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*Strengthening Global Food Science and Technology for Humanity*

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## Partially Hydrogenated Oils

### Introduction

Full hydrogenation of edible oils leads to the formation of saturated fatty acids that are important for texturing certain processed foods, such as pastries. However, incomplete hydrogenation can lead to the formation of partially hydrogenated oils (PHOs), sometime referred to as “trans fatty acids”. With their double bonds in the trans (E) configuration, PHOs have been associated with adverse health effects. In general, naturally-occurring double bonds in edible oils and fats are in the cis (Z) configuration, especially those of plant origin. However, low amounts of trans-fats are also produced by bacteria in the rumen of cattle, goats and sheep. Consequently, meat from these animals typically contain 1% of trans-fats and butter may contain 3% trans-fats. However, these trans fatty acids are not of significant health if consumed in moderate amounts.

About 100 years ago, it was discovered that hydrogen could be added to natural oils, such as soybean oil, fish oil and even whale oil, to produce a semi-solid fat that had many uses in manufactured foods. Trans fats are made incidental to the hydrogenation process as the double bonds with the hydrocarbon chain on same side (cis) is flipped to the opposite side (trans), which is favored thermodynamically. The hydrogenation process is sensitive to the pressure at which the process is carried out. It has been reported that hydrogenation of soybean oil carried out at between 140°-170° under pressure of 1400 kPa (200 psig) generates about 17% trans fatty acids by weight, while hydrogenation carried out at 140 pKa (20 psig) produces 40% trans fatty acids by weight.<sup>1</sup>

Within the last 20 years, epidemiological and other evidence has accumulated that trans-fatty acids are metabolized by the body by a pathway that is detrimental to health. In response, many countries have taken steps to reduce or eliminate trans-fatty acids in the diets of their populations.<sup>2</sup> One source of trans fats is commercially processed foods, which are often labelled as containing “partially hydrogenated oils”. Restaurants, snack shop, street-food vendors and even consumers in the home may use PHOs for deep frying and cooking. This Scientific Information Bulletin is intended for food scientists and technologists who have the major role to play in the elimination of these synthetic trans-fatty acids from the food supply by reformulating processed products that now contain them. This SIB complements and updates a previous bulletin on trans fatty acids that was published by IUFOST a decade ago.

## **Adverse health effects of partially hydrogenated and trans fats**

Trans fats raise levels of low-density lipoprotein (LDL), which is commonly called bad cholesterol, and lower levels of high-density lipoprotein (HDL) levels, which is called good cholesterol. LDL is associated with higher risk of stroke and as well as type 2 diabetes.<sup>3</sup> Epidemiological studies in places that have reduced or banned PHOs have shown a reduced risk of stroke.<sup>4</sup> The European Food Authority has concluded from controlled intervention studies and prospective cohort studies, that consumption of diets containing trans fatty acids has adverse effects on blood lipids that predict an increase in coronary heart disease risk compared with diets containing cis fatty acids and recommended that dietary intakes of trans fatty acids should be as low as possible.<sup>5</sup> By reducing the levels of trans fatty acids in the diet, the body burden of these chemicals have been shown to be reduced. The World Health Organizations (WHO) estimates the consumption of PHOs causes more than 500,000 deaths from cardiovascular disease a year, mostly in low- and middle-income countries.<sup>6</sup> Increased intake of PHOs (>1% of total energy intake) is associated with increased risk of coronary heart disease events and all-cause mortality.<sup>7</sup>

## **Uses in Food**

In the early part of the 20<sup>th</sup> century, PHOs from vegetable oils were used to make margarine and later they were used in commercial baked goods and snacks. In countries that have not restricted PHOs, they may be found in many foods – especially fried foods but also in baked goods such as, pies, cakes, frozen pizza, cookies, crackers, and in margarines and butter-like spreads.<sup>8</sup> Many baked foods require semi-solid fats to suspend solids at room temperature; PHOs have the right consistency and mouthfeel in order to replace animal fats, such as butter, lard and tallow at lower cost. They are also an inexpensive alternative to other semi-solid oils, such as palm oil. PHOs can also extend the shelf life of products and reduce refrigeration requirements.

In particular, PHOs are often used for deep-frying in restaurants as they can be used for longer periods than most conventional oils before becoming rancid. The use of different PHOs and in different applications means that the exposure to trans fats can have large variations. In addition, the abuse of cooking oils is expected to increase the isomerization of cis double bonds to trans because of the times and temperatures involved. The abuse of cooking oils is common in street-vended food in developing countries, but no systematic data is available to confirm trans-fat content of such foods.<sup>9</sup> Even in advanced countries, “trans-free” on the label means a content of less than 2%, which is legally the upper regulatory limit.

Various studies have shown that the trans-fat contents in various foods and even within the same food can be highly variable. For example, the percentage of trans fat (g/100 g) has been estimated for shortenings, 10-33% ; margarine and spreads, 0.2-26%; butter, 2-7%; whole milk, 0.07-0.1%; breads/cake products, 0.1-10%; cookies and crackers, 1-8%; salty snacks, 0-4%; cake frostings and sweets, 0.1-7%; animal fat, 0-5%; and ground beef, 1%. In processed foods, levels of trans fat can be reduced by substitution with naturally occurring non-hydrogenated vegetable oils, such as canola, safflower, sunflower or olive oil, for PHOs. In addition, softer margarines can be a substitute for margarine varieties that are formulated to be harder, as in many tropical countries.

## Reducing PHOs in the Food Supply

Policy actions implemented by various countries as well as local jurisdictions have demonstrated that implementation of strategic actions can effectively eliminate PHOs from the food supply. For example, the US Food and Drug Administration now prohibits any processed food from containing PHOs.<sup>10</sup> While global food companies have greatly reduced PHOs in developed countries, greater efforts are needed for countries of Asia and Africa to address this problem. To this end, WHO initiated a campaign that advocates the elimination of industrially-made trans fats by 2023 throughout the world.<sup>11</sup> The initiative calls on international policymakers to follow the recommendations outlined in “**REPLACE**” — an acronym for **R**eview, **P**romote, **L**egislate, **A**ssess, **C**reate and **E**nforce. Implementing these six strategic recommendations outlined in the REPLACE program will significantly reduce the global burden of cardiovascular disease. The program specifically calls for countries to:

**Review** dietary sources of PHOs and the landscape for required policy change.

**Promote** the replacement of PHOs with healthier fats and oils.

**Legislate** or enact regulatory actions to eliminate PHOs.

**Assess** and monitor PHO content in the food supply and changes in PHO consumption in the population.

**Create** awareness of the negative health impact of PHOs among policy-makers, producers, suppliers, and the public.

**Enforce** compliance with policies and regulations.

WHO monitors countries' implementation of legislative and other measures to reduce and eliminate PHOs and has developed a scoring system to track countries' progress on a continuous basis. Currently about one-third of the world's populations is protected by mandatory PHO limits according to the monitoring.<sup>12</sup>

## Role of Food Scientists and Technologists

Given the evidence of harm caused by consumption of PHOs, the food industry, including processors, manufacturers, restaurants and street food vendors, should voluntarily replace their use of PHOs with more healthy ones devoid of them. Current evidence indicates that saturated fats do not pose a serious risk of cardiovascular disease as once thought and may be an acceptable substitute for PHOs. In the past, food scientists and technologists have responded to consumer demands for foods lower in fat and many foods have their “reduced fat” or “no fat” counterparts. Similarly, the food science and technology community in developed countries has risen to the challenge of producing “no trans fat” foods that consumers demand and that the law requires.<sup>13 14 15 16</sup> In this regard, the food science and technology community and the food industry in developing and middle-income countries should support legislation to restrict or ban PHOs from entering the food chain.<sup>17</sup> In addition, other sources of trans fatty acids in abused frying oils, should be explored.

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<sup>1</sup> Eller FJ, List GR, Teel JA, Steidley KR, Adlof RO. Preparation of spread oils meeting U.S. Food and Drug Administration Labeling requirements for trans fatty acids via pressure-controlled hydrogenation. *Journal of Agricultural and Food Chemistry*, 2005, 53 (15): 5982–4.

<sup>2</sup> European Commission. Regulation (EC) No 1925/2006 of the European Parliament and of the Council, amended on 24 April 2019. [https://ec.europa.eu/food/safety/labelling\\_nutrition/trans-fat-food\\_en](https://ec.europa.eu/food/safety/labelling_nutrition/trans-fat-food_en)

<sup>3</sup> Lichtenstein AH. Dietary trans fatty acids and cardiovascular disease risk: past and present. *Current Atherosclerosis Reports* 2014; 16: 433.

<sup>4</sup> Mozaffarian D, Aro A and Willett WC. Health effects of trans-fatty acids: experimental and observational evidence. *European Journal of Clinical Nutrition* 2009; 63: S5.

<sup>5</sup> European Food Safety Agency. Technical report on scientific and technical assistance on trans fatty acids, 19 June 2019. <http://www.efsa.europa.eu/en/supporting/pub/en-1433>

<sup>6</sup> Wang Q, Afshin A, Yakoob MY, et al. Impact of non-optimal intakes of saturated, polyunsaturated, and trans fat on global burdens of coronary heart disease. *Journal of the American Heart Association* 2016; 5: e002891.

<sup>7</sup> De Souza RJ, Mente A, Maroleanu A, et al. Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: systematic review and meta-analysis of observational studies. *British Medical Journal* 2015; 351: h3978.

<sup>8</sup> Wanders AJ, Zock PL and Brouwer IA. Trans fat intake and its dietary sources in general populations worldwide: a systematic review. *Nutrients* 2017; 9: 840.

<sup>9</sup> Gupta V, Downs SM, Ghosh-Jerath S, et al. Unhealthy fat in street and snack foods in low-socioeconomic settings in India: a case study of the food environments of rural villages and an urban slum. *Journal of Nutrition Education and Behavior* 2016; 48: 269-279. e261.

<sup>10</sup> US Food and Drug Administration. Final determination regarding partially hydrogenated oils, 17 June 2015. <https://www.federalregister.gov/documents/2015/06/17/2015-14883/final-determination-regarding-partially-hydrogenated-oils>

<sup>11</sup> WHO. REPLACE - An Action Package to Eliminate Industrially Produced Trans-Fatty Acids, WHO/NMH/NHD/18.4, updated June 2019. <https://www.who.int/nutrition/topics/replace-transfat>

<sup>12</sup> WHO. Global database on Implementation of Nutrition Action (GINA) – Trans Fatty Acid Country Score Card. <https://extranet.who.int/nutrition/gina/en/scorecard/TFA>. Accessed on 5 July 2020.

<sup>13</sup> Rippin H, Hutchinson J, Ocke M, et al. An exploration of socioeconomic and food characteristics of high trans fatty acid consumers in the Dutch and UK national surveys after voluntary product reformulation. *Food and Nutrition Research* 2017; 61: 1412793.

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<sup>14</sup> Mozaffarian D, Jacobson MF and Greenstein JS. Food reformulations to reduce trans fatty acids. *New England Journal of Medicine* 2010; 362:2037-2039.

<sup>15</sup> Otite FO, Jacobson MF, Dahmubed A, et al. Trends in Trans Fatty Acids Reformulations of US Supermarket and Brand-name Foods between 2007 and 2011. *Preventing Chronic Disease*, 2013; 10

<sup>16</sup> Skeaff C. Feasibility of recommending certain replacement or alternative fats. *European Journal of Clinical Nutrition* 2009; 63: S34.

<sup>17</sup> WHO. International Food and Beverage Alliance (IFBA) to align with the WHO target to eliminate industrially produced trans fat from the global food supply by 2023. Press release 7 May 2019. <https://www.who.int/news-room/detail/07-05-2019-who-welcomes-industry-action-to-align-with-global-trans-fat-elimination-targets>. Accessed on 5 July 2020.

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The International Union of Food Science and Technology (IUFoST) is the global scientific organization working with more than 300,000 food scientists and technologists in over 100 countries around the world. IUFoST is a full scientific member of ISC (International Science Council) and the only elected representative of Food Science and Technology in the ISC. IUFoST represents food science and technology to international organizations such as WHO, FAO, UNDP, UNIDO, The World Bank, and others. IUFoST organizes world food congresses, among many other activities, to stimulate the ongoing exchange of knowledge and to develop strategies in those scientific disciplines and technologies relating to the expansion, improvement, distribution and conservation of the world's food supply.

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