# Trans fat

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Types of <u>Fats</u> in <u>Food</u>

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See Also

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- Essential fatty acid

*Trans* fatty acids (commonly termed **Trans Fats**) are a type of <u>unsaturated fat</u> (and may be <u>monounsaturated</u> or <u>polyunsaturated</u>). Trans fats are found naturally in small quantities in meat and dairy products from <u>ruminants</u> but are now commonly created by partial <u>hydrogenation</u> of plant oils and animal fat by the processed food industry.

Chemically speaking, trans fats are made of the same building blocks as non-trans fats, but are a slightly different shape. From a <u>molecular</u> perspective, the different shape is caused by <u>double bonds</u> between <u>carbon atoms</u> (characteristic of all unsaturated fats) being in the <u>trans</u> rather than the <u>cis</u> configuration. Trans fats are more of a straight shape, while the *cis* shape is more kinked.

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# **Presence in food**

Trans fats occur naturally in the milk and body fat of <u>ruminants</u> (such as <u>cows</u> and <u>sheep</u>) at a level of 2-5% of total fat<sup>[1]</sup>. They originate in the <u>rumens</u> of these animals. Animalbased fats were once the only trans fats consumed but by far the largest amount of trans fats consumed today are plant-based trans fats (made from partially hydrogenated vegetable oil). These have displaced natural solid fats and liquid oils in many areas, notably in the fast food, <u>snack food</u>, fried food and baked good industries. Vegetable <u>shortenings</u> are primarily trans fats packaged for home use, and some <u>margarines</u> contain a large proportion of them. Foods containing artificial trans fats formed by partially hydrogenating plant fats may contain up to 45% trans fat compared to their total fat.<sup>[1]</sup>

Benefits of hydrogenating plant-based fats for food manufacturers include an increased product shelf life and decreased refrigeration requirement. Partial hydrogenation raises the melting point of fat, producing a semi-solid material, which is much more desirable than liquid oils for use in baking. Plant-based hydrogenated vegetable oils are much less expensive than the animal fats traditionally favored by bakers, such as <u>butter</u> or <u>lard</u>.

Because partial hydrogenation of plant oils can replace animal fats, the resulting products can be consumed (barring other ingredient and preparation violations) by adherents to <u>Kashrut</u> (kosher) and <u>Halal</u>, as well as by adherents to <u>vegetarianism in Buddhism</u>, <u>ahimsa</u> in <u>Jainism</u> and <u>Hinduism</u>, <u>veganism</u>, and other forms of <u>vegetarianism</u>.

It has been established that trans fats in <u>human milk</u> fluctuate with maternal consumption of trans fat, and that the amount of trans fats in the bloodstream of breastfed infants fluctuates with the amounts found in their milk. Reported percentages of trans (compared to total fats) in breastmilk range from 1% in Spain, 2% in France and 4% in Germany to 7% in Canada<sup>[2]</sup>.

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### **Nutritional guidelines**

The <u>National Academy of Sciences</u> (NAS) advises the United States and Canadian governments on nutritional science for use in public policy and product labelling programs. Their 2002 *Dietary reference intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids* <sup>[3]</sup> contains their findings and recommendations regarding consumption of Trans fat (<u>summary</u>).

Their recommendations are based on two key facts. First, "trans fatty acids are not essential and provide no known benefit to human health"<sup>[4]</sup>. Second, while both saturated and trans fats increase levels of <u>LDL cholesterol</u> (so-called "bad" cholesterol), trans fats also lower levels of <u>HDL cholesterol</u> (so-called "good" cholesterol) <sup>[5]</sup>; this increases the risk of <u>coronary heart disease</u> (CHD). The NAS is concerned "that dietary trans fatty acids are more deleterious with respect to CHD than saturated fatty acids".<sup>[5]</sup>

Because of these facts and concerns, the NAS has concluded there is no safe level of trans fat consumption. There is no adequate level, recommended daily amount or tolerable upper limit for trans fats. This is because any incremental increase in trans fatty acid intake increases the risk of CHD.<sup>[5]</sup>

Despite this concern, the NAS dietary recommendations have not recommended the elimination of trans fat from the diet. This is because trans fat is naturally present in many animal foods, and therefore in most non-vegan diets; its removal from ordinary diets might introduce undesirable side effects and nutritional imbalances if proper nutritional planning is not undertaken. The NAS has therefore "recommended that trans fatty acid consumption be as low as possible while consuming a nutritionally adequate diet" <sup>[6]</sup>. Like the NAS, the <u>World Health Organization</u> has tried to balance public health goals with a practical level of trans fat consumption, recommending in 2003 that trans fats be limited to less than 1% of overall energy intake<sup>[11]</sup>.

The US National Dairy Council has asserted that the trans fats present in animal foods are of a different type than those in partially hydrogenated oils, and do not appear to exhibit the same negative effects <sup>[7]</sup>.

Although the NAS has based its analysis on cardiovascular concerns, there are other deleterious effects of trans fat consumption, see *Nutritional biochemistry* below.

#### [edit]

# History

<u>Nobel</u> laureate <u>Paul Sabatier</u> worked in the 1890s to develop the chemistry of hydrogenation which enabled the margarine, oil hydrogenation, and synthetic methanol industries<sup>[8]</sup>. While Sabatier only considered hydrogenation of vapours, the <u>German</u> chemist Wilhelm Normann showed in 1901 that liquid oils could be hydrogenated, and patented the process in 1902<sup>[9]</sup>. In 1909 Procter & Gamble in <u>Cincinnati</u> acquired the US rights to the Normann patent and in 1911 they began marketing <u>Crisco</u>, the first hydrogenated <u>shortening</u>, which contained a large amount of partially hydrogenated cottonseed oil. Further success came from the marketing technique of giving away free cookbooks with every recipe calling for Crisco. Hydrogenation strongly stimulated whaling, as it made it possible to stabilize <u>whale oil</u> for human consumption.

In the 1950s, advocates said that the *trans* fats of margarine were healthier than the <u>saturated fats</u> of butter, but this has been proven incorrect. One example of the effects of

*trans* fats vs saturated fats came from the "Walter Willett Nurses Study" (Professor of Medicine, <u>Harvard Medical School</u>). The 14-year study of 80,082 women who were 34 to 59 years of age concluded that a 2% increase in *trans* fats, compared to the same increase in carbohydrates, increased a woman's risk of <u>heart disease</u> by 19.3%, while the same study found that a 5% increase in saturated fats increased heart disease risk by 17% compared with the same increase in carbohydrates. <sup>[10]</sup>

The <u>Center for Science in the Public Interest</u> (CSPI) campaigned against <u>fast foods</u> using saturated fats starting in <u>1984</u>. When fast food companies replaced the saturated fat with *trans* fat, CSPI's campaign against them ended. CSPI defended *trans* fats in their <u>1987</u> <u>Nutrition Action</u> newsletter. However, by <u>1992</u>, CSPI began to speak against *trans* fats and is currently strongly against their use.

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### Chemistry

In a natural fatty acid, the hydrogen atoms are usually on the same side of the <u>double</u> <u>bonds</u> of the carbon chain. However, partial hydrogenation reconfigures most of the double bonds that do not become chemically saturated, twisting them so that the hydrogen atoms end up on different sides of the chain. This type of configuration is called *trans*, which means "across" in Latin. (Note that it is not just a swapping of the position of the single hydrogen atom, rather it is a twisting of the whole molecule from that point on that creates the *trans* alignment; note the arrangement of the red oxygen atoms in the diagram below to see this effect.)

#### Oleic acid

Oleic acid is a *cis* unsaturated fat that comprises 55-80% of olive oil. To visualize the reason for the different shape, count the carbon atoms on the "top" vs. the "bottom" of both molecules.

#### Elaidic acid

Elaidic acid is a *trans* unsaturated fat and a major trans fat found in hydrogenated vegetable oils. It is a <u>geometric isomer</u> of Oleic acid (chemically identical except for the arrangement of the double bond).



Technically speaking, the conversion from *cis* to *trans* configuration is a <u>catalytic</u> reaction, meaning that another atom is temporarily bonded into the fat during the conversion process and then released. The other elements used (the <u>catalysts</u>) are finely divided <u>nickel</u>, <u>palladium</u>, <u>platinum</u> or <u>cobalt</u>.

The amount of *trans* fatty acid in the product is dependent on reaction conditions. Increasing the pressure at which an oil is hydrogenated reduces *trans* fat formation. Researchers at the <u>United States Department of Agriculture</u> applied 1400 kPa (200 psi) of pressure to soybean oil in a 2-litre vessel while heating it to between 140°C and 170°C. The standard 140 kPa (20 psi) process of hydrogenation produces a product of about 40% *trans* fat by weight, compared to about 17% using the high pressure method. Blended with pure soybean oil, the high pressure processed oil produced margarine containing 5 to 6% *trans* fat which could qualify for a label of zero grams of *trans* fat.<sup>[12]</sup>

Trans fats are formed from a process described as *partial* hydrogenation because the reaction is not allowed to go to completion; if it were there would be no *trans* fatty acids left, but the resulting material would be too solid for practical use. A notable exception is <u>The J.M. Smucker Company</u>'s new <u>Crisco</u> formulation which contains the high melting point, waxlike, fully hydrogenated <u>cottonseed oil</u>. This is blended with liquid vegetable oils to yield a shortening much like the previous partially hydrogenated Crisco which was made from partially hydrogenated vegetable oil.

#### [edit]

### Nutritional biochemistry

Although synthetically created *trans* fatty acids have been a significant part of the human diet for just over 100 years, the <u>biochemistry</u> of *trans* fatty acids is poorly understood. Little is known about how *trans* fatty acids are incorporated into the developing fetal brain tissue, cell membranes, and arterial plaque. Some clinical studies suggest a possible association of *trans* fatty acids with <u>cancer</u>, <u>coronary heart disease</u>, <u>obesity</u>, <u>metabolic</u> syndrome and <u>diabetes</u>. It is unclear whether the naturally present *trans* fatty acids in beef, <u>mutton</u> and <u>dairy products</u> (created through fermentation processes in the stomach of <u>ruminant</u> animals) pose the same risks.<sup>[7]</sup>

Trans fats are associated with an increased prostate cancer risk with researchers noting that "blood levels of trans fatty acids, in particular trans fats resulting from the hydrogenation of vegetable oils, are associated with an increased <u>prostate cancer</u> risk" <sup>[13]</sup>. There is preliminary evidence that other cancers may also be related to trans fat intake<sup>[14]</sup>.

Human metabolism requires <u>essential fatty acids</u> which are destroyed by the hydrogenation process by which trans fat is produced. The destruction of some of the essential fatty acids is one of the intended goals of hydrogenation, since reducing the proportion of unsaturated fatty acids which are at risk of oxidation creates shortening that is less likely to undergo <u>rancidification</u>. For example, a typical <u>candy bar</u> might have a

<u>shelf life</u> of 30 days without use of hydrogenated oils, while the same product with hydrogenated oils can last up to 18 months. For this reason, many believe that trans fat should be classified as a preservative.

*Trans* fat behaves like <u>saturated fat</u> by raising the level of <u>low-density lipoprotein</u> in the blood (LDL or "bad <u>cholesterol</u>") which increases the risk of <u>coronary heart disease</u> (CHD). It has the additional effect of decreasing levels of <u>HDL</u>, the "good" lipoprotein which helps remove cholesterol from arteries. The net increase in LDL/HDL ratio with trans fat is approximately double that due to saturated fat.<sup>[15]</sup> (Higher ratios are more deleterious)

A study of over 700 nurses showed that those in the highest <u>quartile</u> of trans fat consumption had blood levels of <u>C-reactive protein</u> (CRP, a pro-inflammatory <u>cytokine</u> which is a <u>cardiovascular disease</u> risk factor) that was 73% higher than those in the lowest quartile.<sup>[16]</sup> Although one group of researchers indicated that CRP may only be a moderate risk factor for cardiovascular disease <sup>[17]</sup>, others have shown that CRP can exacerbate <u>ischemic necrosis</u> in a <u>complement</u>-dependent fashion and that CRP inhibition can be a safe and effective therapy for <u>myocardial</u> and <u>cerebral infarcts<sup>[18]</sup></u>.

The majority of clinical research reports have suggested that *trans* fats may be worse for the body than saturated fats; in fact, the 2002 summary statement by the Institute of Medicine on trans fatty acids concluded that there was no safe level of trans fatty acids in the human diet.

A confounding issue may arise from the cooking process itself, in that trans-fats are often associated with high temperature cooking processes which also favor the formation of <u>Advanced glycation endproduct</u> (AGEs) and oxidation products. It appears some of the studies have not controlled for these AGEs and oxidation products. It has been suggested that, "given the prominence of this type of food in the human diet, the deleterious effects of high-fat foods may be in part due to the high content in glycotoxins, above and beyond those due to oxidized fatty acid derivatives." <sup>[19]</sup> The glycotoxins, as he called them, are more commonly called AGEs.

Trans fats are metabolized differently by the <u>liver</u> than other fats and interfere with delta 6 <u>desaturase</u>. Delta 6 desaturase is an <u>enzyme</u> involved in converting essential fatty acids to <u>arachidonic acid</u> and <u>prostaglandins</u>, both of which are important to the functioning of cells<sup>[20]</sup>. Trans fats which cannot be metabolized normally end up in the liver for biotransformation. If they simply can never be metabolized, they are returned in the blood to fat cells for storage, possibly posing a risk of permanent obesity<sup>[citation needed]</sup>.

Research with monkeys indicates that trans fat may also increase weight gain and abdominal fat, despite a similar caloric intake <sup>[21]</sup>. A 6-year experiment revealed that monkeys fed a trans-fat diet gained 7.2% of their body weight, as compared to 1.8% for monkeys on the mono-unsaturated fat diet. Monkeys eating trans fats also had 30% more abdominal fat. Abdominal fat is associated with <u>diabetes mellitus type 2</u> and <u>heart</u> <u>disease</u>.

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# **Public response and regulation**

The lengthy political process of balancing the public health versus private profit from the public sale of processed foods containing artificially hydrogenated oils and fats continues today. Some countries are considering a complete ban against artificial hydrogenation products in food.

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#### Canada

<u>Canada</u> is one of the largest consumers of trans fats in the world <sup>[22]</sup>. The food regulator, <u>Health Canada</u> requires the listing of the amount of *trans* fats in the food described.<sup>[1]</sup>

In November 2004, an <u>opposition day</u> motion seeking a ban similar to Denmark's was introduced by <u>Jack Layton</u> of the <u>New Democratic Party</u>, and passed through the <u>Canadian House of Commons</u> by an overwhelming 193-73 vote.<sup>[23]</sup>

In June 2006, a task force co-chaired by Health Canada and the <u>Heart and Stroke</u> <u>Foundation of Canada</u> recommended a limit of 5% trans fat (to total fat) ratio in all products sold to consumers in Canada (2% for tub margarines and spreads).<sup>[11]</sup> The amount was selected such that "most of the industrially produced trans fats would be removed from the Canadian diet, and about half of the remaining trans fat intake would be of naturally occurring trans fats". This recommendation has been endorsed by the Canadian Restaurant and Foodservices Association<sup>[24]</sup> and the Food and Consumer Products of Canada has congratulated the task force on the report<sup>[25]</sup>.

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### Denmark

<u>Denmark</u> became the first country to introduce laws strictly regulating the sale of many foods containing *trans* fats in <u>March 2003</u>, a move which effectively <u>bans</u> partially hydrogenated oils. Naturally present trace amounts of *trans* fatty acids in <u>dairy</u> and <u>meat</u> products are unaffected by these bills. The UK campaigning body tfX offers an English translation on its <u>Denmark's trans fat law</u> page.

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### **European Union**

The <u>European Food Safety Authority</u> was asked to produce a scientific opinion on trans fats.<sup>[26]</sup>

#### [edit]

#### **United Kingdom**

In October 2004, the <u>Food Standards Agency</u> (FSA) has asked for better labelling in the UK. <sup>[27]</sup> In the 29 July 2006 edition of the <u>British Medical Journal</u>, an editorial also called for better labelling.<sup>[28][29]</sup>

Some companies such as <u>Nestlé<sup>[citation needed]</sup></u>, <u>Marks & Spencer<sup>[30]</sup></u> and <u>Waitrose<sup>[31]</sup></u> have voluntarily removed or reduced trans fats from their products. Two major supermarkets will be withdrawing trans fats from their own-brand products: <u>Sainsbury's</u> from January 2007 and and <u>Tesco</u> by the end of 2006.<sup>[32]</sup>

#### [edit]

#### **United States**

In May 2003, BanTransFats.com Inc., a U.S. non-profit corporation, filed a lawsuit against the food manufacturer <u>Kraft Foods</u> in an attempt to force Kraft to remove *trans* fats from the <u>Oreo</u> cookie. The lawsuit was withdrawn when Kraft agreed to work on ways to find a substitute for the *trans* fat in the Oreo. This suit was very effective at bringing the *trans* fat controversy to public attention.

Before 2006, consumers in the <u>United States</u> could not easily determine the presence (or quantity) of *trans* fats in food products. This information could only be inferred by reading the ingredient list on the food label. If the ingredients included the words "shortening," "partially hydrogenated vegetable oil," or "hydrogenated vegetable oil," the food probably contained *trans* fat. Because ingredients are listed in descending order of predominance, smaller amounts are present when the ingredient is close to the end of the list.

Some consumer advocates wanted a ban on trans fats in the US, but the United States Food and Drug Administration (FDA) responded with a labelling requirement instead. On July 9, 2003, the FDA issued a regulation (21 CFR 101.9 (c)(2)(ii)) requiring manufacturers to list *trans* fatty acids, or *trans* fat, on the Nutrition Facts panel of foods and some dietary supplements<sup>[33][34]</sup>. This new information must appear below the listing of saturated fat content, which was already required. The regulation allows *trans* fat levels of less than 0.5 grams per serving to be labeled as 0 grams per serving, or *trans* fat free. (In this case, manufacturers may use the synonyms "free", "without," "no" and "zero" in their packaging claims.) However, it should be noted that small amounts may be significant, depending on how many servings are consumed. The FDA defines *trans* fatty acids as containing one or more *trans* linkages that are not in a <u>conjugated system</u>.

The new labeling rule took effect <u>January 1</u>, <u>2006</u>. The FDA created a process where companies may petition for an extension that will be reviewed on a case-by-case basis. Extensions will be granted until <u>January 1</u>, <u>2008</u>. The FDA estimates that by 2009, *trans* 

fat labeling will have prevented from 600 to 1,200 cases of <u>coronary heart disease</u> and 250 to 500 deaths each year. This benefit is expected to result from consumers choosing alternative foods lower in *trans* fatty acids as well as manufacturers reducing the amount of trans fatty acids in their products.

While the FDA regulation was strictly a labeling directive, many food manufacturers used the 2006 deadline as a target date to reduce or eliminate *trans* fats from their products. This required some experimentation with alternative oils in an attempt to preserve the flavor and "mouth feel" of the food while maximizing shelf life. The solution for some products was a return to the saturated fats and tropical oils abandoned 20 years earlier, when saturated fats were a high-profile health concern. Another solution was the use of new <u>soybean</u> varieties and processing methods, which produce oils with many of the desirable characteristics of hydrogenated oils without requiring hydrogenation.

The movement away from *trans* fat has been seen in restaurant chains as well. In June 2006, the fast food chain <u>Wendys</u> announced that they would switch to non-hydrogenated cooking oil to reduce *trans* fat. <u>New York City</u> has asked all its restaurants to eliminate *trans* fat from their offerings, on a voluntary basis. In May 2005, <u>Tiburon, California</u> became the first city in the world where all restaurants cook with trans fat-free oils. In June 2006, Panera's food chain has removed transfats from all breads and bagels, and most of their other baked goods.<sup>[35]</sup>

On 16th June 2006, research found that <u>KFC</u> uses trans fat when frying. The <u>Center for</u> <u>Science in the Public Interest</u> has sued KFC and will try to bring down the use of trans fat in KFC. KFC's reply was that it is looking into new methods of cooking but to use any other fat would jeopardise their unique flavour, availability and cost.

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[edit]

# **External links**

- Ban Trans Fats
- Chemical Structure of Fats and Fatty Acids
- Research on the Safety of Hydrogenated Vegetable Oils

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Categories: Articles with unsourced statements | Lipids | Nutrition | Fatty acids | Carboxylic acids