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Dairy Update

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Effectiveness of Tunnel Ventilation as Dairy Cow Housing in Hot Climates

Serdal Dikmen, Colleen Larson, Albert De Vries and Peter Hansen

Tunnel ventilation is an increasingly popular approach to mitigate the effects of heat stress on dairy cattle. Tunnel-ventilation barns use a bank of high-power fans to move air horizontally from one end of the barn to the other at cow level. The overall objective of two experiments was to determine whether tunnel ventilation is superior to housing with fans and sprinklers with respect to rectal temperature during heat stress and seasonal variation in milk yield.

In the first study, rectal temperatures were measured for 1097 lactating Holstein cows in six freestall barns with fans and sprinklers and 575 lactating Holsteins in four tunnel-ventilated freestall barns in Florida at a time point between 2 PM and 4 PM during the months of June to August. Rectal temperatures were lower for cows in tunnel-ventilation barns than sprinkler-and-fan barns when the tunnel-ventilation barns were built new, but not when the tunnel-ventilation barns were produced by retrofitting a sprinkler-and-fan barn.

In the second study, average daily milk yield in the first 90 days in milk was examined for 8470 lactating Holsteins housed in three sprinkler-and-fan barns and two tunnel-ventilation barns. Milk production for cows calving in cool weather (October to March) was greater than for cows calving in hot weather (April to September). The seasonal reduction in milk yield was less for cows in tunnel-ventilation barns (3.5% decrease) than for cows in sprinkler-and-fan barns (5.8% decrease). With this difference in impact of heat stress, it was estimated at a dairy farm could invest up to a $332 more per cow space in a tunnel-ventilated barn than in a sprinkler-and-fan barn. It was concluded that housing cows in tunnel-ventilation barns can reduce the impact of heat stress on body temperature regulation and milk yield.

The study was published in the journal *Tropical Animal Health and Production* (2020) 52:2687-2693 https://doi.org/10.1007/s11250-020-02309-3. Corresponding author is Peter Hansen, pjhansen@ufl.edu. A copy of the paper is also available from Albert De Vries devries@ufl.edu

University of Georgia Dairy Research Center in Tifton, GA, Closed

The University of Georgia closed its Dairy Research Center on the Tifton campus on September 4, 2020. This comes after several years of depressed milk prices which reduced revenues for operating the dairy and the state of Georgia mandate to cut budgets due to reduced revenue collections. All animals are sold. Of the two dairy scientists at UGA Tifton, Dr. John Bernard will retire at the end of October and Dr. Sha Tao will be relocated to the Animal and Dairy Science Department in Athens. Tao will join UGA dairy scientists Dr. Jillian Bohlen, a reproductive physiologist, and Dr. Valerie Ryman, an immunologist whose research focuses on mastitis. UGA will transition the Tifton campus toward research and Extension efforts impacting the beef industry. Sources: Georgia Dairyfax, July August September, 2020, and Southeast AG NET Ratio Network

Feed Efficiency and its Impacts on Production and Health in Dairy Cows

Mariana Nehme Marinho, Roney Zimpel, Francisco Peñagaricano, and José E. P. Santos

Why is selection for traits that improve feed efficiency important?

Feed represents more than 50% of total costs on a dairy farm, of which protein sources are the most expensive among the components of a diet. Selecting dairy cows by the efficiency of nutrient utilization is desirable because of its relationship with farm profitability and the environmental impact of dairy farming. The fact that protein is expensive and nitrogen excretion by cows impacts the footprint of dairy farming makes it logical to seek methods to improve efficiency of dietary nitrogen utilization. There are multiple methods to improve feed efficiency such as grouping and feeding cows according to level of production, diet formulation, improving reproduction, and through genetic selection for increased production.

Nevertheless, a novel opportunity to improve feed efficiency is through genetic selection targeting cows that require less feed to produce the same amount of milk. Ideally, genetic selection programs should aim to identify animals that are highly productive, fertile, resistant to diseases, and very efficient in converting dietary nutrients into milk products (**Figure 1**, at the end of the article).

There are numerous methods to calculate feed efficiency, one of which is residual feed dry matter intake, also called residual feed intake or **RFI**. Residual feed intake is a potential target trait for genomic selection in dairy cattle as a measure of feed efficiency and it has the advantage of accounting for multiples aspects of how nutrients are utilized by animals. Residual feed intake is a measure of feed conversion efficiency that is calculated by the difference between observed and predicted dry matter intake, when the predicted dry matter intake is calculated after adjusting for multiple nutrient sinks such as energy-corrected milk yield, the maintenance requirement according to body weight, body condition score, parity, and the changes in body weight. The most efficient cows have negative RFI values because they consume less feed dry matter than expected based on the energy used for maintenance, production, and body weight change. It is anticipated that the Council on Dairy Cattle Breeding will release genetic values for RFI in December 2020 and incorporate RFI in multi-trait indexes such as lifetime net merit sometime in 2021. It will be incorporated probably under the name of “feed saved” as more efficient cows and sires are expected to save feed relative to less efficient cows and sires.

Although RFI is considered a moderately heritable trait and seems to be repeatable across lactational phases, measurements of RFI have been widely reported when cows are in mid-lactation, after the period in which cows undergo extensive mobilization of body reserves and have increased risk of diseases. Thus, the consequences in early lactation of selection for RFI based on mid-lactation measurements remains unknown. A concern of selecting cows for increased feed efficiency is that the reduced DMI might be detrimental to energy balance and affect losses of body weight and body condition in early lactation, which might affect health in dairy cows.

Assessing feed efficiency

Recently, we completed a study at the University of Florida (Nehme Marinho et al., 2020) using data from 4 previous experiments including 399 Holsteins cows with daily dry matter intake, body weight, and energy-corrected milk yield in the first 15 weeks of lactation. The project is part of a large multi-institutional and interdisciplinary grant funded by the Foundation for Food and Agriculture Research and the Council on Dairy Cattle Breeding. The individual experiments used to generate the data for this study were supported by the Southeast Milk Check Off program.

Our objectives were to evaluate the phenotypic associations between efficiency in early and mid-lactation through measurements of RFI and residual nitrogen intake, and assess production and health performance according to rankings of RFI determined in mid-lactation. Residual dry matter and nitrogen intake were calculated for each cow as the observed minus the predicted intake. To predicted dry matter or nitrogen intake, calculations were made accounting for energy or nitrogen sinks such as maintenance, synthesis of milk, and body energy or nitrogen mobilization or accretion.

Intakes of dry matter and nitrogen, yields of milk and milk components, body weight, and body condition were evaluated for the first 105 days in lactation. Milk yield by 305-day postpartum also was measured. Incidence of diseases was evaluated for the first 90 days postpartum and survival up to 300 days postpartum. Cows were ranked by the efficiency in mid lactation, from 9 to 15 weeks postpartum, and associated with productive performance in the first 5 or the first 15 weeks postpartum. Residual feed intake in early and mid-lactation and residual nitrogen intake in early and mid lactation were correlated, meaning that more efficient cows in mid-lactation were also more efficient in early lactation, although some re-ranking occurred.

Figure 1 illustrates the distribution of RFI expressed as feed saved and yield of energy-corrected milk in primiparous and multiparous cows in the study. Ideally, producers would select high-producing cows that have high yields of energy-corrected milk, but at the same time cows that require less feed to produce that milk without affecting body reserves. Those are the cows on the left-top quadrants, labeled in green. Also, producers would select against the low-producing cows that consume more feed to produce milk, which are those on the right-bottom quadrants, labeled in red.

A concern with selecting for improved feed efficiency is that cows might experience more postpartum diseases because of the reduced intake in more efficient cows. Indeed, the 25-percentile most efficient cows in the study consumed 8 lb/day less dry matter intake but produced the same amount of energy-corrected milk, fat, and protein (**Table 1, Figure 2**). However, in spite of the improved efficiency of feed utilization and an 11% increase in efficiency of nitrogen utilization, the mean body weight and body condition score did not differ, although more efficient cows lost 0.5 lb/day more body weight than the least efficient cows. More importantly, differences in efficiency were not associated with risk of morbidity or of multiple diseases in the first 90 days postpartum, or risk of leaving the herd by 300 days postpartum (**Table 1**).

How do these results affect the dairy industry?

Our findings showed that improvements in efficiency were caused by reduced feed intake. The most efficient cows consumed 16% less dry matter than the least efficient cows in the first 15 weeks of lactation, although they produced the same amount of milk measured in the first 15 weeks or the first 305 days postpartum without changes in health or body reserves. This means that our current system of analyzing feeds and attributing a certain concentration of metabolizable or net energy does not apply equally to all cows as some can either extract more energy from feeds or they are more efficient at using the nutrients provided by the diet for their maintenance and milk synthesis. The differences in intake between the 25% most and least efficient cows would result in considerable reduction of farm costs and land utilization for the same level of production (**Figure 2**). Moreover, not only those cows ate less, but they also utilized dietary protein more efficiently to partition into milk and body protein.

Mechanistic experiments have not been conducted with lactating dairy cows to explain differences in their ability to utilize nutrients. Nevertheless, we can speculate that more efficient cows might host a gastrointestinal microbiota that, perhaps, can digest carbohydrates and proteins more extensively and synthesize more microbial cells that supply amino acids needed for milk synthesis. Also, it is possible that the energy costs to absorb and transport nutrients across tissues are less in more efficient cows, thereby reducing their maintenance costs. Because these cows utilized dietary nitrogen 11% more efficiently, it is possible that they are more capable of recycling nitrogen to the gut or that microbes in the rumen might supply more essential amino acids, or that their tissues, including the mammary gland catabolizes less amino acids during metabolism, which spare them for productive purposes.

It is a matter of time until feed saved will be incorporated into selection programs in the United States dairy industry. Although improvements will be slow because accuracy of measurements will require continuous collection of data on individual cow dry matter intake, which today is not available in commercial farms, thereby relying on data from research farms such as the University of Florida. Nevertheless, once genomic markers for feed efficiency are identified and available, dairy scientists will be able to study the possible underlying mechanisms that make some cows more able to produce milk with less inputs.

Reference

Nehme Marinho, M., R. Zimpel, F. Peñagaricano, and J. E. P. Santos. 2020. Assessing feed efficiency in early and mid-lactation and its associations with performance and health in Holstein cows. J. Dairy Sci. 103: under review.

Acknowledgments

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More information

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Table 1. Intake, production, nitrogen efficiency, morbidity, and survival in the most and least efficient cows

	RFI in mid-lactation[1]	
Item[2]	25% most efficient	25% least efficient
Cows, n	98	98
Dry matter intake, lb/day	42.5	50.4
Yield, lb/day		
Energy-corrected milk	85.0	86.5
Fat	3.1	3.2
Protein	2.4	2.5
Nitrogen efficiency,[3] %	31.6	28.4
Body weight		
Mean, lb	1,395	1,375
Change, lb/day	-1.1	-0.6
Body condition, 1 to 5 score	3.23	3.17
Morbidity[4]	37.8	43.9
Multiple diseases[5]	13.3	20.4
Left herd by 300 days, %	10.2	9.2
305-day milk,[6] lb	21,750	21,830

[1] Residual DM intake calculated in weeks 9 to 15 postpartum.

[2] Intake, production, body weight, and body condition measured in the first 15 weeks postpartum. Incidence of diseases evaluated in the first 90 days postpartum.

[3] Proportion of the nitrogen intake as dietary crude protein used for synthesis of milk and body protein.

[4] Diagnosis of at least one disease event (milk fever, retained placenta, metritis, mastitis, displaced abomasum, lameness, or respiratory disease) in the first 90 days postpartum.

[5] Cows diagnosed with more than one type of disease in the first 90 days postpartum.

[6] Milk yield measured daily and produced by 305 days postpartum.

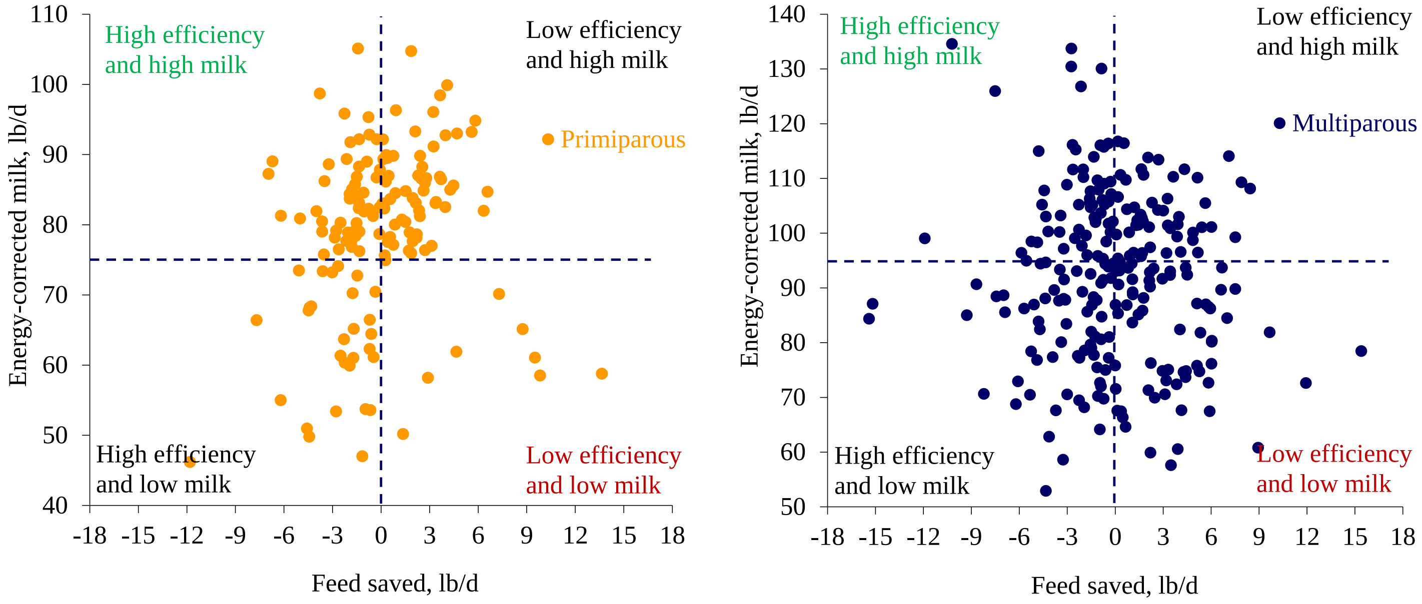


Figure 1. Yield of energy-corrected milk (Y-axis) and residual feed intake (X-axis) expressed as feed saved in primiparous (left panel, orange circles) and multiparous cows (right panel, blue circles) in the first 15 weeks of lactation. The most feed efficient cows are those with negative values for feed saved because they required fewer pounds of dry matter intake to produce the same amount of energy-corrected milk adjusting for body weight and changes in body energy. Ideally, selection would emphasize high-producing cows that are highly feed efficient (top left corner, green) and avoid low production inefficient cows (bottom right corner, red). (*"Feed Efficiency and its Impacts on Production and Health in Dairy Cows" by Mariana Nehme Marinho, Roney Zimpel, Francisco Peñagaricano, and José E. P. Santos.*)

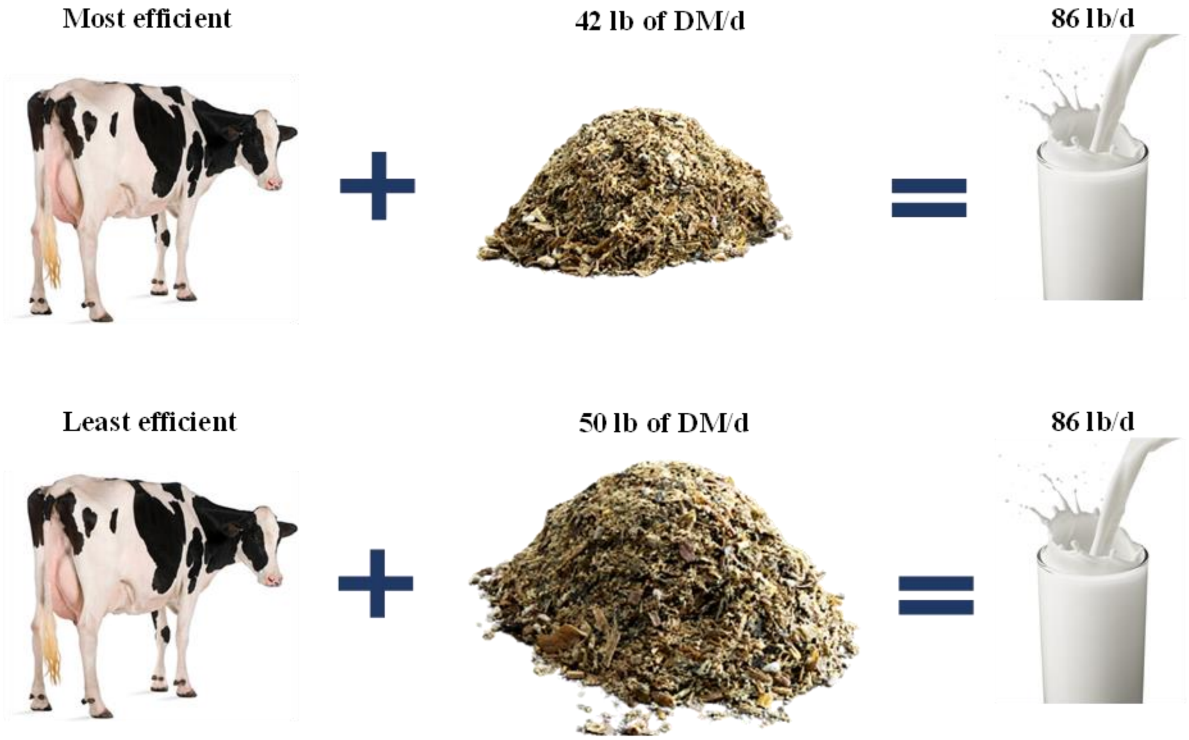
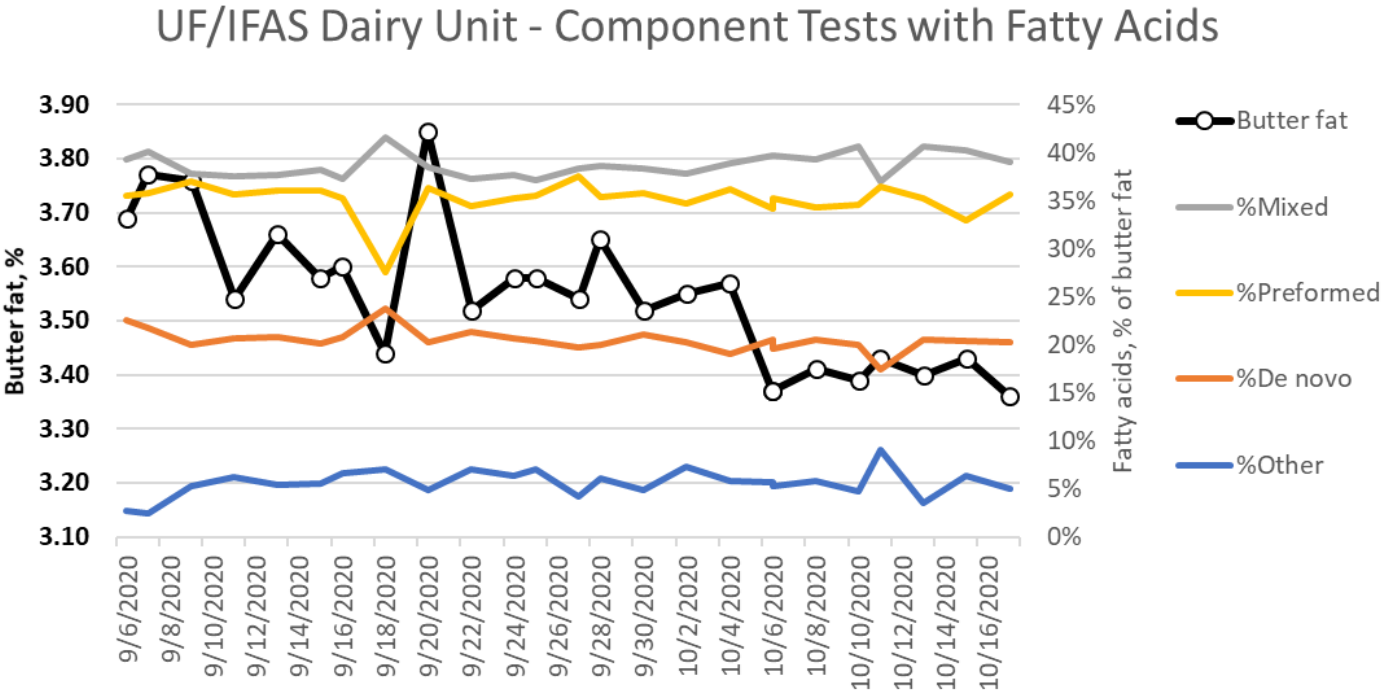


Figure 2. The mean daily dry matter intake and yield of energy-corrected milk in the 25% most and least efficient cows in the study. (*"Feed Efficiency and its Impacts on Production and Health in Dairy Cows" by Mariana Nehme Marinho, Roney Zimpel, Francisco Peñagaricano, and José E. P. Santos.*)

Tests for De Novo, Mixed Origin and Preformed Fatty Acids

Albert De Vries

Southeast Milk Inc. now has available tests for De Novo, Mixed Origin and Preformed fatty acids along with the routine component tests. The figure shows %De Novo, %Mixed, %Preformed and %other components of the butter fat tests from 9/6/2020 to 10/16/2020 for the UF/IFAS Dairy Unit. The article by José Santos and Benjamin Saylor explains what these fatty acids are and how they can help with herd management.



Understanding Milk Fatty Acid Analysis

José Eduardo P. Santos and Benjamin Saylor

Milk fat synthesis

The mammary gland of cows secretes fat as triacylglycerols containing fatty acids, which vary in their length of carbon chains and the degree of chain saturation. Fatty acids in milk triacylglycerols with a chain length from 2 to 5 carbons are called short-chain, from 6 to 12 carbons are called medium-chain, and those from 14 to 18 carbons are called long-chain fatty acids, and more than 18 carbons are called very-long chain fatty acids. These same fatty acids can be classified according to the number of double bonds in the carbon chain as saturated (no double bonds), monounsaturated (a single double bond), and polyunsaturated (more than 1 double bond). Milk fat contains mostly saturated and monounsaturated fatty acids, with limited concentration of polyunsaturated fatty acids. Also, milk fat contains mostly fatty acids up to 18 carbons, with a very small concentration of fatty acids with 20 to 22 carbons. Finally, the configuration of the double bond in the carbon chain can vary. They can be present in the native cis configuration in which the hydrogen atoms are on the same side of the carbon chain, or in a trans configuration, in which the hydrogen atoms are on opposite sides of the carbon chain. Unsaturated fatty acids with trans double bonds, also called trans-fats, are normally present in milk because they are synthesized by bacteria living in the rumen of cows. **Figure 1** illustrates a triacylglycerol containing one medium chain fatty acid located in the sn-1 position, a 12-carbon fatty acid with no double bond called lauric acid. The other two fatty acids have long-chains of carbons, one in the position sn-2 with 16 carbons and 1 double bond of cis configuration located in carbon 9, palmitoleic acid, and one in the position sn-3 with 14 carbons and no double bonds, myristic acid.

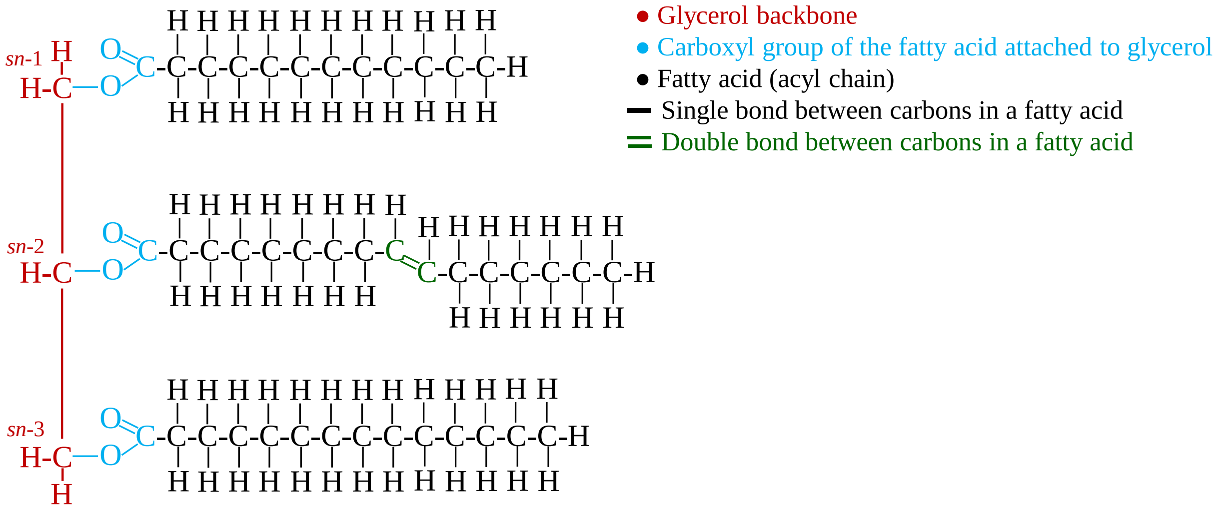


Figure 1. Illustration of a triacylglycerol containing a glycerol backbone and 3 fatty acids with 12, 16, and 14 carbons in the *sn*-1, *sn*-2, and *sn*-3 positions, respectively. The fatty acid in the *sn*-2 position of the triacylglycerol contains a double bond that creates a kink in the molecule. (*"Understanding Milk Fatty Acid Analysis" by José Eduardo P. Santos and Benjamin Saylor*)

Milk fat is one of the few products in human diets that contain an abundant concentration of short and medium chain fatty acids. The reason for the relatively large concentration of short and medium chain fatty acids is because the mammary gland of a dairy cow synthesizes milk fat by two pathways. One called **de novo** synthesis of fatty acids, in which the mammary cells use 2- to 4-carbon fatty acids present in blood originated from ruminal digestion of carbohydrates and combine them to make fatty acids with up to 16 carbons.

The second pathway is a process called incorporation of **preformed** fatty acids, which involves transferring fatty acids with 16 or more carbons from blood into the mammary cells and then packaging them to be secreted into milk. Thus, fatty acids with 16 carbons can be derived from de novo synthesis or incorporation of preformed fatty acids from blood and, therefore, they are usually labeled as **mixed** fatty acids.

The types of fatty acids present in milk fat vary with stage of lactation, nutritional state, and type of diet fed. In general, in a well-fed cow past the first month of lactation, approximately 25 to 30% of the fatty acids will be formed solely through de novo synthesis (up to 14 carbons); 30 to 35% will be fatty acids with 16 carbons (mixed origin). Approximately 40% will be strictly preformed fatty acids containing primarily 18 carbons.

When cows lose large amounts of body weight, which is common in early lactation or during disease, the concentration of fat in milk increases because of incorporation of more preformed fatty acids (fatty acids with more than 16 carbons) that are in circulation originated mostly from body fat mobilization. On the other hand, when cows undergo diet-induced milk fat depression, the concentration and yield of fat in milk decrease because the mammary gland is less capable of producing fatty acids through de novo synthesis (fatty acids with fewer than 16 carbons).

Changes in fatty acids in milk fat

A variety of factors can affect the profile of fatty acids in milk fat, which results in changes in the proportions of de novo synthesized, mixed and preformed fatty acids, as well as the presence of some specific fatty acids that either cause or are associated with milk fat depression. For instance, the relative proportion of preformed fatty acids with more than 16 carbons increases in early lactation or in periods in which the cow is sick or losing body weight, whereas the proportion of de novo synthesized fatty acids is low in the same periods.

When farms undergo periods of diet-induced milk fat depression, the group of fatty acids mostly affected is the de novo synthesized, those with up to 14 carbons. Diets that promote milk fat depression typically are those with excessive concentrations of starch, inadequate forage fiber, or with excessive concentration of unsaturated fatty acids. On the other hand, when diets are supplemented with fat sources rich in 16-carbon fatty acids, such as those derived from palm fatty acid distillates, it is common to observe an increase in milk fat content and in the proportion of fatty acids of mixed origin in milk, those with 16 carbons.

Diet-induced milk fat depression is characterized by a sudden drop in milk fat content that occurs after a change in diet and results in reduced milk fat yield. Small day-to-day variation in content and yield of milk fat is expected either within a group of cows or in the bulk tank, but such daily variability is relatively small. When cows experience diet-induced milk fat depression, the changes in milk fat content are usually larger than 0.20 percentage units in milk fat (e.g., from 3.80% to less than 3.60%), resulting in appreciable loss of fat yield. Altered ruminal fermentation can induce production of specific trans fatty acids by rumen microbes during digestion of dietary fats, and at least 2 of these trans fatty acids are known to suppress de novo synthesis of fatty acids in the mammary gland. These anti-lipogenic fatty acids leave the rumen and are absorbed in the intestine to the bloodstream and eventually are transferred to the mammary gland and incorporated into milk fat. Therefore, when diets favor the accumulation of these specific trans fatty acids, milk fat content typically decreases, which can lead to reduced fat yield.

Analysis of milk fatty acids

Until recently, milk samples were analyzed using infrared methods for concentrations of fat, true protein, lactose, somatic cells, and other compounds such as urea nitrogen. The fat content analyzed in milk reflected the total triacylglycerols, but not the individual fatty acids that make up those triacylglycerols. In 2014, Dr. David Barbano form Cornell University reported a rapid mid-infrared called Fourier transform mid-infrared spectroscopy (FT-MIR) method of milk analysis to quantify the concentrations of de novo, mixed, and preformed fatty acids in milk fat. The method uses light from the mid-infrared region to scan milk being analyzed and determine the presence of specific features such as chemical bonds in the compounds present in milk that allow rapid and high-throughput quantification of fatty acids, among other components. The equipment is integrated with a software that provides data on groups of fatty acids, saturated fatty acids, monounsaturated fatty acids, and those with cis or trans double bonds. In addition, Barbano's group developed prediction models to be incorporated into the FT-MIR system to estimate the mean milk fatty acid chain length (mean number of carbons per fatty acid), the degree of unsaturation expressed as number of double bonds per fatty acids, and the estimated concentration of nonesterified fatty acids (NEFA) in blood plasma of cows.

The rationale for quantification of those components in milk and estimated concentrations of NEFA was to potentially use these measures as herd monitoring tools. It is well known that cows consuming inadequate amounts of dry matter that result in body weight loss have increased concentrations of NEFA in blood. These fatty acids originate from mobilization of fat depots that is typical of early lactation or when cows are sick. Combining NEFA with the profile of fatty acids in milk has been proposed by Barbano's group as a tool to monitor postpartum health or monitor dietary changes in dairy herds. Furthermore, monitoring pens or bulk tank milk fatty acids might provide insights into potential reasons for milk fat depression.

The idea proposed by Barbano is to use FT-MIR to analyze milk from individual cows, pens, or bulk tank as a rapid method to assist with nutritional and health monitoring. For instance, a decrease in the proportion of de novo synthesized fatty acids as the total fatty acids in milk fat that might occur concurrent with a decrease in bulk tank milk fat content would suggest that the milk fat depression is of dietary origin. On the other hand, an increase in milk fat associated with an increase in pre-formed fatty acids in the fresh pen could indicate more sick cows or cows losing too much body condition in early lactation. The producer or the consultant would use this information to assist troubleshooting problems such as cows calving overconditioned or overcrowding in the group resulting in competition that might result in more postpartum diseases, or a possible case of diet-induced milk fat depression, or other possible causes of changes in milk fatty acid profiles.

It is still early to determine how sensitive and specific the results of milk fatty acid analysis will be to identify problems such as sick cows in the fresh pen. It is anticipated that integration of individual cow milk fatty acid profile concurrent with other measures that would be taken cow-side would allow monitoring of individuals or groups of cows to assist in decision-making. Furthermore, it is anticipated that use of milk components, urea N, and fatty acid profile of milk fat would eventually be used to feed algorithms incorporated into the herd management software to identify potential dietary issues before drastic changes on herd performance eventually occur. As the technology evolves and FT-MIR capabilities expand, it might be possible to link the spectra of milk with other traits of interest that are difficult to measure in large numbers of cows. For instance, let us suppose that feed intake in cows affects the spectra of milk analyzed by FT-MIR. Obviously, measuring individual animal feed intake is tedious, expensive, and usually only possible in research institutions. If intake or other traits are linked to milk spectra, it would be possible to assess the spectra of milk of hundreds of thousands of cows routinely and indirectly identify individuals that are superior for particular phenotypes of interest.

As any new technology, the fundamentals of analysis of milk fatty acids are based on sound science, but its application to allow decision making in herd monitoring and management still requires further scrutiny and validation to understand when these measures will become useful to make correct decisions on an individual or group of cows.

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Advantages and Disadvantages of Various Dry-off Methods for Dairy Cows

Pornpamol Pattamanont, Marcos Marcondes, and Albert De Vries

We have written a University of Florida EDIS (Electronic Data Information Source) Extension publication on advantages and disadvantages of 4 methods to dry off cows. The 4 methods are: abrupt dry-off, gradual milking, gradual feeding, and administration of a prolactin inhibitor. The publication reviews these dry-off methods and presents economic cost-benefit calculations. The publication is available at https://edis.ifas.ufl.edu/an360. More information: Albert De Vries, devries@ufl.edu

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