Introduction

Monitoring the milk components of a herd can help identify the health and nutritional status of lactating cows. Typical milkfat and milk protein values for Holsteins are greater than 3.7 percent and 3.0 percent, respectively. For Jerseys, milkfat can be greater than 4.9 percent and milk protein greater than 3.8 percent. A herd milkfat test below 0.3 percent of breed average can indicate a problem situation. In the short-term milk production may be normal, but animals may be experiencing subclinical acidosis. The long-term effects can be a decline in milk production along with the onset of laminitis and other health problems (i.e., off-feed, digestive upsets, and displaced abomasum). Milk protein is not as sensitive to nutritional or other external factors compared to milkfat. Even though component percent can be indicative of a performance problem, for economic reasons, pounds of components is the key metric to monitor. In Pennsylvania, many herds struggle to obtain greater than 5.50 lb. of components when the ideal goal is greater than 6.0 lb. of components.

There are several approaches for monitoring components. Most milk processors test components on every pick-up and report the results online. The advantage is numerous results, but the data reflect the entire herd, not a specific group of animals. Herds testing monthly with DHIA will have results on individual animals and can be filtered by grouping strategy, days in milk, lactation number, or any other criteria. The disadvantage is the test results only represent one day out of the month. However, if there is good agreement between test day and the bulk tank results, then interpretation of the data should accurately reflect the herd’s performance. Two or three consecutive low milkfat tests from the milk handler should be considered a problem. Also, check groups of cows as it is not uncommon to see a certain group(s) of animals affected while others may not be.

Energy intake is a major nutrient influencing both milk volume and components. Ideally, milk production should be converted to an energy corrected basis (ECM). The equation used by the Penn State Extension dairy team is \((12.82 \times \text{fat lb.}) + (7.13 \times \text{protein lb.}) + (0.323 \times \text{milk lb.})\). This is an important metric to utilize when examining herd performance. Energy corrected milk should be used when calculating dry matter intake (DMI) efficiency. The expected range in DMI for cows averaging between 75 and 85 lb. of milk is 45–55 lb. Feed efficiency between 1.45 and 1.70 is ideal and when greater than 1.70 may result in animals not receiving adequate lb. of fiber or other nutrients.
Examples: ECM for a herd averaging 85 lb. of milk with 3.8 percent fat and 3.2 percent protein is 88.3 lb. The pounds of components are 5.95. If the herd is consuming 55 lb. of DMI, the feed efficiency is 1.61.

\[
\frac{[12.82 \times (85 \times 0.038)] + [7.13 \times (85 \times 0.032)] + (0.323 \times 85)}{41.4 + 19.4 + 27.5} = 88.3 \text{ lb. ECM}
\]

ECM for a herd averaging 85 lb. of milk with 3.3 percent fat and 2.8 percent protein is 80.4 lb. The pounds of components are 5.19. If the herd is consuming 55 lb. of DMI, the feed efficiency is 1.46.

When addressing nutrition-related inefficiencies on a farm, evaluating DMI should be considered the first step. Dairy rations are formulated to deliver required nutrients within a pre-determined amount of feed, typically based on a percentage of body weight. However, many outside factors can directly impact DMI, causing an imbalance in nutrients delivered. A rough estimate of DMI can be calculated using the amount of feed delivered, the amount of feed refused, the current ration dry matter, and the current number of animals being fed.

Example: A pen of 150 cows received 17,200 lb. of TMR. There is 175 lb. of refusals. The dry matter percent of the TMR is 47 percent.

\[
\frac{(17,200 - 175)}{150} \times 0.47 = 53.3 \text{ lb. of DMI}
\]

Nutrition plays a key role in affecting milk composition, but there are other factors involved. They include milking equipment problems, improper handling of milk or milk samples, stage of lactation, season, genetics, and mastitis.

### Nutritional and Management Factors

A. **Low fiber intake**

Check forage and total neutral detergent fiber (NDF) intake of the ration. Cows consume pounds, not a percent. Levels of NDF that may be acceptable for cows consuming 50 lb. of dry matter may not be for animals consuming less than 42 lb. (see example box). The minimum forage NDF intake as a percent of body weight should be 0.85. The minimum total NDF intake as a percent of body weight should be 1.1 to 1.2.

Example: The average cow body weight is 1,300 lb. and the total NDF in the ration is 32 percent on a dry matter basis.

A cow consuming 50 lb. of dry matter would receive 16 lb. of total NDF (50 x .32) or 1.23 percent of body weight as total NDF.

A cow consuming 42 lb. of dry matter would receive 13.4 lb. of total NDF (42 x .32) or 1.03 percent of body weight as total NDF.

B. **NDF Digestibility**

Dairy cattle diets in Pennsylvania are typically high forage diets, comprising 50–55 percent of the total ration dry matter. Given that diets contain a high percentage of forage, the respective digestibility of these forages will largely determine energy availability. As forage digestibility declines, limitations in milk and component production could be seen.

C. **Low forage intake**

Lactating cows need a minimum amount of forage in the ration. Forages should be included in the diet at no less than 1.40 percent of body weight. In most situations, forage should make up no less than 40–45 percent of the total ration dry matter.

D. **Ration particle size that is too fine**

Forages and/or total mixed rations (TMR) that are too fine in particle size, coupled with inadequate forage or fiber levels can aggravate a milk fat depression problem. Cows need adequate levels of effective fiber in the diet to maintain normal rumen function. The main goal in analyzing the particle size of the total ration is to measure the distribution of feed and forage particles that the cows consume. Evaluate particle size from different locations along the bunk or mangers. Further, evaluate the particle size of individual forages. Forages chopped too fine could lead to low physically effective fiber present in a TMR.

E. **Ration particle size that is too coarse**

Forages and/or TMRs that are too coarse in particle size allow animals to sort feed. On paper the ration may appear fine, but cows are not consuming what has been formulated. TMRs containing coarsely chopped forage, balage, and considerable amounts of hay can lead to problems.

F. **High starch intake**

The carbohydrate fraction is highly digestible and can be quickly digested compared to NDF. Excessive starch can depress fiber digestibility, reduce acetic acid production, and depress fat test. In addition to the starch content, examine the grain's particle size, moisture, and processing method. Depending on the digestibility of the NDF and starch, the latter can range between 20–30 percent. In many cases, ration starch falls between 24–28 percent on a dry matter basis.
G. Excessive fat and oil intake

The source and processing method of a high-fat ingredient and the amount of fat in the ration can affect the milkfat test. Feeding considerable amounts of extruded, ground, or pelleted soybeans may lower milkfat. Several experiments in the literature have shown that feeding cows diets high in polyunsaturated fatty acids or trans fatty acids leads to a low milkfat test. This can be the result of high intake of vegetable oils from one or more ingredients. Rations high in concentrates or soluble carbohydrates can increase the accumulation of trans fatty acids. Marine oils that may be high in some fish meal sources may lower milkfat. Rations too high in fat may reduce fiber digestibility and increase the susceptibility of animals to milkfat depression.

H. Protein deficiency

A deficiency of protein and degradable protein can lower DMI and fiber digestibility. This problem could occur on rations containing large amounts of corn silage or low-quality grass silage (overly mature grass containing protein less than 10 percent on a dry matter basis).

I. Sulfur deficiency

Sulfur is necessary for the synthesis of essential amino acids by rumen microbes. Sulfur supplementation is important in rations containing high levels of non-protein nitrogen (i.e., urea) since rumen microbes must make several sulfur-containing amino acids. Low sulfur intake can result in an induced protein deficiency. This problem could occur with rations containing large amounts of corn silage or low-quality grass silage. Sulfur should be included in rations at 0.20 percent DM for mid-lactation animals, with an acceptable range of 0.15–0.25 percent DM, depending on the group of animals being fed.

J. Fluctuations in rumen pH

Maintaining a consistent rumen pH between 5.8 and 6.4 is important to support a healthy rumen microbial population. As rumen pH shifts away from desired ranges, growth of populations of rumen microbes will be limited while other populations will flourish, changing rumination characteristics. Rumen pH can be impacted by improper feeding management, infrequent feeding, or rations high in starch or low in physically effective NDF.

K. Energy deficiency

This can be a problem particularly in early lactation when cows are unable to meet their energy requirement while producing large amounts of milk. A herd containing more than 30 percent thin cows (body condition score [BCS] less than a 2.75–3.0 on the 5-point scale) can be the result of under-feeding fresh cows, a ration imbalance, or feet and leg problems. There is a tendency for both thin and fat cows to have a low milkfat test once they are past early lactation. Energy deficiency can also lower milk protein. Dairy cows should enter the dry period at a BCS between 3.25 and 3.5 and maintain this condition throughout the dry period, into early lactation.

L. Infrequent feeding

This can have an impact in component-fed herds. Feeding forages and grains frequently throughout the day can help improve components. Avoid feeding large amounts of grain at any single feeding. Grain should be fed at least four times per day to high-producing cows (>80 lb. of milk/day). This may help minimize milkfat depression and associated health problems by avoiding low rumen pH and reducing the length of time that it may be low. Ideally, in TMR-fed herds, rations should be delivered at least two times daily and pushed back toward the pen multiple times throughout the day. If labor and time permit, for two hours after milking, feed should be pushed back every thirty minutes to encourage standing behavior and feed intake. A feed ridge formed between the curb and the far side of the feed bunk is an indication that feed should be pushed back.

M. Poor feeding-management practices

Regardless of the type of feeding system, feed should be in front of the cows at least twenty-one hours per day. Feed refusals should be cleaned out daily. Cows should have access to fresh feed, not moldy or spoiled feed. Appropriate sizing of feed storage is important to maintain appropriate feed-out rates and high-quality dairy feeds. For all ensiled feeds, careful attention should be paid to ensiling management to ensure feed quality is maintained. In component feeding systems, hay or some forage should be fed before grain is offered. Herds feeding a true TMR should not be feeding any forage or grain outside of the TMR, otherwise it is a partial mixed ration (PMR). When forage or grain are offered outside of the TMR, this allows cows to preferentially choose what they want to consume.

Inappropriate mixing order can directly influence the physical form of the ration delivered to animals, potentially facilitating sorting behavior. Cows should be transitioned gradually when any major ration change is made. Cows should have free-choice access to water. Both water quality and quantity are important.
Other factors involved

A. Season of the year
It is not uncommon to observe lower milkfat tests in the spring and summer months. Switching to pasture can depress milkfat because of the lower fiber and higher sugar content of the pasture. Hot weather and high humidity can depress DMI and result in lower forage and fiber intake. Also, cows tend to eat larger quantities at a time instead of taking numerous, smaller meals.

B. Stage of lactation
A cow’s fat test is likely to be lowest at peak production and highest toward the end of lactation. Using the DHIA 202 summary report, high concern is when milkfat for all lactation animals is <3.4 percent or >4.6 percent in the first 40 days in milk. This can indicate transition cow problems. If the fat-to-protein ratio for all lactation animals is <1.35 in the first 40 days in milk, excessive fat mobilization or underfeeding protein may be occurring. If a herd’s fat test is low in late lactation (e.g., 3.5 percent), then nutrition and management should be investigated. If the average protein percent between 41–100 days in milk is less than 2.7 percent, this can indicate cows are in negative energy balance.

C. Genetics
If fat and protein have not been emphasized in the breeding program, then it is possible that a herd may have a genetic predisposition for low components below breed standards.

D. High somatic cell counts
Mastitis, both subclinical and clinical, may depress fat test. This may be a factor in low-testing herds.

E. Milking-equipment problems
Freezing or churning of milk in the bulk tank lowers the tank test. Clumps of milkfat seen after emptying the tank indicate such a problem. Freezing can occur if there is a malfunction in the controls and refrigeration unit or if milk is excessively agitated. Problems can also occur if the temperature is too high. This can happen when old and raw milk is blended, and the temperature exceeds 45°F. Excessive agitation in the pipeline or a malfunctioning pump may reduce milkfat due to churning the milk.

F. Improper milk handling
Milk samples must be collected and handled properly to give accurate results. Samples need to be kept below 40°F. This usually requires ice or water-cooling. Completely fill sample bags or bottles to prevent churning if samples are not kept below 40°F. Samples should not be frozen. The bulk tank should be agitated for at least five minutes and larger tanks require a longer agitation time before sampling.

G. Miscellaneous factors
There is a considerable day-to-day variation in fat tests in individual cows and even in herds. Individual differences usually balance out in the bulk tank in larger herds. A longer-than-normal period between milkings can reduce fat test. Milk pick-up schedules may result in more variation in plant test, especially in herds shipping less than a day’s supply due to variation between milkings.

Suggestions for Control
1. Obtain a recent analysis on all forages or the TMR currently being fed. Included in the analysis should be soluble protein, NDF, 30-hour NDF digestibility, starch (corn silage or TMR), starch digestibility, ash, fat, and sulfur.
2. In a herd feeding a TMR, take 6–8 grab samples, evenly spaced along the bunk, before the cows eat. Preferably submit a 1-gallon sample and request that the lab dry and grind the entire sample sent to them. This helps eliminate any sampling bias at the farm or lab especially when hay is mixed in the TMR, or large pieces of cob are present. Evaluate results for any deficiencies or excesses and compare the analysis to the formulated ration.
3. Evaluate the ration for nutrient content. Check that nutrient densities for the current level of production are appropriate (Table 1).

Table 1. Guide to ration composition for high-producing cows.

<table>
<thead>
<tr>
<th></th>
<th>&gt;81 lb.</th>
<th>61–80 lb.</th>
<th>&lt;60 lb.</th>
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</thead>
<tbody>
<tr>
<td>Crude protein, % dry matter</td>
<td>16–17.5</td>
<td>15–16.5</td>
<td>15–16</td>
</tr>
<tr>
<td>Soluble protein, % crude protein</td>
<td>30–34</td>
<td>32–36</td>
<td>32–38</td>
</tr>
<tr>
<td>Starch, % dry matter</td>
<td>25–30</td>
<td>24–28</td>
<td>20–25</td>
</tr>
<tr>
<td>Fat, maximum, % dry matter</td>
<td>5–7</td>
<td>4–6</td>
<td>4–5</td>
</tr>
<tr>
<td>Sulfur, % dry matter</td>
<td>0.23–0.24</td>
<td>0.21–0.23</td>
<td>0.20–0.21</td>
</tr>
</tbody>
</table>

*Maximum starch levels reflect corn silage as part of the forage dry matter.
**Fat at over 5 percent should be furnished by rumen-inert or bypass fats.
4. Evaluate the forage NDF, total NDF, and forage DMI on rations being fed to animals producing milk less than 60 lb., 61–80 lb., and greater than 81 lb. Refer to Table 2 for suggested guidelines.

Table 2. Recommended guidelines on forage and fiber intakes

<table>
<thead>
<tr>
<th>Production</th>
<th>Forage NDF</th>
<th>Total NDF</th>
</tr>
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<tbody>
<tr>
<td>&gt;81 lb.</td>
<td>21–27</td>
<td>28–32</td>
</tr>
<tr>
<td>61–80 lb.</td>
<td>25–32</td>
<td>33–37</td>
</tr>
<tr>
<td>&lt;60 lb.</td>
<td>29–36</td>
<td>38–42</td>
</tr>
</tbody>
</table>

5. Evaluate the particle size distribution for the TMR or for the individual forages in conventionally fed herds. See Table 3 on guidelines for both forages and the TMR. Additionally, evaluate if feed is delivered evenly across the bunk and that particle size remains similar from first feed delivered to the last feed delivered. Differences between first- and last-delivered feed can be due to either mixing order or delivery practices.

Table 3. Observed forage and TMR particle sizes using the Penn State Separator

<table>
<thead>
<tr>
<th>Source</th>
<th>Upper sieve &gt;0.75&quot;</th>
<th>Middle sieve 0.30–0.75&quot;</th>
<th>Lower sieve 0.07–0.30&quot;</th>
<th>Bottom pan &lt;0.07&quot;</th>
</tr>
</thead>
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<table>
<thead>
<tr>
<th>Forage</th>
<th>2–4% if not sole forage</th>
<th>45–65%</th>
<th>30–40%</th>
<th>&lt;5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage</td>
<td>10–15% if chopped and rolled</td>
<td>45–75%</td>
<td>20–30%</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Haylage</td>
<td>10–15% in sealed silo</td>
<td>45–75%</td>
<td>20–30%</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Haylage</td>
<td>15–25% in bunker silo, wetter mixture</td>
<td>30–50%</td>
<td>30–50%</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>TMR</td>
<td>2–6% focus on TNDF and FNDF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Evaluating particle size of forages and TMRs using the New Penn State Forage Particle Separator, DAS 02-42, Jud Heinrichs and Paul Kononoff, Dept. of Dairy and Animal Science, Pennsylvania State University, University Park, PA.

6. Evaluate the physical form of the concentrate portion of the diet.

High-moisture grains (ensiled)
Proper preparation is necessary to prevent sorting of ear corn during ensiling, to increase digestibility of the grain and the entire ration, and to minimize sorting during feeding. Ensiled grains may be prepared more coarsely than dried grains. Starch in ensiled grains is more soluble and degrades more quickly in the rumen than starches in dry grains. This can be offset by somewhat coarser preparation.

Dry grains
To increase the digestibility of the grain and the entire ration, grains need to be properly prepared and broken. Preparation usually needs to be equivalent to grinding through a 1/2-to-5/8-inch screen. Cracked poultry corn is not fine enough for good digestibility on some forage rations. Starch in finely ground grains is degraded more rapidly by rumen microorganisms than coarsely processed grain. Finely ground grains are higher in digestibility because there is more surface area to which rumen bacteria can attach. The proper grain particle size will depend on the forage ration and the starch level in the diet.

Heat-processed ingredients
Steamed flaked grains (thin flake) are like finely ground dry grains in extent of ruminal starch digestion. Steamed, crimped, and rolled grains are usually more like a medium and coarsely ground dry grain. Heat-processed grains should be limited to 35–40 percent of the concentrate mix to avoid milkfat depression. Heating grains enhances the starch digestion by
gelatinizing the starch in a manner that increases fermentability in the rumen. In addition to cereal grains, other heat-treated starch ingredients include bakery products, hominy, and chocolate products.

Pelleting
Ingredients in a pellet generally must be finely ground (3/32-inch screen or finer) to enable efficient pelleting. High-starch ingredients should be limited to 35–40 percent of the pelleted concentrate mix.

Fat sources
Evaluate how much fat is provided by vegetable, animal, and bypass sources. Some byproduct feeds like distillers, bakery product, hominy, and chocolate can contribute a substantial amount of fat to the diet. To one degree or another, most fat is toxic to rumen microorganisms and may reduce fiber digestion when total fat from natural sources exceeds 5.0–5.5 percent in the total ration dry matter. Using rumen bypass fat sources may allow total fat content in the diet to reach 6.0–7.0 percent. Oils are more toxic than hard fats such as tallow. Blends of vegetable and animal fat may be intermediate in their effect on milkfat. Fats, oils, or high-fat ingredients that have been subjected to very high temperatures during processing may be more toxic to rumen microorganisms than those processed at more usual temperatures.

7. Evaluate feeding management practices. This should include feeding frequency and sequence, feed availability, amounts of refusal, and what makes up the refusals (check for sorting of feed). Lactating animals should be fed so that fresh feed is available as animals return from milking. Batch mixes should be calculated for 1–3 percent refusal. Sorting behaviors can contribute to multiple milkfat depressing factors, such as low fiber intake and fluctuating ruminal pH.

8. Evaluate the bunk after the cows have had access to feed. Patterns in bunk consumption might offer further insight into animal behavior that could be contributing to fat depression. In free-stall systems, uneven feed delivery, bunching, or overcrowding can limit feed intake. If sorting is occurring, this could further exacerbate fat depression issues.

9. Use production records or data available (e.g., DHIA) to evaluate individual animals as well as groups of animals.

10. Body condition score cows and compare results to either group or production data. Evaluate whether body condition is appropriate based on production and days in milk.

11. Check the amount of buffer, such as sodium bicarbonate, that is in the diet. In problem herds, a buffer should be included in the ration at 0.80 percent of the total ration dry matter. Do not rely solely on offering a buffer-free choice to correct a milkfat depression problem. Check that magnesium levels are adequate. It may be necessary to raise magnesium up to 0.36–0.40 percent in the total ration dry matter by including magnesium oxide at a level of 0.25 percent in the total diet dry matter. This helps control rumen pH.

12. Check the functioning and operation of the bulk tank and the pipeline system. Ensure milk samples are being handled properly.

Conclusion
Correcting low milkfat and protein can be challenging. There may be multiple issues contributing to the problem. This publication provides some of the common areas that could be contributing to the issue. However, it may be necessary to consult with a specialist to determine the cause and the best course of action. Monitoring the bulk tank milk samples after adjustments have been made is the ideal manner to confirm the effectiveness of any changes implemented.