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Rumen inert fat supplements reviewed for dairy cows

The mode of action for reduced intake when using calcium salts of fatty acids appears to be primarily due to negative effects of gastrointestinal motility, rumen function and palatability, in that order. Reduced intake affects the amount and duration of negative energy balance in early lactation, subsequent milk production and reproduction and economic value.

By L.C. SOLORZANO and A.F. KERTZ

This review is primarily based on the recent publication by Loften and Cornelius (2004). Rumen inert (i.e., not being significantly changed in the rumen or having a significant effect on rumen function) fats are currently being used throughout the U.S. and other countries of lactating dairy cow rations. The main purpose in their use is to increase energy density and milk production, but reported responses range from none to variably positive effects on milk components and reproductive efficiency.

The purpose of this article is to review literature and to provide a clearer and more concise picture of the three main types of rumen inert fats and their effects on milk production, milk components and reproductive efficiency and, most critically, on dry matter intake (DMI).

The three main categories of rumen inert fats used in lactating cow rations today are: partially hydrogenated tallow (PHT), calcium salts of fatty acids (CaSFAs) and hydrogenated free fatty acids (FFAs). These fat compounds were developed to enhance the use of fats by

TABLES

1. Effects of feeding FFAs and CaSFAs to lactating dairy cows on milk production and milk components; means are differences between FFAs and CaSFAs (FFA-CaSFA)

Author	No. of cows	Milk, lb./day	FCM, lb./day	Fat, %	Protein, %
Grummer, 1988	4	-6.16	-5.06	0.24	0.18[b]
Schauff and Clark, 1989	4	-1.54	-1.76	-0.07	0.07
Schauff and Clark, 1989	6	-1.98	-2.64	-0.04	0.03
Wu et al., 1993	24	2.80	2.40	0.02	0.04
Elliott et al., 1996	5	3.28	6.10	0.19	0.16
Harvatine and Allen, 2002	32	-1.49	-0.90	0.04	0.05[a]
Harvatine and Allen, 2003	8	6.40	5.60	0.03	0.15
Weighted mean	83	0.49	0.69	0.04	0.04

[a] $P < 0.05$.
[b] $P < 0.01$.

2. Effects of feeding FFAs and CaSFAs to lactating dairy cows on DMI, fatty acid digestibility and bodyweight changes; means are differences between FFAs and CaSFAs (FFA-CaSFA)

Author	No. of cows	DMI, lb. per day	Fatty acid digestibility, %	Bodyweight change, lb. per day
Grummer, 1988[a]	4	0.0	-2.50	NA
Schauff and Clark, 1989	4	0.44	NA	NA
Schauff and Clark, 1989	6	-1.98	NA	NA
Palmquist, 1991	6	NA	-0.80	NA
Wu et al., 1993	24	3.10	-0.40	0.38
Elliott et al., 1996	5	3.30	-8.00	NA
Harvatine and Allen, 2002	32	1.60[c]	NA	0.68
Harvatine and Allen, 2003	8	3.00[b]	NA	-0.52
Weighted Means	—	1.88	-1.65	0.42
No. of cows in mean	—	83	39	64

[a] Data corrected for one cow that had low value. FFA and CaSFA comparison made at 680 g daily intake of each fat source. Digestibilities were 87.4 and 84.9% for CaSFAs and FFAs, respectively. The 910 g daily intake treatment for FFAs resulted in digestibility of 87.2%. Using marginal digestibility measurements from Grummer (1998), each 100 g additional fat intake should result in 2.8% lower digestibility. Using 910 g versus 680 g of FFAs, digestibility at 680 g should be greater than 90% [(910-680) = 230/100 = 2.3 x 2.8 = 6.44 + 87.2 = 93.64% digestibility at 680 g FFA intake]. However, the correction in Grummer's study was used in this Table.
NA indicates data not available in paper.
[b] $P < 0.05$.
[c] $P < 0.01$.

3. Effects of CaSFAs and saturated fats fed to lactating dairy cows on DMI, 4% FCM, milk components and bodyweight change; means are differences between control and CaSFA or saturated fats

Treatment	No. of cows	DMI, lb. per day	4% FCM, lb. per day	Fat, %	Protein, %	BW change, lb./day
CaSFA	404	-1.54[b]	1.98[a]	0.05	-0.10[b]	-0.07
Saturated fats	170	0.0	3.96[b]	0.05	-0.06[a]	0.12

[a] $P < 0.05$.
[b] $P < 0.01$.

4. Effects of CaSFAs and hydrogenated fat on DMI, expressed as percent DMI depression for each 1% added fat to the ration dry matter above control ration

Treatment	No. of means	DMI, % reduction	Significance
CaSFAs	28	-2.52	$P < 0.0001$
Hydrogenated fat	29	-0.26	$P = 0.57$

■ *Dr. L.C. Solorzano is with Milk Specialties Co., Dundee, Ill. Dr. A.F. Kertz is with ANDHIL LLC, St. Louis, Mo.*

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chemically altering them to be used in a dry form, thus providing dairy producers with a more functional physical form and facilitating on-farm handling.

PHT was the first generation of rumen inert fats. They are produced by hydrogenating tallow or vegetable fats to increase the melting point of the end product. Tallow or vegetable fats may contain as much as 85% unsaturated fatty acids prior to hydrogenation and as little as 15% after the hydrogenation process. The iodine value, which is an indicator of the degree of unsaturation, can vary from 14 to 31 (NRC, 2001).

Hydrogenation of tallow and vegetable fats reduces negative effects fatty acids have on rumen fermentation. However, the same process severely reduces the digestibility of the end product and its potential for value in lactating dairy cow rations (Weiss and Wyatt, 2004).

Elliott et al. (1994; 1999) found that resistance to ruminal and small intestinal lipolysis was a major factor contributing to the poor digestibility of highly saturated triglycerides contained in hydrogenated tallow.

CaSFAs were the second generation of rumen inert fats. Palm oil, soybean oil or other fat sources are hydrolyzed and reacted with calcium to form salts, which increases the melting point of the end product.

Fatty acids of calcium salts are stable in the rumen at pH greater than 6.5 (Sukhija and Palmquist, 1990). However, Enjalbert et al. (1994), Van Nevel and Demeyer (1996), Ferlay et al. (1993) and Wu et al. (1991) found that unsaturated fatty acids of CaSFAs are extensively hydrogenated in the rumen. This indicates that dissociation occurs when the pH drops below 6.5 after a meal or when manipulating pH *in vitro*.

These researchers observed that up to 57% of CaSFAs were, in fact, biohydrogenated. Since Hawke and Silcock (1969) found that a free carboxyl group of fatty acids is required for biohydrogenation to occur, CaSFAs have to dissociate prior to biohydrogenation. This indicates that CaSFAs may not be as rumen inert as previously thought and may be deleterious to rumen fermentation and possibly to DMI.

FFAS were the third generation of rumen inert fats. Rumen-inert FFAs are pre-hydrolyzed, mostly hydrogenated and purified during manufacturing. This form of rumen inert fat requires no further chemical modification by the cow prior to digestion.

FFAs usually have a lower melting

TABLES

5. Biohydrogenation (%) of unsaturated fatty acids in the rumen of cows fed CaSFAs at 3% of the ration dry matter

Fatty acid	0% CaSFAs added	3% CaSFAs added
C18:1	44.3	47.1
C18:2	72.9	67.3
C18:3	89.7	81.0
Total C18	67.3	58.3

6. Effects of abomasally infusing into lactating dairy cows 450 g of either PUFA or saturated fatty acids (SFA) on DMI, total fatty acid digestibility percent (TFADIG%) and DEI

	No. of	------DMI, lb./day------			------TFADIG, %-----			-----DEI, Mcal/day-----		
Author	cows	Control	SFA	PUFA	Control	SFA	PUFA	Control	SFA	PUFA
Drackley et al., 1992[a]	4	53.9*	55.2*	49.4*	69.6	70.5	77.8	66.5*	72.1*	63.9*
Christensen et al., 1994[b]	5	50.4	46.9	44.4	81.0	76.9	76.0	67.1*	68.7*	62.0*
Bremmer et al., 1998[c]	6	50.2^{x}	47.5^{x}	43.9^{y}	73.0	75.2	78.2	65.3^{x}	61.2^{x}	55.9^{y}
Weighted means	15	51.25	49.35	45.67	74.76	74.51	77.36	66.22	66.61	60.07

[a] DMI linear contrast $P < 0.02$; DEI linear contrast $P < 0.01$.
[b] DEI orthogonal contrast of SFA versus PUFA $P < 0.05$.
[c] Means with different superscripts within DMI or DEI differ by $P < 0.05$.

7. Effects of CaSFAs on DMI and milk production of lactating dairy cows

	-----------------------------% CaSFAs in DMI-----------------------------			
	0	3	6	9
Intake				
DMI, lb. per day	52.6	47.7	44.7	43.6
NE_L, MJ per day	152	153	142	139
Yield				
Milk, lb. per day	70.2	70.8	71.5	65.8
4% FCM, lb. per day	62.7	64.9	65.1	59.0
Milk fat, %	3.30	3.15	3.34	3.41
Milk protein, %	3.10	2.97	2.96	2.99

8. Effects of CaSFAs in diets on reproductive parameters of lactating dairy cows

		First service --conception rate, %--		--Pregnancy rate, %--	
Author	No. of cows	Control	CaSFAs	Control	CaSFAs
Schneider et al., 1988	108	43	60	NA	NA
Sklan et al., 1988	108	28	44	NA	NA
Carroll et al., 1990	46	33	75	57	30
Sklan et al., 1991	126	42	39	82	62[a]
Holter et al., 1992	58	35	44	83	79
Lucy et al., 1992	40	44	12[a]	NA	NA
Sklan et al., 1994	122	55	33[a]	75	61
Moallem et al., 1997	48	45	45	82	73
Garcia-Bojalil et al., 1998	45	33	46	52	86*
Weighted means	—	41	44	75	64

[a] $P < 0.05$.

9. Effects of mostly saturated dietary FFAs in diets on reproductive parameters of lactating dairy cows

	Control	500 g FFAs	P-level
No. of cows	138	115	—
Pregnant cows	119	107	—
Services per conception, pregnant cows	1.91	1.59[a]	< 0.05
Services per conception, all cows	1.96	1.57[a]	< 0.05
First service conception rate, %	42.6	59.1[a]	< 0.005
Overall conception rate, %	40.7	59.3[a]	< 0.005
Overall pregnancy rate, %	86.2	93.0	< 0.08
Days open	96.2	91.9	> 0.10

[a] FFA treatment significantly differs from control at indicated P-level.

10. Effects of prepartum FFAs fed to dry cows during last three weeks of gestation on reproductive measures

Parameter	No FFAs	200 g/day FFAs
Pregnancy rate, %	58[a]	86[a]
Days open	141[a]	110[a]
Conception rate, %	26[a]	40[a]

[a] $P < 0.05$.

point than PHT or CaSFAs and have the tendency to be less soluble in the rumen than fat supplements high in unsaturated fatty acids. FFAs also have few or no negative effects on ruminal fermentation compared to fat sources high in unsaturated fatty acids (Chalupa et al., 1984; Chan et al., 1997). They also have been shown to have minimal or no negative effects on DMI (Chilliard, 1993; Davis, 1993; Allen, 2000).

Due to the known and accepted negative effects of PHT on both digestibility and milk production (Elliott et al., 1994; 1999; Weiss and Wyatt, 2004), the remainder of this article will be devoted to comparing the other two rumen inert fats when used in lactating dairy cow rations.

Effects on milk production

Although many studies have been done with feeding rumen inert fats, only a few have directly compared feeding CaSFAs and FFAs. Table 1 reviews seven trials where these two rumen inert fats were directly compared.

As Table 1 shows, early trials used few cows to determine differences among treatments. Despite this, Grummer (1988) and Harvatine and Allen (2002) did observe a significant ($P < 0.01$ and 0.05, respectively) decrease in milk protein response for CaSFAs versus FFAs. Weighting means by number of cows for each study indicated a trend toward greater daily milk production, fat-corrected milk (FCM) production, milk fat percent and milk protein percent when FFAs were compared to CaSFAs.

Effects on DMI

Studies directly testing differences between FFAs and CaSFAs on DMI, fatty acid digestibility and bodyweight changes are shown in Table 2.

Data indicated that there was little difference in digestibility of fatty acids delivered by either CaSFAs or FFAs. The most pronounced difference between these two rumen inert fats was effect on DMI.

In the two most recent studies conducted by Harvatine and Allen and reported at the 2002 and 2003 joint American Dairy Science Assn. and American Society for Animal Science meetings, a significant ($P < 0.01$ and 0.05) DMI depression occurred when CaSFAs were compared to FFAs. Data also showed that in five of seven direct study comparisons, FFAs resulted in numerically greater DMI than CaSFAs.

TABLE

11. Effects of FFAs fed to prepartum cows on early ovulation and pregnancy rates during subsequent lactation

	---First ovulation prior to 50 days postpartum---		
Treatment	Cows observed pregnant	% cows pregnant	P-level
Control	14 of 21	66.6	—
200 g/day FFA	23 of 23*	100*	< 0.05

In 1993, Chilliard reviewed use of rumen inert fats and saturated fats in lactating cow rations (Table 3).

Data from this review are consistent with data in Table 2 in that DMI was significantly ($P < 0.01$ or 0.05) depressed by the addition of CaSFAs to lactating cow diets. Saturated fats also resulted in twice ($P < 0.01$) 4% FCM production than CaSFAs compared to controls.

Milk fat percentage was unaffected while milk protein percentage was negatively affected by both saturated fats ($P < 0.05$) and CaSFAs ($P < 0.05$) but less with saturated fats. Bodyweight change was not significantly affected by the addition of saturated fats or CaSFAs, but saturated fats had a numerical increase while CaSFAs had a negative numerical influence on bodyweight change. This logically follows since DMI was significantly depressed ($P < 0.01$) with CaSFAs in diets.

More recently, Allen (2000) extensively reviewed effects of fat supplementation on DMI (Table 4).

A regression equation involving 24 studies, where CaSFAs were fed and compared to controls, showed that for every 1% added CaSFA over the control, a 2.5% DMI depression was found. This finding is reiterated in the National Research Council (NRC) 2001 dairy nutrient recommendations on p. 31.

Allen (2000) also reported that in 11 out of 24 comparisons, CaSFAs significantly depressed DMI. Furthermore, 22 out of the 24 comparisons were numerically lower in DMI when CaSFAs were added to rations. Allen reported, “Although energy utilization is more efficient for digested fat than digested carbohydrate, it is clear that addition of fat to the diet does not always result in increased net energy intake and that reduction in DMI is one of the primary reasons.”

From these published data (Table 2) and the critical review papers published in the *Journal of Dairy Science* (Chilliard, 1993; Allen, 2000), it is evident that feeding lactating dairy cows CaSFAs, even at 0.50 lb. per day, can significantly depress DMI. Allen (2000) also noted that no effect of added fatty acids on DMI was observed for hydrogenated fat in 21 comparisons.

Based on these published journal articles and critical reviews, DMI depression due to the inclusion of CaSFAs in the rations of lactating cows is problematic. It is reasonable to assume that if a nutritionist or a dairy producer decided to replace 0.5 lb. of corn, or 0.45 Mcal of net energy, with 0.5 lb. of CaSFAs, or 1.085 Mcal of net energy, the difference should be 1.085-0.45 or 0.635 Mcal.

However, when a 2.5% reduction in DMI is factored in, the net effect is a reduction in total daily net energy intake. Assuming that a cow is consuming 50 lb. per day of dry matter and that the ration contains 0.78 Mcal net energy for lactation (NE_L), total daily NE_L intake would be 39 Mcal. If DMI is reduced 2.5%, or 0.98 Mcal, adding back NE_L from CaSFAs, or 0.635 Mcal, still leaves a deficit of 0.34 Mcal NE_L.

This is consistent with Chilliard’s (1993) review that a negative bodyweight change occurred when CaSFAs were included in the ration. Financial consequences can be calculated with current and local data.

Mode of action affecting DMI depression from feeding CaSFAs to lactating cows has been delineated in three primary areas: palatability, ruminal and gastrointestinal motility effects. Grummer et al. (1990) studied palatability effects of four different fat products (sodium-alginate encapsulated dry tallow, tallow, FFAs and CaSFAs) on two university and two commercial farms involving 209 lactating cows. Different fat products were fed alone, top dressed on the grain or included in the grain mix.

In all cases, FFAs were preferred to CaSFAs whether using qualitative or quantitative measurements. In addition, it was observed that cows improved intake of three fat products, but not of CaSFAs, when a seven-day period was allowed for adaptation. This observation was significant because it indicated a possible inhibitory mechanism beyond palatability or general adaptation that led to continued and prolonged DMI depression.

A second possible mode of action regarding DMI depression from use of CaSFAs is disruption of ruminal fermentation due to unsaturated fatty acid effects. Although CaSFAs were observed to be inert in the rumen in an *in vitro* trial (Sukhija and Palmquist, 1990), Wu et al. (1991) observed that unsaturated 18 carbon fatty acids in CaSFAs were 58% biohydrogenated *in vivo* (Table 5).

The authors noted that biohydrogenation could only occur after dissociation of the calcium salt. Hawke and Silcock (1969) had similar findings and concluded that a free carboxyl group of the fatty acid was required for biohydrogenation to proceed. Consequently, CaSFAs are not inert in the rumen. Therefore, negative effects of unsaturated fatty acids on rumen fermentation are probable.

Wu et al. (1991) also concluded that the percent of biohydrogenation increased as the level of unsaturation increased, as noted in Table 5. Negative effects of unsaturated fatty acids on fiber digestion and milk fat content are well recognized (NRC, 2001). However, since studies show only small differences in fiber digestion and milk fat content when CaSFAs are fed to lactating cows, this mode of action is probably not the major factor in DMI depression.

Interestingly, significant biohydrogenation of C18:1, C18:2, and C18:3 fatty acids results in higher levels of stearic acid reaching the duodenum regardless if the dietary source is CaSFAs or oilseeds or forages. Ruminal action largely converts these fatty acids to C18:0. This picture is further confused when applying non-ruminant fat digestion aspects to ruminants, particularly when downgrading digestibility of stearic versus palmitic or C18 unsaturated fatty acids.

Most recently, Bauman et al. (2003) noted that digestibility does not differ significantly between C16 and C18 saturated fatty acids and is lower for longer-chain saturated fatty acids compared to polyunsaturated fatty acids (PUFA). They further noted "that differences in digestibility among individual fatty acids contribute very little to the extensive variation (about 60-90%) in the digestibility of dietary lipids. Rather, the majority of this variation reflects differences among individual experiments and, thus, relates to differences in diets and specific feed components (Demeyer and Doreau, 1999)."

The third possible mode of action regarding DMI depression in cows fed CaSFAs is the effect on gastrointestinal motility. Drackley et al. (1992), Christensen et al. (1994) and Bremmer et al. (1998) conducted a number of experiments where they abomasally infused into lactating dairy cows 450 g per day of oils containing high levels of saturated fatty acids or unsaturated fatty acids (Table 6).

These data show an average DMI depression of 8% from abomasally infusing PUFA into lactating dairy cows. Reviews of Chilliard (1993) and Allen (2000) estimated a reduction of only 3.5-5.0% at this level of DMI. However, authors also concluded that DMI depression and the subsequent drop in digestible energy intake (DEI) was greater than the energy value of infused PUFA.

These three studies illustrated the most likely primary mode of action affecting DMI depression when feeding CaSFAs. As the level of PUFA flow increases into the small intestine, there appears to be a mechanism that triggers the satiety center to reduce DMI.

Woltman et al. (1995) found that duodenal infusion of oleic acid in rats reduced feed intake and that a portion of the effect was mediated through a gut hormone, cholecystokinin (CCK). Choi and Palmquist (1996) observed that feeding increasing levels of CaSFAs to lactating dairy cows decreased DMI linearly and increased concentrations of CCK. Table 7 illustrates data adapted from that study.

The authors concluded that feeding increasing amounts of dietary fat (CaSFAs) linearly decreased feed and energy intakes and linearly increased plasma CCK and pancreatic polypeptide concentrations in lactating cows. They suggested that decreased feed intake in cows fed CaSFAs was mediated by increased plasma CCK and pancreatic polypeptide concentrations.

Interestingly, even though DMI and net energy intake decreased, milk and 4% FCM production increased. The only logical reason for the increase in production would have been from mobilization of body fat stores. This study clearly indicated a physiological mechanism associated with DMI reduction due to CaSFA addition to lactating dairy cow diet and is in agreement with Allen's (2000) review. Drackley et al. (1992) also had suggested that degree of unsaturation of fatty acids reaching the small intestine of dairy cows could affect gastrointestinal motility and reduce DMI.

Given that DMI depression experienced when CaSFAs are fed is now well documented, the dilemma becomes how to meet early-lactation, high-producing dairy cows' energy requirements for milk production, reproduction and bodyweight gain.

A recent review (Grummer and Rastani, 2003) summarized time required after calving for lactating cows to reach positive energy balance and concluded that total energy intake was the key factor. They found energy intake was more highly correlated than FCM production with time postcalving for cows to reach positive energy balance. Energy intake is the product of energy density in the diet and DMI. If an increase in energy density is accompanied by a reduction in DMI, the level of energy intake is limited, which, in turn, limits the return to positive energy balance and/or reduces production response.

Effects on reproduction

Influence of rumen inert fat supplements on reproduction is not well understood and is a hot topic among nutritionists, reproductive physiologists and veterinarians.

Research feeding FFAs (Ferguson et al., 1990) and CaSFAs (Sklan et al., 1991) showed significant positive effects of rumen inert fat addition to lactating cow rations on services per conception, pregnancy rates and days open. However, Sklan et al. (1994), Moallem et al. (1997), Garcia-Bojalil et al. (1998) and Moallem et al. (1999) have all observed a combination of negative results, positive results and some contradictory results.

A review of nine studies with 701 cows (Table 8) found very few significant differences due to high variability in data. Thus, reproductive parameters require more observations to make meaningful statistical comparisons.

These data indicated few significant differences ($P < 0.05$) between treatments for either first service conception rate or pregnancy rate. Slight improvement in first service conception rate appeared from CaSFA treatments, but a larger numerical reduction was noted in overall pregnancy rate when CaSFAs were added to rations of high-producing, early-lactation cows in these studies.

There are fewer published studies comparing added FFAs to control diets with reproductive measurements. Ferguson et al. (1990) compared FFAs added at 500 g per day to control diets fed in three Pennsylvania herds and one Israeli herd (Table 9).

The authors generally concluded that

FFA addition to rations fed in these herds benefited reproduction by minimizing bodyweight loss and hastening bodyweight gain postpartum. Both of these effects have been shown to benefit conception rate.

Most recently, Frajblat and Butler (2003) reported reproductive responses when 81 dry cows were fed either 200 g FFAs or no FFAs during the last 21 days of the dry period (i.e., close-up cows). Cows were first bred postpartum beginning at day 55 and were bred by signs of standing heat until day 220 postpartum (Table 10).

The authors observed that close-up cows receiving 200 g per day of FFAs in their diets had higher ($P < 0.05$) pregnancy rates and conception rates and fewer ($P < 0.05$) days open. Additionally, cows exhibiting their first ovulation before 50 days postpartum were observed to be nearly twice as likely to become pregnant prior to 220 days postpartum than cows having their first ovulation after 50 days postpartum.

The authors also observed that cows fed 200 g FFAs in the close-up period and that had an ovulation prior to 50 days postpartum were even more likely to be pregnant at 220 days postpartum. Furthermore, cows losing less body condition score in early lactation were observed to have more ovulations prior to 50 days in milk (Table 11).

These results are the first to show a benefit when fat was fed to dry cows. A possible mechanism for this response may be derived from the work of Moallem et al. (1999). They observed that oleic and linoleic acids were found in lower concentrations in the non-esterified fatty acids (NEFA) fraction of follicular fluid in estradiol-active versus estradiol-inactive or estradiol-less active follicles as determined by follicular size.

A significant negative correlation coefficient between these unsaturated fatty acids and the estradiol concentration in follicular fluid suggested that preovulatory growth was accompanied by a decrease in these two fatty acids and an increase in the proportion of palmitic acid.

Stearic acid was numerically elevated by nearly 14% at the same time in NEFA fraction of follicular fluid of estradiol-active follicles over the inactive or less active follicles. Stearic acid in the phospholipid fraction of follicular fluid of estradiol-active follicles was significantly higher ($P < 0.05$) than the less active or inactive follicles (26.4 versus 23.6% of phospholipids).

FFAs fed in this study contained 47% stearic acid, 37% palmitic acid and only 15% oleic acid. This research may explain why CaSFAs, which are higher in oleic and linoleic acid compared to FFAs, have more variable results in reproductive trials.

Another potential factor is Grummer and Rastani's (2003) finding in their study that net energy intake is more highly correlated ($r = 0.58$, $P < 0.0001$) with time required to reach energy balance, and thus, cows may be in negative energy balance longer and lose more body condition when fed CaSFAs because of DMI depression.

Frajblat and Butler (2003) concluded that cows losing less body condition had more ovulations prior to 50 days in milk, and those cows with an ovulation before 50 days in milk were 2.4 times more likely to become pregnant before 220 days in milk.

Conclusions

Dry fat products are generally thought to be rumen inert and to have beneficial physical properties, particularly for on-farm use. PHT is limited primarily by its higher melting point, which reduces its digestibility and subsequent energy value to the dairy cow. FFAs and CaSFAs now have a considerable body of literature for comparison of effects when fed to lactating dairy cows.

This paper reviewed direct comparison studies of these two dry fat sources and found primary differences due to greater DMI and palatability of FFAs. This in turn has corresponding positive effects on energy balance, bodyweight change and reproductive performance with similar digestibility.

The mode of action for reduced DMI when using CaSFAs appears to be primarily due to negative effects of gastrointestinal motility, rumen function and palatability, in that order. Reduced DMI affects the amount and duration of negative energy balance in early lactation, subsequent milk production and reproduction and economic value.

REFERENCES

The extensive list of references may be found at www.feedstuffs.com or by contacting Tim Lundeen at tlundeen@feedstuffs.com. ■