Fat facts: dietary fats

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Knowing the various types of dietary fat will help you advise patients on how to modify their fat intake so they do not become overweight, with the associated cardiovascular and metabolic problems.

Fat plays a major role in all the components of the 'WXYZ syndrome', which affects many Australians and puts them at risk of cardiovascular and metabolic problems, including diabetes. The components of this syndrome are:[1]

- W = the weight/waist factor. Fat is the most energy dense nutrient (9 calories or 36 kJ versus 4 calories or 16 kJ per gram for both carbohydrate and protein). Overconsumption of energy dense food and drinks can contribute to an expanding waistline.
- X = syndrome X, or the metabolic syndrome as it is more often known. Over-waist or central overweight is associated with metabolic problems and high cardiovascular risk.
- Y = why a particular person develops the metabolic syndrome. The syndrome is associated with the 'f' words (forty, family and fat). The fixed risk factors of age and genes set the scene, but it is the modifiable risk factor of fatness that usually precipitates the cardiovascular and metabolic problems. Fatness is also the usual target for lifestyle interventions and sometimes also for medical interventions.
- Z = sleep apnoea, or not getting enough zzz's, is associated with the other cardiometabolic factors and further increases risk of cardiovascular and metabolic problems. Night-time sleep disturbance adversely affects the hormone profile and daytime tiredness reduces capacity and motivation for lifestyle change.

These cardiovascular and metabolic risk factors will become more common in the future.

Depending on the type and amount consumed, fat can contribute to excess weight and lifestyle diseases, including diabetes.[2] This article reviews the types of dietary fats and aims to provide a simple framework for understanding what the various fats are, what they do to us and how we can advise patients to modify their fat intake. Cholesterol and plant sterols are also discussed.

The chemistry of fats

Triglycerides are the major form of plant and animal fat – what we eat and what is under our skin, around our organs and in our blood. Their chemical structure is three 'zigzags' of carbon (fatty acids) attached to a 'coat hanger' (glycerol) – hence triglyceride. The specific fatty acids in a triglyceride gives the fat its specific flavour, texture and melting point.

Fatty acids differ in the length of their carbon chains and the number, position and type of double bonds in the molecule. Common fatty acids range in length from 12 to 24 carbon atoms. All fatty acids need bile salts to be emulsified into micelles. After lipolysis, all short chain fatty acids are directly absorbed into the portal system while longer chain acids are re-esterified into triglycerides that combine with proteins (forming chylomicrons) and are then absorbed via the lymphatic system.

Saturated fatty acids do not contain any double bonds as all the carbon bonds are occupied (saturated) with hydrogen. Saturated fats are straight zigzag molecules and can stack up and bind to each other. They are likely to be solid at room temperature (22°C).[3]

Unsaturated fatty acids have double bonds along the carbon chain that cause 'kinks' in the molecule. There are two kinds of double bonds in unsaturated fats, cis and trans, leading to different geometric configurations. In a cis fatty acid, the hydrogen atoms are present on the same side of the double bond, whereas in the trans configuration, they are on opposite sides. Cis bonds cause big kinks in the carbon chain whereas trans bonds result in the chain remaining fairly straight. Although the molecules of both cis and trans unsaturated fatty acids do not stack up as easily as those of saturated fats, this is more pronounced with the cis fatty acids. Both cis and trans fats are likely to be liquid at room temperature but trans fatty acids more closely resemble saturated fatty acids. Almost all naturally occurring unsaturated fatty acids have cis bonds. Fatty acids with trans bonds are found naturally in small amounts in dairy products and the meat of ruminants (such as cows and sheep) but most are formed during food processing or cooking.

The position of any double bond is important. Position is usually defined in terms of the distance from the methyl end (also known as the omega end) of the fatty acid molecule. Thus the two major classes of unsaturated fatty acids, omega-3 (or n-3) fatty acids and omega-6 (or n-6) fatty acids, have their first double bonds between the third and fourth or sixth

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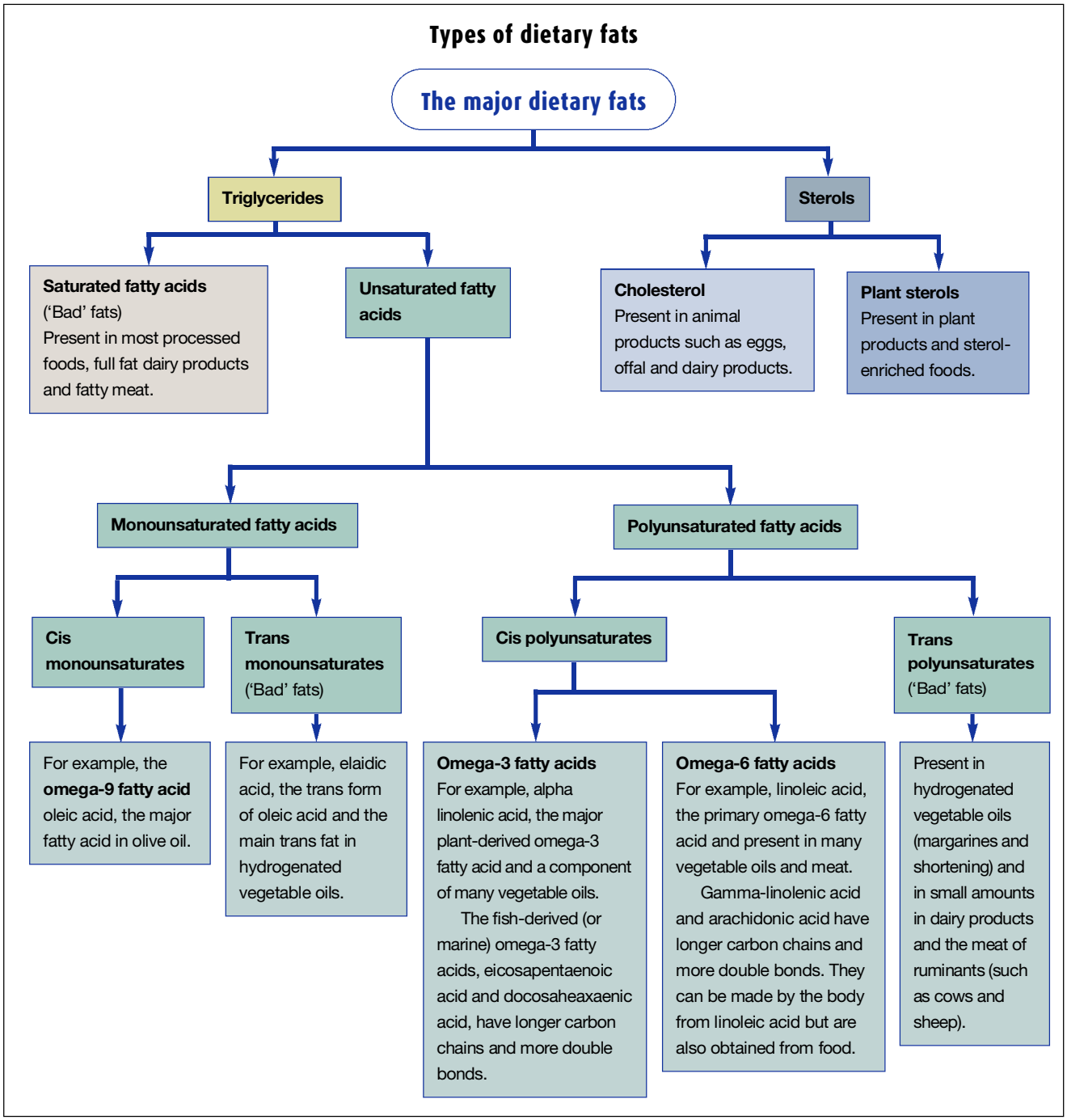
and seventh carbon atoms, respectively, from the methyl end.[3]

The human body can make its own saturated fatty acids and monounsaturated fatty acids with a double bond at the omega-9 position, but not the polyunsaturated fatty acids as it does not have the enzymes necessary to introduce double bonds at the omega-3 and omega-6 positions. These fatty acids have to be obtained from the diet, making them essential fatty acids.

Most, but not all, of the vegetable fats we eat are monounsaturated or polyunsaturated fatty acids. During processing at high temperatures into solid or spreadable fats (shortenings and margarines), these largely unsaturated oils acquire extra



hydrogen atoms to become saturated fats (hydrogenation). Although hydrogenation increases the stability of the fat so it does not go rancid, the change of nature of the fatty acids to saturated and trans unsaturated makes the fat more harmful to our health. (Trans fat formation is a side effect of incomplete or partial hydrogenation – the remaining unsaturated cis bonds are converted to lower energy trans bonds.) High temperature catalyst mediated hydrogenation of polyunsaturated fat is rarely used now.

The chemistry of the dietary fatty acids is summarised in the boxes on page 58 and this page.

The 'bad' fats

Saturated fats

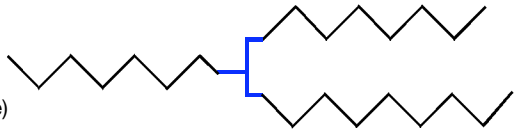
Saturated fats are found in both animal and plant foods (Table 1). Long chain saturated fatty acids (more than 14 carbon atoms) are the predominant type. These fatty acids are found in almost all fast foods, takeaways, fried processed foods, commercial pastries, cakes and biscuits, full fat dairy products and fatty meats.

An increase in the consumption of saturated fatty acids is associated with increased total and LDL cholesterol levels and increased risk of coronary heart disease. Saturated fat should be limited in the diet to reduce the risk of elevated cholesterol and LDL cholesterol. Limiting saturated fat in the diet can lower the risk of coronary heart disease.[4]

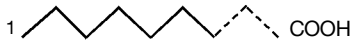
'Partially hydrogenated vegetable oil' listed on food labels normally has a higher concentration of saturated fat than the original oil it was made from. Consumers often believe vegetable oils (unhydrogenated and partially hydrogenated) are better than solid fats such as butter, lard (rendered pig fat) and beef dripping because the products display the word 'vegetable' on their packaging, but these oils are often higher in saturated fat than the solid fats (Table 2). Also, when heated to high temperatures, as in frying, the polyunsaturated fatty

Simplified structural formulae of some fatty acids and sterols*

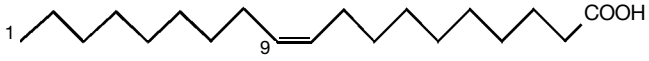
Triglyceride
– three fatty acids (zigzags) attached to glycerol (shown in blue)



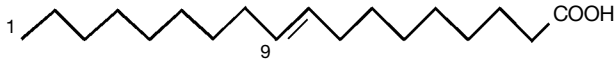
Saturated fatty acid



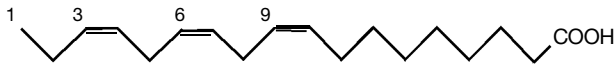
Oleic acid – a cis monounsaturated fatty acid (omega-9)



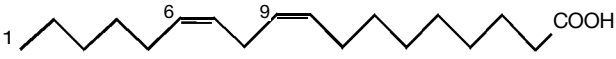
Elaidic acid – a trans monounsaturated fatty acid



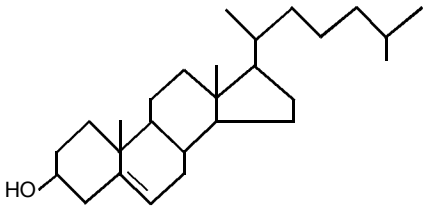
Alpha linolenic acid – an omega-3 fatty acid (polyunsaturated, cis)



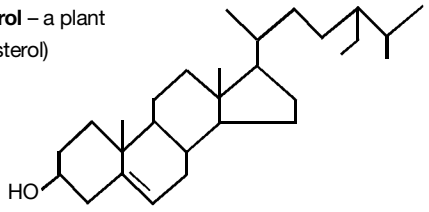
Linoleic acid – an omega-6 fatty acid (polyunsaturated, cis)



Cholesterol



Beta sitosterol – a plant sterol (phytosterol)



* The large bends at the cis bonds in cis fatty acids are not shown in these simplified structural formulae.

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acids are changed into saturated and trans fatty acids. Most frying fat is unhydrogenated palm oil, which is naturally rich in saturated fatty acids and therefore less susceptible to the harmful effects of heating.

Trans fats

As previously mentioned, trans fatty acids are monounsaturated and polyunsaturated fatty acids that behave in similar ways to saturated fatty acids and are mainly formed when polyunsaturated fatty acids such as vegetable oils are hydrogenated (hardened) to make margarine and shortening for processed foods.

Studies indicate that a 2% increase in energy intake from trans fatty acids is associated with a 23% increase in the incidence of coronary heart disease.[5]

Some food products (mainly margarines) now list the amount of trans fatty acids on the nutritional panel. Currently manufacturers only have to list trans fatty acids on the nutritional panel if they are making a nutritional claim about cholesterol or unsaturated fat, such as 'cholesterol free'. When choosing margarines, care should be taken to choose those with the least amount of trans fats. In general, the eating of processed and fast foods should be limited.

Recently, the National Heart Foundation has worked with the food industry to reduce the levels of trans fats in spreads. Since the end of 2006, all spreads carrying the Heart Foundation Tick should have a maximum level of 1% of their total fat as trans fat. The Heart Foundation recommends that saturated and trans fats contribute no more than 8% of total energy intake.[4]

The 'better' fats

The 'better' fats are the naturally occurring unsaturated fats, almost all of which have cis bonds.

Monounsaturated fats

The major sources of monounsaturated fats are listed in Table 1. Oleic acid is the

Table 1. Sources of different fats

Saturated fats	Monounsaturated fats	Polyunsaturated fats
Fats	**Oils and margarines**	**Oils and margarines**
Butter, lard, copha, cooking margarine, ghee, dripping, dairy blends, vegetable shortening	Canola	Sunflower
Cream, sour cream	Olive	Safflower
	Macadamia	Corn
Meat and dairy products	Sunola (a sunflower oil high in oleic acid)	Soybean
Fatty meat (chops, poultry skin, chicken wings, fatty mince)	Peanut	Sesame
Smallgoods (sausages, saveloys, fritz/devon, salami, bacon, metwurst)	Sunflower	Cottonseed
Full fat dairy products (milk, cheese, cream cheese, yoghurt, ice cream)	**Vegetables**	Grapeseed
Paté	Avocados	**Nuts and seeds**
Plant sources	Olives	Walnuts
Coconut oil, cream and milk	**Nuts**	Pine nuts
Palm oil (used in many fast foods, takeaway foods, cakes and biscuits)	Almonds	Brazil nuts
Toasted breakfast cereal, e.g. muesli	Peanuts	Sesame seeds
Takeaway foods	Cashews	Sunflower seeds
Commercial cakes, pastries, biscuits and chocolates	Hazelnuts	Linseeds
Deep fried or battered foods	Macadamias	**Spreads**
Pies, pasties, sausage rolls	Pecans	Tahini
Pastries – shortcrust and puff pastry	**Spreads**	**Fish and other seafood**
Potato crisps, hot chips	Peanut butter	Sardines, mackerel
	Almond spread	Salmon, tuna, mullet
		Calamari
		Gem fish
		Blue eye cod

most widespread of all fatty acids and the most common monounsaturated fatty acid.

Monounsaturated fats have become famous because of their association with Mediterranean diets. There is good evidence that total cholesterol and LDL cholesterol are lowered when saturated fatty acids are replaced with monounsaturated fatty acids, although not to the same extent as with polyunsaturated fatty acids. There is little evidence that monounsaturated fatty acids have an independent effect on coronary end points.

The Heart Foundation recommends reducing saturated fat intake by replacing a proportion with monounsaturated fats.[4]

Polyunsaturated fats

Polyunsaturated fatty acids fit into two major classes, omega-3 and omega-6, as discussed above. Dietary sources are listed in Table 1. The dietary balance of these two types of fats has changed over the last 20 to 30 years because of increased consumption of linoleic acid (an omega-6 fatty acid) in margarines and oils. Omega-3 fatty acids are less readily available in the food we eat. Vegetables, some seeds, canola oil and some soy-bean oils contain small amounts of the omega-3 fatty acid alpha-linolenic acid, while fish and other seafoods are excellent sources of other omega-3 fatty acids.

Replacing saturated fat with omega-6 polyunsaturated fatty acids reduces LDL cholesterol, total cholesterol and triglycerides levels and the risk of coronary events.

There is some evidence that marine omega-3 polyunsaturated fatty acids reduce coronary heart events and that fish intake reduces the risk of coronary death.[6] There is also good evidence that marine omega-3 fatty acids reduce the concentration of plasma triglyceride levels.[4]

The Heart Foundation recommends that at least two fish meals (preferably oily fish) be consumed each week. It also recommends that both plant and marine omega-3 fatty acids be consumed because these may reduce coronary heart disease by different mechanisms.[4]

Table 2. Fat content of vegetable oils and animal fats[3]

Food	Fat content (g per 100 g)		
	Saturated fat	Monounsaturated fat	Polyunsaturated fat
Vegetable oils			
Canola oil	7	63	30
Coconut oil	92	6	2
Olive oil	12	76	12
Palm oil	51	39	10
Peanut oil	19	46	35
Soybean oil	15	23	62
Sunflower oil	11	23	66
Animal fats			
Butter*	54	20	3
Dripping (beef)	51	42	7
Lard	40	45	15

* Butter contains about 20 g water per 100 g.

The sterol family

Cholesterol

Cholesterol belongs to the class of fats called sterols, and the levels of it circulating in the blood are influenced by the diet, particularly the amount and type of fat eaten. It is a constituent of cell membranes and is used in the production of some hormones, vitamin D and bile acids. The body produces its own cholesterol in the liver and other tissues but some is also obtained as dietary cholesterol from foods of animal origin, such as meat, eggs and dairy products.

Cholesterol biochemistry is complex. Cholesterol is transported in the blood bound to various lipoproteins. Of these, high density lipoprotein (HDL) carries cholesterol from cells to the liver, and low density lipoprotein (LDL) carries oxidised cholesterol from the liver to cells. High levels of HDL cholesterol are cardioprotective and it is therefore considered the 'good' cholesterol. Elevated LDL cholesterol is associated with increased cardiovascular risk and LDL cholesterol is therefore considered the 'bad' cholesterol.

Cholesterol is an antioxidant and free radical scavenger; however, when oxidised it is a free radical generator. Although the mechanism of how cholesterol affects the body is unclear, it is likely that free radical damage caused by unhealthy foods such as processed fat and processed (i.e. oxidised) cholesterol is involved (free radical damage to our blood vessels is one of the primary causes of atherosclerosis). Commercially processed and fast foods contain animal fats that are usually high in oxidised cholesterol when cooked. Foods cooked in animal fat and fried in hydrogenated vegetable oils also have high oxidised cholesterol content.

The Heart Foundation recommends that, although people at low risk of coronary heart disease can eat moderate amounts of cholesterol rich foods, those

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with plasma cholesterol above 5 mmol/L or with other cardiovascular risk factors should limit the intake of cholesterol rich foods.[4] Foods that are rich in cholesterol include egg yolks, offal meats and full fat dairy products.

Plant sterols

Plant sterols (phytosterols) and stanols are found naturally in small amounts in vegetables, fruit, leaves, nuts and cereals. They are also available in large amounts in sterol-enriched margarines. Plant sterols are chemically similar to cholesterol except for a methyl or ethyl group in their side chains. Stanols are the same as plant sterols but without double bonds (i.e. they are saturated). Although, in comparison to cholesterol, plant sterols are not or only minimally absorbed, they do have the effect of reducing the absorption of cholesterol when eaten in sufficient quantities. When less dietary and biliary cholesterol is absorbed, less cholesterol is returned to the liver. This stimulates LDL cholesterol receptor formation, which in turn increases the hepatic uptake of LDL cholesterol and thus decreases the serum LDL cholesterol levels.[7]

A daily intake of 2 to 3 g of plant sterols can reduce LDL cholesterol levels by about 10%.[7,8] There is no increase in the cholesterol lowering effect of plant sterols when eaten in amounts greater than 3 g. In addition to lowering cholesterol absorption,[8] plant sterols may also lower the absorption of fat soluble vitamins such as beta-carotene.[7] Including orange coloured fruit and vegetables as well as dark green leafy vegetables which are high in beta-carotene can minimise this problem.

An intake of 2 to 3 g of plant sterols can be achieved by including 1 to 1.5 tablespoons of sterol-enriched margarine daily. The intake of plant sterols is complementary to a cholesterol lowering eating plan and has an additive effect to statin therapy. General healthy eating principles and the importance of weight management should be highlighted to patients wishing to add sterol-enriched margarines to their diets. An Australian and New Zealand food standard was passed in November 2006 that allows a range of foods to be supplemented with plant sterols.[9] These foods include low fat milks, low fat yoghurts and breakfast cereals as well as the previously allowed margarines.

Fat facts – a final word

- Fatty acids differ in the length of their carbon chain and the number, position and type of double bonds.
- Saturated and trans fats should be limited in the diet to reduce the risk

of elevated total cholesterol and LDL cholesterol and lower the risk of coronary heart disease.

- Saturated fat intake can be reduced by replacing a proportion with monounsaturated fats.
- Replacing saturated fat with omega-6 polyunsaturated fatty acids reduces LDL cholesterol, total cholesterol and triglyceride levels and the risk of coronary events.
- Both plant and marine omega-3 fatty acids should be consumed because they may reduce coronary heart disease by different mechanisms. At least two fish meals (preferably oily fish) should be consumed each week.
- People with elevated plasma cholesterol or with other cardiovascular risk factors should limit their intake of cholesterol-rich foods.
- A daily intake of 2 to 3 g of plant sterols (achievable by consuming 1 to 1.5 tablespoons of sterol-enriched margarine) can reduce LDL cholesterol levels by about 10%. MT

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