Influence of dietary fats and oils on animal product quality

Julian Wiseman and Phil Garnsworthy

Much attention has been paid to the deliberate modification of the composition of vegetable oils for a variety of purposes, e.g., human health benefits and improved quality of food products. But comparable studies on animal fats have been limited.

Dietary and genetic manipulations of the fat and fatty acid contents of animal tissues do not always produce favorable results. The following discussion considers the fat and fatty acid contents of animal products using pig meat and bovine milk as examples. In addition, modifications to the fatty acid profile through both genetic and dietary routes are considered.

Pig meat

The traditional assessment of pig meat quality has been based on the depth of subcutaneous fat at specific points along the back of the carcass. The “P2” measurement is commonly used, and levels below 12 mm are required for top-grade carcasses (down from around 17 mm in the United Kingdom in the early 1980s), which have been achieved through genetic selection and improved nutrition. It is unlikely that further reductions will be recorded, as they would be accompanied by reduced intramuscular fat (which has a positive influence on the juiciness of meat) and unsightly separation of lean from fat tissue.

More recently, assessments of carcass quality for pig meat have included appearance (color, drip loss, separation of fat from lean), organoleptic parameters (taste, flavor, texture; these are more qualitative than quantitative), shelf life of products, microbiological safety, and production methods (“welfare-friendly meat,”—which dietary raw materials are allowed).

There is increasing interest in the nutritional value of meat to the consumer. Much official advice is available. One example is the United Kingdom’s Committee on Medical Aspects (COMA) report (1991) on Dietary Reference Values (DRVs), which recommends that dietary fat should not be more than one-third of energy intake and that saturated fat should not be more than one-third of total fat intake. In addition, the ratio of monounsaturated (MUFA) to polyunsaturated fatty acids (PUFA) should be 2:1, and the ratio of PUFA n-6 (e.g., linoleic acid)/n-3 (e.g., linolenic acid) should be 5:1. Fatty acids present in the adipose tissue of animals may be derived from two discrete sources: de novo synthesis or directly from the diet. Fatty acid profiles are relatively easy to modify through nutritional routes: Our data demonstrate that the majority of changes take place within 5 weeks of a dietary change.

Although increased unsaturation of carcass fatty acids may be of nutritional benefit, there are possible problems including in vivo oxidation within the animal (giving rise to metabolic problems), more unstable meat (fresh and cooked), and greater risk of the generation of volatiles through oxidation, which would adversely influence both smell and taste. Thus, increasing the levels of linolenic acid in meat has been associated with abnormal flavors and odors. Both oxidative processes (in the animals and within meat) may be reduced in the presence of high levels of vitamin E. Processing of softer meat (i.e., higher levels of PUFA) is more difficult.

Assessments of deterioration in meat quality have been based on the TBA (thiobarbituric acid) number (a measure of lipid peroxidation); figures below around 1 are normally regarded as acceptable. Although an industry standard, TBA does have limitations. A more recent approach has been the evaluation of volatile products generated during storage and cooking that may influence flavor and/or aroma. A very large number of volatiles are generated. Figure 1 presents a gas chromatography–mass spectrometry (GC–MS) trace of the contents of the headspace (air above the product), showing some of these volatiles.

A recent program conducted in our laboratories at Nottingham, and reported by Darling and coworkers in 1998, evaluated headspace volatiles produced from meat derived from animals fed a high-PUFA diet with (offering a degree of protection against oxidation) or without vitamin E. Data indicated that the concentrations of those volatiles associated with off-odor

Figure 1. Typical headspace profile of raw pork (day 10 at 4°C). Int. std., internal standard.

Figure 2. Conjugated linoleic acid isomers.
and off-flavor (2-pentylfuran, 2-nonenal, 2,4-decadienal) were higher in the latter group.

Bearing in mind the ease with which the fatty acid profiles of pig (and, indeed, poultry, another nonruminant) meat may be altered through dietary means, the key question is whether the nutritional advantages outweigh the possible problems. One issue that requires consideration is whether the fat in pig meat is in fact saturated, which is in fact a popular but inaccurate myth. Thus, the fatty acids in “normal” pig fat are only 40% saturated, and lean only around 36%. Increasing the α-linolenic acid content of pig meat is perceived to be a healthy option as it is a precursor for the very important long-chain PUFA that are essential for humans. However, the efficiency of conversion of α-linolenic (C18:3) to eicosapentaenoic acid (C20:5—one of the intermediates in the metabolic chain to the longer-chain PUFA) is only 0.2%, so this is not an acceptable means of providing these fatty acids. It could be argued that a more useful means of promoting the consumption of pig meat is to emphasize its already healthy fatty acid profile, which can be supplemented by eating oily fish (which do contain very high levels of the long-chain essential PUFA). The debate continues.

**Bovine milk**

Milk is another animal product that has a negative image. Milk consumption has been linked to coronary heart disease (CHD)—although the current weight of evidence suggests that regular milk intake is either neutral or beneficial for CHD—and to cancer. Although 35% of cancer deaths are attributable to diet, many studies suggest milk and dairy products are beneficial against a number of cancers, with certain components in milk having been shown to be anticarcinogenic. Fat can be removed from milk during processing so that it is, in fact, low-fat or even fat-free.

It is more difficult to modify the fatty acid profiles of dairy fat through dietary means because the reducing conditions in the rumen of the cow saturate the unsaturated fatty acids present in the diet. In addition, because the fat will be softer, it will have benefits on the spreadability of butter from the refrigerator, which in some countries is a major technological issue.

One fatty acid group that has received considerable recent attention is conjugated linoleic acid (CLA); the commoner isomers are presented in Figure 2. CLA is found naturally in bovine meat and milk. A number of possible health benefits are associated with increased CLA intake including reduced incidence of cancer, arteriosclerosis, type II diabetes, and body fat. Enhancement of the immune system and bone mineralization has also been claimed. Although many of the biomedical studies to date have used animal models, human epidemiological work is consistent with a role for CLA in cancer prevention. Currently, the adult human intake of CLA is one-fourth to one-third of that which is effective in animal models. Thus, the value of CLA would be to improve human health and the nutritious value of dairy products, with a potential for greater economic benefits to the dairy producer and an improved public perception of dairy products.

The metabolism of CLA is presented in Figure 3. In the rumen, linoleic acid (cis-9,cis-12 18:2) is saturated to form stearic acid; however, the cis-9,trans-11 CLA intermediary may be absorbed and incorporated into milk fat in the mammary gland. Vaccenic acid (trans-11-octadecenoic acid (18:1)) may also be desaturated in the mammary gland to cis-9,trans-11 CLA.

Alteration of CLA content in milk through dietary means is possible through changing rumen fermentation patterns (e.g., feeding on lush pasture and high forage) or feeding unsaturated fatty acids in processed plant seeds and plant oils. An additional 2.4 g CLA per cow per day was achieved by Andy Lock and Phil Garnsworthy at the University of Nottingham (Animal Science 74:163–176, 2002) through feeding a diet containing soybeans high in linoleic acid and linseed oil high in linolenic acid.

A further interesting development is the possibility that there may be variability in Δ9-desaturase activity (the enzyme in the mammary gland that desaturates vaccenic acid), suggesting a genetic component. Heritability is currently being determined at Nottingham through examining a structured population of cows, being 100 daughters from each of 100 bulls (n = 10,000). Results will allow identification of bulls that could enhance CLA production in their daughters.

**The future**

Modifications to fatty acid profiles of meat and milk are possible. The benefits are improved nutritional value and greater public perception of quality, which one would hope will increase consumption of these healthy products. There are, however, risks associated with such modifications including keeping quality of the product (meat) and whether there will be a market for these differentiated products.

**Background reading**


![Julian Wiseman](image)