n-3 Fatty acids and health

Fatty acids are the building blocks for lipids (fats). They comprise a string (or chain) of carbon atoms to which are joined hydrogen atoms. Fatty acids can be saturated (have the maximum number of hydrogen atoms and no double bonds between the carbons), monounsaturated (one double bond) or polyunsaturated (two double bonds).

There are two families of polyunsaturated fatty acids: the *n*-6 (or omega-6) family derived from the essential fatty acid, linoleic acid, and the *n*-3 (or omega-3) family derived from the essential fatty acid, alpha-linolenic acid. These two fatty acids are 'essential' because they cannot be made in the body and have to be provided by the diet. The two families cannot be interconverted. Linoleic acid was the first fatty acid to be identified as essential and over the past 20-30 years its intake has been encouraged by the medical profession because of its ability to lower blood cholesterol levels. However, recognition that the longer chain derivative of alpha-linolenic acid, docosahexaenoic acid (DHA) is a major constituent of human brain and retina has resulted in considerable research in the past decade or so, particularly in relation to the needs of new born babies.

Eicosanoids are biologically active substances that are synthesised from the long chain metabolites of linoleic acid (*n*-6) and alpha-linolenic acid (*n*-3). Similar substances are produced from each of the two essential fatty acid families and the two systems compete for the same enzymes. However, those derived from the *n*-3 family tend to have less potent inflammatory and immunological effects than those from the *n*-6 family. This has led to interest in whether there is a role for fish oils, rich in very long chain *n*-3 fatty acids (*i.e.* with more than 18 carbon atoms), in the treatment of inflammatory conditions such as rheumatoid arthritis. Evidence to date suggests that the symptoms of some rheumatoid arthritis sufferers, *e.g.* morning joint stiffness and pain, may be alleviated by fish oil supplements to some extent. The evidence for beneficial effects in other conditions, such as asthma, psoriasis and Crohn's disease, is far weaker.

The very long chain *n*-3 fatty acids, DHA and eicosapentaenoic acid (EPA) are provided in abundance in fish oils, and they are also present in the flesh of oil-rich fish, such as mackerel, salmon, kippers, herrings, sprats, trout, sardines and pilchards. Tinned tuna is not a good source, however. They can also be synthesised in the body from alpha-linolenic acid. The richest dietary sources of alpha-linolenic acid are some seed oils, *e.g.* linseed oil, rapeseed oil, soya oil, mustard oil and some nuts, particularly walnuts. Meat and meat products and cereal products are also quantitatively important sources, and some is available from green leafy vegetables.

However, the rate of synthesis of very long chain *n*-3 fatty acids from alpha-linolenic acid by preterm babies may be inadequate for optimal growth and for this reason it has been suggested that it may be useful to enrich formula milk with very long chain *n*-3 fatty acids. (DHA is present in breast milk but historically has not been added to infant formula.)

The essential fatty acids and their longer chain derivatives are vitally important structural elements and are therefore essential for the formation of new tissues. They are particularly important for the development of the brain, nervous tissue and retina. During the last three months of pregnancy, there is rapid accumulation of *n*-3 fatty acids in these tissues. A recent workshop comprising experts in the field of *n*-3 fatty acids acknowledged that consideration needs to be given to whether the diets of pregnant and lactating women and bottle-fed infants are adequate with respect to the very long chain *n*-3 fatty acids, given the structural role played by DHA in the brain and the retina, and the rapid brain development that takes place during the last three months of fetal life and during infancy.

In particular, it is the balance between intakes of the two families of polyunsaturated fatty acids, rather than the individual levels of intake of the two families, that is a specific focus of

scientific interest. This is because of knowledge of how the two families interact metabolically, and that a shift in the ratio may influence the types and potency of eicosanoids formed.

Changing dietary patterns have led to a substantial change in the balance of intakes of *n*-6 and *n*-3 fatty acids. Vegetable oils with a high ratio of linoleic acid to alpha-linolenic acid, *e.g.* sunflower and corn oils, are now widely used throughout the food industry in place of more traditional fats such as butter and lard. Meat from ruminant animals can make a substantial contribution to alpha-linolenic acid intake, but consumption of lamb and beef has fallen over the past two decades and changes in animal feeding practices, away from grass, have led to lower concentrations of alpha-linolenic acid in meat and dairy products.

In the UK, current total intakes of *n*-6 and *n*-3 fatty acids are 10.2g/day and 1.8g/day, respectively; equating to a ratio of 5.67:1. Intakes of the essential fatty acids, linoleic acid and alpha-linolenic acid are 10.04 and 1.55g/day, respectively. These data are derived from the Total Diet Survey, which does not include an estimate of total energy intake. However, if the data on energy intake from the National Food Survey for the same year are applied to the intakes of these individual fatty acids, these values translate to energy intakes of 5% of energy from linoleic acid and 0.8% from alpha-linolenic acid.

The suggested minimum requirement for an individual for alpha-linolenic acid (*n*-3) in the UK is 0.2% of dietary energy (1% for linoleic acid, *n*-6). On the other hand, the WHO/FAO have recommended a minimum intake of alpha-linolenic acid of 0.5% of dietary energy and a recent international workshop held in the USA has recommended 1%. The same workshop has suggested an intake of 0.3% of energy for very long chain fatty n-3 acids, which is considerably higher than the amount recommended by the UK department of health (about 0.09% of energy). In 1992, the BNF Task Force on Unsaturated Fatty Acids suggested a desirable population intake for very long chain *n*-3 fatty acids of 0.5% of energy, which equates to about 8g EPA/DHA per week for women and 10g per week for men. In food terms, using the latest data on oil-rich fish composition, this is equivalent to 2-3 medium servings of oil-rich fish per week. Current intake of oil-rich fish among consumers of this food in the UK (about a third of the population) equates to about one small portion per week, but average intakes in the population as a whole are very small (total fish intake is only 144g/person/week, most of which is white fish).

Although *n*-3 fatty acids have little or no effect on total blood cholesterol levels, a substantial amount of recent work has focused on their ability to reduce blood triacylglycerol levels, both in the fasting state and following a meal. This, together with evidence that long chain *n*-3 fatty acids reduce the risk of having a fatal heart attack, indicates an important role in maintaining heart health. A number of mechanisms have been proposed, including protection against blood clot formation (thrombosis), protection against heart arrhythmias and a beneficial impact on blood pressure. Links have also been proposed between *n*-3 fatty acid intake, triacylglycerol response and improved insulin sensitivity.

Despite government recommendations to increase intake of oil-rich fish, for many people this advice is not a readily accepted means of consuming *n*-3 fatty acids. Developments such as micro-encapsulation technology have enabled the production of *n*-3 fatty acid formulations that can readily be incorporated into a wide range of food products to provide palatable and shelf-stable alternatives, enriched with *n*-3 fatty acids. Such products provide the consumer with choice with regard to their supply of very long chain *n*-3 fatty acids. However, because polyunsaturated fatty acids are highly susceptible to oxidation, characterised by rancidity, it is essential that adequate quantities of appropriate antioxidants are incorporated into products rich in these fatty acids. Furthermore, these products should be viewed in the context of a healthy balanced diet providing foods naturally rich in antioxidants, such as fruit and vegetables.