

Variation in Milk Fat of Fresh Cows

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Abstract

Monitoring milk fat concentration during early lactation is important for management of the risk for ketosis. The concentration of fat in milk is quite variable, and but this variation can be greater within a milking and day than between cows within a herd or the day-to-day variation for a given herd. New approaches to analyzing concentration of milk components on the farm using counter top or in-line instrumentation offer the daily monitoring of milk composition of individual cows. Changes in the concentrations of milk fat or the milk fat: milk protein (**MF:MP**) can elicit actions by herd managers, especially for the induction of a preventive approach for reducing the risk of ketosis or for use of another analytical method with greater specificity for ketosis on flagged cows. Improvement in providing management information for rapid response to “out of control” variables will be very valuable for reducing treatment costs for disease, improving efficiency of milk production, and increasing farm profitability.

Introduction

The variation in the composition of milk from dairy cows has been studied for many years, and it is well known that breed, stage of lactation, feeding practices, genetics, and environmental conditions can affect the composition of milk. With the variation of milk fat being greater than any other component in milk and its importance relative to pricing of milk

and as an indicator of metabolic and rumen health, much attention in nutritional research has been focused on milk fat concentration.

Ketosis is one of the primary metabolic diseases affecting dairy cattle during early lactation. Early diagnosis is very important so that treatment can begin because success of recovery is generally high and reducing the duration of clinical ketosis reduces the amount of milk loss and the risk for other metabolic diseases. Milk fat concentration varies with days-in-milk (**DIM**), and milk fat concentration during early lactation has been purported by some, especially veterinarians, to be an indicator of the risk for ketosis (caused by a high degree of fatty acid mobilization in response to the negative energy balance).

Variation in the Crude Composition of Milk

The components in milk are primarily water, lactose, fat, protein, minerals, and vitamins (ranked in descending order of concentration generally found in milk). The concentration of lactose in milk (generally about 4.85%) is low in variability, and lactose is the primary regulator of milk volume. In milk pricing, it is often lumped into the other solids or solids-not-fat concentrations in milk. The variation in concentration of protein in milk is considerably less than for milk fat (Table 1). For the Holstein breed, the variation in milk fat is about 2.7 times greater than for milk protein. The variations in milk yield and fat concentration are greater than

the variations in concentrations of protein and lactose, both between animals and days of lactation (Rook et al., 1992). In addition, the variation caused by time of milking (am versus pm) was greater than the variation between cows or from day-to-day.

Importance of Monitoring Concentration of Fat in Milk

Milk fat is very important in the pricing of milk for payment to dairy farmers. Generally for most milk markets, but not all, the price for protein is higher than the price for fat. The pricing of milk is based on the mass of the components, not proportions. Thus, we have stressed for many years that yield of milk fat is much more important than the concentration of fat. So, in reviewing research data, we must examine the yield of milk, concentration of fat, and yield of fat as we examine the factors that affect milk fat and its corresponding implications to the profitability of dairy enterprises.

Of course, fat concentration varies by breed, with Brown Swiss, Guernsey, and Jersey having the highest concentrations of fat and protein among the 5 major dairy breeds (Table 1). However, it is interesting to note that milk from Brown Swiss cows is less variable in fat concentration than milk from the other 4 major breeds, with the variation being only 60% of the variation in fat concentration of Holstein herds. However, the variation in concentration of milk fat is about the same for the Holstein and Jersey breeds, the two most prominent breeds and differing in about one percentage unit in milk fat. The average of individual Holstein cows milk fat percentage with ≥ 200 DIM at completion of the lactation was 3.67% (SD = 0.56, CV = 15.3%) and was 4.78% (SD = 0.61, CV = 12.8%) for Jersey cows (Figure 1). The variation in milk composition is almost 2-fold higher for individual cow versus herd data.

Besides the economic importance of monitoring milk fat concentration and yield, milk fat

serves as an indicator for rumen health (Eastridge, 2000) and metabolic balance of cows, especially ketosis. Although milk fat concentration relative to the expected breed average sheds some evidence on animal health, the MF:MP is used more typically as an indicator of rumen health. The ratio of 1.2 to 1.3 is expected (Table 1). The value is greater for monitoring animal groups within a herd than the overall herd. The ratio for the herd may be normal, but the ratio for a given group within a herd may be low or inverted. The average ratio for a herd or a group within a herd is expected to be within the stated range; however, 10 to 20% of the cows within a group may have inverted MF:MP without there being dietary conditions adversely affecting rumen health.

The concentration of fat in milk is much higher in early lactation than later stages, primarily due to the mobilization of adipose tissue following parturition. About 50% of the fatty acids (FA) in milk originate from the diet and 50% from adipose tissue, but the contribution by adipose tissue is much higher in early lactation. This results in not only higher milk fat concentration but also milk with an increased portion of long chain FA and lower proportion of short-chain FA compared to later stages (Palmquist et al., 1993). In fact, stage of lactation has a greater impact on the molecular weight of FA in milk than the feeding of supplemental fat (Eastridge and Palmquist, 1989). Because of the effect of DIM on milk fat concentration, milk fat can be monitored as an indicator of the risk for ketosis. It is generally regarded that milk fat concentration should not exceed one unit above the breed average during the first 30 DIM (Phase A, Figure 1) and then not fall by more than one unit from 30 to 60 DIM. During 30 to 90 DIM (Phase B, Figure 1), milk fat concentration should continue to drop whereby it would be similar to the breed average by ≥ 90 DIM. Holstein cows completing lactations in Ohio DHI were plotted against DIM (Figure 1). Cows completing lactations from 0 to 30 DIM averaged 5.53% milk fat and then the drop was 0.91 units

from 30 to 60 DIM. Although the drop was as expected, the average milk fat was extremely high. It must be kept in mind that these milk fat data along with DIM do not represent the same cows and that cows with ≤ 30 when the lactation ended likely left the farm for health problems associated with negative energy balance. So, the dashed line was drawn in Figure 1 to represent the expected change in milk fat concentration for Holstein cows with advancing DIM.

Using Milk Fat Concentration in the Diagnosis of Ketosis

In order to effectively diagnose clinical ketosis, on-farm methods of analysis are needed for immediate treatment to occur. On-farm analysis of urine ketones (acetoacetate; e.g. KetoStix; Bayer Healthcare, LLC, Monheim Company, Germany) has been the common method for diagnosis of clinical ketosis. However, it is often difficult to get a fresh cow to urinate to use this method. The validity of analyzing ketones in milk has been recognized for many years and practiced widely in Europe. Recently, an on-farm milk ketone test kit (Keto-Test; β -hydroxybutyrate) for the US was released by Elanco (Greenfield, IN). More simple, less expensive instruments have been developed in recent years that are suitable for on-farm measurement of milk composition for individual cows. In addition, in-line sampling and analytical methodology are being provided by the major milking equipment companies (Barbano and Worjciechowski, 2012), which provide for milk composition data for every cow at every milking. Calibrations for these systems and usefulness for actual component values versus identifying deviations from the “norm” are still under evaluation.

Krogh et al. (2011) compared using the KetoLac test kit (Sanwa Kagaku Kenkyusho Co. Ltd., Nagoya, Japan) for β -hydroxybutyrate in milk, the Keto-Stix with urine, and using the MF:MP for determination of ketosis during 7 to 21 DIM and

having a test-date for milk fat and protein within 1 d before the day of the ketosis tests. Test results of ≥ 4 mmol/L of acetoacetate in urine, ≥ 200 μ mol/L of β -hydroxybutyrate in milk, and > 1.5 MF:MP were used as the cut-off for positive indication of ketosis. The overall prevalence of ketosis was 10 and 12% based on the milk and urine tests for ketones, respectively. The specificity for the milk and urine tests were high (99%) but lower for the MF:MP (79%), and the sensitivity was highest for the urine test (78%) and followed by the MF:MP (63%) and the milk test (58%). Specificity refers to the proportion of negatives which are correctly identified (e.g. the percentage of healthy animals which are correctly identified as not having the condition; true negatives/(true negatives + false positives), and sensitivity refers to the proportion of actual positives which are correctly identified (e.g. the percentage of animals which are correctly identified as having the condition; true positives/(true positives + false negatives).

Using 93 Canadian dairy herds, serum samples from 20% of the cows within each herd, with a minimum of 12 cows per herd, were taken from randomly selected cows within various stages of lactation within a herd (1 to 100, 101 to 200, and > 200 DIM) (Duffield et al., 1997). Milk, fat, and protein production data were collected from DHI corresponding to the test date closest to the time of blood sampling. When serum β -hydroxybutyrate concentrations > 1200 μ mol/L were used as the cut-off for identification of subclinical ketosis, the prevalence of ketosis was 14.1%. Although neither milk fat, milk protein, nor MF:MP provided high specificities or sensitivities for identifying subclinical ketosis, each of the variables were significantly associated with the risk for subclinical ketosis, and increasing milk fat by one percentage unit increased the risk for ketosis by 200%. In addition, it is important to note in this study that the test date data were recorded on average 7 days prior to the blood sampling, thus the data were not collected at the same time for

direct reflection on the metabolism of the animal. Also, when the risk for ketosis is the highest, e.g. first 2 wk postpartum, the milk fat and protein percentages interpreted in series resulted in the highest potential as an indicator for ketosis.

In a recent OSU study (Stevens et al., 2012), milk samples were collected at 7 and 14 DIM from 204 cows on a single farm. Composite milk samples were collected using a BouMatic (Madison, WI) in-line sampler and right-front (RF) quarter strip samples were collected and analyzed for milk components at the farm using a LactiCheck (LIC; Page & Pedersen, International, Ltd., Hopkinton, MA), with weekly calibration using samples from Eastern Laboratory Services (Medina, OH). Composite milk samples also were sent to DHI Cooperative, Inc. (Columbus, OH) for analysis of milk components. Keto-Test strips were used to measure ketones in milk stripped from the RF quarter, and urine ketones were measured with KetoStix. The average fat concentration from LIC composite samples was $5.36 \pm 2.05\%$ and $5.15 \pm 1.90\%$ from DHI, with the RF strippings having a lower milk fat ($3.17 \pm 1.88\%$) (Figure 2). Average milk ketone concentration was 0.55 ± 0.98 mg/dl, and urine ketone concentration was 4.41 ± 15.4 mg/dl; however, the incidence of clinical ketosis was relatively low in the herd (3.4% based on urine ≥ 40 mg/dl or 6.9% based on milk ≥ 2.0 mg/dl). The correlation coefficient for LIC and DHI composites was 0.70 ($P < 0.0001$), and the correlations between the composites and the RF samples were similar for both methods of analysis (0.30; $P < 0.0001$). The changes in milk fat concentrations from 7 to 14 DIM were similar for LIC and DHI composites and the RF samples (-0.63, -0.88, and -0.77, respectively). For cows with clinical ketosis based on concentration of urine ketones, the average milk fat for LIC and DHI analyses on composite samples were 6.54 and 6.98% and 4.20% for the quarter samples. For cows with clinical ketosis based on concentration of milk ketones, the average milk fat for LIC and DHI analyses on composite

samples were 7.42 and 6.40% and 4.74% for the quarter samples. In both of these situations, the milk fat concentration was elevated about 1 SD for either the composite or quarter samples.

Summary

Optimizing the yield of milk fat is important for the profitability of dairy farms. Monitoring milk fat concentration (along with MF:MP) during early lactation is important for management of the risk of ketosis. The concentration of fat in milk is quite variable, and but this variation can be greater within a milking and day than between cows within a herd and the day-to-day variation for a given herd. New approaches to analyzing concentration of milk components on the farm using counter top or in-line instrumentation offer the daily monitoring of milk composition of individual cows. Changes in the actual concentrations of milk fat or the MF:MP from composite milk samples can elicit actions by herd managers, or cows with concentrations of milk fat and MF:MP falling “out of control” relative to the baseline (plus one SD) for the herd from quarter strippings also can elicit actions by the herd manager (Table 2). Such actions may not include treatment for ketosis but the use of another analytical method with greater specificity for ketosis on the flagged cows, or use of a preventive approach for reducing the risk of clinical ketosis, such as the administration of propylene glycol. This later type of action may reduce the risk of subclinical ketosis leading to clinical ketosis and also increase milk yield in early lactation (McArt et al., 2011). Improvement in providing management information for rapid response to “out of control” variables will be very valuable for reducing treatment costs of disease, improving efficiency of milk production, and increasing farm profitability.

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Table 1. Variation in concentrations of milk fat and protein among herds.^{1,2}

Breed	Herds	Milk Fat (MF)			Milk Protein (MP)			MF/MP
		%	SD	CV	%	SD	CV	
Ayrshire	18	3.90	0.32	8.24	3.19	0.17	5.40	1.22
Brown Swiss	20	4.13	0.19	4.68	3.40	0.12	3.52	1.21
Guernsey	12	4.63	0.39	8.43	3.40	0.14	4.20	1.36
Holstein	687	3.79	0.30	7.82	3.09	0.09	2.87	1.23
Jersey	91	4.80	0.36	7.58	3.63	0.13	3.70	1.32

¹Data taken from herds enrolled in the Ohio Dairy Herd Improvement program during 2008.

²SD = Standard deviation and CV = coefficient of variation [(mean/SD)*100].

Table 2. “Out of control” milk fat measurements for identification of the risk for ketosis (prevalence goal < 5%; “out of control” > 10%) in Holstein cows.¹

Animal Group/Indicator	“Out of Control” Benchmark
Individual Cows (7 to 14 DIM)	
Milk fat, composite samples	> 7.0%
Milk fat, quarter strippings	> 5.0%
Milk fat: milk protein	> 2.0
Herd (Group; e.g. Fresh Cows) ²	
Milk fat	> 4.5% during 30 DIM > 6.5% during 14 DIM
Milk fat: milk protein	> 1.5 during 30 DIM > 2.0 during 14 DIM

¹Some of these values are based on research data but others warrant further validation (DIM = days in milk).

²Even if the herd or group average is “within control”, if greater than 40% of the cows (Bremmer, accessed April 2012) are outside the “within control”, then “out of control” measures need to be taken.

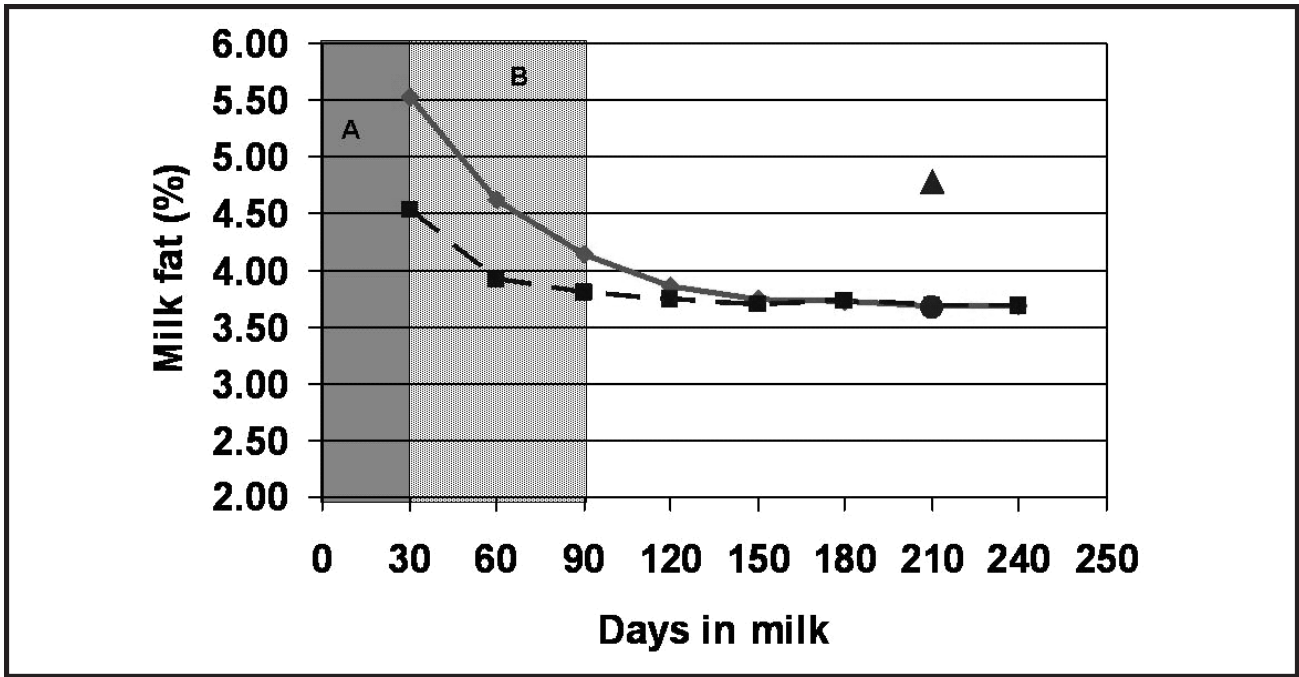


Figure 1. Milk fat percentage by days in milk (DIM) for Holstein cows. Solid line represents actual data and the dashed line represents projected data. Phase A = 0 to 30 DIM and Phase B = 30 to 90 DIM. The (●) represents the average milk fat percentage for Holstein cows having completed lactations with ≥ 200 DIM, and the (▲) represents the average milk fat percentage for Jersey cows having completed lactations with ≥ 200 DIM.

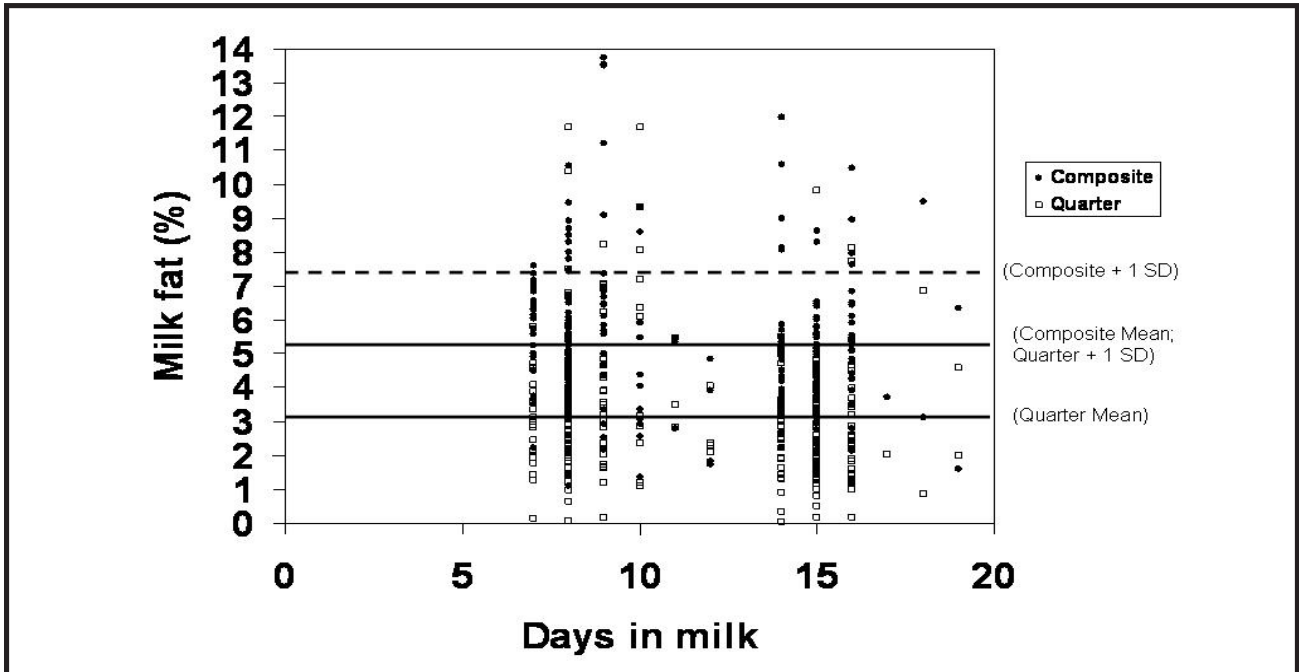


Figure 2. Concentration of milk fat in samples taken at 7 and 14 days in milk from composite samples and right front quarter strippings (SD = standard deviation).