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CONSULTANT'S DIGEST

Feeding High Levels of Linoleic Acid Depresses Intake and Milk Fat Production

Milk fat depression (MFD) in lactating cows has been researched heavily for the past 30 years or more with the emphasis placed on low fiber diets, finely cut forages, hot summer temperatures, and high starch and grain intake just to name a few. Recently, new published research has indicated that unsaturated fatty acid intake, particularly linoleic acid (C18:2), can severely affect milk fat production.

Linoleic Acid

Linoleic acid is an unsaturated fatty acid common in oil seeds such as soybeans, cotton seed, sunflower seed, distiller's grains and solubles, Ca-salts of palm fatty acids, and even tallow. The following table illustrates the linoleic acid content in plant oils.

Table 1.

Oil source	Soybean	Cottonseed	Linseed	Sunflower	DDGS	Ca-salts	Tallow	Corn
% Linoleic	54	54	16	68	58	10	1-12	58

As you can see, the linoleic acid content of the oil from common oil seeds and byproducts are moderate to high in their linoleic acid content. Even tallow from beef cattle fed high levels of DDGS and corn has been observed recently to contain up to 13% linoleic acid. Most ration balancer libraries show around 1% linoleic acid in tallow. Samples recently tested at Michigan State University showed C16:0=23%, C18:0=11%, C18:1=46%, C18:2=12.2%, C18:3=1.2%, other (all <1.0%) =6.6%. Ca-salts of palm fatty acids contain from 10-35% linoleic acid.

A common diet fed to lactating cows may contain 10 lbs of corn, 4 lbs of DDGS, 4 lbs of whole cottonseed, 0.5 lbs of tallow and 0.5 lbs of a Ca-salt on a dry matter basis plus forages and proteins, minerals and vitamins. This common diet would deliver nearly 450 g/h/d of linoleic acid to a lactating cow.

Linoleic acid is readily biohydrogenated in the rumen to an intermediate fatty acid known as conjugated linoleic acid (CLA) (Bauman et al Proc. Cornell Nutr Conf 2003).

Linoleic Acid > cis-9 trans-11 CLA (cis-9 trans-11 C18:2) > trans-11 Vaccenic Acid (trans-11 C18:1) > Stearic Acid (C18:0)

This CLA (cis-9 trans-11 C18:2) has been shown to have significant positive effects in humans. It is known to be one of the most potent naturally occurring anti-carcinogens. It also has also been shown to be antiatherogenic, antidiabetic and reported to improve immune modulation and bone mineralization, (Lock and Bauman Proc. Cornell Nutr. Conf. 2003). This CLA, which most people associate with human health benefits, can play a major role in human health and nutrition. The cis-9 trans-11 CLA has been shown to not cause MFD or milk fat synthesis in lactating cows in several studies (Perfield, et al 2007).

However, another partially biohydrogenated intermediate of C18:2, has been shown to cause MFD when over 5g/h/d is infused post ruminally. There as many as 200 possible intermediates of ruminal biohydrogenation of C18:2. But the form which has been found to be most potent and prevalent in MFD is trans-10 cis-12 C18:2. Harvatine, et al 2009 found that trans-10 cis 12 CLA infused post ruminally at 7.5 g/d per day caused severe MFD, while Perfield, et al. 2007 found trans-9 cis-11 caused similar responses in lactating cows when 5g/h/d was infused in a similar manner. The following table adapted from Scollan, et al. 2001 shows the degree of biohydrogenation measured in common oils and a Ca-salt of palm fatty acid distillate.

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Table 2. Biohydrogenation of Ca-salts of Palm Fatty Acid Distillate (PFAD), linseed oil, and fish oil in the rumen.

Biohydrogenation %	Ca-salts of PFAD	Whole Linseed	Fish Oil	Avg
Oleic	75	75	67	73
Linoleic	87	91	92	90
Linolenic	89	95	95	93
Total C:18	83	90	90	88
EPA	--	--	92	92
DHA	--	--	91	91

*Adapted from Scollan et al 2001

It is easy to see that unsaturated fatty acids are readily biohydrogenated by rumen bacteria. This study also shows that Ca-salts are not rumen inert by-pass fats since over 80% of their total C18 unsaturated fatty acids are converted to other C18 fatty acids intermediates, even to stearic acid, the fatty acid cows' system is designed to provide for milk fat synthesis. Even the reproductive formulas of Ca-salts have significant problems since the EPA and DHA content in them are over 90% biohydrogenated, similar to it's linoleic acid fraction.

Now that we have discovered that research trials show that linoleic acid is transformed by biohydrogenation, and that one of the intermediate compounds, trans-10 cis-12 C18:2, is the most potent and prevalent result of this process, the next table illustrates the effects of this particular biohydrogenation intermediate of C18:2 on MFD in lactating cows through a meta-analysis of 14 different published studies.

Table 3. The effects of post ruminal infusion of trans-10 cis-12 C18:2 on MFD and fatty acid metabolism, a meta-analysis of 14 published studies.

VARIABLE	CONTROL	TREATMENT trans-10 cis-12 C18:2	P VALUE
DM INTAKE LB/DAY	48.0	44.7	<0.001
NE INTAKE MJ/DAY	140	130	<0.001
MILK LB/DAY	57.2	56.3	0.38
MILK FAT %	3.36	2.17	<0.001
MILK PROTEIN %	3.01	3.04	0.160

*Adapted from Harvatine et al 2009

Harvatine et al 2009 also observed a short-term response to energy spared during MFD and the gene expression changes in adipose tissue suggesting increased lipid deposition in this tissue. This would indicate that energy intake was being partitioned away from milk and milk fat production when 7.5 g/d of trans-10 cis-12 C18:2 was infused post ruminally. It was being directed towards adipose tissue deposition.

These research results indicate that feeding high levels of linoleic acid by feeding corn, corn silage, DDGS, whole cottonseed, roasted or whole soybeans, and Ca-salts can lead to reduced dry matter intake, severely reduced milk fat, and changes in metabolism in lactating cows throughout their lactation. It also indicates that linoleic acid is the primary culprit in reducing milk fat production from feeding unsaturated fatty acids that result in trans-10 cis-12 C18:2 accumulation.

Dairymen and nutrition consultants should take stock of their byproduct feed fat composition and discover their linoleic acid intake, particularly in early lactation when the cows metabolism is in high gear. Cut back on the linoleic acid sources and use Energy Booster 100 or Energy Booster H to deliver the saturated fatty acids that cows prefer.

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