FAT SUPPLEMENTATION WITH PASTURE-BASED SYSTEMS

Larry Muller
Penn State University (lmuller@psu.edu)

Introduction

Energy is the most limiting nutrient for milk production with pasture based systems. Cereal grains are the most common energy supplements used for dairy cows fed in pasture-based systems. Starch-based concentrates provide fermentable energy, improve the protein/energy balance, and can potentially increase rumen microbial protein synthesis. The increased genetic merit of dairy cows has led to higher supplementation of cereal. However, feeding large amounts of cereal grains can decrease ruminal pH, reduce ruminal fiber digestibility, decrease the ruminal acetate/propionate ratio, increase the risk of ruminal acidosis, and reduce milk fat concentration. To overcome these problems and to increase energy intake, supplemental feeding of fat to grazing dairy cows has some of the following advantages:

- Increase the energy density of the diet because fat contains three times more net energy of lactation than protein and carbohydrate rich feeds.
- Improve the energetic efficiency because of reduced loss of energy as heat, methane, and urine may be expected and because the dietary fatty acids (FA) are incorporated directly into milk fat by the mammary gland.
- Reduce the risk of rumen acidosis and decreased milk fat percent induced by feeding high levels of cereal grains in the diet.

Feeding high levels of supplemental fat to dairy cows (more than 7-8% fat in the total diet) can result in a depression in the concentration of fat and/or protein in milk due to its effect on dry matter intake and fiber digestion in the rumen. These effects have been described in previous reviews on TMR diets. Although the inclusion of supplemental fat is common in TMR-based systems, information on fat supplementation for dairy cows on pasture is more limited. The objectives of this paper are to review the experimental results obtained with fat supplementation to the diets of dairy cows grazing high-quality pastures (Schroeder et al., 2003), and to use this research to make practical recommendations.

Research and Fat Content of Pasture

Eighteen experiments involving 25 comparisons were reviewed to describe the main effects of fat supplementation on milk production and milk composition with grazing dairy cows (Schroeder et al., 2003). Results were analyzed comparing the fat-supplemented groups with control groups fed no supplemental fat and were segmented according to the stage of lactation (early- or mid-lactation) and the degree of saturation of the fat supplement (unsaturated or saturated). The total fat and individual fatty acids (FA) play a major role in the supplementation strategy and the animal response to fat. The total fat content in fresh forages typically ranges between 3 to 6% of the DM. Of the total fat, about 40 to 50% are FA, mainly galactolipids, and the rest are cuticular waxes, phospholipids in cellular membranes, pigments such as chlorophyll, and other unsaponifiable material. Temperate pastures contain 1 to 3% of FA (Table 1), with the highest FA concentration during the fall and the spring. The FA content of pasture is highly unsaturated (average 70 to 90%), with a large amount of linoleic (C18:2) and linolenic acids (C18:3) (Table 1). Research results show that grazing different ryegrass cultivars results in differences in CLA concentration in milk. Pasture management, including the intervals between cuts or grazing cycles, can also have a large effect on the amount of FA.

The inclusion of fat in the diet will increase energy density and, therefore, the energy intake, if DMI and ruminal digestion are not affected by fat supplementation. The inclusion of fat supplements in TMR has been associated with a small reduction in DMI. The reduction in DMI has been associated with the source and amount of fat supplement used.

Another limitation to be considered when fat is added to the concentrate rations of grazing dairy cows is the potential reduction in the palatability of the whole supplement. Reductions in concentrate DMI when fat was added have been attributed to a lower rate of intake and size of each meal. This could represent a concern with grazing cows that commonly receive the concentrate for a limited time during each milking. Palatability problems were found when dairy cows were fed 0.5 kg of different sources of fat during a 15 min period; however, when fat supplements were offered mixed with cereal grains the problems disappeared. Addition of increasing amounts of free FA from 0 to 40% (as fed) to a concentrate supplemented twice daily at each milking to grazing dairy cows decreased concentrate DMI when the fat concentration was higher than 22%. In the research studies reviewed, the results are in agreement with those reported in a recent review where the DMI was slightly (0.3 kg/d) reduced by fat supplementation in some grazing studies.

Effects of Supplemental Fat on Milk Production

Milk production is generally increased by the inclusion of fat in confined feeding systems. The response to fat addition in TMR diets is usually higher in early-lactation than in mid-lactation, and higher in high genetic merit cows than in cows with low genetic merit. Fat supplementation of grazing cows <u>increased milk production 4.5% (1.0 kg/d) compared to control cows</u>, although the variation was large (Schroeder et al., 2003). Milk production was numerically increased in 80% of the analyzed experiments. The response to supplemental fat was greater when expressed as fat corrected milk yield and averaged +5.2% over control cows, indicating the simultaneous increase in both milk yield and milk fat percentage.

The effect of supplementation of dietary fat on milk and FCM production was related to the <u>degree of saturation</u> of the fat supplement and to the stage of lactation. Supplementation with unsaturated FA sources did not significantly increase milk or FCM production whereas both parameters were increased by saturated FA supplements. Mid-lactation cows had higher milk yield response to fat supplementation but a lower production of FCM than early-lactation cows. Maximum milk production response to fat supplementation may not be achieved until cows are in a positive energy balance.

Effects of Supplemental Fat on Milk Fat Percentage and Production

The effect of fat supplementation on milk fat percentage was not different from zero. However, when the effects were separated by type of fat supplement, saturated FA sources increased milk fat percentage by 5.1% (3.50 to 3.68%), and unsaturated FA sources reduced milk fat percentage 8.0% (3.5 to 3.22%).

Fat supplementation affects milk fat percentage and composition in different ways. Fat feeding may have negative effects on rumen fiber digestion and decrease acetic and butyric acid (precursors of short- and medium-chain FA in milk) production, affecting *de novo* fat synthesis in mammary gland. When fat is included in the ration, the uptake and direct incorporation of long-chain FA into TG by the mammary gland are increased. In 36% of the 25 comparisons, a significant increase in milk fat production was observed. Similar to the results found for milk fat percentage, milk fat yield was increased more by saturated fat supplements [+75.5 g/d (+9.3%)] than by unsaturated fat supplements [-27.9 g/d (-3.8%)]. The overall effect of unsaturated fats on milk fat yield in grazing conditions was not different from zero and can be explained by the combination of a decrease in the milk fat concentration and an increase in milk production.

A recently reported study confirms the research discussed (Salado et. al., 2004). Early lactation Holstein cows fed 0.7 kg of saturated fat from hydrogenation of vegetable oils which replaced 1.6 kg of corn grain produced 1.3 kg more milk. The milk fat was increased from 3.64% to 3.86%. Milk protein was not changed.

Supplemental Fat on Milk Protein Percentage and Production

In a previous review which included results from 49 trials with fat inclusion in TMR diets, a decrease in milk protein concentration was commonly observed, but its magnitude was not related to the source of fat utilized. The results from grazing studies suggest that milk protein concentration generally was not affected by fat supplementation, although the overall mean effect summarized over the 18 studies resulted in a small reduction in milk protein percentage. The decrease in milk protein percentage was not related to the amount of lipids fed and seemed to be greater in mid-lactation cows than in early-lactation cows and with unsaturated fat supplements than with saturated fat supplements.

Conclusions

Supplementation of fat to pasture based system appears to increase milk production by dairy cows grazing high-quality pastures. The responses are highly dependent on the type of fat supplement and the stage of lactation. A higher milk response was observed with saturated than with unsaturated fat supplements. These increases in milk production often observed may be related to an improvement in energy utilization and to an increase in energy intake. Milk fat concentration was increased with saturated fat supplements and was reduced with unsaturated fat supplement probably due to an inhibition of *de novo* fat synthesis in the mammary gland. Supplementation with unsaturated fat sources increased the content of unsaturated long-chain FA and conjugated linoleic acid (CLA) in milk, and therefore could improve the nutritional value of the milk. Milk protein concentration was reduced a small amount with fat supplementation, although this effect may be associated with a dilution effect due to an increase in milk volume. Changes in body condition and reproductive performance were not reported in many of the research studies. The additional benefits of improved body condition and reproductive performance need to be considered.

References

Schroeder, G. F., G. A. Gagliostro, F. Bargo, J. E. Delahoy, and L. D. Muller. 2003. Effects of fat supplementation on milk production and composition by dairy cows on pasture. Livestock Production Science, 86: 1-18.

Salado, E. E., G. A. Gagliostro, D. Becu-Villalobos, and I. Lacau-Mengido, 2004. Partial replacement of corn grain by hydrogenated oil in grazing dairy cows in early lactation. J. Dairy Sci. 87: 1265-1278.

Table 1. Fatty acid (FA) composition in some common pastures and concentrates.

	Ether Extract (% DM)	FA (% DM)	FA Composition (g/100g FA)							
			C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0
<u>Pastures</u>										
Perennial ryegrass	3.4	1.8	<0.5	11.9	1.7	1.0	2.2	14.6	68.2	-
Red clover	5.1	2.3	1.5	14.2	-	3.7	-	5.6	72.3	-
White clover	5.0	2.2	1.1	6.5	2.5	0.5	6.6	18.5	60.7	2.0
Alfalfa	5.3	2.5	<0.5	2.7	<0.5	<0.5	<0.5	1.7	95.0	-
Small meadow fescue	3.2	1.6	-	17.7	-	1.5	4.4	15.9	43.4	-
Orchardgrass	3.6	1.9	1.4	11.2	6.4	2.6	-	76.5	-	-
Grass, cool season	3.3	1.7	1.1	16.0	2.5	2.0	3.4	13.2	61.3	<0.05
<u>Cereal Grains</u>										
Corn	4.3 ± 0.7[1]	3.2	<0.5	16.3	-	2.6	30.9	47.8	2.3	-
Wheat	2.3 ± 1.1	1.0	<0.5	20.0	0.7	1.3	17.5	55.8	4.5	-
Barley	2.2 ± 0.6	1.6	-	27.6	0.9	1.5	20.5	43.3	4.3	-
Oilseeds										
Sunflower	41.9 ± 3.5	34.7	<0.5	5.5	-	3.6	21.7	68.5	<0.5	<0.5
Cottonseed	19.3 ± 1.4	18.6	0.8	25.3	-	2.8	17.1	53.2	0.1	0.1
Soybeans	20.1 ± 4.5	19.0	<0.5	10.7	<0.5	3.9	22.8	50.8	6.8	<0.5
Canola	40.5 ± 5.3	38.0	-	4.3	<0.5	1.7	59.1	22.8	8.2	1.0

[1]Mean ± standard deviation

Adapted from Palmquist and Jenkins, 1980; Palmquist, 1988; Van Soest, 1994; Dewhurst and Scollan, 1998; Grummer and Rabelo, 1999; Perry et al., 1999; Given et al., 2000; Thomson and van Der Poel, 2000; Chilliard et al., 2001, Dewhurst et al., 2001; NRC, 2001; and Agenas et al., 2002.