Position paper: *Trans*-fatty acids

Since January 2006 the US Food and Drug Administration has required that the *Nutrition Facts* panel on food labels includes the amount of *trans*-fatty acids in the food, as well as the amounts of saturated fat and cholesterol (which have been required since 1993). Foods may be labelled as containing "zero *trans*-fat" if they contain less than 0.5 g in a serving [1]. According to a British Nutrition Foundation information sheet [2], the UK Food Standards Agency is in favour of revision of the EU directive on nutrition labelling to include *trans*-fatty acids on food labels within the European Union as well.

The FDA regulations apply only to packaged food sold in shops; there is no requirement for nutrition labelling of foods served in restaurants. Stender and coworkers have reported that French fries and chicken nuggets in American fast food restaurants may contain between 5 – 10 g of *trans*-fat in a serving. They note that in Denmark, where there are restrictions on the use of industrially-produced *trans*-fats, similar fast foods contain negligible amounts of trans-fatty acids [3].

On December 5th 2006, the New York City Public Board of Health voted to ban the use of all but "tiny amounts of artificial *trans*-fats" in restaurant cooking, to be phased in from July 2007 [4], and other cities in USA are considering similar moves. Some supermarket chains in UK and elsewhere have announced that they will eliminate all (artificial) *trans*-fatty acids from their own-label products.

What was less noticed in the press coverage of the reports from New York was that at the same time the Board also voted to require that the calorie content must also be displayed in restaurants, as part of the drive against obesity. It will doubtless surprise many to learn that a standard double hamburger with a standard (relatively small) serving of French fries will provide some 1200 kcal, while a double cheeseburger alone will provide almost 1400 kcal – out of a notional 2000 kcal per day for an adult [5].

The public debate is, predictably, highly polarised. At one extreme there is the BanTransFats.com website, which prides itself on having persuaded all 18 restaurants in Tiburon, California, to use only oils free from *trans*-fats. The same organisation sued Kraft Foods in 2003 (amazingly for American law suits, for zero dollars) and forced them to cease using *trans*-fats in the manufacture of Oreos cookies [6]. At the other extreme, the junkscience.com website [7] dismisses the peer-reviewed papers (published in highly reputable journals) that suggest that *trans*-fatty acids are hazardous to health on the grounds that individual studies are relatively small, some were inconclusive, and the same authors (all highly respected epidemiologists) were involved in several different studies. More soberly, the American Council on Science and Health (ACSH) listed *trans*-fats as number 1 of its *The Top Ten Unfounded Health Scares of 2006* [8], largely on the grounds that "overstating the health effects of TFAs is harmful to public health because it promotes an overemphasis on this single dietary factor as opposed to other aspects of diet, other risk factors for coronary heart disease, and other public health priorities. … the current exaggerated focus on TFAs may actually cause more problems than it solves."

Hydrogenated vegetable oils and *trans*-fatty acids

The difference between oils and fats is that oils are liquid at room temperature, while fats are solid. This is because solid fats contain mainly saturated fatty acids, while liquid oils contain relatively large amounts of mono- and polyunsaturated fatty acids (see Figure). In terms of cooking and food manufacture, the difference is important. Unlike liquid oils, solid fats can be spread on bread (butter and margarine); they can be used to make pastry, cakes and biscuits. They have a higher fire point (the temperature at which they will catch fire). This means that they can be used for frying at higher temperatures (anyone who has eaten potatoes fried in olive oil, as is usual in Greece, will know that the oil does not become hot enough to make a good chip). More saturated fats can also be used for frying for longer – an important consideration in commercial catering and food manufacture – because they are less susceptible to oxidative rancidity.

The catalytic hydrogenation of liquid oils, by converting all or part of the unsaturated fatty acids to saturated fatty acids, was patented in 1902, opening the way for use of vegetable oils to produce solid fats to replace butter, lard and suet. By controlling the extent of hydrogenation it is possible to produce fats with whatever melting point and other properties as are required.

Almost all of the naturally occurring unsaturated fatty acids are in the *cis*-configuration, in which the carbon chain continues on the same side of the double bond (see figure below), although small amounts of *trans*-isomers of fatty acids occur in fat from ruminants (including milk fat), as a result of intestinal bacterial synthesis of *trans*-fatty acids that are absorbed by the animal.

When relatively simple methods for differentiating between the *cis*- and *trans*-isomers of fatty acids became widely available, in the 1980s, it was discovered that partially hydrogenated oils contain relatively large amounts of *trans*-fatty acids. This is not surprising – the process of catalytic hydrogen involves destabilising the double bonds of the unsaturated fatty acids; some are then hydrogenated (so becoming saturated), while others are not hydrogenated, but return to their stable unsaturated state in either the *cis*- or *trans*-configuration at random.

Health effects of different types of fat and the introduction of *trans*-fats

A series of feeding experiments in the 1950s and 1960s revealed the effects of varying the relative amounts of saturated and unsaturated fatty acids on serum cholesterol, and later specifically low density lipoprotein (LDL) cholesterol, the main risk factor for atherosclerosis and coronary heart disease). In these studies, mono-unsaturated fat was replaced by an equivalent amount of either saturated fat (which raised LDL cholesterol) or polyunsaturated fat (which lowered LDL cholesterol) [9,10].

The conclusion from these studies was obvious – saturated fats are nutritionally undesirable, even though they have highly desirable properties for cooking and food manufacture. *Trans*-isomers of unsaturated fats have many of the desirable physical properties of saturated fats, and manufacturers, especially in USA, started to use partially hydrogenated vegetable oils to provide solid fats with a lower content of saturated fatty acids.

What is surprising (with hindsight) is that although the *trans*-fats behaved more like saturated than unsaturated fats in food manufacture, it was apparently assumed that physiologically they would behave like *cis*-unsaturated fats. This is certainly not the case for their behaviour in cell membranes, where they have a more deleterious effect on membrane fluidity than do saturated fats. There is also evidence that, like saturated fatty acids, *trans*-isomers inhibit cholesterol esterification, and so might be expected to increase LDL cholesterol

The health risks of *trans*-fats

In 1993, Willett and coworkers [11] analysed data from 85,095 women in the Nurses' Health Study, estimating intake of *trans*-fatty acids from diet questionnaires, and showed that over 8 years of follow-up there was a significantly increased risk of cardiovascular disease with increased consumption of foods rich in *trans*-fatty acids, even when other risk factors were taken into account. In 1995 the report of a British Nutrition Foundation task force [12] concluded that current intakes of *trans*-fatty acids in the UK were about 2% of energy, and should not increase. More recent dietary surveys [13] suggest that average intakes in the UK have fallen to about 1.2% of energy intake.

Mozaffarian *et al*. [14] reviewed 12 randomised controlled trials of replacing saturated or *cis*-unsaturated fatty acids with *trans*-fatty acids; their meta-analysis showed that *trans*-fatty acids raise low density lipoprotein, lower high density lipoprotein and have a number of other effects on blood lipids that all point to an increased risk of cardiovascular disease. They also reported a meta-analysis of prospective cohort studies involving 140,000 people that suggests that a 2% increase in the proportion of energy coming from *trans*-fatty acid intake was associated with a 23% increase in coronary heart disease. They noted that these adverse effects were associated with *trans*-fatty acids from partially hydrogenated vegetable oils. Analysis of studies of *trans*-fatty acid intake from ruminant fats shows no significant hazard. This is probably because the predominant *trans*-fatty acid in ruminant fat, vaccenic acid, is readily isomerised to conjugated linolenic acid, and there is some evidence of beneficial effects of conjugated linolenic acid.

Can *trans*-fatty acids be eliminated?

Partial hydrogenation of vegetable oils yields fats with more useful properties for food manufacture and commercial catering than complete hydrogenation to yield fully saturated fats. Simply mixing fully hydrogenated fats with unsaturated fats does not give useful products. However, the process of interesterification does. Interesterification involves partial hydrolysis of triglycerides, liberating free fatty acids, followed by re-esterification under controlled conditions, so as to yield triglycerides containing the desired mixture of saturated and unsaturated fatty acids. The end product has similar physical (and hence industrial) properties to partially hydrogenated oil, but without the formation of *trans*-fatty acids. Because of the additional step of inter-esterification, the final product is, of course, more expensive.

Health benefits of eliminating *trans*-fatty acids

There is a convincing body of evidence that (industrially produced) *trans*-fatty acids are hazardous to health. It is far too soon to know whether the elimination of *trans*-fatty acids from foods in Denmark will have any effect on cardiovascular disease, but it would seem prudent to follow the advice of the Dietary Guidelines for Americans [15] to "consume less than 10% of calories from saturated fat … and keep *trans*-fatty acid consumption as low as possible". The American Heart Association [16] says that "consumers should limit their intake of saturated fat to less than 7 percent of energy, limit *trans*-fat intake to less than 1 percent of energy, and limit cholesterol intake to less than 300 mg per day while consuming a nutritionally adequate diet."

The problem arises in predicting the benefits of eliminating (industrially produced) *trans*-fatty acids from the diet. The American Council on Science and Health report on *trans*-fatty acids and heart disease [17] notes that on the basis of intervention studies of the effects of *trans*-fatty acids on blood lipids, Mozaffarian *et al.* [14] suggested that replacing *trans*-fatty acids with *cis*-polyunsaturated fatty acids would reduce the number of "coronary events" by about 6%. (There are about 1.2 million coronary events – fatal and non-fatal heart attacks – in USA each year, some 40% of which are fatal, so that some 29,000 deaths would be avoided). On the basis of their meta-analysis of the epidemiological studies, Mozaffarian et al. [14] suggest that replacing *trans*-fatty acids with *cis*-polyunsaturated fatty acids would avert 19 – 22% of heart attacks.

However, it is more likely that *trans*-fatty acids will be replaced by saturated fatty acids than polyunsaturated fatty acids, since unsaturated oils simply do not have the properties needed for food manufacture and commercial catering, so the benefits of eliminating trans-fatty acids will be less than predicted. The ACSH report [17] concludes that "focussing too much on a single "bad" factor … can even promote unwise dietary choices, such as selecting a food containing a much larger amount of saturated fat rather than one with a small amount of *trans* fat".

While it would seem prudent to reduce *trans*-fatty acid intake as much as possible, replacement with saturated fatty acids is unlikely to be beneficial. It is important to realise that over the last two decades deaths from coronary heart disease have fallen in most developed countries, while intakes of *trans*-fatty acids have changed little. *Trans*-fatty acid intake is only one of the dietary and life-style factors that influence the risk of coronary heart disease, and perhaps one of the less important ones.

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References

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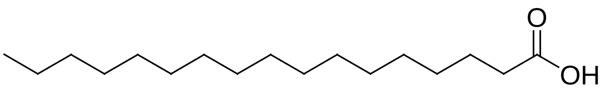
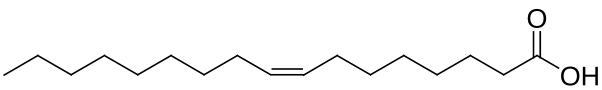
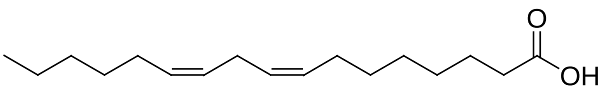


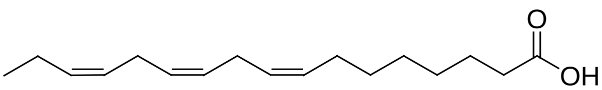
saturated fatty acid (stearic acid, C18:0)



mono-unsaturated fatty acid (oleic acid, C18:1 ω9)

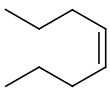


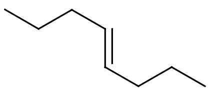
polyunsaturated fatty acid (linoleic acid, C18:2 ω6)



polyunsaturated fatty acid (α-linolenic acid, C18:3 ω3)

In *cis*-isomers, the carbon chain continues on the same side of the double bond;
in *trans*-isomers the carbon chain continues on the opposite side of the double bond


cis


trans