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TRANS FATTY ACIDS

What are *trans* fatty acids (TFAs)?
Fatty acids found in foods can be saturated (i.e. no double bonds), monounsaturated (1 double bond) or polyunsaturated (2 or more double bonds). The double bonds provide rigidity to the molecule and result in specific molecular configurations. Naturally occurring fatty acids in foods usually have the *cis* configuration, i.e. the hydrogen atoms with respect to the double bond are on the same side of the molecule. This results in the molecule having a "V" shape. In *trans* fatty acids (TFAs), the hydrogen atoms are on the opposite sides of the molecule, and the molecule assumes a nearly linear configuration similar to that for saturated fatty acids. Thus TFAs behave more like saturated fatty acids than unsaturated fatty acids, and this has consequences when they are incorporated into membranes and other cellular structures.

Major TFAs include isomers of oleic acid (9 *cis* C18:1), including elaidic acid (9 *trans* C18:1), primarily found in partially hydrogenated vegetable oils, and vaccenic acid (11 *trans* C18:1), primarily found in meat / dairy products. However, many isomers are found in foods.

TFAs are also present as conjugated linoleic acid (CLA, C18:2) that contains both *cis* and *trans* double bonds. Two of several CLA isomers (*cis* 9 *trans* 11, and *trans* 10 *cis* 12) possess biological activity as TFAs.

In which foods are they found, and at what levels?
Unsaturated fatty acids in vegetable oils are normally in the *cis* form. Partial hydrogenation, which is carried out to alter the plasticity and functional properties of the resulting fat, produces several *cis* and *trans* fatty acids from intramolecular rearrangements. However, not all TFAs are produced by commercial hydrogenation. Some unsaturated fatty acids are biohydrogenated by rumen bacteria in ruminant animals such as cows and sheep, producing TFAs in meat (beef, lamb) and dairy products.

Foods containing TFAs include:

- milk, cheese and butter
- eggs
- some meat and meat products
- oils and fats, especially when heated
- biscuits (cookies), cakes, pastries, doughnuts
- pies, sausage rolls, chips, French fries
- partially hydrogenated vegetable oils.

TFAs can be determined in foods by several techniques, including infrared (IR) spectroscopy, gas-liquid chromatography (GLC), high-performance liquid chromatography (HPLC) and silver ion thin-layer chromatography (TLC). Current techniques cannot reliably distinguish between naturally occurring TFAs in ruminant products from those resulting from partial hydrogenation of fats and oils (EFSA 2004).

There is wide variability in TFA levels both between and within foods. While some processed foods may contain TFA levels at 20-40% of total fatty acids, levels from natural sources are generally <10% of total fatty acids. Unfortunately, foods are not routinely analysed for TFAs in food composition studies.

TFA levels in foods in the USA varied from very low (0.01 - 0.7 g/serving) for products such as vegetable oils, RTE breakfast cereals and white bread, to high (up to 4 g/serving) for margarines, doughnuts, French fries and chocolate chip cookies (USDA 1995).

The Transfair study in the EU during 1995 -1996, involving 14 countries and 1300 foods, showed that oils and fats, dairy products, biscuits and cakes contributed most to TFA intakes. Pork and poultry contained <1% TFA (of total fatty acids), meat and dairy products 3-6%, while bakery products (1-30%), breakfast cereals, French fries and snacks (20-40%) contained higher levels (EFSA 2004).

In a survey conducted for the Australian Consumers Association, 18/55 foods (pies, cakes, confectionery, biscuits, deep-fried fast foods) contained TFA levels >2% of total fat (ACA 2005).

TFA intakes

TFA intakes by consumers vary widely, depending on how the intake is measured. Early US data showed intakes of 2.6 -12.8 g/day, while more recent data indicates average intakes of 1.5-2.2% of energy intake, with a mean of 2.6% of energy intake. In the EU, TFA intakes were 0.5-2% of daily energy intake (with saturated fat 10.5-18%, and total fat 36% of energy intake). The mean intake was 2.8 g/day (or 1.3% of energy intake). TFA intakes by EU consumers have decreased in recent years, with lowest intakes in the Mediterranean countries. In Canada, TFA intakes appear to be 1-2% of energy intake.

What are their effects on human health?

Concerns about the health effects of TFAs have concentrated on their role in changing various metabolic risk parameters related to coronary heart disease (CHD), and several studies have also examined their effects on type 2 diabetes, some cancers, strokes and food sensitivities.

Coronary heart disease

Little direct evidence of the role of TFAs on CHD emerged during the 1960s -1970s. In the 1980s, the hypercholesterolemic effect of TFAs was noted in animal studies. During the 1990s, however, clear evidence emerged from human and animal studies and from epidemiological data that TFAs have an adverse effect on the risk of CHD because of their affect on blood lipids (HSPH 1999). TFAs not only increase the levels of low density lipoprotein (LDL or 'bad') cholesterol, as do saturated fatty acids, but also decrease the levels of high density lipoprotein (HDL or 'good') cholesterol in the blood. An increase of 1% in TFA as total energy is reported to decrease HDL by ~1%, and increase LDL by ~1%. There is also some evidence for an elevation of blood triacylglycerols (triglycerides), another risk factor for CHD, and TFAs may also increase blood lipoprotein (a) levels in individuals with elevated initial levels.

The strongest epidemiological evidence for a link between TFA intake and the risk of heart disease come from three major prospective studies involving about 150,000 subjects monitored for 6-14 years: the Health Professionals Follow-up Study (USA, 1996), the Alpha-Tocopherol Beta Carotene Cancer Prevention Study (Finland, 1997), the Nurses' Health Study (USA, 1997), and the Zutphen Elderly Study (Netherlands, 2001) (Danish Nutrition Council 2003). All studies found a positive association between TFA intake and the risk of heart disease.

Data compiled by the Danish Nutrition Council show that TFAs, when substituted for polyunsaturated fatty acids in the diet, increase the LDL / HDL ratio to an extent about double that for saturated fatty acids (DNC 2003). The same study reported a significant decrease in mortality from CHD of both men and women in Denmark during the period 1977 _ 96, during which time TFAs in the diet of these consumers decreased from an average of nearly 8 g/day to less than 3 g/day. This correlation does not, however,

prove that a reduction in TFA consumption alone is responsible for the observed decrease in cardiovascular morbidity. There is some evidence that the naturally-produced TFAs found in meats and dairy products do not contribute to CHD, unlike those derived from partially hydrogenated vegetable oils used in processed foods.

Based on the recommendations of the DNC and the de*cis*ion by Denmark to legislate for reductions in TFA levels in a range of foods, the European Union requested a scientific opinion on TFAs and their effects on the health of consumers from the European Food Safety Authority (EFSA) Scientific Panel on Dietetic Products, Nutrition and Allergies. This opinion, published on 8 July 2004, details considerable information available at that time on the occurrence of TFAs in foods, the health effects of TFA consumption, and methods of analysis (EFSA 2004). The Panel concluded that "….TFAs, like saturated fatty acids, raise LDL (or 'bad') cholesterol levels in the blood, thereby increasing the risk of CHD ……at equivalent dietary levels, the effect of TFAs on heart health may be greater than that of saturated fatty acids. However, current intakes of TFAs are generally more than 10-fold lower than those of saturated fatty acids whose intakes in many European countries exceed dietary recommendations ….".

There appears to be no consistent evidence that TFAs elevate blood pressure, contribute to arrhythmia, interfere with haemostatic function (platelet aggregation, coagulation, fibrinolysis), increase the susceptibility to LDL oxidation, or have a role in strokes (EFSA 2004).

Cancers

There is conflicting evidence concerning the role of TFAs and CLA in cancers (DNC 2003, EFSA 2004, IFST 2004). The Nurses' Health Study in the USA, involving nearly 89,000 women who were free of cancer in 1980 and followed up for 14 years, suggested that TFA intake was negatively associated with the risk of breast cancer, and no evidence was found that lower intake of total fat or specific types of fat decreased the risk of breast cancer, while a Netherlands study showed a weak association between total TFA intake and postmenopausal breast cancer.

In part of the EURAMIC (European Community Multicentre Study on Antioxidants, Myocardial Infarction and Breast Cancer) study a positive association was found between TFA intake and adipose tissue levels and the incidence of breast and large intestinal cancers, while there was no association with prostate cancer. Other studies have shown no association between TFA intake and colorectal adenomatous polyps.

Type 2 diabetes

A positive association was observed in the Nurses Health study between TFA intake and the risk of developing type 2 diabetes, especially for obese women. It was reported that a reduction in TFA intake from 3% to 1% of energy could reduce the incidence of type 2 diabetes by 40%. Elaidic acid (9 *trans* C18:1) produced higher blood insulin levels than oleic acid at the same blood sugar levels (DNC 2003). In other case control and prospective cohort studies, it was not possible to draw any association betweenTFA or total fat intake and their sources and risk of type 2 diabetes.

Food sensitivities

Positive relationships have been observed between the prevalence of asthma, allergic rhinoconjunctivitis and atopic eczema with TFA intake but not with *cis*-MUFA and *cis* PUFA in teenagers around the world (EFSA 2004).

Alternative fat sources and manufacturing techniques

Several possibilities exist to reduce TFA levels in foods and thus reduce intakes.

Vegetable oil composition can be modified by:

- interesterification or molecular rearrangement, and blending with TFA-free vegetable oils,
- modifying the hydrogenation process, such as using electrocatalysis (lower temperatures),

precious metal catalysts (platinum, palladium) or supercritical fluids states (IFT 2005), and
- genetically modifying the fatty acid profile, e.g. to produce high(er) oleic acid levels.

Vegetable oils can also be substituted for animal fats in food formulations, and in frying. In some countries (e.g. Australia and New Zealand), regulatory authorities have approved the addition of cholesterol-lowering food additives, such as plant sterols (phytosterols), to foods such as margarines and fat-based spreads.

Regulatory approaches to control TFA levels in foods

Different regulatory approaches to control TFA levels in foods and thus reduce intakes have been used. In recent years, several national and international food manufacturers have marketed products with low or no TFAs.

USA

It has been reported that about 12.5M US citizens suffer from CHD, with a mortality of 0.5M per annum. CHD is the leading cause of death.

In 1993, the US Food and Drug Administration changed labeling laws to require saturated fat and cholesterol levels to be included in the Nutrition Facts panel on all labels. In April 2004 the FDA Advisory Committee recommended that TFA intake be reduced to "…<1% of energy intake…". Subsequently (January 2006), the FDA required TFA levels also to be included on food labels, with % saturated fat equal to the sum of saturated and *trans* fatty acids. Foods containing <0.5 g/serving are defined as containing no TFAs, while those foods containing >4 g saturated + *trans* fatty acids cannot carry a health claim (USFDA 2006). The FDA decided not to distinguish between industrially produced TFAs and those derived from rumen hydrogenation, thus dairy products must be labeled with TFA levels.

Canada

Nutrition information changes to Food and Drug Regulations were made in January 2003, requiring compliance by 12 December 2005 for large manufacturers, and by 12 December 2007 for small manufacturers. Total fat, saturated fat and TFAs are now required on food labels. If claims are made (e.g. reduced TFA levels), immediate compliance is required.

Denmark

In 2003 the Danish Nutrition Council recommended restrictions on and phasing out of the use of industrially-produced TFAs in foods. By 1 June 2003, oils and fats were limited to <2% TFAs, and from 1June to 31 December 2003, <5% TFAs were permitted in oils and fats used in processed foods. From 1 January 2004, <2% TFAs are permitted in oils and fats used in both local and imported processed foods.

European Union

Except for Denmark, TFA levels are required on labels only if a TFA claim is made (e.g. 'low in TFA').

Australia / New Zealand

Mandatory TFA labeling was considered during a comprehensive review of the Food Standards Code in1999 - 2002, however Food Standards Australia New Zealand (FSANZ) and its precursor decided not to mandate labelling of TFAs, as it was believed that TFA consumption was relatively low; and that similar reductions in saturated fat intake would be more likely to have a greater impact. TFA contents are required on labels only if a nutrition claim is made with respect to cholesterol, saturated or unsaturated fatty acids, or TFAs. Voluntary labeling is permitted, and many vegetable oil spread manufacturers include TFA levels on labels. FSANZ permits the addition of phytosterols to margarines and edible oil spreads under the Novel Food Standard (Standard 1.5.1), providing that saturated fat + TFAs are <28% of the total fatty acid content. Recently, manufacturers have sought approval for the addition of phytosterols to low-fat milk and yoghurt, breakfast cereals and fruit juice drinks.

The Australian Heart Foundation recommends that saturated and TFAs be <8% of total energy intake.

In recent times, several national and international food manufacturers have launched a variety of low or TFA-free products.

Nutritional advice to help reduce TFA intakes
TFA-free diets are difficult to develop and maintain, as they may lead to undesirable effects such as micronutrient deficiencies from removing foods such as some meats and dairy products from the diet. Nutritionists, dietitians and health professionals recommend that consumers should reduce their TFA intake, while consuming a nutritionally adequate diet.

What can consumers do? Some suggestions include:

- use TFA-free margarine spreads, not butter
- use low / reduced / modified fat milk, cheese, ice cream
- have fish at least twice/week (but if pregnant, especially not predatory fish)
- have meals based on vegetables, grains
- limit take-away foods to less than once per week
- limit snack foods, cakes, pastries, cholesterol-rich foods (egg yolks, offal).

Consumer education campaigns and food labels will be important tools to provide consumers with factual information on current levels of TFAs in foods, and how they can reduce their intake of TFAs.

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