Fatty acids: which ones do we need?

Some fatty acids are widely promoted for good health. In this article, **Pam Mason** explores some of the evidence for their benefits

Fatty acids are the main components of dietary fat and the building blocks from which body fats are made. Dietary fat is one of the most frequently investigated aspects of nutrition, but interest is increasingly turning to specific fatty acids, rather than total fat intake.

Structure and nomenclature

Fatty acids are composed of a chain of carbon atoms, with a methyl (CH_3) group at one end and a carboxyl (COOH) group at the other. The number of carbon atoms in common fatty acids ranges from four to 22, and they can be linked by single or double bonds.

Fatty acids are known by their common names (eg, linoleic acid, see Panel 1, p749) but they can also be described by an abbreviated system based on their structure. There are three parts to this system: the number of carbon atoms, the number of double bonds and the position of the first double bond in relation to the methyl end of the carbon chain. Thus, palmitic acid is "16:0" because it has 16 carbon atoms and no double bonds. Similarly, linoleic acid is "18:2n6" because it has 18 carbon atoms and two double bonds, the first of which starts at the sixth carbon atom from the methyl terminal.

SFAs, MUFAs and PUFAs

Fatty acids can also be classified into three main groups: saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs).

Saturated fatty acids SFAs contain carbon atoms linked only by single bonds and are usually solid at room temperature. They are principally obtained from animal fats and animal products (eg, meat fat, lard, dripping, milk, butter, cheese and cream). Foods of plant origin generally have a much lower content of SFAs, although there are some exceptions, such as coconut and palm oil. Margarines and fat spreads made from vegetable oils also contain significant amounts of SFAs.

Monounsaturated fatty acids MUFAs contain only one double bond and are usually liquid at room temperature. The most concentrated dietary sources of MUFAs are olive oil and rapeseed oil. However, MUFAs also comprise about one third of the fatty acid content in meat fat and most of the fat present in nuts and seeds.

Polyunsaturated fatty acids PUFAs contain two or more double bonds and are liquid at room temperature. They can be divided into two types: n6 (or "omega-6") and n3 (or "omega-3") which have different metabolic effects. The parent fatty acids in each of these groups, linoleic acid (n6) and alpha-linolenic acid (n3) are also called "essential fatty acids" (EFAs) because we lack the enzymes to make them and must, therefore, get them from our diet. EFAs are principally derived from vegetable oils, nuts and seeds.

Trans fatty acids Double bonds in fatty acids can be in the cis or trans form. Most dietary fatty acids contain cis double bonds. Trans fatty acids are created during the manufacture of margarines when PUFAs in liquid vegetable oils are hydrogenated to create more solid fats for spreading — trans fats are also often referred to as hydrogenated fats. Significant quantities of trans fatty acids are, therefore, found in margarines and manufactured foods (eg, biscuits, cakes, crisps, pies).

Trans fatty acids, like SFAs, increase low density lipoprotein (LDL) cholesterol, but they also reduce high density lipoprotein (HDL) cholesterol. These two effects lead to an increase in the LDL:HDL ratio, which is associated with an increased risk of cardiovascular disease (CVD). However, most people only eat small amounts of trans fatty acids compared with SFAs.

Other dietary lipids include cholesterol, lecithin and phytosterols. Common phytosterols include β-sitosterol, β-sitostanol and campesterol. Recent interest has focused on phytosterols because they inhibit cholesterol absorption. As a result, these are included in several spreads, yoghurts and milk products (eg, Benecol, Flora Pro-Activ).

Effects of lipids

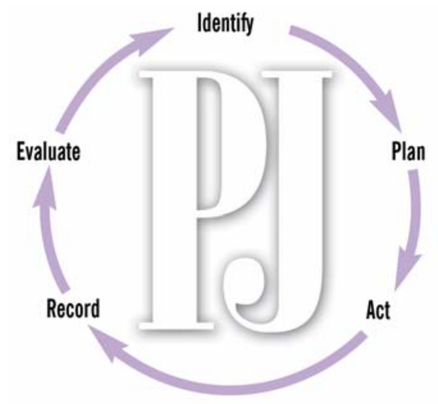
Although dietary fat has had a great deal of bad press, some are needed for the body to function healthily. However, not all fatty acids need to come from our diets.

SFAs The most common dietary SFAs are palmitic and stearic acid. These are important for energy metabolism, cell membrane structure and normal growth. Saturates with 20 to 24 carbon atoms are important constituents of myelin. However, the requirement for SFAs can be met by endogenous synthesis and it seems unlikely that a dietary source is necessary. Furthermore, chronic excessive intake or synthesis, or both, of palmitic and stearic acids tends to raise the level of LDL cholesterol in blood. A high intake, therefore, could enhance the process of atherogenesis and increase the risk of CVD.

MUFAs There is enormous interest in the health implications of MUFAs mainly because, unlike saturates, they do not raise blood cholesterol. Substituting SFAs with MUFAs, therefore, lowers LDL cholesterol. In addition, unlike n6 PUFAs (which have been used as the main replacement for SFAs for some 30 years) MUFAs do not lower HDL cholesterol and are associated with less risk of lipid peroxidation, which means less free radical production. Substituting SFAs with MUFAs also does not unfavourably alter the balance of n6 to n3 PUFAs. The main dietary MUFA is oleic acid, which is found in olive oil.

PUFAs The two essential fatty acids, linoleic acid and alpha-linolenic acid, are converted to longer chain, more unsaturated polyunsaturates in the body (see Figure 1, p750). These longer chain derivatives are, therefore, not essential components of the diet unless intake of their EFA precursors is limited or synthesis is inhibited. PUFAs have a pivotal role in many processes. For example, they act as components of phospholipids in cell membranes, regulators of cholesterol metabolism and precursors of eicosanoids (eg, prostaglandins, leukotrienes, thromboxanes).

Cell membranes Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have a structural role in cerebral, retinal and nervous tissue and play an important part in neural development in fetal and early life. There is increasing speculation that deficiency at this



Identify knowledge gaps

1. What kind of fatty acid is linoleic acid?
2. Are trans fatty acids good or bad?
3. List three conditions for which fish oils are reputed to have beneficial effects.

Before reading on, think about how this article may help you to do your job better. The Royal Pharmaceutical Society's areas of competence for pharmacists are listed in "Plan and record", (available at: www.rpsgb.org/education). This article relates to "health promotion" and "dietary products" (see appendix 4 of "Plan and record").

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Panel 1: Dietary fatty acids

Saturated fatty acids	
Butyric (4:0)	Dairy produce, coconut oil
Caproic (6:0)	Dairy produce, coconut oil
Caprylic (8:0)	Dairy produce, coconut oil
Capric (10:0)	Dairy produce, coconut oil
Lauric (12:0)	Dairy produce, coconut oil
Myristic (14:0)	Dairy produce, coconut oil
Palmitic (16:0)	Palm oil, cottonseed oil, butter, meat fat
Stearic (18:0)	Butter, meat fat, lard, chocolate
Arachidic (20:0)	Nut and seed oils
Behenic (22:0)	Peanuts, peanut oil
Monounsaturated fatty acids	
Oleic (18:1n9)	Olive oil, nut and seed oils, meat fat, butter, eggs, avocados
Erucic (22:1n9)	Rapeseed oil
Polyunsaturated fatty acids	
Linoleic (18:2n6)	Nuts, seeds and vegetable oils (eg, sunflower, safflower, corn, soyabean), lean meat, eggs
Alpha-linolenic (18:3n3)	Nuts, seeds and vegetable oils (eg, flaxseed, hemp, pumpkin, walnut, rapeseed, soyabean)
Gamma-linoleic (18:3n6)	Evening primrose oil, borage oil, blackcurrant oil
Arachidonic (20:4n6)	Lean meat, game, offal0, eggs
Eicosapentaenoic (20:5n3)	Oily fish (eg, herring, mackerel, tuna, salmon, sardines)
Docosahexaenoic (22:6n3)	Fish, liver, egg yolk

time can impair subsequent brain, optical and cortical function.

Cholesterol metabolism The n6 PUFAs have a hypocholesterolaemic effect and their substitution for SFAs has been encouraged since the 1970s — the butter vs margarine debate. However, as well lowering LDL cholesterol, n6 PUFAs also lower "good" HDL cholesterol. PUFAs are also susceptible to oxidation and high intakes can lead to excessive free radical production and potential adverse effects (eg, development of atherosclerosis and cancer). Unlike n6 PUFAs, n3 PUFAs have minimal effects on blood cholesterol levels, although in doses exceeding 1g per day they can reduce triglyceride concentrations.

Eicosanoids Eicosanoids are formed mainly from arachidonic acid and to a lesser extent from eicosapentaenoic acid (EPA) and dihomogammalinolenic acid (DGLA). They are produced in response to physiological stimuli (eg, hormones such as adrenaline or antigen-antibody complexes or cell injury). Eicosanoids have a range of regulatory actions, eg, they influence smooth muscle contraction and blood clotting and mediate inflammatory and immunological responses. Different eicosanoids can have opposing actions and provide a critical balance in the overall response to cell injury.

In general, eicosanoids derived from EPA and DGLA tend to be less potent in their ability to cause platelet aggregation and an inflammatory response than those derived from arachidonic acid. The amounts of different eicosanoids produced, to some extent, depends on the ratio of n6 to n3 fatty acids in the diet. This is because the two families of polyunsaturates compete for the same enzyme systems during chain elongation, desaturation and eicosanoid production. However, there is no recommended ratio (see Panel 2). During the past 30 years there has been a substantial change in the ratio of n6 and n3 fatty acids intake. As vegetable oils and fat spreads high in n6 PUFAs have replaced SFAs, the ratio of n6 to n3 fatty acids has increased. This is thought to have contributed to the increasing incidence of chronic inflammatory conditions such as CVD.[1]

Benefits of fatty acids

There are many fatty acid supplements available and a common question asked of pharmacists is "which should I take?".

Omega-3 oils Many epidemiological and clinical trials have associated n3 fatty acid consumption with a lower risk of CVD. The potential benefits include a reduction in plasma triglycerides. However, this can be accompanied by an increase in total and LDL cholesterol in patients with low LDL levels and hypertriglyceridaemia.[2,3] It has been suggested that the increased LDL cholesterol may not necessarily increase atherosclerosis risk because of the antithrombotic, anti-inflammatory effects of n3 fatty acids.[4] In other studies, n3 fatty acid supplements did not clearly reduce atherosclerosis after angioplasty.[5,6] However, there is evidence that n3 fatty acids reduce blood clotting in vessel walls and also ventricular arrhythmias. They may also produce a small reduction in blood pressure, especially in hypertensive subjects.[7]

In the secondary prevention of CVD, low intakes of n3 fatty acids (1g daily or less) have been associated with reduced mortality[8] and cardiac events.[9,10] There is also evidence of benefits in patients with diabetes mellitus. A meta-analysis in such patients reported favourable effects of fish oils on triglyceride levels and on glucose and glycosylated haemoglobin.[11]

Fish oil can have mild beneficial effects (reduction of tender joints and morning stiffness) on rheumatoid arthritis[12] and in patients with ulcerative colitis[13] and Crohn's disease.[14] There is evidence that patients with mood disorders have reduced n3 fatty acid concentrations.[15] However, controlled trials are needed to determine the role of n3 supplements in depression, schizophrenia, dementia and other mental disorders.

Panel 2: n6:n3 ratio

The average British diet contains an n6 to n3 ratio of 5.67:1 (ie, daily intake of n6 is about 10g and n3 between 1 and 2g). There is currently insufficient information on which to base an ideal ratio. In breast milk the ratio is between 8:1 and 14:1. Department of Health recommendations (1991) for essential fatty acid intake are based on preventing deficiency only — not on altering disease risk. These are as follows:

- As a minimum, alpha-linolenic acid (n3) should provide at least 0.2 per cent and linoleic acid (n6) 1 per cent of total dietary energy
- Polyunsaturated fatty acids should not make up more than 10 per cent of total energy intake

The World Health Organization has recommended a minimum of 0.5 per cent and the British National Foundation task force a minimum of 1 per cent of total energy intake to be from alpha-linolenic acid and 0.5 per cent from long chain n3 PUFAs (eg, eicosapentaenoic acid). Generally, advice is to try to increase n3s but not n6s.

Most of the studies have looked at the effects of oily fish or fish oils (which contain EPA and DHA). Evidence relating to alpha-linolenic acid, which is converted to EPA and DHA, is limited. Although flaxseed preparations can increase the n3 fatty acid content of the diet, there is insufficient evidence to recommend flaxseed for reducing the risk of stroke and heart attack. Clinical trials are also needed to determine the effect of flaxseed on rheumatoid arthritis and other inflammatory disorders such as psoriasis, multiple sclerosis and lupus.

The Food Standards Agency currently recommends that everyone should try to eat at least two portions of fish a week, at least one of which should be oily fish. It also recommends avoiding marlin, shark and swordfish and limiting tuna intake during pregnancy. Consumption of an average serving of oily fish provides approximately 1g of n3 fatty acids. The fattier the fish, the higher the content of n3 fatty acids. Farm-raised fish contain a lower amount of n3 fatty acids than fish found in rivers, lakes and the sea. Lipid content can also depend on water temperature and place of capture.

Gamma-linolenic acid Gamma-linolenic acid (GLA) is an n6 fatty acid found in evening primrose oil (8–10 per cent GLA), borage oil (23–26 per cent GLA) and blackcurrant oil (15–20 per cent GLA). Interest in GLA supplements arose when it became known that some individuals have a limited ability to convert linoleic acid to GLA as a result of a defect in the delta-6 desaturase enzyme. In animal studies and some human studies, impaired GLA formation has been associated with ageing, diabetes, excessive alcohol intake, deficiencies of calcium, magnesium, zinc and vitamin B_6, high cholesterol

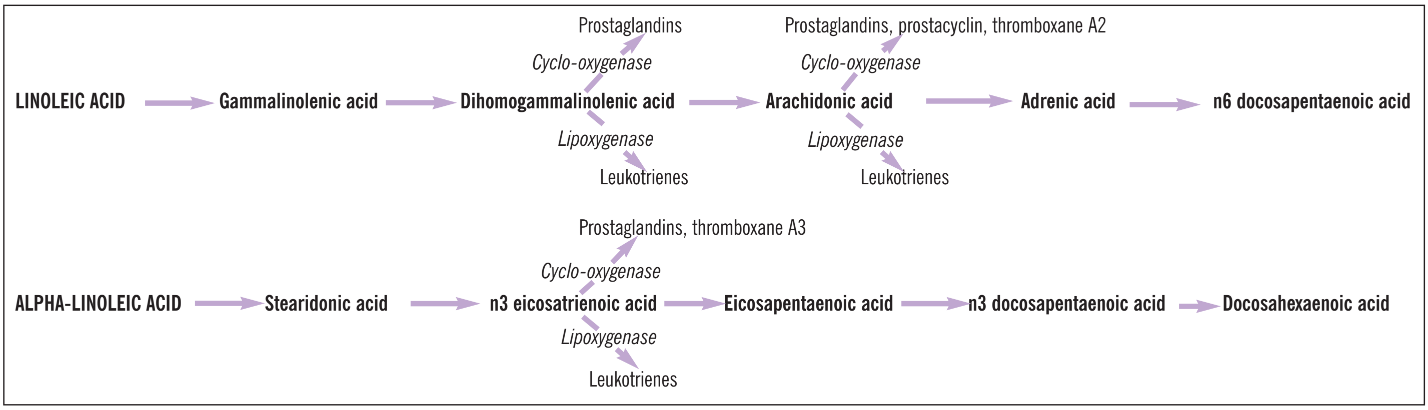

Figure 1: n6 and n3 pathways

levels, viral infections and elevated stress hormone levels.

Atopic dermatitis, premenstrual syndrome, rheumatoid arthritis, cancer and CVD have indirectly been associated with the reduced ability to convert linoleic acid to GLA. Because supplementation with GLA bypasses the rate limiting step for linoleic acid conversion to GLA, the role of evening primrose, borage and blackcurrant oils has been investigated in these conditions. Overall, however, evidence concerning the effects of GLA is conflicting and additional controlled trials on the efficacy and safety of GLA are needed before supplements can be recommended.

Conjugated linoleic acid Conjugated linoleic acid (CLA) is available as a supplement. The name describes a group of linoleic acid isomers in which the double bonds are conjugated at carbons 10 and 12 or 9 and 11 in both cis and trans configurations. CLA is found naturally in foods sourced from ruminant animals (eg, beef and dairy produce). Supplements have been investigated for their effect on body composition. Studies in humans also suggest that CLA reduces body fat, but overall weight loss has not been particularly impressive.[16] It has been claimed that CLA has other benefits, for example, anti-cancer, anti-inflammatory and anti-atherogenic effects.

Some animal studies have found CLA to be safe and human trials have generally not reported significant side effects. However, there exists the possibility that CLA might increase insulin resistance. Results from studies are conflicting on this issue.[17] As overweight people are those most likely to have insulin resistance, it would seem appropriate to urge caution in the use of CLA until more is known.

Omega-9 fatty acids Nervonic acid (24:1n9) is a MUFA of emerging interest in the US and supplements are being promoted for regulation of brain cell function and increasing mental acuity. However, there have been no clinical trials in humans.

Summary

It is important to ensure that any fat consumed is of a beneficial type. More emphasis should be placed on MUFAs and n3 PUFAs to replace both SFAs and n6 PUFAs. This will help to ensure an appropriate balance of n3 to n6 PUFAs and a reduced intake of SFAs. This could help to reduce the risk of CVD and other chronic conditions with an inflammatory component.

Irrespective of the type of fatty acids contained, all fats provide 9kcal (37kJ) per gram, making fat the most concentrated source of energy in the diet and a potentially significant risk factor for obesity so, although some fatty acids are essential for health, total fat intake should still be limited. Topping up on EFAs is best done through dietary measures. Usually, it is the n3 EFAs that are needed. Hence the best advice is to eat n3-rich oily fish and seeds or seed oils (see Panel 1, p749). For people who do not like eating oily fish and who are concerned about the risk of CVD, a supplement providing 1g of n3 fatty acids (from fish oils) can be suggested. If supplements are used, because of their instability, it is best to buy them in small quantities and to keep them refrigerated.

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Action: practice points

Reading is only one way to undertake CPD and the Society will expect to see various approaches in a pharmacist's CPD portfolio.

1. Visit www.food.gov.uk for the latest recommendations on oily fish.
2. Read the Scientific Advisory Committee on Nutrition's report on the benefits and risks of fish consumption (www.food.gov.uk).
3. Consider which omega-3 supplement you would take and why.

Evaluate

For your work to be presented as CPD, you need to evaluate your reading and any other activities. Answer the following questions: What have you learnt? How has it added value to your practice? (Have you applied this learning or had any feedback?) What will you do now and how will this be achieved?