

# Lipid Feeding and Milk Fat Depression

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## KEYWORDS

- Dietary lipids • Rumen • Biohydrogenation • Milk fat depression
- Conjugated linoleic acid

## KEY POINTS

- Diets fed to cattle contain mostly unsaturated fatty acids supplied in grains and forages, by-products, and fat supplements.
- Lipid intake by dairy cattle must be restricted to prevent alterations of microbial populations in the rumen that can negatively affect the yield of milk and components.
- Unsaturated fatty acids consumed by cattle are extensively metabolized by microorganisms in the rumen in a process called biohydrogenation, yielding stearic acid as the end product plus a multitude of bioactive intermediates.
- Intermediates of biohydrogenation include a variety of conjugated linoleic acid (CLA) and *trans*-monoenoic acid isomers. Production of bioactive CLA isomers by rumen microorganisms is controlled by interactions among several dietary risk factors.
- Three specific CLA intermediates of biohydrogenation have been shown to cause milk fat depression in dairy cattle through coordinated suppression of mammary lipogenic genes by a transcription factor that is a central regulator of lipid synthesis.

## FEED LIPIDS

### *Key Definitions and Nomenclature*

- **Ether extract:** The fraction of feed extracted by organic solvents that includes nonlipid contaminants (such as pigments, water, and sugars), non-glycerol-based lipids (such as alkanes and waxes), and glycerol-based lipids (such as triglycerides, glycolipids, and phospholipids).
- **Fatty acids:** Chains of carbons that end in an acid or carboxyl group. In cereal grains and forages, the predominant fatty acids vary in length from 12 to 18 carbons.

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- Fatty acid abbreviations: Because of the large number of fatty acids found in plant and body tissues, it is often difficult to remember all their names. It is common to simply refer to a fatty acid by the abbreviation “# carbons:# double bonds.”
- Saturated fatty acids: Have no double bonds in the fatty acyl chain, such as C16:0 (palmitic acid) or C18:0 (stearic acid).
- Monounsaturated fatty acids: Have a single double bond somewhere in the fatty acyl chain, such as C16:1 (palmitoleic acid) or C18:1 (oleic acid).
- Polyunsaturated fatty acids (PUFA): Have more than 1 double bond in the fatty acyl chain, such as C18:2 (linoleic acid) or C18:3 (linolenic acid).

### Lipid Components

Lipids are generally defined as organic compounds that are relatively insoluble in water but soluble in organic solvents.<sup>1</sup> A simple classification divides lipids into glycerol-based and non-glycerol-based components. Nonglycerol lipids include waxes and cutin, which provide an indigestible, impervious barrier on the exterior plant surface to reduce water loss and provide protection against plant pathogens and toxins. Surface lipids also inhibit plant digestion by ruminants because they limit bacterial penetration into the inner plant structures where most of the digestible nutrients are located. Disruption of this barrier by chewing or processing (eg, grinding or chopping) greatly increases bacterial access and rates of nutrient digestion.

The glycerol-based lipids contain fatty acids bound to a glycerol backbone. The value of fats and oils as animal feed ingredients is based on their fatty acid content and fatty acid composition. Content refers to the total concentration (% dry matter [DM]) of fatty acids in a lipid supplement, and composition (% total fatty acids) refers to the mixture of individual fatty acids that make up the lipid supplement. The most important glycerol-based lipids found in animal feed include triglycerides, phospholipids, and galactolipids (Table 1).

### Fatty Acids

Fatty acids are chains of carbons that end in an acid group, or carboxyl group as it is referred to in biochemistry. An example of a common fatty acid is stearic acid, with 18 carbons and no double bonds. Fatty acids, such as stearic acid, are referred to as saturated because all the carbons are holding the maximum number of hydrogens possible, so the fatty acid is “saturated” with hydrogen. Stearic acid is low in plant oils but is present in higher amounts in animal fats, particularly in fats obtained from ruminant species such as beef tallow.

Oleic acid and linoleic acid are examples of unsaturated fatty acids containing 1 or more double bonds (Fig. 1). Oleic acid has a single double bond between carbons 9 and 10, and is referred to as a monounsaturated fatty acid. Linoleic acid is a PUFA

**Table 1**  
Glycerol-based lipids in animal feed ingredients

Lipid	Components	Source	Fatty Acids (g/100 g) <sup>a</sup>
Triglyceride	Glycerol, 3 FA <sup>b</sup>	Cereal seeds	95
Galactolipids	Glycerol, 2 FA, sugar	Forages	56
Phospholipids	Glycerol, 2 FA, P, N	Plant membrane lipids	72 <sup>c</sup>

<sup>a</sup> Calculated for a pure compound containing only oleic acid.

<sup>b</sup> Fatty acids.

<sup>c</sup> Assuming the phospholipid consisted only of lecithin or phosphatidylcholine.

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