Forages, fat, fitness and flavour

Richard Dewhurst and Nigel Scollan

Fatty acids in grasses

Fatty acids in grass silage

Fatty acids and beef

Effects of fatty acids on meat appearance and flavour

FORAGES, FAT, FITNESS AND FLAVOUR

Richard Dewhurst and Nigel Scollan

Figure 6.1 A selection of familiar ruminant products.

Amongst the conflicting "evidence" about diet and health with which consumers are bombarded, ruminant products (milk, butter, cheese, beef and lamb, see Figure 6.1) have been criticised for the possible adverse effects of their saturated fatty acids on human health. As a result, methods of altering the fatty acid composition of these products are of great interest. The Department of Health has recommend an increase in the intake of unsaturated fatty acids, and in particular the omega-3 polyunsaturated fatty acids (PUFA) found in fish oils (Figure 6.2) because they are thought to be beneficial to human health, especially in reducing the risks of coronary heart disease. Green plants are the primary source of omega-3 fatty acids. Fish, which derive their omega-3 fatty acids from marine plankton, are used extensively in concentrated animal feeds, but forage plants would represent a more natural and environmentally sustainable source of these fatty acids. At IGER, we have investigated the potential to exploit this source of omega-3 fatty acids. Fresh grass contains a high proportion (50-75%) of total fatty acids as the omega-3 (α-linolenic acid (C18:3 n-3) and this varies with plant factors such as stage of maturity and light treatments. Earlier studies have shown that a small, but useful, amount of forage (α-linolenic acid is absorbed in the animal's digestive tract and appears in ruminant products.

Fatty acids in grasses

We have looked at the changes in fatty acid levels in a range of grass species and varieties at different times of year (November 1995, July 1996, August

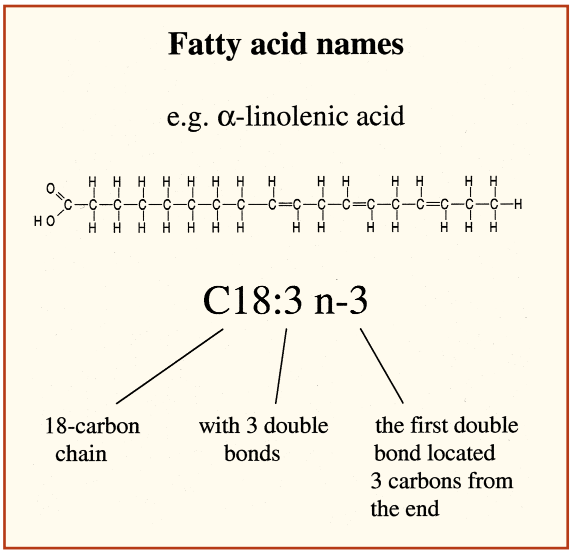

Figure 6.2 Fatty acids are described as "saturated" (containing no double bonds between carbon atoms) or "polyunsaturated fatty acids - PUFA" (containing more than one double bond). The position of double bonds in fatty acids affects the way that they work. The structure and simplified formula for (α-linolenic acid is shown as an example of the system used in this article.

1996), under a simulated (9-cut) grazing regime (Figure 6.3). In some cases, the amount of (α-linolenic acid in grasses varied considerably between the different cutting times. In vegetative grass (November 1995), (α-linolenic acid levels were highest with Italian Ryegrass and Hybrid Ryegrass (about 15 g/kg DM), intermediate with Perennial Ryegrass and lowest with Fescues, Timothy and Cocksfoot. However, the opposite trend was found during the following summer. There was much less variability in the contents of (α-linolenic acid at different cutting dates within the other species. We think that these variations may be related to the ability of the different species to flower under the cutting regime used.

There are approximately 10 major fatty acids in grasses. These can be used to define fatty acid

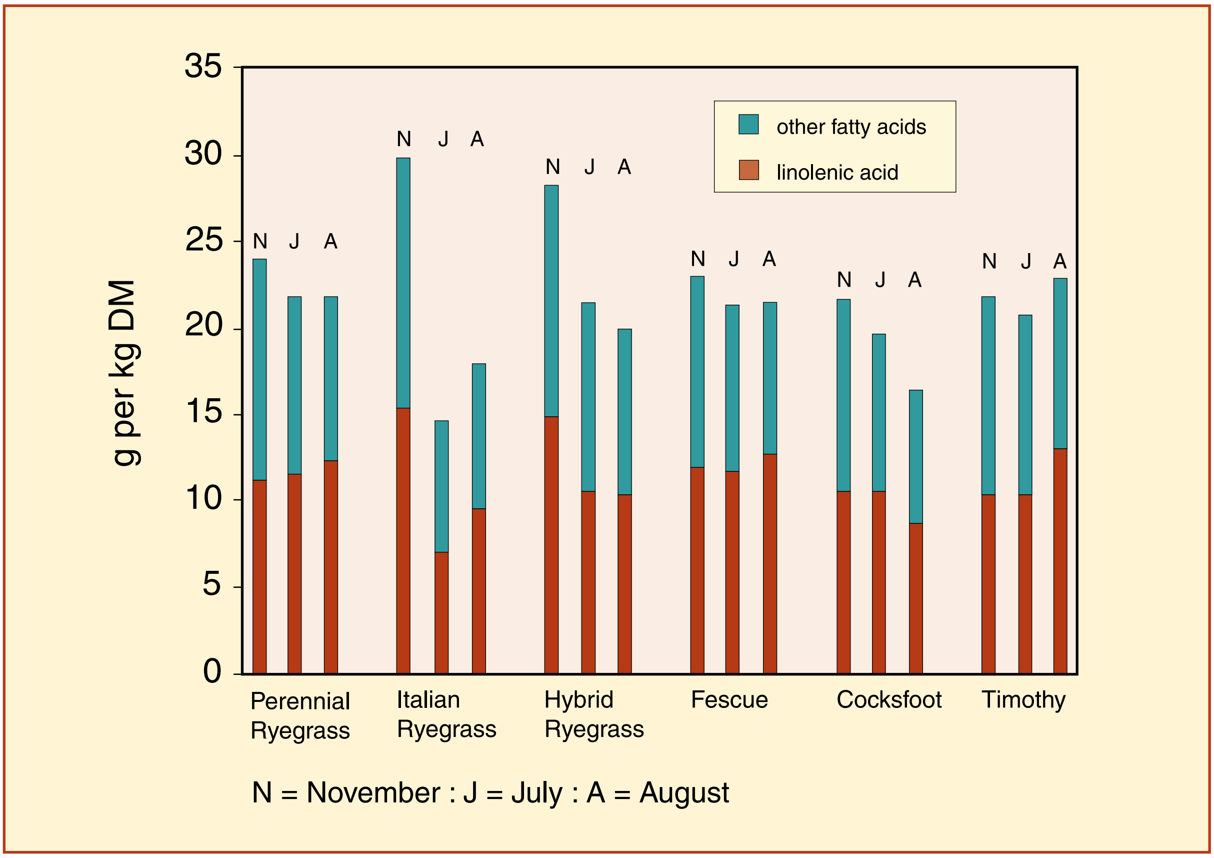

Figure 6.3 Changes in (α-linolenic acid and total fatty acids (g per kg DM) in a range of grasses harvested on three separate occasions (November 1995, July 1996 and August 1996).

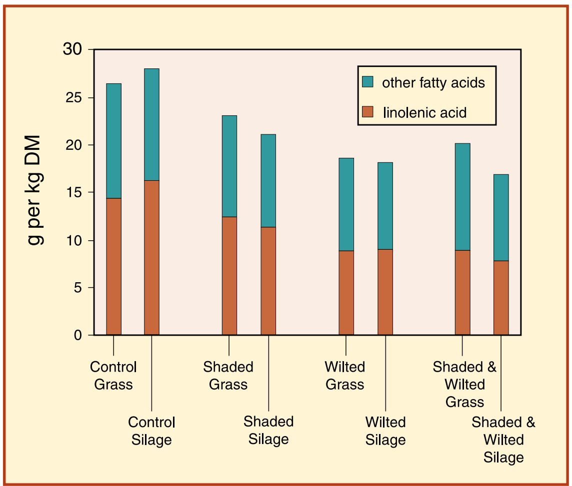

Figure 6.4 Effects of shading and wilting on the (α-linolenic acid and total fatty acid content (g per kg DM) of fresh grasses and grass silages.

profiles or 'fingerprints' which are distinctive to particular species and in broad agreement with other evidence about how closely one species is related to others. This confirms that the fatty acid composition of grasses is under considerable genetic control and highlights the potential to select for grasses with higher levels or altered types of fatty acids.

Fatty acids in grass silage

The majority of ruminants are fed on grass silage during the winter months. Silage-making represents a simple way to conserve forage crops, during times of plenty, by fermenting cut grass in a low oxygen environment. We have investigated the effects of silage-making techniques on the quantity and quality of fatty acids in the silage produced (Figure 6.4). A series of silages were made from Perennial Ryegrass using small-scale laboratory silos. The grass had been treated in different ways in the field; the two main treatments involving shading the grass with a black plastic sheet for 24 hours before cutting, or leaving the cut grass to dry ('wilt') for 68 hours before making it into silage. We also looked at the effects of a range of chemical additives which are often used in silage-making, but these had no effect on fatty acid composition.

Three fatty acids (palmitic, linoleic and (α-linolenic acids) made up almost 90% of the total fatty acids in the silages prepared in this work. Wilting had the most dramatic effect on fatty acids with a marked loss of both (α-linolenic acid and total fatty acids. Shading the grass for 24 hours had a similar, but less dramatic effect. The similarity between fatty acid concentrations in fresh grass, before it was made into silage, and in the silages produced, confirms that the major differences in fatty acid composition were largely generated during field operations (shading, wilting). The silage making process itself did not affect fatty acid content or composition.

Fatty acids and beef

We have investigated the opportunity to manipulate the fatty acid composition of beef, and the resulting effects on meat quality, by feeding animals on feed sources which are rich in omega-3 fatty acids. Animals were fed on grass silage plus one of four concentrates (Figure 6.5).

In comparison to the control, feeding linseed doubled the concentration of linolenic acid and significantly enhanced eicosapentaenoic acid, C20:5 n-3 in the meat. This is particularly interesting because it suggests that synthesis of this longer chain fatty acid, C20:5 n-3, may be encouraged by feeding animals on feed sources rich in (α-linolenic acid. Feeding fish oil doubled the levels of C20:5 n-3 and C22:6 n-3, whilst the mix gave results intermediate between feeding linseed and fish oil. This work clearly demonstrates that quality feeds can be translated into quality meat.

Effects of fatty acids on meat appearance and flavour

Increasing the levels of PUFA in meat may sometimes lead to accelerated colour changes from red to brown, due to oxidative changes. Muscle samples from animals fed on fish oil showed higher oxidative changes during retail display and faster

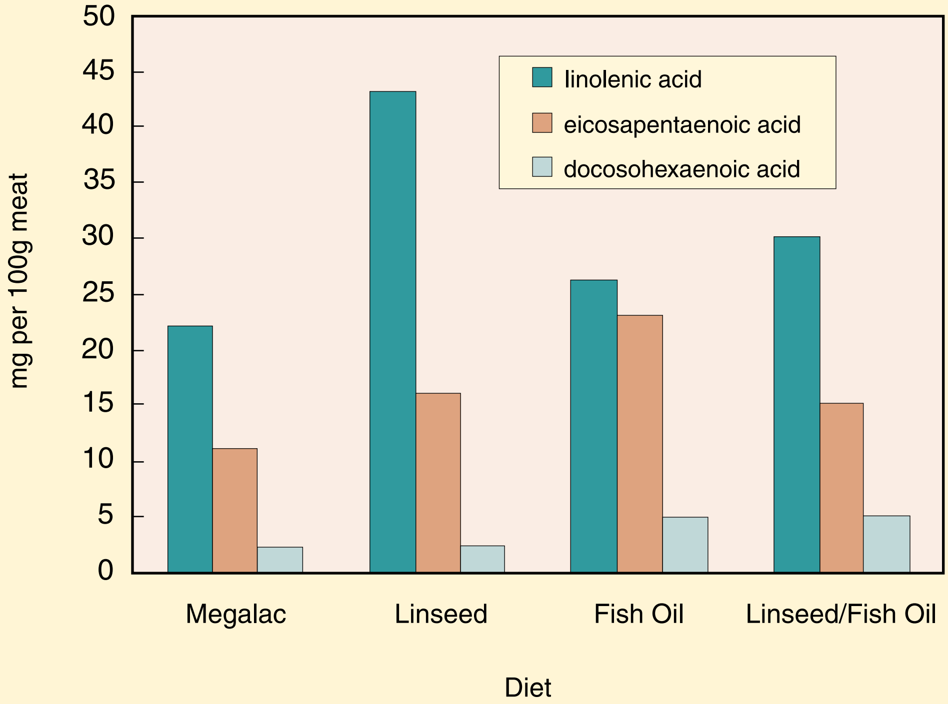

Figure 6.5 Effects of polyunsaturated fatty acid supplements in feed on the amounts of various fatty acids in the meat. Animals were fed ad libitum on grass silage plus one of four concentrates for 120 days, just prior to slaughter (60:40 forage : concentrate on a dry matter basis): megalac (the experimental control, rich in saturated palmitic acid, C16:0), whole linseed (α-linolenic acid, C18:3 n-3), fish oil (eicosapentaenoic acid, C20:5 n-3 and docosahexaenoic acid, C22:6 n-3) and, finally, linseed plus fish oil in equal amounts.

colour deterioration. However, animals fed on a linseed supplemented diet produced beef with as long a shelf-life as the controls. The level of anti-oxidants in the muscle play a key role in limiting the extent of these oxidative changes (see the article by Foyer and Dewhurst, this volume) and hence feeding high levels of anti-oxidants are important when manipulating the PUFA content.

We know that the fatty acid composition of muscle lipids has important consequences for meat flavour, because lipid degradation products such as aldehydes, participate in the flavour forming reactions which occur during cooking. In this study, the high levels of long chain C-20 and C-22 PUFA from fish oils produced the greatest oxidative lipid changes in meat, and this coincided with generally negative comments on odour and flavour from a taste panel. However, taste and appearance were good in meat derived from the linseed diet, with a high concentration of (α-linolenic acid and medium levels of C-20 and C-22 PUFA. Other studies have suggested that the UK consumer prefers grass-fed to concentrate fed beef. Since grass contains high levels of (α-linolenic and normal concentrates do not, this suggests that the oxidation reactions in meat resulting from (α-linolenic are not deleterious to taste. These studies are now progressing to examine ways of enhancing the uptake of omega-3 PUFA from grass into beef, and to study the subsequent effects on meat quality.

This work is being carried out in collaboration with Dr Jeff Wood and his team at the University of Bristol and is funded by MAFF.

Contact: richard.dewhurst or nigel.scollan@bbsrc.ac.uk