UNSATURATED FATTY ACIDS - THE RUMEN AND BEYOND

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DIETARY FATS DEFINED.

Diets for lactating dairy cows usually contain fats as supplied by forages, concentrates, oil seeds, and/or concentrated animal (tallow and grease) and vegetable fats. The ether extract procedure is normally used as a laboratory measure of the fat portion of a feed. However, a feedstuff's ether extract concentration is often an overestimate of its fatty acid content. The ether extract procedure removes fatty acids as well as other ether-extractable compounds such as waxes (plant cuticle), pigments such as chlorophyll, and essential oils. These nonfatty acid compounds have little nutritive value for the cow. Fatty acids made up only 40, 65, and 90% of the ether extract fraction of alfalfa hay, corn, and soybean seeds, respectively (Palmquist and Jenkins, 1980). A gas chromatograph is needed to measure the true fatty acid content of a feedstuff which most commercial labs don't employ.

Dietary fats can be grouped into triglycerides, glycolipids (galactolipids), and phospholipids. These groups consist of a glycerol molecule with fatty acids bound to it. Triglycerides have a fatty acid attached to each of the three carbons of the glycerol molecule and are a storage form of fat, found mainly in seeds (concentrate feedstuffs). The glycolipids and phospholipids are diglycerides having a fatty acid attached to only the first two carbons of the glycerol molecule and a galactose or a phosphorus-based molecule attached to the third carbon, respectively. The diglycerides are found mainly in plant leaves and are metabolically important to the plant.

Individual fatty acids are classified according to 1) the number of carbons in the carbon chain, 2) the number of double bonds present between carbons, and 3) the configuration of the fatty acid around the double bond (cis or trans). Saturated fatty acids do not have double bonds in the acyl chain. Fatty acids with one double bond in the carbon chain are called monounsaturated fatty acids (MUFA) and those with two or more are called polyunsaturated fatty acids (PUFA). Table 1 lists the major fatty acids typically found in selected feedstuffs for dairy cows. The short-hand notation for identifying fatty acids is to give the number of carbons and double bonds in the molecule. For example, a designation of 18:2 indicates a fatty acid of 18 carbons long having 2 double bonds.

Dietary fats are normally rich in eighteen-carbon fatty acids (stearic [18:0], oleic [18:1], linoleic [18:2], and linolenic [18:3]). Forage fats typically contain high concentrations of linolenic acid and linoleic acid whereas seed oils are rich in linoleic acid and oleic acid. Rendered fats contain more palmitic (16:0) and stearic acids. Fish oils are unique in that they have relatively high concentrations of fatty acids which are quite long and very highly unsaturated, namely eicosapentaenoic (EPA, 20:5) and

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docosahexaenoic (DHA, 22:6).

TABLE 1. Typical fatty acid (FA) composition of some feedstuffs (Coppock and Wilks, 1991; Harfoot and Hazelwood, 1988; Van Soest, 1994).

	Feedstuff								
	Cotton-seeds	Soy-beans	Mixed grass	Corn	Distil. grains	Beef Tallow	Yellow grease	Menhaden fish oil	Ca salt of palm oil
% FA	18.6	18.0	2.5	3.2	10.5	100	100	100	82
Fatty acid	% of fatty acids								
C14:0	0.8	T	3.3	T	–	3.0	0.9	8.8	2.1
C16:0	25.3	10.7	9.4	16.3	15.6	25.8	24.4	21.6	60.5
C16:1	–	T	3.0	T	–	6.1	6.5	12.2	0.1
C18:0	2.8	3.9	1.5	2.6	2.7	18.8	10.6	3.3	4.7
C18:1	17.1	22.8	13.2	30.9	24.2	39.7	38.4	10.6	29.4
C18:2	53.2	50.8	20 - 25	47.8	54.5	4.5	19.3	1.7	3.3
C18:3	T	6.8	30 - 39	2.3	1.8	1.0	–	1.9	–
C20:5	–	–	–		–	–	–	11.6	–
C22:6	–	–	–		–	–	–	6.6	–

Unsaturated fatty acids found in plant fats and most of those found in animal fats are in the cis-isomeric configuration (cis-fatty acids). Trans-fatty acids are products of bacterial or artificial biohydrogenation of fatty acids. The structure of fatty acids, that is, the length of the carbon chain, the number of double bonds in the chain, and the type of isomers (cis- or trans-) formed by each double bond largely determines their biological function.

FAT METABOLISM IN THE RUMEN.

Extensive modification of dietary fats takes place in the rumen. Lipolytic anaerobic bacteria secrete enzymes (lipases) which rapidly hydrolyze fats to release the fatty acids and galactose from their glycerol molecule. The glycerol and galactose that are liberated are fermented by the bacteria to volatile fatty acids. The bacteria, however, are unable to utilize fatty acids for energy because they are highly reduced compounds. Nevertheless, bacteria can and do incorporate fatty acids into their cytoplasm as free fatty acids and into their cell membranes as phospholipids (Bauchart et al., 1990). These authors reported that the total lipid content of ruminal bacteria adhering to ruminal digesta increased from 9.0 to 21.4% when lactating dairy cows were changed from diets of 0 to 8.7% soybean oil and increased from 10.5 to 20.6% when changed from 0 to 9.8% tallow diets.

After the bacteria have hydrolyzed the dietary fats, the fatty acids are neutralized

by the addition of calcium or magnesium. These have a low solubility in rumen fluid so they adhere to digesta and ruminal microorganisms.

Once hydrolysis has occurred, unsaturated fatty acids can be further metabolized via biohydrogenation and isomerization by ruminal bacteria. Protozoa only play a minor role. Biohydrogenation is attained through the addition of a hydrogen ion at the point of the double bond. Hydrogenation will result in the conversion of unsaturated fatty acids into their saturated counterparts. For example, most of the unsaturated fatty acids which have eighteen (18:3, 18:2, and 18:1) or sixteen (16:1) carbons will be converted to stearic acid (18:0) and palmitic acid (16:0), respectively. Bacterial biohydrogenation of PUFA involves sequential steps of hydrogenation and isomerization. Isomerization is the change of the orientation of the fatty acid molecule around a double bond, converting the native cis–isomers into trans-isomers. Isomerization also can change the location of the double bonds in the carbon chain. Figure 1 depicts the pathway of biohydrogenation of two eighteen-carbon fatty acids: linoleic and linolenic.

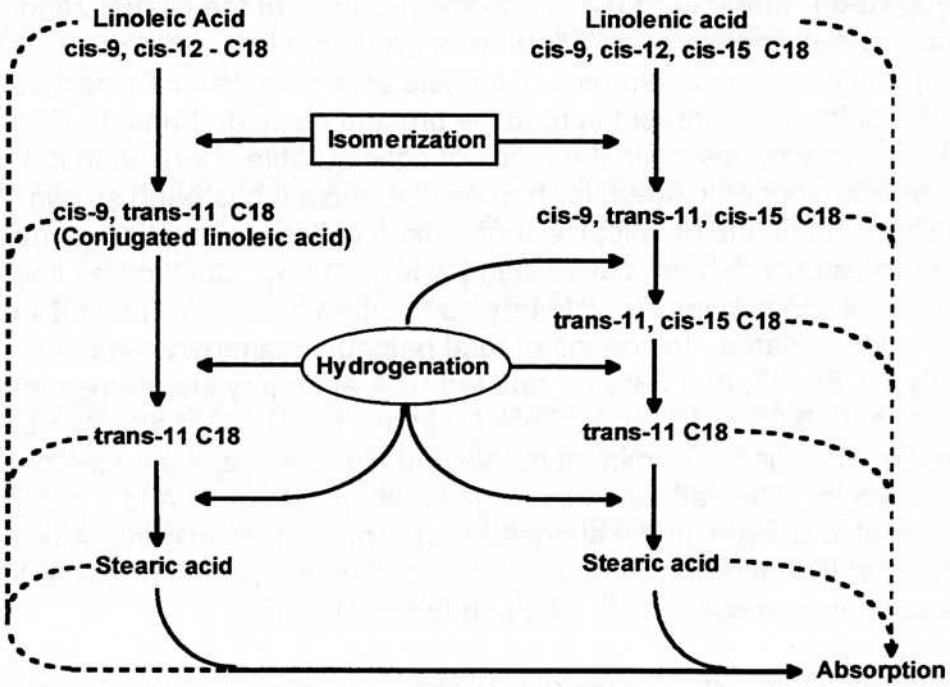


Figure 1. Schematic pathway of isomerization and hydrogenation of linoleic and linolenic acids to stearic acid. The isomerization step changes the position of the double bond from position 12 to position 11 and changes its configuration from cis- to trans-. Trans-fatty acids are subsequently hydrogenated and converted to stearic acid. Since the process of biohydrogenation is not 100% complete for all PUFA, some linoleic acid, linolenic acid, and intermediate products such as conjugated linoleic acid and trans-11 C18:1 reach the duodenum and are absorbed (indicated by dotted lines).

The reason for biohydrogenation is not fully known. It has been suggested that it serves to detoxify unsaturated fatty acids that are toxic to many microbes (Harfoot and Hazelwood, 1988). The more toxic unsaturated fatty acids, linoleic and linolenic, are biohydrogenated more quickly than the MUFA, oleic acid (18:1).

A certain proportion of unsaturated fatty acids do not undergo complete biohydrogenation prior to passage to the duodenum. These partially unsaturated fatty acids are normally in the trans- configuration because they have undergone at least one step of isomerization. Trans- fatty acids are more resistant to further biohydrogenation than the cis- forms. Ruminants therefore have a constant supply of trans- fatty acids leaving the rumen which are absorbed and incorporated into tissues and milk. The conversion of trans-11 C18:1 to stearic acid is thought to be the rate-limiting step to complete biohydrogenation (Polan et al., 1964).

Two intermediate fatty acids in the biohydrogenation process have received considerable attention recently because of their potentially unique impact on milk fat and its impact on human health.

Conjugated linoleic acid (CLA). Some products of the isomerization of PUFA are called conjugated linoleic acid. They are a group of eight positional (e.g 9,11; 10,12; 11,13) and geometrical isomers of linoleic acid, with distinct bioactive properties. Most (80-90%) of the CLA present in foods is present as cis-9, trans-11 CLA. Conjugated linoleic acid has been the focus of considerable attention in the past few years as an anticarcinogenic agent for humans because it has been shown experimentally to inhibit the development of tumors in tissues such as rat mammary gland, mouse forestomach, and mouse skin (Belury, 1995). Conjugated linoleic acid appears to be protective at very low dietary concentrations (0.05%) and it's effect appears to be dose related. Incidence of total palpable mammary tumors in rats were approximately 73, 58, 47, and 38% for rats fed CLA at dietary supplementation concentrations of 0, 0.05, 0.10, and 0.25% (Ip et al., 1994). CLA also has been labeled as antiatherogenetic agent. Ruminant meats and milk are major sources of CLA for human consumption. The estimated average consumption of CLA is 1 g/d for adults, below the estimated 3.5 g/d intake suggested as a protective amount. A recent epidemiological study involving >2300 middle-aged men reported a lowered incidence of heart disease for men consuming milk and butter (Table 2).

Considerable interest in increasing concentrations of CLA in milk has emerged. Concentrations of CLA often vary 7-fold among cows, from ~0.25 to 1.8% of milk fat (Kelly and Bauman, 1996; Jiang et al., 1996). The CLA content of milk can be increased by supplementing diets with unsaturated fats. The CLA content of the milk fat increased from 0.35 to 1.98% as cows were switched from being supplemented with a saturated fat (Energy Booster 100® at 3.6% of diet) to an unsaturated fat (corn oil at 4% of diet) (Griinari et al., 1998). McGuire et al. (1996) demonstrated that concentration of CLA in milk fat increased in a dose response fashion as dietary linoleic acid intake increased. Different sources of PUFA can influence milk fat CLA

Table 2. Relationship of intake of whole milk and butter to heart disease. Study funded by United Kingdom Medical Research Council, (Elwood et al., 1991).[1]

Milk intake	Number of men	Men that experienced a major heart disease event
None	162	16 (9.9%)
< ½ pint	1104	70 (6.3%)
½ to 1 pint	973	56 (5.8%)
> 1 pint	164	2 (1.2%)
Type of fat used on bread		
Butter	1380	73 (5.3%)
Polyunsaturated margarine	250	24 (9.6%)

[1]Intake of food recorded daily for 10 years for men 45 to 59 years old at the start of the study.

differently. Calcium salts of soybean oil and linseed oil increased milk fat CLA ~6-fold whereas that of canola oil elevated CLA only 3.7-fold above a control diet (0.35% CLA) (Chouinard et al., 1998). It is interesting that feeding 200 ml of Menhaden fish oil daily, a oil source that typically contains very little linoleic acid, also increased milk fat CLA from 0.6 to 1.7% (Chouinard et al., 1998). Changing the grain to forage proportion in the diet from 50:50 to 65:35 also has increased the CLA concentration in the milk fat (from 0.5 to 1.1%; Jiang et al., 1996).

The formation of CLA may not be limited to the rumen. Normally the mammary gland desaturates stearic acid at the 9th carbon to increase the MUFA content (cis-11 18:1) of milk fat. Corl et al. (1998) demonstrated that the mammary gland also may synthesize CLA from trans 18:1. Cows abomasally infused with a mixture of trans-11 and -12 18:1 had milk fat CLA elevated by 55% on the third day of infusion.

Trans-fatty acids (TFA). Another intermediate product of biohydrogenation is trans 18:1. Trans-11 18-1 is the main TFA found in food; however, as with CLA, there are many forms of 18:1 produced naturally. Various forms of trans-11 are created by hydrogenation of PUFA of vegetable oils by the margarine industry. Some TFA have been linked to high plasma cholesterol and coronary heart disease in humans but TFA in dairy products have not been one of them (Willet et al., 1993).

Formation of TFA has been linked to milk fat depression in the cow. However a specific TFA, trans-10 18:1, may have the most negative association. The greatest milk fat depression was observed in cows fed a low fiber diet containing corn oil, the same diet that resulted in the greatest concentration of trans-10 18:1 in the milk fat (Griinari et al., 1998) (Table 3). If diets can be modified to allow cows to produce milk of a low fat content while maintaining good rumen health, a milk product could be produced that better fits the current consumer demand.

Table 3. Effect of fat source and proportion of dietary concentrate on milk fat measurements. Effects of fat source, dietary concentrate, and fat source by dietary concentrate interaction were $P < 0.10$.

Measurement	HF[1] + SFA[2]	HF + UFA[3]	LF[4] + SFA	LF + UFA
% milk fat	3.58	3.36	3.33	2.49
All trans 18:1, % of fatty acids	1.33	6.23	1.38	5.88
trans-10 18:1, % of fatty acids	0.33	0.70	0.42	2.90
trans-11 18:1, % of fatty acids	0.63	4.53	0.57	2.52
CLA, % of fatty acids	0.35	1.98	0.33	1.10

[1] HF = high forage diet; 50% forage:50% concentrate.
[2] SFA = saturated fatty acid (Energy Booster 100® at 3.6% of diet DM).
[3] UFA = unsaturated fatty acid (corn oil at 4% of diet DM).
[4] LF = low forage diet; 35% forage:65% concentrate.

Effect of fat on ruminal fermentation. Fat supplementation can disrupt microbial fermentation. The addition of fatty acids to pure cultures of bacteria has reduced bacterial growth and metabolism. Gram positive bacteria appear to be more sensitive than gram negative bacteria. The growth of bacterial species that degrade cellulose, *Butyrivibrio fibrosolvens*, *Ruminococcus albus*, and *R. flavefaciens*, were inhibited by fatty acid addition to the medium, with the greatest inhibition caused by the unsaturated fatty acid, oleic acid (Table 4). It's been proposed that these bacteria may be more sensitive to lipids because the permeability of their cell membranes can be altered as they take up lipid from their environment, which reduce's the cell's ability to regulate intracellular pH and interferes with nutrient uptake. Other bacteria may prevent lipids from penetrating the lipopolysaccharide layer of their outer membrane (Nagaraja et al., 1996).

The antimicrobial effect of fat can be reduced by the addition of fiber to pure culture media. This effect may result because the fat adsorbs to the fiber particles rather than to the bacteria (Harfoot et al., 1974). This attachment of fat to bacteria and fiber in the rumen has resulted sometimes in a lowering of fiber digestion in the rumen. Ruminal NDF digestion deceased from 48.9 to 43.8% when an animal-vegetable blend was fed at 5% of diet DM. Whether this is due to the fat adsorbing to the fiber-digesting bacteria and having a toxic effect or the fat coating the fiber to prevent digestion is unknown. The NDF digestion decreased even further (36.9%) when the soybean hulls in the diets were replaced with corn (Pantoja et al., 1994). The soybean hulls may have provided more surface area for fat to attach to it rather than to bacteria and thus reduced fat's toxic effect on the bacteria. The occasional decreased fiber digestion in the rumen of cows fed fat often shifts more of the fiber digestion to the lower gut. The potentially digestible fiber which escapes ruminal digestion often is fermented postruminally, resulting in little change in total tract digestion of fiber (Pantoja et al., 1994). The negative impact of dietary fatty acids on bacteria are minimized if the carboxyl end is not exposed. Calcium soaps of tallow did not have the

Table 4. Effect of fatty acids in media on growth of pure cultures of some ruminant bacteria (Nagaraja et al., 1996.

Organism (strain)	Fatty acid (0.001%)		
	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)
Butyrivibrio fibrosolvens (H10b)	81	95	67
Ruminococcus albus (7)	90	100	15
R. flavefaciens (B34b)	88	89	0
Fibrobacter succinogenes (S85)	101	100	101
Selenomonas ruminantium (GA 192)	94	91	127

negative effect on ruminal fiber digestion as did tallow fed at 9% of diet DM (Jenkins and Palmquist, 1984).

As with bacteria, ciliated protozoa in the rumen may be inhibited by dietary fat. The proportion of cows that were defaunated increased as the dietary concentration of tallow increased in the diet from 0 to 8% of DM (Towne et al., 1991).

If fat feeding has a negative impact on fiber digestion, a shift in volatile fatty acid proportions can be observed. The molar proportion of propionate can be increased under these conditions. Propionate concentration in vitro increased as corn oil and tallow were individually added from 0 to 10% of the hay substrate with corn oil having the greater effect (Jenkins, 1987). The production of methane can be reduced as well.

A review of 6 to14 treatment comparisons involving lactating dairy cows indicated that digestion of organic matter in the rumen was about 2.6 percentage units lower in cows fed supplemental fat (average of 4.5% added fat). However efficiency of microbial protein synthesis (g of bacterial N per kg of ruminally fermented organic matter) was apparently enhanced using fat supplemented diets (Erdman, 1995). This improvement has been attributed to 1) reduced numbers of protozoa in the rumen caused by fat supplementation and thus less recycling of bacterial nitrogen occurs and 2) direct incorporation of dietary fatty acids by bacteria thus improved efficiency of use of fermented energy.

POLYUNSATURATED FATTY ACIDS ESCAPE BIOHYDROGENATION

In addition to the passage of CLA and TFA to the lower gut for metabolism, fatty acids of dietary origin may escape biohydrogenation and be absorbed in the small intestine in significant amounts. These absorbed PUFA may be important nutrients for improving conception of lactating dairy cows (Staples et al., 1998). As stated earlier, bacteria can incorporate into their cells those fatty acids consumed by the cow and then carry these fatty acids out of the rumen as they are washed out. The lipid content of bacteria associated with the rumen digesta reflected the fatty acid profile of the fat source consumed by lactating dairy cows (Bauchart et al. 1990). When soybean oil

was fed, the proportion of 18:2 increased 98% in the diet (from 25 to 50%) and 141% in the bacteria (from 5.6 to 13.5%). When cows were fed palmitostearin, the proportion of 16:0 increased about 140% in both the diet and the bacteria (Table 5). Much of this fatty acid was located in the cytoplasm of the bacteria. Therefore ruminal bacterial may play a key role in delivering unsaturated fatty acids to the small intestine for absorption.

Table 5. Fatty acid (FA) profile of diet and digesta-adhered bacteria from lactating dairy cows fed soybean oil (8.7%) or palmitostearin (PS; 9.4%) (Bauchart et al. 1990)

	Fatty acid profile of diets			Fatty acid profile of bacteria[1]		
Fatty acid	Control[2]	Soybean oil	PS	Control	Soybean oil	PS
	------ % of total fatty acid ------			------ % of total fatty acid ------		
14:0	1.2	6.1	0.8	1.1[a]	0.4[b]	1.0[a]
16:0	19.9	12.1	48.5	18.8[a]	12.3[b]	44.2[c]
18:0	2.6	3.7	4.6	39.8[a]	24.3[b]	26.0[b]
18:1	12.6	18.8	24.4	15.1[a]	33.2[b]	13.3[a]
18:2	25.3	50.0	12.3	5.6[a]	13.5[b]	3.8[c]
18:3	28.4	13.0	4.8	3.7[a]	4.0[a]	2.0[b]
FA, % of diet or of bacteria DM	1.6	8.9	9.6	9.0	21.4	16.8

[1]Rumen fluid sampled for bacteria at 0, 2, 4, and 6 h after feeding.
[2]Diet of 50% grass hay and 50% concentrate (beet pulp, barley, soybean meal, rapeseed meal).

Extent of biohydrogenation of C18 unsaturated fatty acids has been measured for some fat sources. Biohydrogenation was between 75 and 85% for diets containing 18% whole cottonseeds (Pires et al., 1997), between 52 and 60% for diets of 19.7% soybeans (Tice et al., 1994), 70 to 74% for diets of 3 to 6% animal-vegetable blends (Wu et al, 1991), 68% for diets of 0 to 6% tallow (Weisbherg et al., 1992), and 67 to70% for diets with no supplemental fat (Klusmeyer and Clark, 1991). Based on these studies, it is reasonable to expect that between 60 and 85% of C18 unsaturated fats to be biohydrogenated, allowing 15 to 40% to flow to the small intestine for absorption.

The unique fatty acids in fish oil, 20:5 and 22:6, are thought to be largely resistant to microbial changes (Ashes et al., 1992; Palmquist and Kinsey, 1994) although Wachira et al. (1998) reported a biohydrogenation of 60% for these two fatty acids when fish oil (6% of diet) was fed to duodenally cannulated sheep consuming a dried grass diet.

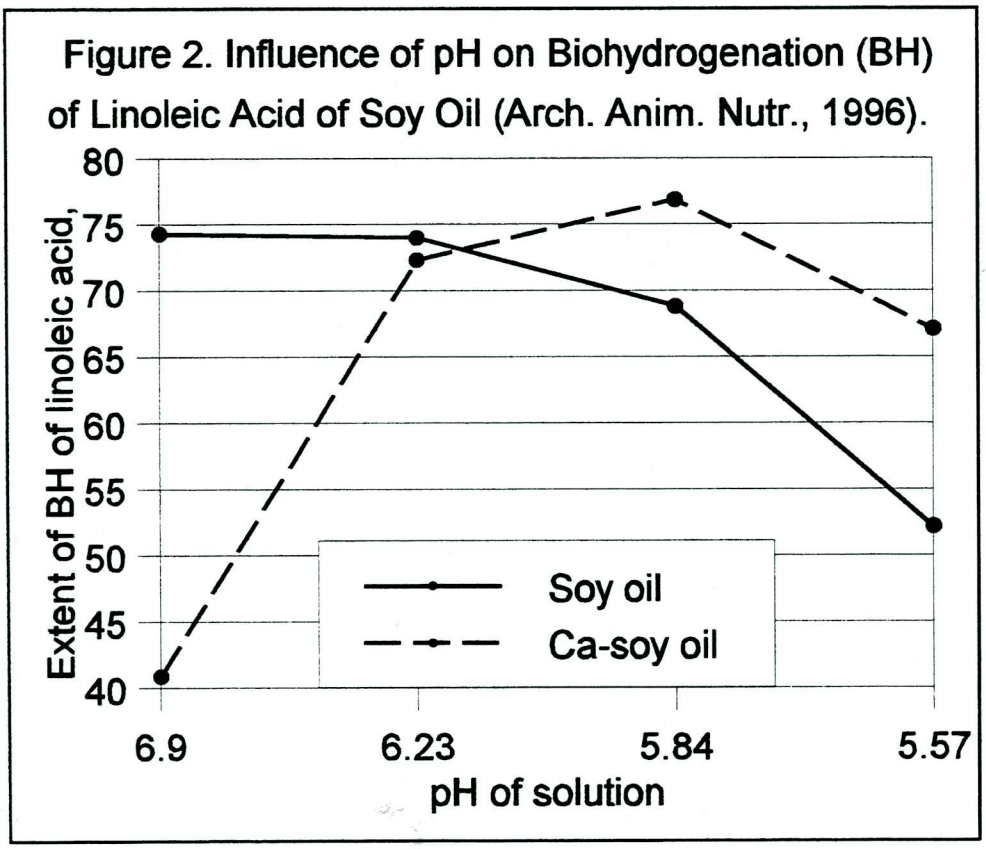
Feeding a fat in the calcium soap form does provide partial protection from biohydrogenation. Biohydrogenation of the calcium salt of palm oil (Megalac®) was calculated to be 33 and 57% by Klusmeyer and Clark (1991) and Wu et al. (1991)

respectively.

All unsaturated fats are not bio-hydrogenated to the same extent. As the degree of unsaturation of the fatty acid increases, the extent of biohydrogenation increases. Extent of biohydrogenation of an animal-vegetable blend averaged 65% for C18:1, 77% for C18:2, and 84% for C18:3 (Wu et al., 1991). The fatty acids that are potentially more detrimental to microbial growth are preferentially biohydrogenated. Extent of biohydrogenation of C18:1, C18:2, and C18:3 of calcium salts of palm oil was 46, ~65, and ~83%, respectively (Wu et al., 1991; Ferlay et al., 1992).

Extent of biohydrogenation of unsaturated fatty acids is pH sensitive. The biohydrogenation of linoleic acid in soy oil decreased as in vitro pH dropped from 6.8 to 5.5 (Van Nevel and Demeyer, 1996) (Figure 2). Lower biohydrogenation at lower pH is thought to be due mainly to a reduction in lipolysis, the necessary step prior to biohydrogenation. The relationship of ruminal pH and degree of biohydrogenation is the reverse for calcium soaps of unsaturated fatty acids; that is, the more acidic the pH, the greater the dissociation of the calcium from the fat leading to increased bio-hydrogenation (Figure 2).

The ruminal pH of the lactating cow in the early postpartum period can often be < 6.2, suggesting that calcium soaps of linoleic acid are extensively biohydrogenated. The inclusion of a buffer such as sodium bicarbonate will likely be helpful to reduce the biohydrogenation of linoleic acid in the soap form as it modulates ruminal pH. Feeding bicarbonates with a calcium soap of canola oil resulted in a greater concentration of linoleic acid in milk fat compared to



protected canola oil alone (2.72 vs. 2.19%) (Chouinard et al., 1997).

In spite of partial biohydrogenation, the feeding of calcium soaps of Megalac® (8% linoleic acid) can result in increased concentrations of linoleic acid in milk fat. Concentration of linoleic acid was increased from 3.2 to 3.5% of milk fatty acids when Megalac® was fed at 0 or 3.4% of dietary DM (Dhiman et al., 1995) and from 4.2 to 5.3% when cows were fed diets of 0 or 3.2% Megalac® (Holter et al., 1992). These increased concentrations of linoleic acid in milk fat of cows fed Megalac® suggest that a portion of the linoleic acid escaping biohydrogenation is taken up by the mammary gland. Uptake by the mammary gland of additional linoleic acid suggests that other tissues such as the uterus may take up additional linoleic acid and may account for improved fertility of cows fed Megalac® (Staples et al., 1998).

Other commonly used fat sources are good sources of linoleic acid and can change the milk fat profile. Feeding soybeans has doubled the linoleic acid content of milk fat (Dhiman et al., 1995; Tice et al., 1994) as soybeans contain > 10% linoleic acid. Whole cottonseeds (Holter et al., 1992; Harrison et al., 1995) and crushed canola seeds (Aldrich et al., 1997) have not changed milk linoleic acid content. The processing of whole seeds also can influence their biohydrogenation. Roasting of soybeans lowered biohydrogenation in the rumen compared to raw soybeans (Reddy et al., 1994; Tice et al., 1994). This was likely due to a slower release of oil from the roasted bean.

Further alterations in the way lactating dairy cows are fed may allow greater delivery of unsaturated fatty acids to the lower gut. Feeding select antimicrobials such as ionophores (FDA approval pending for feeding to lactating dairy cows) along with supplemental unsaturated fats, may decrease cleavage of glycerol from the triacylglycerol molecule by ruminal bacteria, thus allowing greater delivery of linoleic acid to the small intestine for absorption (Van Nevel and Demeyer, 1995). Reacting butylamine with soybean oil to produce butylsoyamide resulted in a ruminally inert fatty acid mixture which increased linoleic acid concentration in plasma and milk compared to untreated soybean oil when fed to lactating dairy cows (Jenkins et al., 1996). Treating whole canola seeds with alkaline hydrogen peroxide increased the delivery of PUFA postruminally of beef steers (Hussein et al., 1996).

SUMMARY

Saturated and unsaturated long chain fatty acids are consumed in the tri- and diglyceride forms in feedstuffs. They makeup a relatively small portion of the diet (~2 to 7% of dietary DM). Although they are not used for energy by the ruminal micro-organisms, the unsaturated fatty acids are subject to extensive biohydrogenation and isomerization by the ruminal bacteria. Some of the intermediate products of this process appear to have very important bioactive properties for people and animal. Consuming conjugated linoleic acid (cis-9, trans-11 C18:2) found in dairy products should have anticarcinogenic and antiatherogenetic properties in humans. The formation of trans-10 and trans-11 C18:1 may greatly suppress fat % of the cow's milk.

Fat feeding may increase the export of these compounds from the rumen. If fed in higher amounts, fat may suppress fiber digestion in the rumen, shift the volatile fatty acid production toward propionic acid, reduce rumen ammonia concentrations, and improve efficiency of microbial protein synthesis by affecting microbial growth. Conversion of unsaturated to saturated fatty acids is not 100% efficient. Unsaturated fatty acids can appear in the small intestine for absorption when absorbed by ruminal bacteria. Some feeding conditions which favor increased passage of polyunsaturated fatty acids (PUFA) to the lower gut include high grain diets, whole soybeans, ionophores, and treating dietary PUFA with chemicals such as calcium, butylamine, or alkaline hydrogen peroxide.

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