linseed in the Ruminant Diet

ADDING LINSEED TO FEED ENHANCES THE FAT PROFILE OF BEEF

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Summary

Feeding beef cattle a ration containing whole flax seeds (linseeds), flax (linseed) oil, rolled linseed or milled linseed increases the alpha-linolenic acid (ALA) and conjugated linoleic acid (CLA) content and decreases the omega-6/omega-3 ratio, but has little effect on the saturated fat content of beef. Adding linseed to feedlot diets has been shown to increase the internal fat of heifers and the U.S. Department of Agriculture yield grades. These enhancements to the fat profile of beef give consumers value-added foods with acceptable sensory qualities and a healthy fat profile.

Glossary of Flax (Linseed) Terms

Flax – a term used in clinical research and the consumer marketplace to describe the oilseed rich in omega-3 fat, dietary fibre and lignans.

Linseed – the term for flax used in the feed industry and also by researchers carrying out animal studies.

Linseed meal or linseed cake – the protein- and fibre-rich material that remains after flax seeds are pressed to express the oil.

Linseed oil – obtained by crushing flax seeds; linseed oil is rich in fat, particularly omega-3 fat, but it contains virtually no dietary fibre, protein or lignans.

Rolled linseed – obtained by processing whole seeds to reduce their size; in one study rolled linseed had a particle size of 1300 μm compared with milled linseed, which had a particle size of 700 μm.[3]

Introduction

Food processors continue to think of innovative ways of adding flax to their food products. Consumers now enjoy traditional and hearth breads, muffins, bagels and cereals, as well as energy bars, pizza, smoothies and meatless vegan meals, all made with added flax.[1] On the livestock side, primary producers add 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, thus making additional omega-3–enriched foods available for health-conscious consumers.

Adding linseed to the rations of steers improves the fat profile of beef. Most research in ruminant nutrition in North America has been undertaken on cattle, although studies have also shown beneficial effects of linseed on the fat profile of lamb meat.[2]

The Challenge of Changing the Fatty Acid Profile of Beef

The fact that ruminants digest their food in stages presents challenges for cattle producers, the main one being the process of biohydrogenation – the chemical reactions whereby microorganisms in the rumen transform the polyunsaturated fatty acids found in animal feed into saturated fatty acids. Ingested feed first enters the rumen, a digestive compartment that works much like a fermentation vat (see box page 2). The ingested dietary fats undergo many chemical changes carried out by bacteria, protozoa and fungi.[4] However, rumen bacteria cannot break down dietary fatty acids. To enrich beef with polyunsaturated fatty acids like alpha-linolenic acid (ALA), the essential omega-3 fatty acid, and its long-chain metabolites, eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and docosahexaenoic acid (DHA), the dietary supply of these fatty acids must be protected from rumen biohydrogenation. Various methods of interfering with the bacterial metabolism of long-chain fatty acids in cattle and sheep have been tried, including the following:[4]

- Feeding whole linseeds with their seed coat intact to slow the release of fatty acids in the rumen and protect against their oxidation;[5] and
- Protecting seeds by encapsulating them in formaldehyde-treated protein.[2]

Ruminants Are Different from Humans!

Ruminant animals have four stomach-like compartments for digesting grasses and other vegetation, whereas humans, chickens and pigs have only one. In ruminants, ingested material enters the rumen, where the digestive process begins. The material mixes with rumen contents and is acted on by rumen microbes. Another rumen compartment, the reticulum, helps in the formation of boli – lumps of partially digested material commonly called "cud" – which are regurgitated and chewed slowly to break down the particle size. After the boli are reswallowed, they are further fermented in the rumen before passing into the omasum – a trap which blocks large particles from exiting. They then travel into the abomasum and finally into the small intestine.[6]

These approaches have proven successful in protecting polyunsaturated fatty acids from biohydrogenation in the rumen. The methods have achieved favourable changes in the fatty acid content of beef, as described in the sections below.

Dietary Linseed Enhances the Fat Profile of Beef

Beef is widely recognized as a good source of high-quality protein, vitamin B_{12} and zinc in the human diet. Beef also contains some nutrients such as cholesterol and saturated fats that are undesirable when consumed in excess amounts.[7] The ALA content of beef ranges from a low of about 5 mg in a beef hamburger to 172 mg in a 3-oz. serving of chuck roast.[8] The CLA content of beef ranges from 2.9 to 4.3 mg CLA/g of fat.[9] This section describes the effects of adding linseed to the rations of feedlot cattle on the ALA and CLA content, the omega-6/omega-3 fat ratio and the saturated fat content of beef muscle. Adding linseed to feedlot diets has been shown to increase the internal fat of heifers and also the U.S. Department of Agriculture (USDA) yield grades, which increased from 2.9 in the control group to 3.2 in the flax-fed groups.[3]

Increasing ALA Content

Adding whole linseed, rolled linseed (particle size of 1300 μm) or milled linseed (particle size of 700 μm) to the rations of yearling beef heifers resulted in greater proportions of ALA, EPA, DPA and DHA in the longissimus lumborum muscle than in the muscle of control animals. As a result, heifers fed linseed had significantly greater total omega-3 fats in muscle than those fed the control ration. A sensory panel rated steaks from the linseed groups as equal in tenderness and flavour but lower in juiciness compared with steaks from the control group.[3]

Similar increases in omega-3 fat content were reported by Mach and coworkers,[5] who found that adding whole linseed to the rations of Holstein bulls at three supplement levels (5%, 8% and 11% of diet dry matter) significantly increased the ALA and total omega-3 fat content of meat compared with meat from bulls fed a ration with added whole canola seed. The linseed treatments had no notable effects on meat quality. In contrast, a sensory panel evaluating steaks derived from Angus steers fed diets containing steam-flaked corn or dry-rolled corn, with or without added tallow, or steam-flaked corn plus milled linseed reported a more pronounced off-flavor in steaks from steers fed linseed, even though the overall juiciness, tenderness and flavor intensity did not differ among the diets. The corn + linseed diet increased the ALA content of ribeye steaks in this study.[10]

Noci and colleagues[11] randomized heifers to one of three dietary regimens: grazing on pasture, grazing plus a ration with added sunflower oil (high in omega-6 fats), or grazing plus a ration with added linseed oil (high in omega-3 fats). Heifers fed the linseed oil ration had consistently higher concentrations of ALA in muscle fat and adipose tissue compared with the sunflower oil ration. The level of total omega-3 fats was generally higher in heifers fed the linseed oil ration compared with the sunflower oil ration.

Decreasing the Omega-6/Omega-3 Ratio

In a study of Holstein bulls fed rations containing whole linseed or whole canola seed at three concentrations (5%, 8% or 11% of diet dry matter), the omega-6/omega-3 ratio was significantly lower in bulls fed linseed, decreasing the ratio by roughly half at each supplement concentration.[5] When whole, rolled or milled linseed was added to feedlot rations, the omega-6/omega-3 ratio in the muscle phospholipids of heifers decreased significantly from 5.85:1 to less than 4.1:1.[3] In heifers, the omega-6/omega-3 ratio was significantly lower after feeding a linseed oil ration compared with a sunflower oil ration.[11]

Benefits of Reducing the Omega-6/Omega-3 Ratio

Human diets rich in omega-6 fats result in a high omega-6/omega-3 ratio. A high dietary omega-6/omega-3 ratio is linked with low-grade chronic inflammation that contributes to diseases such as Alzheimer disease, cancer, coronary heart disease, metabolic syndrome, obesity, type 2 diabetes, osteoporosis and even dry eye syndrome.[12] Reducing the omega-6/omega-3 ratio helps decrease inflammatory reactions and lowers the risk of chronic disease. A dietary ratio between 4:1 and 10:1 is recommended.[13,14] Improving the ratio can be achieved by eating less omega-6 fats, eating more omega-3 fats or doing both. Buying milk and meat products with a low omega-6/omega-3 ratio helps improve the dietary mix of fatty acids in the human diet.

Increasing CLA Content

The concentration of *cis*-9, *trans*-11-CLA (c9,t11-CLA) in beef muscle was significantly greater in Holstein bulls fed whole linseed at three dietary levels (5%, 8% and 11% of diet dry matter) compared with those fed whole canola seed. Bulls fed whole linseed experienced increases in CLA of 23-35% in muscle.[5] In a study in grazing heifers, the c9,t11-CLA content of beef muscle, expressed as a proportion of total lipids in muscle fat, was 73% greater in heifers allowed to graze on pasture plus a linseed oil supplement compared with those grazed on pasture alone. Linseed oil was not as effective as sunflower oil in increasing the c9,t11-CLA content of muscle fat in this study. The t10,c12-CLA content of muscle fat from heifers fed linseed oil was greater than that obtained from heifers fed sunflower oil but did not differ from that obtained from heifers grazed on pasture alone.[11]

No Effect on Saturated Fat Content

With few exceptions, adding whole linseed,[3,5] rolled or milled linseed[3] or linseed oil[11] to the rations of steers did not affect the saturated fat content of beef muscle. However, in a study of Holstein bulls,[5] the proportion and content of caprylic acid (8:0) and the content of lauric acid (12:0) in muscle were greater in bulls fed whole linseed than in bulls fed whole canola seed in their rations.

Good Reasons for Adding Linseed to the Diets of Steers

Adding linseed to the rations of beef cattle increases the content of two polyunsaturated fatty acids – specifically, ALA and CLA – and decreases the omega-6/omega-3 ratio in beef. The saturated fat content of beef is largely unaffected by supplementing the ration with linseed. Consumers who eat beef obtain more dietary ALA and CLA and less omega-6 fats from these enhancements.

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