soybeans</td>
<td>18-20</td>
<td>Crude protein (bypass protein(^a))</td>
</tr>
<tr>
<td>Tallow</td>
<td>100</td>
<td>None</td>
</tr>
<tr>
<td>Ruminally inert fats</td>
<td>80-99</td>
<td>None or negligible amounts</td>
</tr>
</tbody>
</table>

\(^a\) Crude protein of cooked (extruded or roasted) soybeans contains 45% to 55% bypass protein, compared to 25% bypass protein in CP of raw soybeans.

What is “Bypass Protein?”

Some of the crude protein fed to cows is degraded by rumen microbes to peptides, amino acids and ammonia. This degradable protein is synthesized into microbial protein in the rumen and flows to the small intestine, where it is digested and absorbed. The rest of the crude protein escapes microbial breakdown in the rumen. This undegradable intake protein (UIP) is commonly called “bypass” protein. It is digested and absorbed in the small intestine.

All cows require adequate amounts of degradable protein for proper fiber and starch digestion in the rumen, and flow of microbial protein from the rumen. Research and on-farm experience shows that high-producing cows require extra bypass protein, because the amount of protein supplied by microbial synthesis flowing into the small intestine does not meet their needs.\(^{10, 14}\)

Rations for high-producing, early lactation cows should contain at least 18% crude protein with 35% to 38% of the crude protein as bypass protein.

Soybean meal (SBM) contains 50% crude protein, while full-fat soybeans (beans) have only 42% CP. Heat-treated beans are higher in “bypass” protein (45% to 55% of CP) than raw beans (25% of CP) or SBM (35% of CP). Heat-treated beans work best in rations for high-producing, early lactation cows that need additional bypass protein. They work particularly well in alfalfa-silage based rations\(^{16, 4}\) because alfalfa protein is highly degradable in the rumen.\(^{14}\) Raw beans can work well when fed in corn-silage based rations or to lower producing cows, since the need for additional bypass protein is lower in both cases. Raw beans can be fed to high-producing cows if fed along with high-bypass protein supplements to meet undegradable protein requirements. For more information on feeding beans, see Extension publication A3534, “Full-Fat Soybeans.”

Tallow is 100% fat and provides no additional nutrients to the ration. Specialty fats...
(summarized in Table 2) range from 80% to 99% fat. Because of the high fat density of tallow and specialty fats, just 1 pound of ingredient can increase dietary fat content two percentage units (this would require 5 to 6 pounds of oilseeds).

High levels of unsaturated fatty acids can decrease rumen fiber digestion and milk fat test, so specialty fats are treated in various ways to avoid these problems. Commercial tallows may be hydrogenated to lower their levels of unsaturated fatty acids. Booster Fat, an “encapsulated” tallow, is coated to prevent it from influencing rumen fermentation. Megalac (calcium salts of palm oil) is relatively insoluble in the rumen. Energy Booster is a blend of relatively saturated free fatty acids.

### Handling, Storage and Feeding

Beans and specialty fats are easier to handle, store and feed than WCS or tallow. Fuzzy WCS does not flow well in augers and bins, but mechanically delinted WCS has fewer handling problems. Tallow must be melted and can be difficult to blend with the total mixed ration (TMR) or feed individually in stall barns, but many herds have been successful. Some companies use insulated heating tanks and bulk delivery to simplify on-farm use of tallow. Blending tallow with the protein concentrate or grain mix at the feed mill or buying commercial high-fat supplements can make it easier to feed tallow.

### Palatability

Heat-treated beans are more palatable than other fat sources when top-dressed. Some cows may adapt slowly to WCS, tallow or specialty fats as a top-dress, but many herds have been successful. Length and size of initial meals were reduced when 10% tallow or animal-vegetable blend was added to grain mixes fed twice daily. This suggests that high levels of added fat in the grain mix may limit consumption when feeding time is restricted, such as in a milking parlor.

A UW-Madison study compared intake of Booster Fat, Megalac, Energy Booster and tallow by feeding lactating cows 1

### Table 2. Summary Of Specialty Fat Sources

<table>
<thead>
<tr>
<th>Product</th>
<th>Company</th>
<th>Ingredient Composition</th>
<th>Fat %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megalac</td>
<td>Church &amp; Dwight Co.</td>
<td>Calcium salts of palm oil fatty acids.</td>
<td>82</td>
</tr>
<tr>
<td>Energy Booster</td>
<td>Milk Specialties Co.</td>
<td>Relatively saturated free long-chain fatty acids - prilled fat.</td>
<td>99</td>
</tr>
<tr>
<td>Booster Fat</td>
<td>Balanced Energy Co.</td>
<td>Tallow plus soybean meal treated with sodium alginate.</td>
<td>90</td>
</tr>
<tr>
<td>Alifet</td>
<td>Alifet U.S.A.</td>
<td>Hydrogenated tallow mixed with wheat starch and crystallized.</td>
<td>92</td>
</tr>
<tr>
<td>Dairy 80</td>
<td>Morgan Mfg.</td>
<td>Hydrogenated tallow - prilled. Contains some phospholipid, flavor and coloring agents.</td>
<td>80</td>
</tr>
<tr>
<td>Carolac</td>
<td>Carolina Byproducts</td>
<td>Hydrogenated tallow - prilled.</td>
<td>98</td>
</tr>
</tbody>
</table>
pound of each fat for 15 minutes either alone, top-dressed on 9 pounds of grain, mixed with the grain at the 10% level, or alone following a one-week adaptation period. Among fats fed alone without adaptation, tallow had the highest intake score. Following adaptation, intake of Megalac was lower than Booster Fat or Energy Booster. Intake scores of the specialty fats were similar when they were top-dressed or fed as part of a grain mix. Diluting fat sources with other feed ingredients and gradually adapting cows to the fat may reduce palatability problems. Feeding fat in a TMR reduces consumption problems and palatability differences between fat sources, but adapting cows to the fat is still a good practice.

### Table 3.

<table>
<thead>
<tr>
<th>Fat Source</th>
<th>Saturatedb %</th>
<th>Unsaturatedc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole cottonseed</td>
<td>29</td>
<td>71</td>
</tr>
<tr>
<td>Whole soybeans</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>Tallow</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Yellow grease</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>Animal-vegetable</td>
<td>28</td>
<td>72</td>
</tr>
<tr>
<td>blend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alifet</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>Booster Fat</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Carolac</td>
<td>61</td>
<td>39</td>
</tr>
<tr>
<td>Dairy 80</td>
<td>87</td>
<td>13</td>
</tr>
<tr>
<td>Energy Booster</td>
<td>86</td>
<td>14</td>
</tr>
<tr>
<td>Megalac</td>
<td>57</td>
<td>43</td>
</tr>
</tbody>
</table>

a Source: Palmquist et al.12,13; De Peters et al.3; Grummer, personal comm. (University of Wisconsin-Madison).
b Saturated fatty acids (C14:0, C16:0, C18:0).
c Unsaturated fatty acids (C16:1, C18:1, C18:2, C18:3).

### Saturation and Ruminally Inert Fat

The saturation of various commodity and specialty fats is presented in Table 3. Fatty acids are either saturated or unsaturated. The degree of saturation affects ruminal inertness and post-ruminal digestibility. Unsaturated fatty acids are more likely to interfere with rumen fermentation than saturated fatty acids.² Saturated fatty acids are solid at room temperature; hence the term “hard” fats for fats high in saturated fatty acids. Unsaturated fatty acids vary in melting point, but tend to be liquid at room temperature and have a lower melting point as the amount of unsaturation increases.

Fatty acids in WCS and beans are 71% and 85% unsaturated, respectively. However, whole oilseeds are less likely to interfere with rumen fermentation than free oils because they are slowly digested and slowly release oil into the rumen.¹¹ Tallow is often called saturated fat, but about 50% of its fatty acids are unsaturated. Saturated fats are relatively inert in the rumen, probably because their high melting point reduces their solubility in rumen fluid. It is difficult to say whether or not tallow belongs in this category because 40% of its fatty acids are oleic acid, which may impair rumen fermentation when added in large quantities.² However, many managers successfully feed 1 pound of tallow to high-producing cows along with 5 to 6 pounds of oilseeds. Fatty acids in grease and animal-vegetable blends are about 70% unsaturated; this high degree of unsaturation has caused concern about their use in milking cow rations.

The saturation of Booster Fat is similar to tallow, but this source is encapsulated to help improve ruminal inertness. Saturation in hydrogenated tallows.

(Alifet, Carolac and Dairy 80) ranges from 61% to 87%; Energy Booster is 86% saturated. The high degree of saturation improves ruminal inertness in these products. Megalac is only 57% saturated, but it acts much like saturated fat in the rumen because the fatty acids have been chemically bound to calcium and are relatively insoluble in rumen fluid.

**Digestibility and Energy Value**

Degree of saturation influences postruminal digestibility. Digestibility of added fat fell from 98% to 34% when soybean oil (12% saturated) was replaced by hydrogenated tallow (96% saturated; 66% stearic acid) in sheep diets.9 Apparent digestibility of fatty acids fell from 68% to 47% when yellow grease (43% saturated) was replaced by hydrogenated yellow grease (99% saturated; 76% stearic acid) in diets of lactating dairy cows.8 This suggests that high levels of saturated fatty acids, particularly stearic acid, can reduce digestibility. However, the presence of unsaturated fatty acids may aid the digestibility of saturated fatty acids.

A UW-Madison study found similar fat digestibility (about 86%) for Megalac (57% saturated; 4% stearic acid, 35% oleic acid) and Energy Booster (86% saturated; 35% stearic acid, 13% oleic acid).5 This suggests that about 10% oleic acid may be a minimum acceptable level. Ohio State researchers reported similar fatty acid digestibility (about 77%) for Alifet, Booster Fat, Energy Booster, Megalac and animal-vegetable blend.13 The oleic acid content of hydrogenated tallows (Alifet, Carolac and Dairy 80) ranges from 10% to 35%. Tallow and Booster Fat contain about 40% to 45% oleic acid.

The National Research Council Dairy 198910 lists an energy value for animal fat and soy oil of 2.65 Mcal NEI/lb.

Researchers reported an energy value for Megalac of 2.92 Mcal/lb from research conducted at the Beltsville energy lab. Since Megalac is 82% fat, this calculates to an energy value for fat of 3.65 Mcal NEI/lb.

The energy value for fat probably falls between 2.65 and 3.65 Mcal NEI/lb. More research is needed to determine energy values and digestibilities of commodity and specialty fats. Digestibility is the most important factor influencing the energy value of fat. Ohio State researchers reported similar fatty acid digestibility for several fat sources.13

**FAT FEEDING GUIDELINES**

Whole oilseeds and animal fat have little influence on intake, rumen fermentation and digestibility in lactating cows, and many producers successfully feed these commodity fats at relatively high levels (2% to 3% of ration DM fed alone or 4% to 5% of ration DM combined).

Select fat sources based on cost. Fat from whole oilseeds costs 10 cents to 20 cents per pound based on the value of the other nutrients (protein, fiber, calcium and phosphorus) provided to the ration, but the price of whole oilseeds varies greatly with season and location. Tallow costs 20 cents to 22 cents per pound delivered in bulk to the farm. Specialty fats cost 40 cents to 55 cents per pound of fat.

Commodity fats (whole oilseeds and animal fat) are your best buy for fat supplementation up to 4% to 5% of ration DM. Research has not shown that cows respond better to specialty fats or combinations of specialty and commodity fats to justify the added cost at the 4% to 5% level. Research is needed to determine whether or not cows...
economically respond to specialty fats above 4% to 5% of ration DM.

Select WCS or beans for the first source of supplemental fat based on whether the ration needs additional fiber or protein as well as local availability and price. Limit fat from whole oilseeds to 1.5 lb. to 2.0 lb. per cow per day, or 3% of ration DM. This limits intake of WCS or beans to 7 lb. to 10 lb. per cow per day, or 15% to 18% of ration DM. This is a fairly liberal recommendation and you may have to reduce these levels if you slug-feed fat in a topdress, or are feeding a low-fiber ration.

Additional supplemental fat should come from a source relatively inert in the rumen, such as tallow or specialty fats. Base your selection on handling, feeding, palatability and cost considerations. Limit total supplemental fat to 5% of ration DM or 2.5 lb. to 3.0 lb. per cow per day; this results in total fat levels of 8% of ration DM.

How Much Added Fat Can Your Herd Use?

Herds reaching 17,000 to 18,000 pounds of milk per lactation are candidates for the first pound of added fat.

Herds averaging 20,000 pounds or more of milk per lactation can use a second pound of supplemental fat.

Some herds averaging more than 24,000 pounds of milk per lactation use 3 pounds of added fat in their rations, but we know little about the economic returns to feeding these high-fat rations. Most managers who supplement fat at high levels combine whole oilseeds, animal fat and specialty fats. Research is needed to determine the most economical strategy for adding fat to milking cow rations.

- Start feeding the first pound of fat at calving. There may be some benefit to including 1/4 lb. added fat per cow in the 2-week prefresh ration to better adapt fresh cows to fat feeding.
- It may be better to delay feeding the second pound of fat until 5 to 6 weeks after calving if your feeding system and grouping strategy allow, since research indicates little benefit to fat supplementation in very early lactation.
- Feed fat as long as level of milk production (greater than 70 lbs per day) and body condition (Body Condition Score less than 3.0) merit the extra energy. Monitor persistency of lactation, body condition and reproductive efficiency to determine the cows’ response. Cows that lack persistency and are getting too fat are candidates for either a low-energy ration or culling, not a high-fat ration.
- Formulate rations properly for bypass protein when feeding supplemental fat.
- Balance rations for .9% to 1.0% calcium and .3% to .35% magnesium.
- Rations should contain adequate fiber and forage.

Fat feeding generally increases ration cost, but when done properly can improve persistency of lactation, body condition and reproductive efficiency, resulting in higher profits per cow.

REFERENCES
