Fat-Feeding Practices for Lactating Dairy Cows

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Introduction

Supplementing cows with fat can have several beneficial effects. It usually increases the energy density of the diet as starch or fiber is replaced with fatty acids. If milk production is increased, then feed efficiency may be improved. Less heat may be produced in the rumen during digestion of fat-supplemented diets as fatty acids are not digested in the rumen. Less heat produced during digestion would help cows during heat stress conditions. Palatability of the diet might be improved and feed particle separation may be reduced. As a result, fat inclusion can be a good choice for diet formulators.

Types of Fats and Measures of "Quality"

The most commonly fed supplemental fats in dairy cow diets in Florida include whole cottonseeds, rendered fats (tallows and yellow grease), and ruminally inert fats such as calcium salts of palm oil (e.g. Megalac® produced by The Arm and Hammer Animal Nutrition Group). The "track record" of each of these fat sources as feed ingredients will be examined, with whole cottonseeds and tallow receiving the most attention.

Whole cottonseeds are graded prime if water content is < 12%, free fatty acids (FFA) are < 1.8%, and foreign matter is < 1%. They are considered "off quality" if water exceeds 12.5%, FFA exceed 20%, and foreign matter exceeds 10%. Tallow is primarily derived from ruminant fat. It can contain some fat from nonruminants such as swine but too much pork fat will reduce the titre ("hardness" of the fat) and move the fat from the tallow (minimum of 40.5 or 41 titre) to the grease (minimum of 36 titre) classification. Tallow can be classified into many grades with the allowable concentration of FFA increasing with decreasing fat quality (Table 1). Free fatty acids are those not bound to glycerol. Free fatty acids per se are not likely to have a negative impact on ruminant growth or milk production if fed in moderate amounts but they do make the fat more susceptible to rancidity. An antioxidant such as ethyoxyquin is often added to rendered fats in order to minimize oxidation and rancidity of fatty acids. The greater the concentration of FFA, the greater the need for an antioxidant. Free fatty acids are formed by exposing the fats to elevated moisture and temperatures. The concentration of FFA are measured by determining the amount (mg) of alkali (KOH) required to neutralize 1 gram of fat. Tallow for feeding to dairy cows should contain no more than ~ 4 to 6% FFA. Choice white grease is a blend of pork, poultry, and beef fat but primarily pork because of the need to have a lower titre. Yellow grease is derived from the collection and processing of primarily restaurant grease but it can contain dead stock fat and/or dark color, high FFA and high MIU fat from any type of rendering operation. Tallow that has a dark color and high FFA can be sold as yellow grease. Because restaurants have been using primarily vegetable oils for frying, yellow grease is primarily vegetable oil. Because these cooking oils are exposed to higher temperatures and moisture, they have a higher maximum FFA level (10 to 25%). When purchasing yellow grease, select ones that have lower FFA levels and contain antioxidants. Calcium salts of palm oil (CSPO) are prepared by reacting palm oil with sodium hydroxide and water by heating and then precipitating calcium salts using calcium chloride ($CaCl_2$).

Table 1. American Fats and Oils Association specifications for tallows and greases (1999).

Grades		Specifications				
		Titre Min °C [a]	% FFA Max [b]	FAC Max [c]	R & B Max [d]	% MIU Max [e]
1.	Edible Tallow	41.0	0.75	3	None	f
2.	Lard (edible)	38.0	0.50	G	None	f
3.	Top white tallow	41.0	2	5	0.5	1
4.	All beef packer tallow	42.0	2	None	0.5	1
5.	Extra fancy tallow	41.0	3	5	None	1
6.	Fancy tallow	40.5	4	7	None	1
7.	Bleachable fancy tallow	40.5	4	None	1.5	1
8.	Prime tallow	40.5	6	13-11B	None	1
9.	Special tallow	40.0	10	21	None	1
10.	No. 2 tallow	40.0	35	None	None	2
11.	A tallow	39.0	15	39	None	2
12.	Choice white grease (pork)	36.0	4	13-11B	None	1
13.	Yellow grease	h	h	39	None	2

[a] Titre: the temperature at which melted fatty acids congeal when cooled. Generally the titre number decreases as the proportion of unsaturated fatty acids in the fat increases.
[b] FFA = Free fatty acids: the percentage of fatty acids not esterified to glycerol.
[c] FAC = Fat analysis committee: indicates color using a scale from 1 (lightest) to 45 (darkest) using only odd numbers. Pure fat is almost colorless, therefore a high FAC number indicates the presence of dissolved foreign material. FAC number is important to soap production but not to nutritional value. A second method of evaluating color is to use the Lovibond scale (more accurate for lighter-colored fats).
[d] R & B = Refined and Bleached: a more precise indicator of color than FAC. Important number used in the oleochemical industry.
[e] MIU = Moisture, impurities, and unsaponifiables: Dilutes energy content and can create handling problems. High moisture can reduce shelf life as it accelerates oxidation and rancidity. Insoluble impurities include dirt, hide, hair, protein, etc. and may clog equipment. Saponification is the splitting of triglycerides into glycerol and fatty acids; non fatty acids such as sterols, pigments, vitamins, hydrocarbons, etc. that are dissolved in fat have no energy value.
[f] Moisture maximum of 0.20%. Insoluble impurities maximum of 0.05%.
[g] Lovibond color 5 ¼ inch cell - max 1.5 red. Lard peroxide value 4.0 ME/K max.
[h] When required, it is to be negotiated between buyer and seller on a contract by contract basis.

Unsaturated fatty acids prepared in this way are less "reactive" in the rumen and so negatively affect microbial fermentation to a lesser degree than untreated unsaturated fats (Chalupa et al., 1986). The acid conditions of the abomasum split the calcium from the fatty acids so that the fats are absorbed for metabolism in the small intestine. A review by French scientists concluded from studying 29 different groups that cows fed an average of 1.3 lb/day of CSPO produced significantly more milk, an additional 2.0 lb/day, with no change in milk fat % compared to cows not fed CSPO (Chilliard et al., 2001). This was across several experiments and types of diets.

Vegetable oils contain more unsaturated fatty acids (contain double bonds between carbon molecules) than animal fats. The typical ratio of unsaturated fatty acids to saturated fatty acids for commonly fed fats is in Table 2. Tallow and palm oil contain about equal proportions of saturated and unsaturated fatty acids whereas other fat sources contain more unsaturated fatty acids. In general, unsaturated fats are more digestible in the small intestine but they may have a negative effect on microbial digestion in the rumen if fed in excess. The ruminal microbes will convert unsaturated fats to saturated fats in a sequence of events called biohydrogenation. Some scientists have speculated that this act of biohydrogenation by bacteria is an attempt to protect themselves, as unsaturated fats can be toxic to bacteria, primarily the bacteria that digest fiber. If the feeding of unsaturated fats reduces the numbers or activity of fiber-digesting bacteria in the rumen, then feed intake can decrease, milk production can decrease, and milk fat concentration can decrease. A simple method of measuring the degree of unsaturation of a fat is to measure its iodine value (IV). This is the number of grams of iodine absorbed by 100 grams of fat. The higher the IV number, the greater the degree of unsaturation. The average IV number for beef tallow is 40, for pork fat (white grease) is 58, for restaurant grease is 80 to 87, and for soybean oil is 125.

Table 2. Typical ratios for unsaturated to saturated fatty acids in commonly fed fats (www.darlingii.com/askross/faq.htm).

Fat Source	Typical ratio of unsaturated to saturated fatty acids
Tallow	0.92
Choice white grease	1.45
Yellow grease	2.85
Palm oil	0.94
Soybean oil	5.64

Not only are fatty acids classified as saturated or unsaturated but are named based upon the length (number) of carbons. The average concentrations of the typical fatty acids found in tallow, yellow grease, and whole cottonseed oil are in Table 3. All three fat sources contain 20 to 25% C16:0 (sixteen carbons in chain length and zero double bonds). Tallow and yellow grease differ in that tallow contains more of the saturated fatty acid C18:0 and less of the unsaturated fatty acids C18:2 and C18:3. Fat found in whole cottonseeds is primarily unsaturated, with >50% being C18:2.

Impact of Fats on Dairy Cow Performance

Most dairy cow rations fed in the southeastern U.S. contain corn silage as the only or dominant forage source. If alfalfa is fed, it is in the hay form and rarely exceeds 12% of the diet. Since there is some evidence that the effect of fat sources on milk production, etc. may be dependent upon the source of forage in the diet, the following discussion is limited to those experiments in which corn silage was the only or dominant forage fed. As a result, the number of studies in the scientific literature examining the potential benefits of including tallow, yellow grease, or whole cottonseeds in rations is limited.

Table 3. Average concentration of major fatty acids (% of total fatty acids) in tallow, yellow grease, and whole cottonseeds fed in experiments using dairy cows.

Fatty acid	Tallow[1]	Yellow Grease[2]	Whole Cottonseeds
C14:0	2.9	2.0	--
C16:0	25.3	21.1	25.0
C16:1	3.3	4.2	--
C18:0	18.0	11.3	3.0
C18:1	43.3	43.5	17.0
C18:2	3.8	13.9	54.0
C18:3	0	3.0	--

[1] Average from 14 scientific journal articles (Amorocho, 2003).
[2] Average from 5 scientific journal articles (Amorocho, 2003).

Yellow Grease. Lactating dairy cows were fed diets of 0 or 5% yellow grease (Jenkins and Jenny, 1989). Digestibility of dietary fiber (ADF) was reduced in cows consuming yellow grease (21.6 vs. 31.6%). As a result, dry matter intake was reduced from 50.5 to 45.2 lb/d. Milk production, however, remained unchanged (69.4 and 70.5 lb/d for cows fed yellow grease or control diet respectively) thus efficiency of milk production was improved. Milk fat % was depressed from 3.50 to 2.83% by feeding yellow grease, indicating that yellow grease had a negative effect on fiber-digesting bacteria in the rumen. This negative effect on feed intake and milk fat % may have been minimized if the feeding rate would have been reduced from 5% to 2%.

Tallow. Five studies fed diets of 0 or 2 - 2.5% tallow in corn silage-based diets (40 to 50% of dietary DM) (Table 4). Feeding tallow significantly decreased DMI in 3 of the 5 studies in a range from 1.7 to 3.3 lb/day. This decreased feed intake was accompanied by reduced milk production of 4.5 lb in one study (Onetti et al., 2001). However in two other studies, milk production was increased by 4.2 lb/d (Smith et al., 1993) and 5.1 lb/d (Onetti et al., 2002). In the most recent study (Ruppert et al., 2003), the 2 lb/d increase in milk by cows fed tallow was not statistically different from the control cows. In all five studies, milk fat % was significantly depressed from as little as 0.15% to as much as 0.47% units, with the average depression being 0.3% units. Based upon this limited number of studies, what might be expected from our cows when tallow is added to corn silage-based diets at 2 to 2.5% of the dietary DM? Assuming a similar response to that shown in Table 4, the DM intake will likely be reduced (3 to 5%), milk production be increased (3%), and milk fat % be decreased by 0.3 percentage units (e.g. from 3.3 to 3.0%).

This negative influence of tallow on milk fat concentration can be eliminated if some of the corn silage is replaced with a different forage such as alfalfa hay. When Smith et al. (1993) replace one-fourth of the corn silage with alfalfa hay, tallow no longer depressed milk fat %. Milk fat % was 3.42 vs. 3.47% from cows fed diets of 0 or 2.5% tallow, respectively when diets were 37.5% corn silage and 12.5% alfalfa hay. When alfalfa hay replaced even more of the corn silage (25% corn silage and 25% alfalfa hay), milk fat % tended to be increased by feeding tallow (3.35 vs. 3.70% for cows fed 0 and 2.5% tallow diets, respectively). However in another study, replacing 25% or 50% of the corn silage with alfalfa silage did not improve milk fat % when tallow was added to the diets (Onetti et al., 2002). This may have been because rumen fluid pH was not improved by replacing corn silage with alfalfa silage. The acid nature of alfalfa silage may not buffer the rumen as well as that of alfalfa hay. Other forages such as bermudagrass hay and cottonseed hulls also have reversed the milk fat-depressing effect of tallow when partially replacing corn silage (Adams et al., 1995). Feeding tallow at 2.5% of the diet reduced milk fat % from 3.65 to 3.35% when corn silage was the sole dietary forage. Replacing 25% of the corn silage with bermudagrass hay maintained or improved milk fat % from 3.37 to 3.47% when tallow was fed. Likewise, supplementing tallow into corn-silage-based diets that contained some cottonseed hulls did not reduce milk fat % (3.53 vs. 3.60% for cows fed 0 or 2.5% tallow diets, respectively).

Table 4. Effect of feeding tallow on performance of lactating dairy cows fed diets containing 40 to 50% corn silage (DM basis).

Reference	% tallow in diet	DM intake, lb/d	Milk, lb/day	Milk fat, %
Smith et al., 1993	0	56.0	50.9	3.30
	2.5	57.8	55.1*	3.15*
Adams et al., 1995	0	48.1	58.8	3.65
	2.5	47.2	58.4	3.35*
Onetti et al., 2001	0	58.0	93.2	3.30
	2	54.7*	89.7*	2.83*
Onetti et al., 2002	0	50.9	77.6	3.11
	2	49.2*	82.7*	2.82*
Ruppert et al., 2003	0	49.8	71.2	3.18
	2	47.2*	73.2	2.89*

* P = 0.05 (estimated if reference did not report exact comparison).

A study from the University of Illinois also suggests that changing the forage in the diet from predominantly corn silage to alfalfa silage can alleviate the depressing effect that tallow has on milk fat % (Table 5). As tallow increased in the corn silage-based diet from 0 to 2 to 4% (% of dietary DM), milk fat % tended to decrease from 3.18 to 2.89 to 2.70% whereas milk fat % was unchanged when tallow was added to an alfalfa silage-based diet (tallow by forage interaction, P = 0.12). The reason for this response was likely due to what was going on in the rumen. Cows fed the corn silage-based diets had a more acidic rumen fluid (average pH of 5.92 vs. 6.04). As shown in Table 5, the concentration of trans C18:1 in milk fat tended to increase to a greater extent when tallow was fed in the corn silage-based diets than in the alfalfa silage-based diets ($P = 0.11$). Therefore the introduction of unsaturated fatty acids (predominantly cis-C18:1 in the case of tallow) into a more acidic environment (caused by feeding more corn silage) produced more trans C18:1 fatty acids.

Table 5. Effect of feeding tallow on selected measurements from lactating dairy cows fed diets based upon corn silage or alfalfa silage (Ruppert et al., 2003).

	40% corn silage:10% alfalfa silage			10% corn silage:40% alfalfa silage		
Measure	0% tallow	2% tallow	4% tallow	0% tallow	2% tallow	4% tallow
Milk fat, %[a]	3.18	2.89	2.70	3.39	3.44	3.41
Rumen pH [b]	5.94	5.88	5.93	6.09	6.10	6.03
Milk trans C18:1, % of milk fat [c]	1.45	2.95	4.86	1.19	1.89	3.05

[a] Dietary forage by tallow interaction, $P = 0.12$.
[b] Dietary forage, $P < 0.01$.
[c] Dietary forage by tallow interaction, $P = 0.11$.

Scientists in New York reported a greater increase in trans-10 C18:1 in milk fat accompanied by a depression in milk fat % when unsaturated fat was fed with a higher grain diet compared to a lower grain diet (Griinari et at., 1998). These trans fatty acids can be formed by a diverse range of bacteria in the rumen during biohydrogenation of unsaturated fatty acids (Bauman et al., 2000). Trans-C18:1 acids were formed as the major end product of biohydrogenation rather than C18:0 when increased levels of C18:2 were present (Polan et al., 1964). Tallow is generally quite low in C18:2 whereas cis-C18:1 is dominant (Table 3). Possibly the isomerization of cis-C18:1 in tallow to trans-C18:1 is carried out under more acidic conditions in the rumen when fewer fiber-digesters are present. Trans fatty acids leave the rumen with the digesta, are absorbed into the blood from the small intestine, and are taken to the mammary gland where they are incorporated into the milk fat. These trans fatty acids may inhibit the synthesis of the short chain fatty acids by the mammary gland, thus accounting for the depressed milk fat % due to the feeding of tallow. It is these trans fatty acids that may be the cause of the lowered milk fat by tallow supplementation to corn silage-based diets (Figure 1).

Whole cottonseeds. Whole cottonseeds are a commonly fed feedstuff supplying fat, protein, and fiber to dairy cows. About 50% of seeds are processed by oil mills and 50% are fed directly to livestock (National Cottonseed Products Assoc. 1995). About 70% of the fatty acids in cottonseeds are unsaturated. This unsaturated fat can reduce milk fat % just as tallow has done. The milk fat % was numerically depressed by feeding whole cottonseeds (10 to 15% of dietary DM) in all nine studies in which corn silage was the main forage fed but was only significantly lower in two studies (Figure 2). The average depression was 0.29% units. In a longer term study from calving through

17 weeks postpartum, Jersey cows were fed diets of 0 or 12.9% whole cottonseeds in which all of the forage came from corn silage. Over the course of the study, cows fed

Figure 1.

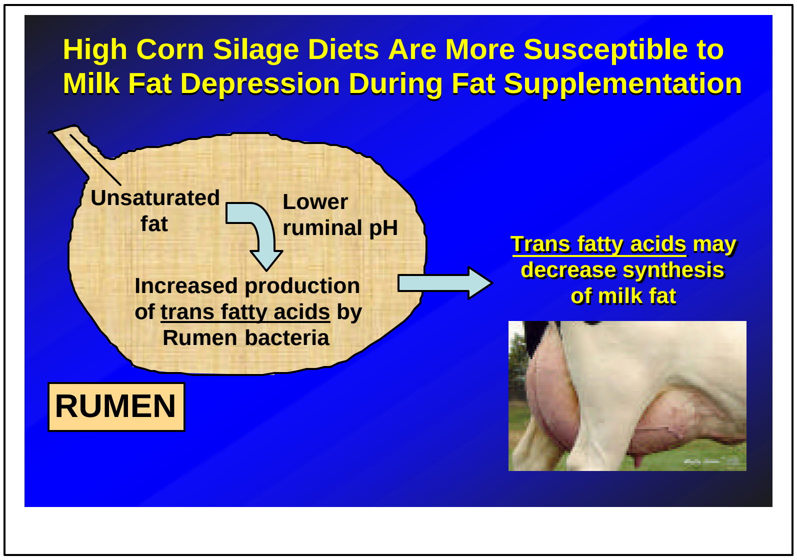
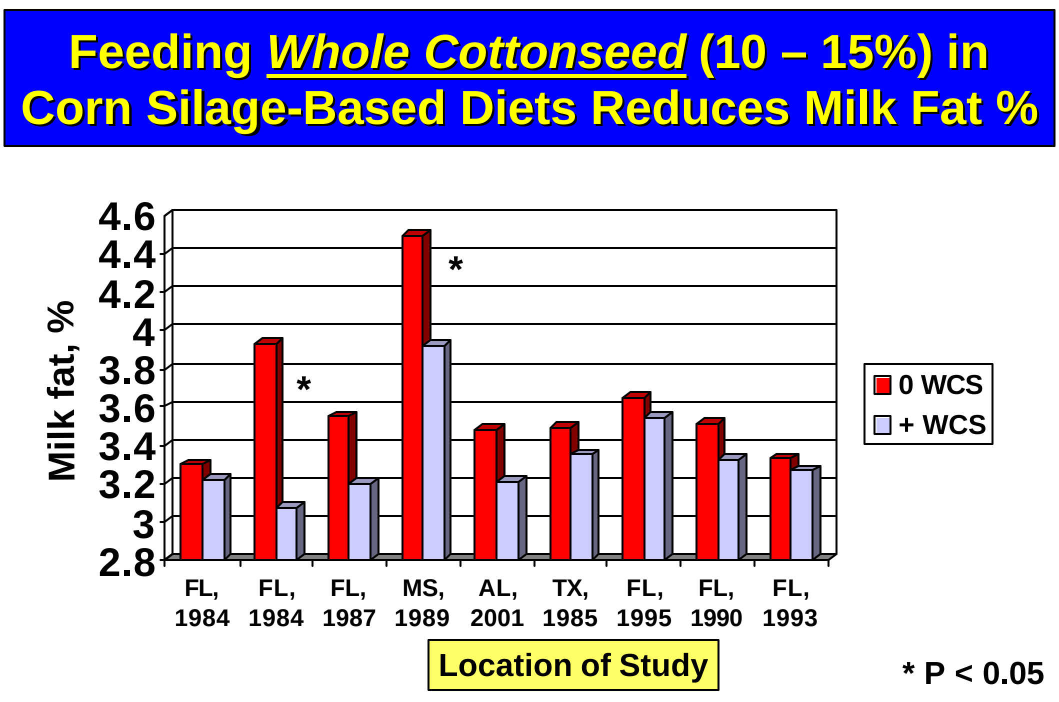


Figure 2.



whole cottonseeds produced milk of significantly lower milk fat % (4.60 vs. 4.88%) (Bertrand et al., 1998). As was the case with tallow, milk fat % responded differently to whole cottonseeds when alfalfa hay partially replaced corn silage. Milk fat % was increased by addition of whole cottonseeds to diets when alfalfa hay replaced 25% (3.55 vs. 3.30%) or 50% (3.46 vs. 3.25%) of the corn silage whereas whole cottonseeds had little effect on milk fat % when corn silage was the only forage (3.27 vs. 3.33%) (Smith et al., 1993). In another study, milk fat % was increased by addition of whole cottonseeds to diets when bermudagrass hay replaced 25% of corn silage (3.60 vs. 3.37%) or when cottonseed hulls replaced 25% of corn silage (3.73 vs. 3.53%) whereas whole cottonseeds had little effect on milk fat % when corn silage was the only forage (3.54 vs. 3.65%) (Adams et al., 1995). In this last experiment, alfalfa hay did not have the positive benefit that it did in the Smith et al. (1993) paper. Therefore it may be generally concluded that a second forage such as alfalfa hay, bermudagrass hay, or cottonseed hulls should be included in diets containing whole cottonseeds in order to prevent a possible milk fat depression due to whole cottonseeds.

The effect of feeding whole cottonseeds in corn silage-based diets on milk production is less straight forward. Milk production was significantly increased by 5.1 and 4.0 lb/day in two studies published out of Florida by Van Horn et al. (1984). However in three other studies, milk production was significantly lower by 2.1 lb/day (Adams et al., 1995), by 6 lb/day (Smith et al., 1993), and by 2.4 lb/day (Lubis et al., 1990) by inclusion of whole cottonseeds in the diet. The lower milk production could be explained by lower DM intakes by cows fed whole cottonseeds as reported in the Adams et al. paper (46.6 vs. 48.1 lb/day), in the Smith et al. paper (49.2 vs. 56.0 lb/day), and in the Lubis et al. paper (48.5 vs. 54.0 lb/day). This milk production and feed intake depression due to feeding whole cottonseed was alleviated by partially replacing corn silage with alfalfa hay (Smith et al., 1993). Milk production (50.0 vs. 50.5 lb/day) and DM intake (58.6 vs. 56.4 lb/day) were similar for cows fed 0 vs. 12% whole cottonseeds when alfalfa hay replaced 25% of the corn silage. Likewise when alfalfa hay replaced 50% of the corn silage, milk production (50.5 vs. 50.3 lb/day) and DM intake (58.0 vs. 58.4 lb/day) were not affected when whole cottonseeds were supplemented at 0 vs. 12% of the diet. Unfortunately this saving feature of alfalfa hay to correct the lowered milk production by feeding whole cottonseed in corn silage diets was not repeated in a later study (Adams et al., 1995). Milk production was consistently lowered by whole cottonseeds in diets that contained only corn silage as the forage source and in diets containing 75% corn silage and 25% of either alfalfa hay, bermudagrass hay, or cottonseed hulls as the forage sources. Averaged across these four forage combinations, milk production was 58.4 lb/day for cow fed no additional fat, 56.0 lb/day for cows fed diets of 12.5% whole cottonseeds, and 58.1 lb/day for cows fed 2.5% tallow. It is unclear why the Smith et al. (1993) and the Adams et al. (1995) papers gave different results. Possibly the acidity of the rumen fluid pH was not lessened by partially replacing corn silage with these other forage sources in the work by Adams et al. (1995).

How Much Fat Can Be Fed?

Tom Jenkins at Clemson University has developed some fat-feeding guidelines based upon the fiber concentration of the diet and the proportion of the unsaturated fatty acids in the fat supplement (Jenkins, 1993). The higher the fiber concentration of the diet, the more fat can be included in the diet. The greater the proportion of unsaturated fatty acids in the fat supplement, the less fat can be included in the diet. Cows fed diets containing more fiber usually have less acidic rumens and therefore fewer trans fatty acids are produced and milk fat depression is avoided. The more unsaturated fat in the supplement, the more trans fatty acids are produced. Two equations exist: one using the NDF and a second using the ADF concentration of the diets. The current equations do not distinguish between diets that contain corn silage or alfalfa as the sole forage species.

Maximum dietary concentration of supplemental fat =

(6 x % dietary ADF) ÷ (% of unsaturated fatty acids as a % of total fatty acids in the fat supplement ÷ % of total fatty acids in fat supplement) x 100% and

(4 x % dietary NDF) ÷ (% of unsaturated fatty acids as a % of total fatty acids in the fat supplement ÷ % of total fatty acids in fat supplement) x 100%.

The unsaturated fatty acids considered are generally C18:1, C18:2, and C18:3. For tallow shown in Table 3, these add up to 47.1%. Tallow is considered to be 100% fatty acids. Therefore, a diet that contains the minimum ADF concentration of 19% may have a maximum dietary concentration of tallow of 2.4% (6 x 19) ÷ (47.1%) ÷ (100%) x (100%) without resulting in a milk fat depression. Using the NDF values from the corn silage-based diets from references cited in Table 4, no milk fat depression would be expected if tallow was fed at less than 2.6% (Onetti et al., 2001), 2.9% (Onetti et al., 2002), 2.8% (Ruppert et al., 2003), 2.9% (Adams et al., 1995), and 3.1% (Smith et al., 1993). However, milk fat depression was observed when tallow was fed at 2 to 2.5% of diet DM indicating that the equations may need to be adjusted if corn silage is the sole forage source in the diet. Equations that would have maximized tallow to <2 to 2.5% of dietary DM in the previous references have the initial coefficients reduced as follows:

(4.5 x % dietary ADF) ÷ etc. and

(2.5 x % dietary NDF) ÷ etc.

As more studies are conducted with fat supplements in corn silage-based diets, proper equations can be developed.

Using the equation guidelines of Jenkins (1993), maximum feeding of whole cottonseeds is 8.9% when diets are of minimum fiber concentration. Whole cottonseeds are 18% fat with 71% of the fatty acids as unsaturated fatty acids.

Therefore the maximum feeding of whole cottonseeds = (6 x 19) ÷ (71) ÷ 18 x 100 = 8.9%. The studies in Figure 2 fed diets of 10 to 15% whole cottonseeds. The pattern of milk fat depression across these studies may have been eliminated if level of dietary cottonseed had been reduced.

Relative Value of Whole Cottonseeds

Whole cottonseeds may be a valuable feedstuff in diets for lactating dairy cows if their performance is not reduced and the purchase price of the seeds is right. Using the relative value software program developed by Dan Webb and Barney Harris, Jr. at the University of Florida, the breakeven market price for a commodity can be calculated based upon the current prices of ground corn used as an energy source, of 44% CP soybean meal used as a protein source, and cottonseed hulls used as fiber source. Using historical prices as listed in Table 6, whole cottonseeds are valued at $141/ton (as-is). Historically, whole cottonseeds can be booked for ~$120 to $125/ton if booked before October. Therefore, whole cottonseeds can be a cost effective feedstuff most years if fed in the right amounts. At the time of this conference, the market prices of the reference ingredients are higher than normal and thus whole cottonseeds are valued at $170/ton. Current prices for whole cottonseeds are ~$175/ton so the software program indicates that they are not a “best buy” at this time.

Timing of Initiation of Fat Feeding

Introduction of fat supplements into the diet can occur prior to calving, right at calving, or after a few weeks post calving. Studies on this topic have proven that fat feeding can begin at any of these times and positive benefits were obtained.

<u>Prepartum feeding of fat</u>. Starting to feed fat in the close-up dry period can adjust the cow’s palate and the rumen bacteria to a fat-enriched diet so that feed intake is not reduced during those early days postpartum when minimizing negative energy balance is so important. The postpartum diet can contain additional energy from the fat to support the demands of milk production. At the University of Wisconsin, cows were fed diets of 5% prilled fat (low in unsaturated fatty acids) starting about 17 days prepartum and through 15 weeks postpartum (Skaar et al., 1989). Diets were 50% concentrate and 50% forage with forage being an equal mix of corn silage and alfalfa silage. The fat was introduced into the cow’s diet gradually by increasing the grain feeding gradually over time. The DM intakes were the same for the two groups of cows in the prepartum and postpartum periods. However, those cows fed prilled fat produced 7.9 lb/day more milk (84.7 vs. 92.6 lb/day) with no difference in milk fat %. All of this advantage from feeding prilled fat came during the warm season rather than the cool season. The liver of cows fed supplemental fat tended ($P < 0.15$) to contain more fat at freshening (27.5 vs. 26.1%, DM basis) and at 5 weeks postpartum (28.9 vs. 24.0%, DM basis). This increased liver fat may have been due to increased uptake of dietary fat from the blood stream rather than increased uptake of mobilized body fat because plasma NEFA concentrations were not increased in cows fed prilled fat. This tendency

for elevated liver fat in cows fed prilled fat prepartum did not negatively affect cow performance; therefore, prepartum fat feeding proved very successful in this study.

Feeding fat at calving. Some have strategized to wait until calving before feeding a relatively expensive feedstuff like fat so that a marketable product (milk) could be realized to help cover the extra feed costs. At the University of Florida, multiparous cows were fed diets of 0 or 2.2% calcium salts of palm oil (Megalac®, The Arm and Hammer Animal Nutrition Group, Princeton, NJ) starting at calving through 15 weeks postpartum (Garcia-Bojalil et al., 1998). Milk production curves began to separate about 3 weeks postpartum with cows fed Megalac® having a 5 lb/day advantage after 13 weeks on trial. At the University of Wisconsin, first calf heifers also produced additional milk of approximately 3.3 lb/day when fed tallow at 2.8% of dietary DM from calving through 150 days postpartum in an alfalfa silage-based diet (Grummer et al., 1995). However the response was not observed until 7 weeks postpartum. Since there is delay from the start of fat supplementation to the point of milk response, some have argued that fat supplementation should be delayed until cows get through their worst part of negative energy balance. This would mean initiating fat supplementation around 4 to 6 weeks postpartum. However, would a positive response in milk production to fat supplementation have a shorter delay using this strategy? This question needs to be addressed in future studies.

Feeding fat starting at 3 to 4 weeks postpartum. South Dakota workers summarized five studies in which cows were fed whole seeds (sunflower or extruded soybeans) at levels ranging from 4.2 to 17.5% from weeks 4 through 16 postpartum (Schingoethe and Casper, 1991). Cows fed the seeds produced 2.8% more milk (average increase of ~2 lb/day over the 91 days of seed feeding). However there was a delay of 3 to 4 weeks after seed feeding was initiated before a milk response was observed. By the end of the seed feeding period, cows fed seeds were producing 5.5 lb/day more milk (an 8.2% increase). A delay in milk response to supplemental fat was not eliminated when fat supplementation was postponed beyond calving. If cows spend one to three weeks in a “fresh group” as they do on some farms, a small amount of fat could be introduced at this time and then an increase in fat feeding made in the next group into which the cows move.

Summary

Commonly used fat sources in Florida include whole cottonseeds, tallow, yellow grease (primarily restaurant grease), and calcium salts of palm oil. These sources differ in their proportion of unsaturated fatty acids and free fatty acids. In general, inclusion of yellow grease (5% of diet DM), tallow (2 to 2.5% of diet DM), or whole cottonseeds (10 to 15% of diet DM) in diets based solely or mainly on corn silage as the forage source typically resulted in lowered milk fat %. This lowered milk fat % may result from a reduced synthesis of short chain fatty acids by the mammary gland that is exposed to increased trans fatty acids coming from the rumen as a result of lowered ruminal fluid pH in cows fed corn silage rather than alfalfa. Replacing some of the corn silage with another forage such as alfalfa hay, bermudagrass hay, or cottonseed hulls may improve the milk fat concentration of cows fed these fat sources. Equations developed by Dr. Jenkins at Clemson University to suggest maximum feeding levels for fats may need to be modified when diets contain corn silage as the sole forage source as it appears that less fat can be supplemented in such diets compared to diets containing substantial alfalfa. Fat supplementation can be initiated prepartum, at calving, or at several weeks post calving with successful results. Care must be taken to minimize potential negative effects of fat on DM intake by not overfeeding or by gradually introducing the fat into the diet.

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