linseed *in the Ruminant Diet*

BACKGROUND INFORMATION ON KEY FATS IN MILK AND BEEF

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Introduction

Consumers want foods with the good taste and health benefits of flax, and food processors have worked to meet their demand, adding flax to traditional and hearth breads, muffins, bagels, hot and cold cereals, energy bars, pizza, pasta, smoothies and meatless vegan meals.[1] Food producers have picked up on the trend, adding flax (often referred to as linseed) to livestock rations, the aim being to increase the content of healthy fats in eggs, meat, poultry and dairy products. Adding linseed to the rations of ruminants like cattle improves the fat profile of milk and beef. Consumers who buy these value-added products can increase their intake of healthy fats. The fats of interest are certain polyunsaturated fats and saturated fats, which are reviewed below.

Polyunsaturated Fatty Acids

Polyunsaturated fatty acids are those with two or more double bonds in their carbon backbone; they have many vital roles in human health. Dairy and beef producers are interested in increasing the content of two polyunsaturated fats in milk and beef products – namely, alpha-linolenic acid (ALA) and conjugated linoleic acid (CLA) – because these fats are important in human nutrition.

Alpha-linolenic Acid (ALA)

ALA is the true essential omega-3 fatty acid, being required in the human diet because our bodies do not make it. In other words, ALA is essential in human nutrition just like vitamin C and calcium.[2]

ALA has several biologic effects:[3]

a. It is required for maintaining a healthy nervous system.

b. It is the most plentiful fatty acid in human breast milk, constituting 75-80% of total omega-3 fatty acids.

c. It is converted to long-chain omega-3 fatty acids like eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and docosahexaenoic acid (DHA).

d. It helps dampen inflammatory reactions, regulate the heart beat and reduce the risk of coronary heart disease.

e. It is used for energy and stored in adipose tissue for future needs.

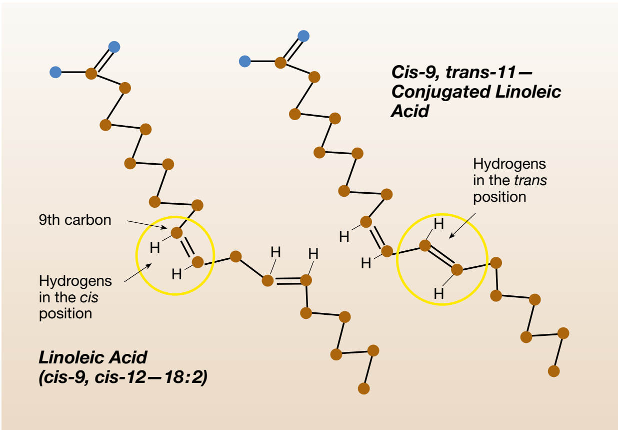
Conjugated Linoleic Acid (CLA)

CLA is a collective term for a group of isomers of linoleic acid, the essential omega-6 fatty acid. These isomers have conjugated unsaturated double bonds in various positions. Conjugated double bonds are ones that alternate with single bonds along the fatty acid backbone. In Figure 1 below,[4] note that linoleic acid, shown on the left, has two single bonds between the double bonds, whereas CLA isomers such as *cis*-9, *trans*-11-CLA (c9,t11-CLA), shown on the right, has only one single bond between the double bonds, thus making it a conjugated fatty acid. There is another important difference between linoleic acid and CLA. Whereas the two double bonds in linoleic acid both carry hydrogen molecules in the *cis* position (*cis* means "on the same side"), conjugated CLA isomers have two double bonds that can exist in either the *cis* or the *trans* form ("*trans*" means "on the opposite side"). The two biologically active CLA isomers studied most intensely to date are c9,t11-CLA and *trans*-10, *cis*-12-CLA (t10,c12-CLA).

CLA is an intermediate in the biohydrogenation of linoleic acid in the rumen. Biohydrogenation is a process whereby microorganisms in the rumen transform the polyunsaturated fatty acids found in animal feed into saturated fatty acids. The rumen is the first of four compartments of the stomach in ruminant animals; it is much like a large fermentation vat in which dietary material undergoes a variety of chemical changes by rumen microorganisms such as bacteria, protozoa and fungi.[5,6]

FIGURE 1

Chemical Structure of Linoleic Acid and c9,t11-CLA[4] *(Used with permission of Dr. Catherine Field, University of Alberta)*



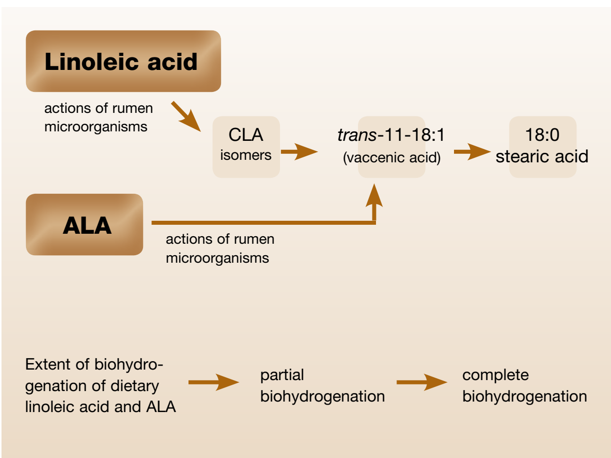
A general scheme describing the rumen biohydrogenation of linoleic acid and ALA is shown in Figure 2. In the case of linoleic acid, rumen microorganisms convert the fatty acid to CLA – mainly c9,t11-CLA – then to *trans*-11-18:1 or vaccenic acid, as it is sometimes called, and finally to the saturated fatty acid stearic acid (18:0). In the case of ALA and the other omega-3 fatty acids, very little is known about the types of fatty acids arising from their biohydrogenation. Most studies show that ALA is transformed into a nonconjugated *trans* fatty acid, which is converted to vaccenic acid and then to stearic acid.[5] Vaccenic acid is converted to c9,t11-CLA in humans, thus supporting ALA's role in increasing the CLA content of tissues.[7]

The formation of stearic acid represents complete biohydrogenation of the dietary fatty acid.[8] The extent of biohydrogenation of dietary fatty acids is influenced by rumen pH, the species of microorganisms present in the rumen, and the activity of bacterial enzymes.[5] Some CLA and vaccenic acid escape complete biohydrogenation to stearic acid in the rumen and are absorbed into the bloodstream. Most CLA is synthesized in body tissues from vaccenic acid by the action of the enzyme Δ^9-desaturase.[9]

FIGURE 2

Transformation of Dietary Linoleic Acid and Alpha-Linolenic Acid (ALA) in the Rumen

(Adapted from Jenkins TC, et al.[5])



Benefits of CLA for animals. CLA has been described as a potent cancer preventive agent in animals.[10] Indeed, mixtures of CLA isomers containing mainly c9,t11-CLA and t10,c12-CLA have been shown to inhibit the initiation, promotion, progression and metastasis of malignant tumours in animals.[11] CLA also enhances growth in young rodents, reduces atherosclerosis in rabbits and hamsters, alters immune cell function in rodents and chickens and reduces body fat gain in several animal species.[12]

Benefits of CLA for humans. In humans, an anticancer effect of CLA has not been established because the study findings have been inconsistent.[11,13-16] Nonetheless, CLA appears to improve blood lipids and insulin resistance in humans.[17,18] In one clinical study involving 23 overweight women and men,[19] a mixture of CLA isomers increased fat oxidation and energy expenditure during sleep. This finding may help explain the results of a meta-analysis of 18 clinical studies which concluded that CLA provided as a dietary supplement had a modest effect in reducing fat mass.[18] The t10,c12-CLA isomer appears to be the bioactive isomer that affects body composition and reduces body fat in animals[12] and humans.[20]

Saturated Fatty Acids

Saturated fatty acids have no double bonds. For this reason, they are less susceptible to oxidation and rancidity than unsaturated fats are. Saturated fatty acids are most often linked with an elevated blood cholesterol, specifically LDL-cholesterol, the so-called bad cholesterol. The saturated fatty acids noted for raising blood cholesterol are those of medium-chain length containing between 12 and 16 carbons: lauric acid (12:0), myristic acid (14:0) and palmitic acid (16:0). (The chemical notation 16:0, for example, denotes a fatty acid with 16 carbons and zero double bonds.) Stearic acid (18:0) is the exception; it does not appear to raise blood cholesterol. However, on a practical basis, it is difficult to separate the effects of stearic acid from those of other saturated fats, because they all tend to occur together in the same foods. (The major sources of saturated fats in the human diet are meat, poultry, milk, yogurt, cheese, eggs, and some vegetable fats and oils like coconut and palm oils.[21])

Good Reasons for Adding Linseed to Ruminant Diets

Milk and beef products derived from cattle fed linseed are enriched with ALA and CLA and contain less saturated fat. Furthermore, the complete biohydrogenation of ALA yields stearic acid, a saturated fat that does not adversely affect blood lipids. These enhancements increase the nutritive and potential therapeutic value of milk and beef.

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