



Trans fats or the tale of the struggle to translate scientific evidence into political action

| Viewpoint

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Abstract: Trans-fatty acids are formed during the commercial hydrogenation of vegetable oils. These partially hydrogenated fats, which improve the taste, texture and shelf-life of processed foods, began to be commonly used in the 1950s. They were considered to be a healthy alternative to saturated fats, which were believed to be a major etiological factor in arteriosclerosis. However, the good culinary properties of trans fats have been shown to be associated with detrimental health effects. They exert a harmful effect on plasma lipid levels and cause inflammation and calcification of arterial cells, which are known risk factors of heart disease. The first reports pointing to the dangers of trans fats were published in 1957, and these were followed by animal studies in the 1970s. Subsequent research was hindered by opposition of the food industry to the funding of research on adverse effects of trans fats. Nevertheless, by the 1990s, many studies had established a strong link between the consumption of trans-fatty acids and the risk of coronary heart disease and heart attacks. Scientific evidence regarding health harms of artificial trans fats, which had been mounting for decades, led the U.S. Food and Drug Administration (FDA) in 2006 to require manufacturers to label trans fat contents on packaged foods. In 2013, the FDA made a tentative determination that trans fats were no longer “generally recognized as safe” for use in human food. A ban of artificial trans fats in 2015 requires food manufacturers in the United States to eliminate partially hydrogenated oils from their products by 2018. This ban came decades after science had first linked commercially produced trans fats to an increased risk of heart disease. The fact that policy lagged decades behind science is likely to have caused large numbers of unnecessary deaths resulting from trans fat consumption. This time lag may be attributable to the food industry’s attempts to obscure scientific evidence and to the unwillingness of scientists to acknowledge new evidence defying common wisdom. A more recent example of the slow pace of progress in the protection of public health relates to efforts to reduce the consumption of sodas and other sugary beverages in order to prevent obesity, diabetes, and heart disease.

Key words: Trans-fatty acids; arteriosclerosis; mortality; sugary drinks; food regulation.

Fred A. Kummerow, a German-born American biochemist and an early opponent of artificial trans-fatty acids in the food supply, died on May 31st, 2017, aged 102 years [1]. The former professor of comparative biosciences at the University of Illinois at Urbana-Champaign continued to conduct research and publish scientific papers as a centenarian. Kummerow’s findings in the 1950s of a role of trans fats in arteriosclerosis led him, over a period of 50 years, to warn against the use of artificial trans fats

and to push for the banning of these substances. Eventually, in 2015, trans fats were declared unsafe by the U.S. Food and Drug Administration (FDA), and food manufacturers were required to remove partially hydrogenated oils, the primary source of artificial trans fats, from their products by 2018. This provides an example of the difficulty of translating major health-related scientific findings into political regulation.

In the 1950s, the prevailing view was that saturated fats, such as those found in dairy products, were a principal factor in the etiology of arteriosclerosis. Fred Kummerow questioned this assumption and was one of the first scientists to suggest a link between heart disease and commercially produced trans-fatty acids in processed foods. Artificial trans-fatty acids began to be produced at the beginning of the 20th century and became ubiquitous in processed foods in the United States after World War II. Trans fats are produced by adding hydrogen to liquid vegetable oil, which turns it into a solid form of fat, such as margarine or shortening. Small amounts of trans fatty acids also occur naturally in dairy, meat, poultry, and fish. Commercially manufactured trans fats are used to improve the taste, texture and shelf-life of processed foods, and their production is less expensive than that of solid animal fats. Processed foods very likely to contain trans fats include baked products, e.g. crackers, cookies or cakes, and frozen foods such as refrigerated dough or frozen pies. Trans fats are also used in restaurant cooking, particularly in frying and baking. These fats were long believed to provide a healthy alternative to the vilified saturated fats. However, a study published by Kummerow in 1957 demonstrated the presence of high levels of trans-fatty acids in the arteries of humans who had died of heart attacks [2]. Animal studies in swine fed various fats showed that a diet including margarine heavy in trans fats caused markedly more plaque deposits in the arteries than diets which had replaced margarine with an equal number of calories from butter or eggs [3].

Kummerow's research showed that the good culinary properties of partially hydrogenated fats are associated with detrimental health effects. Trans fats change plasma lipid levels in harmful ways and cause inflammation and calcification of arterial cells, which are known risk factors of heart disease [4]. Thus the sole beneficiary of the use of artificially-manufactured trans fats is the food industry. Reviews commissioned by the FDA concluded in 1976 that there was no evidence in the available information on artificial trans fats demonstrating reasonable grounds to suggest a hazard to the public. Since then, vested interests of the food industry have sought to influence scientists, practitioners and policy makers. Scientists employed by food companies have attempted to protect trans fats from the taint of negative scientific results and routinely cast doubt on the emerging science of health harms associated with trans fats. Scientists disagreeing with the industry's view that

trans fats cause no harm have been unable to obtain research funding and have been derided by their peers [1]. While Kummerow's early research on trans fats was widely criticized and dismissed for years, he was able to inspire other researchers to include trans fats in the Nurses' Health Study of more than 100,000 women, which reported in 1993 that trans-fatty acids caused an increase in heart disease [5]. This led to a change in scientific and medical thinking about trans fats. In addition, artificial trans fats have been implicated in type 2 diabetes, and a diet low in trans fats was shown to help prevent diabetes in women [6]. By the 1990s, an ever-increasing number of studies revealed that trans-fatty acid consumption was a key contributor to the increased incidence of heart disease [7–9]. Trans-fatty acids were shown to increase low-density lipoprotein cholesterol while decreasing high-density lipoprotein cholesterol in healthy individuals [10]. Interestingly, this study was funded by a company producing margarine free of trans fats. In a meta-analysis of four prospective cohort studies involving nearly 140,000 subjects, a 2% increase in energy intake from trans fatty acids was associated with a 23% increase in the incidence of coronary heart disease [8]. It was concluded that "on a per calorie basis, trans fats appear to increase the risk of coronary heart disease more than any other macronutrient, conferring a substantially increased risk at low levels of consumption (1 to 3 percent of total energy intake)" [8].

By the early 1990s, available evidence was compelling enough to cause the urging of the FDA "to eliminate or greatly reduce the amount of artificial trans fatty acids in the food supply" or to at least require labelling of trans fats on foods [11]. It took more than a decade until, in 2006, the FDA required food manufacturers to identify on nutrition labels the amount of trans fats in food products. However, products containing less than 0.5 grams of trans fat per serving were allowed to list zero trans fat on package labels. The 2006 regulation, together with pressure from health advocates, led to the voluntary removal of trans fats by many food companies and restaurants from their products [12]. In 2009, Kummerow filed a citizen petition with the FDA requesting a ban of partially hydrogenated fat from the American diet. Having received no response, he sued the FDA in 2013, asking that it rule on his petition. In the same year, the FDA decided that partially hydrogenated oils no longer fall into the "generally recognized as safe" category for use in human food, and in 2015 eventually announced a ban on trans fats, requiring food

manufacturers in the United States to eliminate partially hydrogenated oils from their products by 2018 [13].

Recent investigations have provided further evidence of the problems related to trans fat consumption. While a meta-analysis reviewed the evidence regarding health effects of trans fats [14], another study translated these findings into effects on population health and health inequalities [15]. While saturated fats were not associated with all cause mortality, cardiovascular disease, coronary heart disease, ischemic stroke, or type 2 diabetes, trans fats were associated with all cause mortality, total coronary heart disease and associated mortality [14]. It is important to note that industrial trans-fatty acids seem to be positively related to coronary heart disease, while ruminant trans fats are not [16]. This difference may be due to the fact that natural trans fats are metabolized differently from hydrogenated trans fats [17]. An epidemiological modelling study in England determined health and equity benefits and cost effectiveness of policies to reduce or eliminate trans fatty acids from processed foods compared with consumption remaining at most recent levels [15]. A total ban on trans fatty acids in processed foods could prevent or postpone around 7,200 deaths (2.6%) from coronary heart disease from 2015 to 2020 and reduce socioeconomic inequality in mortality from coronary heart disease by about 3,000 deaths (15%) [15]. Policies to improve labelling or remove trans-fatty acids from restaurants or fast food could save 0.7–1.3% of deaths from coronary heart disease and reduce inequalities by 3–7% of deaths [15]. In conclusion, a regulatory policy to eliminate trans-fatty acids from processed foods in England would be the most effective and equitable policy option.

A number of U.S. communities have eliminated the use of trans fats in restaurants in recent years. A retrospective observational pre-post study determined whether restrictions in the use of trans-fatty acids in 11 highly urbanised New York State counties were associated with fewer hospital admissions for myocardial infarction and stroke compared to 25 New York State counties of similar urbanicity without restrictions from 2002 to 2013 [18]. Three or more years after the restrictions were implemented, people living in areas with restrictions had significantly fewer hospitalizations for heart attack and stroke based on trends in similarly urban areas without the restrictions. The decline for the combined conditions was 6.2%. Enacting a more complete restriction on trans fats, including food sold in stores, could lead to more widespread long-term

benefits. In summary, the New York State populations with trans-fatty acid restrictions experienced fewer cardiovascular events, beyond temporal trends, compared with those without restrictions. These findings highlight the impact of public policy on the cardiovascular health of a population.

Most studies positing an increased risk associated with trans-fatty acids recruited patients in previous decades when trans-fatty acid levels were higher than today. In addition, most studies were conducted in the United States, where trans-fatty acid concentrations were generally higher than in Europe [19]. In Germany, the association of trans-fatty acids with mortality was investigated in the Ludwigshafen Risk and Cardiovascular Health (LURIC) study [20]. The generally low concentrations of total trans-fatty acids were inversely associated with mortality due to cardiovascular causes or sudden cardiac deaths [20]. While the naturally occurring ruminant-derived trans-palmitoleic acid was associated with reduced risk, no increased risk was found for industrially produced trans-fatty acids [20]. It needs to be pointed out that the higher concentrations of trans-fatty acids in the LURIC study were low compared to those reported in the United States at a similar time period [20,21]. Another study reported that the average trans fat intake in Germany was 2.4 g per day, which is below 1% of total energy intake, and that 79% of trans fat intake was derived from milk and ruminant fats [22]. The results of the LURIC study may suggest that measures to further decrease trans-fatty acids in foods in Germany are not required. Trans-fatty acid concentrations in food products have significantly declined in most industrialized countries in recent decades [23,24]. However, the decline has been smaller in Eastern Europe [25] and high trans fat concentrations are found in several developing countries [26]. Furthermore, many food products labelled as trans fat free continue to contain significant amounts of trans fatty acids [27]. Strategies encouraging voluntary reduction of industrially produced trans fats in foods containing high amounts appear to have been ineffective in several European countries, and alternative approaches are necessary to protect all population subgroups from an increased risk of coronary heart disease [28].

The picture of an ever-increasing body of research demonstrating health hazards of artificial trans-fatty acids and the ensuing slow-moving progress of policies attempting to protect the public spans about half a century. The substantial time lag between scientific investigations demonstrating, between 1957 and 1993,

severe adverse health effects of trans fats and revisions in standards from 2006 to 2015 is an example of the persistence needed to translate health-related scientific evidence into meaningful political action. The fact that policy lagged decades behind science is likely to have caused thousands of unnecessary deaths related to trans fat consumption. The substantial time lag may be attributable partly to the food industry's attempts to obscure scientific evidence and partly to a scientific community that had been committed to campaigns against saturated fat and was not prepared to abandon a cherished theory and to accept new evidence. The degree to which government intervention is justified in the elimination of hazardous food ingredients when, for example, trans-fatty acid amounts in processed food are generally low in certain countries and do not appear to pose a threat to public health is open to discussion. However, there is a reasonable public demand for transparent food labeling disclosing all ingredients in plain language and bold print, not requiring food shoppers to use magnifying glasses while checking lists of cryptically described ingredients. Transparency in food labeling will enable the critical and responsible public to make informed shopping decisions.

Similar stories of the frustratingly slow pace of policy changes seeking to protect public health can be related in the context of tobacco and, more recently, sodas and other sugary beverages. Sugary drinks, which are made from water, high-fructose corn syrup, and flavoring, have no nutritional value. Their intake has been rising over recent decades and contributes to increased calorie intake and weight gain. Soda consumption has been shown to increase the risk of obesity [29,30], type 2 diabetes [31] and heart disease [32]. The first line of defense against any of these conditions is to stop drinking carbonated sugar waters. However, as was the case with processed foods containing trans fats, soda manufacturers use their lobbying and marketing power to conceal the adverse health effects of their products. Measures suggested to reduce soda consumption include government health warnings, taxation, and limits on advertising [33]. Opponents of sodas attempting to influence public health policies should remember the trans fat tale and prepare to face the same obstacles encountered by their predecessors.

Conflict of interest

The author declares no conflict of interest.

References

- Hafner K. Fred A. Kummerow, an early opponent of trans fats, dies at 102. *New York Times* 2017 June 1. Available: <https://www.nytimes.com/2017/06/01/science/fred-kummerow-dead-biochemist-ban-trans-fatty-acids.html>. Accessed 4 June 2017.
- Johnston PV, Johnson OC, Kummerow FA. Occurrence of trans fatty acids in human tissue. *Science* 1957; 126: 698–699.
- Kummerow FA, Mizuguchi T, Arima T, Cho BHS, Huang WYT. The influence of three sources of dietary fats and cholesterol on lipid composition of swine serum lipids and aorta tissue. *Artery* 1978; 4: 360–384.
- Kummerow FA. The negative effects of hydrogenated trans fats and what to do about them. *Atherosclerosis* 2009; 205: 458–465.
- Willett WC, Stampfer MJ, Manson JE, Colditz GA, Speizer FE, Rosner BA, et al. Intake of trans fatty acids and risk of coronary heart disease among women. *Lancet* 1993; 341: 581–585.
- Salmerón J, Hu FB, Manson JE, Stampfer MJ, Colditz GA, Rimm EB, Willett WC. Dietary fat intake and risk of type 2 diabetes in women. *Am J Clin Nutr* 2001; 73: 1019–1026.
- Ascherio A, Katan MB, Zock PL, Stampfer MJ, Willett WC. Trans fatty acids and coronary heart disease. *N Engl J Med* 1999; 340: 1994–1998.
- Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC. Trans fatty acids and cardiovascular disease. *N Engl J Med* 2006; 354: 1601–1613.
- Willett WC. Trans fatty acids and cardiovascular disease—epidemiological data. *Atheroscler Suppl* 2006; 7: 5–8.
- Mensink RP, Katan MB. Effect of dietary trans fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects. *N Engl J Med* 1990; 323: 439–445.
- Willett WC, Ascherio A. Trans fatty acids: are the effects only marginal? *Amer J Publ Health* 1994; 84: 722–724.
- Dyer O. Bans and labelling helped to reduce Americans' trans fat levels by 58%. *BMJ* 2012; 344: e1084.
- FDA News Release. The FDA takes step to remove artificial trans fats in processed foods. 2015 June 16. Available: <http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm451237.htm>. Accessed 4 June 2017.
- De Souza RJ, Mente A, Maroleanu A, Cozma AI, Ha V, Kishibe T, 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. *BMJ* 2015; 351: h3978. DOI: 10.1136/bmj.h3978.
- Allen K, Pearson-Stuttard J, Hooton W, Diggle P, Capewell S, O'Flaherty M. Potential of trans fats policies to reduce socioeconomic inequalities in mortality from coronary heart disease in England: cost effectiveness modelling study. *BMJ* 2015; 351: h4583. DOI: 10.1136/bmj.h4583.
- Bendsen NT, Christensen R, Bartels EM, Astrup A. Consumption of industrial and ruminant trans fatty acids and risk of coronary heart disease: a systematic review and meta-analysis of cohort studies. *Eur J Clin Nutr* 2011; 65: 773–783.
- Kummerow FA, Zhou Q, Mahfouz MM, Smiricky MR, Grieshop CM, Schaeffer DJ. Trans fatty acids in hydrogenated fat inhibited the synthesis of the polyunsaturated fatty acids in the phospholipid of arterial cells. *Life Sci* 2004; 74: 2707–2723.

- 18 Brandt EJ, Myerson R, Peraillon MC, Polonsky TS. Hospital admissions for myocardial infarction and stroke before and after the trans-fatty acid restrictions in New York. *JAMA Cardiol* 2017; DOI: 10.1001/jamacardio.2017.0491.
- 19 Craig-Schmidt MC. World-wide consumption of trans fatty acids. *Atheroscler Suppl* 2006; 7: 1–4.
- 20 Kleber ME, Delgado GE, Lorkowski S, März W, von Schacky C. Trans-fatty acids and mortality in patients referred for coronary angiography: the Ludwigshafen Risk and Cardiovascular Health Study. *Eur Heart J* 2016; 37: 1072–1078.
- 21 Harris WS, Pottala JV, Vasan RS, Larson MG, Robins SJ. Changes in erythrocyte membrane trans and marine fatty acids between 1999 and 2006 in older Americans. *J Nutr* 2012; 142: 1297–1303.
- 22 Hulshof KF, van Erp-Baart MA, Anttolainen M, Becker W, Church SM, Couet C, et al. Intake of fatty acids in western Europe with emphasis on trans fatty acids: the TRANSFAIR Study. *Eur J Clin Nutr* 1999; 53: 143–157.
- 23 Downs SM, Thow AM, Leeder SR. The effectiveness of policies for reducing dietary trans fat: a systematic review of the evidence. *Bull World Health Organ* 2013; 91: 262–269H.
- 24 Leth T, Jensen HG, Mikkelsen AA, Bysted A. The effect of the regulation on trans fatty acid content in Danish food. *Atheroscler Suppl* 2006; 7: 53–56.
- 25 Stender S, Astrup A, Dyerberg J. A trans European Union difference in the decline in trans fatty acids in popular foods: a market basket investigation. *BMJ Open* 2012; 2: e000859.
- 26 Karn S, Abraham R, Ramakrishnan L. Assessment of trans fatty acid content in widely consumed snacks by gas chromatography in a developing country. *Food Nutr Sci* 2013; 4: 1281–1286.
- 27 Stender S, Astrup A, Dyerberg J. Tracing artificial trans fat in popular foods in Europe: a market basket investigation. *BMJ Open* 2014; 4: e005218.
- 28 Stender S, Astrup A, Dyerberg J. Artificial trans fat in popular foods in 2012 and in 2014: a market basket investigation in six European countries. *BMJ Open* 2016; 6: e010673.
- 29 Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet* 2001; 357: 505–508.
- 30 Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. Changes in diet and lifestyle and long-term weight gain in women and men. *N Engl J Med* 2011; 364: 2392–2404.
- 31 Malik VS, Popkin BM, Bray GA, Despres JP, Willett WC, Hu FB. Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. *Diabetes Care* 2010; 33: 2477–2483.
- 32 De Koning L, Malik VS, Kellogg MD, Rimm EB, Willett WC, Hu FB. Sweetened beverage consumption, incident coronary heart disease, and biomarkers of risk in men. *Circulation* 2012; 125: 1735–1741.
- 33 Nestle M. Soda politics: Taking on big soda (and winning). Oxford: Oxford University Press; 2015.