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REVIEW

Approaches to removing *trans* fats from the food supply in industrialized and developing countries

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A number of approaches have been initiated by governmental and public health organizations in different countries to reduce *trans*-fatty acid (TFA) intakes. These have included nutrition recommendations with regard to TFAs and general nutrition recommendations regarding the selection of healthy fats, programmes to raise awareness about the adverse effects of TFAs through nutrition and health claims, voluntary or mandatory labelling of the *trans* content of foods, voluntary or legislated programmes to encourage or force industry to reformulate food products to remove TFAs, the promotion of health and agricultural policies that encourage the production of healthy alternatives to *trans* fat and finally, mandatory regulation of food standards to remove or reduce the TFA content. This paper reviews a number of initiatives to reduce the intake of TFAs underway in selected industrialized and developing countries, which serves to illustrate the merits and limitations of the available options and how the approaches that have been taken reflect local conditions.
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Introduction

A number of approaches have been initiated by governmental and public health organizations in different countries to reduce *trans*-fatty acid (TFA) intakes. These included nutrition recommendations on TFAs, raising awareness about the adverse effects of TFAs through nutrition and health claims, voluntary or mandatory labelling of the *trans* content of foods, legislated or voluntary reformulation by industry to remove TFAs, promotion of *trans* reductions through health and agricultural policies that encourage the production of healthy alternatives to *trans* fat and mandatory regulation of food standards. Some of the initiatives underway in a range of countries are shown in Table 1. A number of initiatives underway in selected industrialized and developing countries are detailed in this paper, which can serve as models to help clarify some of the approaches used, and the considerations involved in their implementation, under a variety of local conditions.

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Country experiences

The TFA story in Denmark

Introduction. The TFA story in Denmark was prompted by a publication on TFA consumption and risk of coronary heart disease by Dr Walter Willett and co-workers in 1993 (Willett *et al.*, 1993) and led to a special course of events in Denmark, which eventually resulted in legislation, limiting industrially produced (IP) TFA in Danish foods.

To understand why the course of events in Denmark was different from that seen in other Scandinavian countries, Europe and the rest of the world, it is necessary to understand the background and how both the media and politicians became involved. The events in Denmark that eventually led to legislation involved elements of science, economics and politics, which were not separate, but substantially intermingled. The driving force in the process to remove IP-TFAs in Danish foods was the Danish Nutrition Council (DNC).

Table 1 Summary of voluntary efforts and mandatory regulations to reduce TFA in the food supply in various jurisdictions

Country	*Measure*	*Outcome*
Denmark (Leth *et al.*, 2006)	2003: Voluntary labelling and/or health claims. No mandatory declaration of TFAs on food labels. Mandatory compositional restrictions of TFAs in fats and oils to <2% of the total fatty acids	Phased-in implementation from June 2003 to January 2004
Netherlands (Katan, 2006)	1995–1996: Industry-led voluntary elimination of TFA from margarines 2004: Product Board for Margarine, Fats and Oils Task Force on Responsible Fatty Acid Composition campaign to reduce PHVO and SF in deep fat frying in restaurants. Joint initiative of the edible oils, restaurant industry, consumer, Heart Foundation and government	TFA content of margarines reduced from 18 to <2 g/100 g By June 2005, 45% of fast food outlets using oils containing <5%TFA, and >55% *cis*- unsaturated fats
United States (Food and Drug Administration, 2003; Eckel *et al.*, 2007; Okie, 2007)	2005: USDA and Department of Health and Human Services issue guidelines recommending reducing TFA consumption and requesting food industry to decrease *trans* fat content 2006: Mandatory labeling of the TFA content in foods containing 0.5 g or more per serving and when claims are made regarding fat, fatty acids or cholesterol. TFA includes both manufactured and ruminant sources	Increased awareness among public, some product reformulation. AC-Nielsen survey reported US sales of 'no *trans* fat'-labelled products increased by 12% between 2003–2004
New York City (New York City Department of Health and Mental Hygiene, 2007a)	2006: New York City Board of Health and Mental Hygiene announces *trans* fat ban in restaurants 2007: By 1 July 2007 all spreads and frying oils in New York City restaurants must contain <0.5 g TFA per serving 2008: By 1 July 2008 all foods sold in New York City restaurants mostly contain <0.5 g TFA per serving (except packaged foods sold in the manufacturer's original packaging)	2007: TFA content limited to less than 0.5 g in most fried foods in New York City restaurants
Canada (Trans Fat Task Force, 2006)	1980s onward: Voluntary labelling. A number of margarines with low TFA introduced 2005: Regulatory action, mandatory nutrition labelling. FDR requires the declaration of TFA content in grams per serving. A declaration of 'zero grams' of *trans* fat may be made on the label if the *trans* fat content is less than 0.2 g per serving and food contains less than 2 g of saturated + *trans* fat ('low' in saturated fat) 2006: The TFTF recommends regulating TFA to less than 2% of total fat in fats, oils and margarines, and to less than 5% of total fat in manufactured foods. Includes retail, food service, and restaurant foods prepared on-site 2007: The Minister of Health announced that Health Canada is adopting the Trans Fat Task Force's recommended limits for *trans* fat in Canadian foods and giving the industry 2 years to reduce *trans* fat to the levels recommended by the TFTF. If significant progress has not been made over the next two years, commits to regulate to ensure the levels are met. Also commits to publish the results of Health Canada monitoring program 2007: Health Canada published the first set of data from its *trans* fat monitoring program from food samples that were collected in 2005, 2006, and spring 2007 from major grocery stores, restaurant and fast-food establishments	2005: Almost all bread and salad dressings are TFA free. Many other foods still contain high amounts of TFA Progress noted in a number of food categories. In many cases, manufacturers have used healthier alternatives when replacing TFAs
Argentina (Valenzuela *et al.*, 2004)	Cooperative agreement for production of sunflower oils with high oleic acid content (*trans* free, high heat resistance) enabling the food industry to replace PHVO 2007: Mercosur countries (Argentina, Brazil, Paraguay and Uruguay) established that all food labels must include information about *trans* content (July 2007)	
PAHO/WHO Task Force (PAHO/WHO, 2007) Australia/New Zealand	Recommend regulatory approach similar to Canada Voluntary labelling of TFA content and/or health claims, mandatory if nutrient content claims made for fatty acid or cholesterol content. Recent review recommends a non-regulatory approach to reduce TFA because intake of IP-TFA is probably low	

Abbreviations: FDR, Food and Drug Regulations; IP-TFA, industrially produced *trans*-fatty acid; PHVO, partially hydrogenated vegetable oil; SF, saturated fat; TFA, *trans*-fatty acid; TFTF, *Trans* Fat Task Force; USDA, United States Department of Agriculture.

How the TFA story started. The DNC had just been founded, with Professor Arne Astrup as chairman, when the study by Dr Willett and co-workers was published in the Lancet on 6 March 1993. At that time, most of the Danish population had probably never heard of TFA, and indeed one cardiologist who was interviewed had apparently forgotten the difference between *cis*- and *trans*-double bonds. A press release based on the paper stated that women who ate four or more teaspoons of margarine per day had a 50% higher risk of heart disease, and the authors of the paper concluded that 'Our findings must add to concern that the practice of partially hydrogenating vegetable oils to produce solid fats may have reduced the anticipated benefits of substituting these oils for highly saturated fats, and instead contributed to the occurrence of CHD'. This was particularly newsworthy in Denmark, given the high consumption of dairy products, and front pages of large Danish newspapers announced: Butter more healthy than margarine.

The DNC convened an emergency meeting on TFA the next day. Subsequently, this was carried by the entire media on 8 March, with headlines such as 'Emergency meeting on margarine hazard'. This emergency meeting, so far the only emergency meeting in the DNC's 15-year history, contributed substantially to the long-lasting interest in TFA among the Danish mass media. The sale of butter increased by 12% during the following month to the joy of the dairies, but to the sadness of the preventive cardiologists and margarine producers. From that time forward, the DNC remained in public domain, linked to the disturbing potentially harmful effects of margarine, which, until then, had been presumed to be healthy.

Three reports on TFAs from the DNC. From the start, the DNC established a working group among its members to produce a scientific report on the health effects of IP-TFAs, with Dr Steen Stender serving as chairperson, seconded by Professor Jørn Dyerberg. The working group members were the driving force within and outside the DNC for the maintenance of a high level of scientific information and evidence.

The first report (1994). The first DNC report on TFAs, released in 1994 (Stender *et al.*, 1994), concluded that the available evidence indicated that there was a well-founded concern regarding the harmful effects of IP-TFAs on human health. The evidence was strongest for a harmful effect on coronary heart disease, but there were also suggestions of harmful effects on development early in life. Importantly, there was no evidence of any beneficial effect of IP-TFAs on health. At this time, the average per person intake of IP-TFAs in Denmark had decreased from 7.5 g/day in 1976 to about 3.5 g/day in 1991, with about 2.5 g coming from margarine. The remainder was due to consumption of ruminant TFA, about 1.2 g/day per person, which has not changed over time.

Importantly, the DNC did not only consider average per person intakes but also whether some segments of the population may be at higher risk. It was estimated that a subgroup of about 150 000 adult Danes had an intake of IP-TFAs that exceeded 5 g per day. This intake corresponded to the intake in the high-risk group reported in the paper by Willet *et al*. The DNC found this situation unacceptable and recommended that the intake of IP-TFAs be reduced as much as possible. This could be implemented by a reduction in the fat content of the diet, together with a reduction of IP-TFAs, to $<5\%$ in all margarines. The DNC urged the producers of margarine in Denmark to launch products free of IP-TFAs and also suggested that Danish authorities ask the EU to consider mandatory labelling of the IP-TFA content of prepackaged foods. The DNC report and recommendations were widely quoted in the media after their release.

The response from the margarine industry was an acceptance of a reduction and eventual elimination of IP-TFAs from all products. The result, in fact, led to a competition among members of the Danish Industrial Margarine Association to launch zero-TFA margarines. Several years later, the Scientific Committee of the EU decided that the scientific evidence for a harmful effect of IP-TFAs on health was insufficient to mandate separate labelling. The issue of TFAs in food never received the same level of attention in Norway, Sweden or Finland as it did in Denmark. A major reason for this was the Danish focus on subgroups with high intakes of IP-TFA, rather than on overall average population consumption. The DNC felt that it was imperative to protect all individuals against the health risks associated with high intakes of IP-TFAs. In other Scandinavian countries, IP-TFAs were considered as a component of foods in the same way as saturated fat, and their recommendations and concern were based more on average consumption than on individual consumption. TFAs and saturated fats were lumped together and treated similarly as 'hard fat'.

The second and third DNC reports (2001 and 2003). After the response from the EU questioning the effects of IP-TFAs on health, the Danish government asked the DNC for an update on the 1994 report. In these two subsequent reports, published in 2001 and 2003, the DNC found that the evidence for a harmful effect of IP-TFAs on coronary heart disease had gained further support, whereas there were still no reports of any beneficial effects (Stender and Dyerberg, 2001, 2003a). In Denmark, the average daily intake of IP-TFA had declined by 1996 to below 1 g/day per person. However, the concern of the DNC remained focused on subgroups of the population with a higher than average intake of IP-TFAs.

To examine this issue in more detail in 2001, the DNC collected 43 popular prepackaged food products sold in Denmark with the term 'partially hydrogenated fat' high in the list of ingredients and meals from two large fast food chains. The results indicated that it was quite easy to obtain and consume a high *trans* fat menu containing >30 g/day of IP-TFAs. A typical menu consisted of a large serving of fried chicken and French fries bought at McDonalds or Kentucky

Fried Chicken outlets, a serving of microwave popcorn and 100 g of wafers. Even if all these foods were not consumed in one meal, frequent consumption of one or more of these foods would mean an average daily intake beyond 5 g of IP-TFAs. It was estimated that up to 50 000 adults in Denmark would have such an intake, despite the mean population intake being <1 g per day (Figure 1). On the basis of these data, the DNC recommended that such intakes should be avoided and recommended a legislative ban on any foods containing $>2\%$ IP-TFAs in the fats or oils used.

The publication of the 2001 report was followed by a press release from the Danish Industrial Margarine Association announcing that the TFA content of all margarines for industrial baking would be reduced to $<5\%$ within 1 year. The Chairman of the Association declared, 'We can get down to 0% in Denmark, but that requires EU legislation to avoid unfair competition'. Both reports received enormous attention from the press in Denmark as well as in other countries. A follow-up report in 2003 was consequently also published in English (Stender and Dyerberg, 2003b).

The Danish Minister of Food and Agriculture, Ritt Bjerregaard, and her successor, Mariann Fischer Boel, were both convinced that the conclusions of the DNC were appropriate, that legislative action was both feasible and cost effective, and, most importantly, that such action would ensure that no one in the country would be exposed to harmful amounts of IP-TFAs. These two politicians, one after the other, took necessary actions to get the *trans* legislation passed through the Danish Parliament and have it endorsed by the EU. Although the food industry objected to the measures in the EU, stating that it would create barriers to trade, it was accepted that Denmark had enacted legislation, in force from 1 June 2003, which restricted the IP-TFA content of all food products and ready-meals to a maximum of 2% of the total fat content (Figure 2).

Why was it possible to ban IP TFAs in Denmark? The public, the mass media and the food and the fats and oil industry had been prepared for such action for nearly 10 years by the work of the DNC. Furthermore, there was no food scientist or food expert in Denmark who defended IP-TFAs, nor did the margarine producers dare to object publicly to the ban. Finally, many politicians found it reasonable to remove an artificial substance that was strongly suspected of being harmful to health.

After the trans fat legislation in 2003. In February 2004, the national television asked the DNC to confirm the extent to which the Danish TFA legislation was being complied with by food providers. Ten foods, earlier containing high amounts of *trans* fat, were bought and analysed. Nine of the foods were below 2% of the fat as IP-TFA, except for one doughnut from a Seven-Eleven store with 6% of the fat as IP-TFA. In response to this, the manager of the entire Seven-Eleven franchise in Denmark appeared on national television to announce that this product represented a mistake with regard to mislabelling of fat imported from Belgium, and within hours, all the doughnuts in Seven-Elevens were removed from the shelves. Similarly, in December 2006, French fries with 10% *trans* fat were discovered in an Ikea restaurant in Copenhagen. This was also covered on prime-time national television and the product was removed within hours. These cases and the reaction to them were very important to raise awareness among food producers of the use of IP-TFAs in foods sold in Denmark, whether produced inside or outside the country.

Recently, the National Food Institute, Danish Technical University, completed analyses of 143 different products collected in 2006, which had high concentrations of IP-TFAs before the TFA legislation. Only one of these 143 foods was

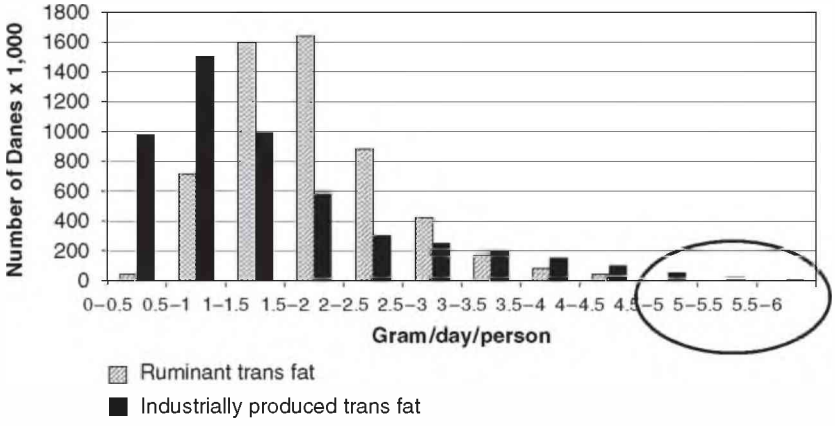

Figure 1 An estimate of the distribution of intake of industrially produced *trans*-fatty acids (IP-TFA) and the distribution of intake of ruminant TFAs in Denmark in 1996. From these data and the Danish population of approximately 5.6 million, it was estimated that about 50 000 Danes ingest more than an average of 5 g IP-TFA/day (area within the circle), the intake that was associated with a 25% increased risk of heart disease, in the study of Willett *et al.* (1993). Source: Jacobsen *et al.* (2006).

Order No. 160 of 11 March 2003

Courtesy translation

Order on the content of transfatty acids in oils and fats etc.
The following is laid down pursuant to Section 13, Section 55, subsection 2 and Section 78 subsection 3 of Act No 471 of 1 July 1998 on foodstuffs etc. (Foodstuffs Act):

Chapter 1
Scope

Section 1. This Order applies to oils and fats, including emulsions with fat as the continuous phase which, either alone or as part of processed foodstuffs, are intended, or are likely, to be consumed by humans.

Subsection 2. The Order does not apply to the naturally occurring content of trans fatty acids in animal fats or products governed under other legislation.

Subsection 3. The Order only applies to products sold to the final consumer.

Section 2. It is prohibited to sell the oils and fats covered by the Order to consumers if they contain a higher level of the trans fatty acids defined in the Annex than that stated in Section 3.

Section 3. As from 1 June 2003, the content of trans fatty acids in the oils and fats covered by this Order must not exceed 2 grams per 100 grams of oil or fat, cf. however subsection 2.

Subsection 2. From 1 June 2003 until 31 December 2003 the oils and fats covered by this Order and included in processed foodstuffs which also contain ingredients other than oils and fats and which are produced by the foodstuffs industry, in retail outlets, catering establishments, restaurants, institutions, bakeries etc. may, however, contain up to 5 grams of trans fatty acids per 100 grams of oil or fat.

Section 4. In products which are claimed to be "free from trans fatty acids", the content of trans fatty acids in the finished product shall be less than 1 gram per 100 grams of the individual oil or fat.

Chapter 2
Penalty provisions etc.

Section 5. A fine shall be imposed on anyone who contravenes Section 2 or Section 4 of this Order.

Subsection 2. The penalty may increase to imprisonment for up to two years if the contravention was committed wilfully or through gross negligence, and the contravention

1) caused damage to health or led to the risk thereof, or

2) resulted in, or was intended to result in, financial gain for the perpetrator themselves or for others, including as a result of savings made.

Subsection 3. Criminal liability may be incurred by companies etc. (legal entities) in accordance with the rules of Chapter 5 of the Penal Code.

Section 6. This Order shall enter into force on 31 March 2003.

Subsection 2. Products manufactured before this Order has entered into force, as well as products manufactured within the periods stated in Section 3(2), may be sold until expiry of the best before date. **Annex 1**

Definition of trans fatty acids

For the purposes of this Order, trans fatty acids are defined as the sum of all fatty acid isomers with 14, 16, 18, 20 or 22 carbon atoms and one or more trans double bonds, i.e. C14:1, C16:1, C18:1, C18:2, C18:3, C20:1, C20:2, C22:1, C22:2 fatty acid trans isomers, but only polyunsaturated fatty acids with methylene interrupted double bonds.

11 March 2003

Section 3. As from 1 June 2003, the content of trans-fatty acids in the oils and fats covered by this Order must not exceed 2 grams per 100 grams of oil or fat, cf. however subsection 2.

Section 5.

...

Subsection 2. The penalty may increase to imprisonment for up to two years if the contravention was committed willfully or through gross negligence...?

Figure 2 Details regarding the legislative ban on industrially produced *trans* fat in Denmark, which was passed, 11 March 2003.

found to have >2% of the fat as IP-TFA (Torben Leth, personal communication), indicating that IP-TFA in Denmark has virtually been eliminated from the food supply (Figure 3). A critical feature with regard to this elimination of IP-TFA is that there is no significant distribution around the value of 0 g/day per person. In other words, no high-risk subgroup of the population can consume >1 g of IP-TFA per day. The intake is nearly zero, both at the population level and at the individual level.

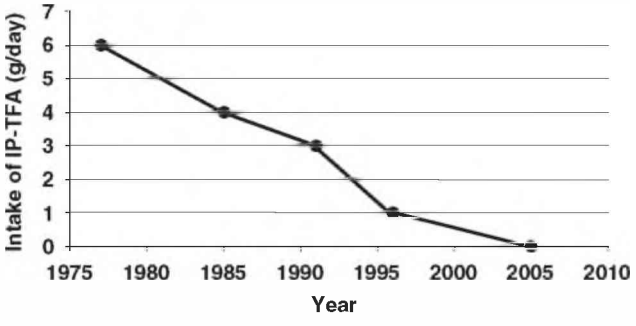

Figure 3 The average intake of industrially produced *trans* fat in Denmark 1978–2005.

Effects on coronary heart disease. From 1970 to the present, mortality due to ischemic heart disease in males has decreased in all Scandinavian countries (Figure 4), with Finland still lagging behind in absolute risk. The decline has been attributed to diverse factors, including anti-smoking policies, use of statins, higher consumption of fruits and vegetables and more efficient treatment at the hospitals. The concomitant decrease in the intake of IP-TFAs may also play a part. On the basis of the recent legislation, one would expect Denmark to experience a more pronounced decrease in CHD risk compared with that in neighbouring countries.

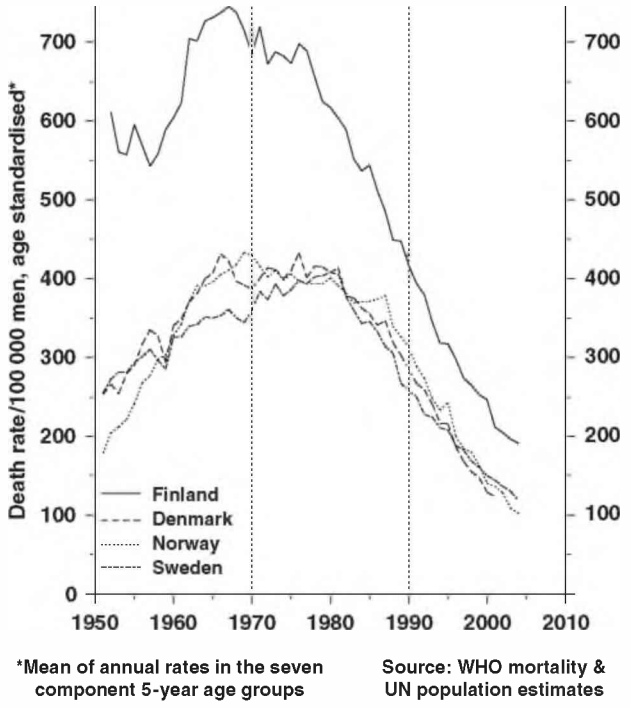

Figure 4 Age standardized mortality rates from ischemic heart disease for males (aged 35–69) in Scandinavian countries, 1951–2004. (Provided by Dr Jillian Boreham, using data from www.who.int/whosis/mort).

However, the potential contribution of the recent decrease in IP-TFA consumption is difficult to quantify. First, the postponement of premature coronary death in the subgroup of the population that would have been at higher risk due to IP-TFA intake may be obscured in overall statistics. Second, the Danish legislative ban and the media attention it received caused a significant spill-over effect on the IP-TFA content of foods sold or produced in other Scandinavian countries, as the various food companies preferred to sell the same foods all over Scandinavia. As a result, the IP-TFA content of foods in Sweden, Norway and Finland also declined considerably, despite these countries not having a specific legislation as in Denmark. Finally, the changes in IP-TFA consumption are still relatively recent, and it may take some years to detect effects on the incidence of CHD events.

What is the replacement for trans fat? This is currently under investigation in Denmark. Preliminary data on fast food, microwave popcorn, biscuits, cakes and wafers suggest that a considerable amount of *trans* fat has been replaced with saturated fat, and also that the content of monounsaturated and polyunsaturated fat has increased in many foods that now do not contain IP-TFAs.

Mandatory declaration of the trans fat content of foods on nutrition labels and a Trans Fat Task Force: The Canadian experience

Background—situation in Canada during the mid 1990s. In Canada, scientists raised concerns about the detrimental effects of *trans* fats and their levels in the Canadian diet as far back as the late 1970s, focussing first on margarines (Davignon *et al*., 1980) and then later on the total diet, recommending that current levels do not increase (Health and Welfare Canada, 1990). These warnings led to the development of a number of margarine products with low *trans* fat levels, targeted at health-conscious consumers. However, although some progress was made in the margarine/fat spread sector, the use of partially hydrogenated vegetable oils continued to increase in other categories of processed foods. By the mid-1990s, using both dietary intake data and analysis of human tissue samples, researchers estimated that Canadians had one of the highest intakes of *trans* fats in the world, with intakes estimated to be approximately 8.4 g/day (Ratnayake and Chen, 1995).

First step—nutrition labelling—mandatory declaration of the trans fat content of pre-packaged foods. In recognition of this high intake of *trans* fat and the impact on the health of Canadians, Canada became the first country to require that the levels of *trans* fat in pre-packaged food be included in the mandatory Nutrition Facts table. The Canadian labelling regulations were promulgated on 12 December 2002, and became mandatory on 12 December 2005. For small companies (annual food sales of less than $1 million), the requirement to implement the regulations was extended to 2007. The nutrition labelling regulations require that calories and the content of 13 core nutrients, including *trans* fat, be listed on the labels in a standardized format (Figure 5).

Relying on mandatory nutrition labelling to reduce TFAs in the food supply had a potential drawback in that, by focussing attention on the TFA content in foods, consumers may overlook the saturated fat content and choose foods that are lower in *trans* fat yet higher in the combined total of *trans* plus saturated fat. On the basis of this concern, in the Canadian Nutrition Facts table, saturated fat and *trans* fat content are both declared on two separate lines (expressed in grams per serving). In addition, the total of saturated + *trans* fat is expressed as a single percentage daily value (based on a reference standard of 20 g). Furthermore, to be labelled '*trans* free', foods must not only contain <0.2 g of *trans* fat but should also be low in saturated fat (i.e., contain <2 g of saturated and *trans* fat combined (per reference amount and per serving of stated size). This can be compared with the US labelling regulations, in which the mandatory declaration of *trans* fat is 0.5 g (versus 0.2 g in Canada) per serving, and foods containing <0.5 g TFAs can be termed '*trans* free' without a separate requirement for the food to be low in saturated fat.

Nutrition facts
Per 1 cup (264 g)

Amount	% Daily Value
Calories 260	
Fat 13 g	**20%**
Saturated fat 3 g + Trans fat 2 g	**25%**
Cholesterol 30 mg	
Sodium 660 mg	**28%**
Carbohydrate 31 g	**10%**
Fibre 0 g	**0%**
Sugars 5 g	
Protein 5 g	

Vitamin A 4% • Vitamin C 2%
Calcium 15% • Iron 4%

Figure 5 Example of a standardized Canadian nutrition facts table showing the required labelling of the saturated and *trans* fat content of food (g/serving as well as combined percentage daily value). Source: Health Canada, 2003.

Formation of the Canadian Trans Fat Task Force. As a result of the nutrition labelling regulations, accompanying intense media attention and mounting consumer concerns about *trans* fats, many companies began working to reduce TFA levels in their products. Nevertheless, the Danish experience led some to argue that a government-imposed ban would hasten the reduction of *trans* fats in the Canadian diet and affect a broader range of foods than those covered by the nutrition labelling regulations, which do not apply to foods consumed in restaurants or other places outside the home. This viewpoint, coupled with heightened awareness of the dangers of *trans* fats among the Canadian public, formed a favourable background for political action, which culminated in the passage of an Opposition Day motion, by a vote of 193 to 73, in the Canadian House of Commons in November 2004. The motion called on Health Canada and the Heart and Stroke Foundation of Canada to co-chair a multi-stakeholder task force whose mandate would be 'to provide the Minister of Health with concrete recommendations and strategies to effectively eliminate or reduce processed *trans* fats in Canadian foods to the lowest level possible'. Members of the Task Force, named in early 2005, included individuals from the food manufacturing and food service sectors, the federal government, non-governmental health organizations, professional associations, academia, consumer groups and oilseed producers and processors.

Work of the Trans Fat Task Force. The *Trans* Fat Task Force completed its work through three full day face-to-face meetings, five teleconferences and numerous email exchanges and secure website postings. During the course of its work, the Task Force also held two public consultations, one with industry and another with scientific experts. The Task Force also commissioned two literature reviews to help inform the discussion between the Task Force members and the scientific experts. Decisions of the Task Force were also informed by data from a targeted market analysis of foods sold in Canada (label review and fatty analysis of reformulated products); consumer research on awareness of *trans* fat; commissioned studies regarding the food industry perspective on eliminating *trans* fats; and advice from the Canadian Expert Committee on Fats, Oils and Other Lipids with regard to the fatty acid composition of fats and oils and their functional characteristics for various food applications. At the request of the Task Force, Health Canada also evaluated the overall effect of limiting the *trans* fat content of foods on the total dietary intake of *trans* fats by modelling a number of possible scenarios. Dietary intake data from nutrition surveys conducted in the late 1990s were used in constructing and evaluating the scenarios. Baseline food composition values for *trans* fats were made as current as possible, by integrating the latest Health Canada files for food composition with food intake patters from the nutrition surveys to estimate the impact on *trans* intakes and distributions within the Canadian population, according to a variety of *trans* fat limit scenarios.

Recommendations of the Trans Fat Task Force. In its publication, Report of the *Trans* Fat Task Force: TRANSforming the Food Supply (2006), the Task Force recommended the following (recommendations are in italics):

> *Foods purchased by retailers or food service establishments from a manufacturer for direct sale to consumers be regulated on a finished product or output basis and foods prepared on site by retailers or food service establishments be regulated on an ingredient or input basis.*

For practical reasons, the Task Force decided to limit the *trans* fat content of manufactured foods on a finished product basis, and the content of foods prepared onsite or in restaurants and food service establishments on an ingredient or input basis. Regulating the latter groups by means of limits on the finished product would have required the measurement of the nutrient content of foods served by thousands of individual retail bakeries, grocery stores, restaurants, fast food outlets and food service operations, who were not necessarily in a position to analyse their finished products. Thus, a regulatory limit on the *trans* fat content of ingredients would shift the regulatory burden up the food supply chain and simplify compliance and enforcement.

> *For all vegetable oils and soft, spreadable margarines sold to consumers or for use on site by retailers or food service establishments, the total trans fat content be limited by regulation to 2% of total fat content.*

For all other foods purchased by a retail or food service establishment for sale to consumers or for use as an ingredient in the preparation of foods on site, the total trans fat content be limited by regulation to 5% of total fat content.
This limit does not apply to food products for which the fat originates exclusively from ruminant meat or dairy products.

On the basis of dietary intake modelling, using the recommended *trans* fat limits above, the average daily intake of *trans* fats for all age groups would represent <1% of energy intake, consistent with the WHO recommendations (WHO, 2003). The modelling results also showed that a lower limit would not provide a significant additional decrease in average *trans* fat intake, but would increase the effort and challenge for industry.

The Task Force recommended a '2 + 2' approach: two years to develop regulations and up to two years for implementation.
To maximize the health benefit to Canadians, the Task Force further recommended that companies use the most healthful oils for their food applications.

A list of more healthful alternatives for a variety of food applications was provided in Appendix 14 of the report and is reproduced here (Table 2).

Current situation—2007. In February 2007, Health Canada updated and released its revised *Canada's Food Guide*, a tool that Canadians are encouraged to use to help make healthier food choices (Health Canada, 2007a). For the first time, the guide contained explicit recommendations to limit *trans* fat and saturated fat intakes. In addition, Canadians were encouraged to read the Nutrition Facts table when making food selections, as it lists the amount of *trans* and saturated fats a product contains, as well as other important nutrition information such as calories and the level of 13 core nutrients.

Another significant event in the goal to reduce the intake of *trans* fat by Canadians occurred on 20 June 2007, when Health Canada announced that it had adopted the recommendations of the *Trans* Fat Task Force to limit the amount of *trans* fats in foods. Recognizing the significant progress that had already been made in reducing *trans* fats in the Canadian food supply, Health Canada gave industry a 2-year window to reduce *trans* fats to the recommended levels; otherwise, the department would introduce regulations to enforce the limits. The department is also closely monitoring the efforts of industry to ensure that significant progress is being made to achieve these limits through its *Trans* Fat Monitoring Program. Data on the TFA levels in over 400 Canadian foods can be found in the *Trans* Fat Monitoring report (Health Canada, 2007b).

The trans fat monitoring programme. Health Canada has been analysing the *trans* fat content of foods intermittently since the late 1970s. More recently, the *Trans* Fat Monitoring Program (Health Canada, 2007b) was established to analyse the *trans* fat content of foods that were, as indicated by earlier surveys, significant sources of *trans* fats, that is, foods with high levels of *trans* fats or foods with lower levels of *trans* fats, which were consumed in large quantities by a large number of consumers. The individual products that were analysed represented the majority of products sold within a particular food category, and represented at least 80% of the market share within their respective food category. The analysis of food samples is ongoing and the results from the programme will be posted approximately every 6 months. The results of Canadian margarine samples have been published in a separate report (Ratnayake *et al.*, 2007).

The first set of data, posted in December 2007 (Health Canada, 2007b), represented food samples that were collected in 2005, 2006 and spring 2007 from major grocery stores or fast food and restaurant establishments in Scarborough ON, Ottawa ON, Winnipeg MB, Delta BC, Greenfield QC and Brossard QC. Samples of foods from fast food and restaurant establishments included chicken strips/nuggets, donuts, fish products, French fries, miscellaneous fast foods (e.g., apple turnovers and hash browns), muffins and onion rings. Samples of prepackaged foods from grocery stores included breakfast bars, cookies, crackers, frozen potato products (frozen French fries, etc.), frozen chicken strips/nuggets and muffins.

The analysis of the fat content was conducted in three Health Canada laboratories (Ottawa, Toronto, and Winnipeg). In certain cases, in which products had been reformulated, companies provided Health Canada with data about the specific reformulated products. The methodology used by the accredited laboratories to analyse the TFA content of the reformulated products was consistent with the methods and standards used by Health Canada for the *Trans* Fat Monitoring Program and was reviewed by Health Canada before its inclusion in the data tables.

Results of the trans fat monitoring programme (released December 2007). The full details of the sample collection, analytical methods, quality assurance programme and data for individual food products, organized on the basis of food category by manufacturer within each category can be found on the Health Canada website (Health Canada, 2007b). The data are presented in tables that show the percentage of total fat in the food samples as well as *trans* and saturated fats, as percentages of total fat. Companies and food manufacturers were encouraged to replace *trans* fats with healthier alternatives, such as monounsaturated and polyunsaturated fats, and not to replace *trans* fats with saturated fats. Using the data presented in the tables, one can determine whether healthier alternatives were chosen when companies reformulated products to reduce the *trans* content.

Table 2 Healthier alternatives recommended by the Canadian *Trans* Fat Task Force for replacement of TFA, sorted by food application[a,b]

Type of application	*Recommended alternatives*	*Type of oils*	*Characteristics*	*Comments on health effects*
Frying fats	Medium- and high-stability vegetable oils	High-oleic canola High-oleic sunflower	High in MUFA Small amount of *n*-6 and *n*-3 PUFA Low in saturates Better oxidative stability than general vegetable oils	+ Improved fatty acid profile including ratio of *n*-6 to *n*-3 fatty acids + May contribute to a diet that reduces CHD risk
		Low linolenic soya Mid-oleic sunflower	High in MUFA or *n*-6 PUFA Low in saturates Better oxidative stability than general vegetable oils	– Increased ratio of *n*-6 to *n*-3 fatty acids + May contribute to a diet that reduces CHD risk
Consumer and food service margarines (soft)	Inter-esterified oils with vegetable oil	(Palm and (PK) stearins) with canola oils	High in MUFA Moderate in *n*-6 High in *n*-3 PUFA Low in saturates	+ Improved fatty acid profile including ratio of *n*-6 to *n*-3 fatty acids + May contribute to a diet that reduces CHD risk
		(Palm and PK stearins) with soya oils	Moderate in MUFA High in *n*-6 PUFA Moderate in *n*-3 PUFA Moderate in saturates	+ Better fatty acid profile than butter and hard margarines, which are higher in saturated fatty acid and lower PUFA + Expected to lower total LDL/HDL-C ratio[c]
		(Fully hydrogenated vegetable oils and liquid vegetable oils) with vegetable oils[d]	Some MUFA High in *n*-6 PUFA Moderate in *n*-3 PUFA Moderate in saturates 2–4% *trans*	+ Better fatty acid profile than butter and hard margarines, which are higher in saturated fatty acid and lower PUFA + Expected to lower total LDL/HDL-C ratio[c]
Consumer and food service margarines (hard)	Inter-esterified oils with vegetable oil	(Palm and PK stearins) with soya oils	Moderate MUFA and *n*-6 PUFA Small amount of *n*-3 PUFA High in saturates	+ Better fatty acid profile than butter, which is high in saturated long-chain fatty acid + Expected to lower total LDL/HDL-C ratio[c]
		(Fully hydrogenated vegetable oils and liquid vegetable oils) with vegetable oils[d] Some MUFA	Moderate in *n*-6 and *n*-3 PUFA High in saturates 2–4% *trans*	+ Better fatty acid profile than butter, which is high in saturated long-chain fatty acid + Expected to lower total LDL/HDL-C ratio[c]
Baking margarines (soft)	Inter-esterified oils with vegetable oil	(Palm and PK stearins) with canola oils	High in MUFA Moderate in *n*-6 PUFA High in *n*-3 PUFA Low in saturates	+ Improved fatty acid profile, including ratio of *n*-6 to *n*-3 fatty acids + Expected to lower cholesterol ratio[c]
	Blending of soft oils + highly saturated oils	Palm oil/palm stearin and general vegetable oils	High in MUFA Moderate in *n*-6 and *n*-3 PUFA Moderate in saturates	+ Improved fatty acid profile, including ratio of *n*-6 to *n*-3 fatty acids + Expected to lower cholesterol ratio[c]
	Inter-esterified oils with vegetable oil	(Palm and PK stearins) with soya oils	Moderate in MUFA High in *n*-6 PUFA Moderate in *n*-3 PUFA Moderate in saturates	+ Better fatty acid profile than butter and hard margarines, which are higher in saturated fatty acid and lower PUFA + Expected to lower cholesterol ratio[c]
		(Fully hydrogenated vegetable oils and liquid vegetable oils) with vegetable oils[d]	Some MUFA High in *n*-6 PUFA Moderate in *n*-3 PUFA Moderate saturates 2–4% *trans*	+ Better fatty acid profile than butter and hard margarines, which are higher in saturated fatty acid and lower PUFA + Expected to lower cholesterol ratio[c]
Baking margarines (hard and laminating)	Blending of soft oils + highly saturated oils	Palm oil/palm stearin and high-stability vegetable oils	Moderate in MUFA Small amount of both *n*-6 and *n*-3 PUFA High in saturates	+ Better fatty acid profile than butter, which is high in saturated long-chain fatty acid + Expected to lower total LDL/HDL-C ratio[c]
	Interesterified oils with vegetable oil	(Palm and PK stearins) with soya oils	Moderate MUFA and *n*-6 PUFA Small amount of *n*-3 PUFA High in saturates	+ Better fatty acid profile than butter which is high in saturated long-chain fatty acid + Expected to lower total LDL/HDL-C ratio[c]
		(Fully hydrogenated vegetable oils and liquid vegetable oils) with vegetable oils[d]	Some MUFA Moderate in *n*-6 and *n*-3 PUFA High in saturates 2–4% *trans*	+ Better fatty acid profile than butter, which is high in saturated long-chain fatty acid + Expected to lower total LDL/HDL-C ratio[c]

Table 2 *Continued*

Type of application	*Recommended alternatives*	*Type of oils*	*Characteristics*	*Comments on health effects*
Bakery/food processor shortening solid	Blending oils for solids and performance	Palm oil/palm stearin + medium-stability vegetable oils	High in MUFA Moderate in *n*-6 PUFA High in *n*-3 PUFA Low in saturates	+ Improved fatty acid profile, including ratio of *n*-6 to *n*-3 fatty acids + Expected to lower cholesterol ratio[c]
	Inter-esterified oils with vegetable oil	(Palm and PK stearins) with canola oil high in MUFA	Moderate in *n*-6 PUFA High in *n*-3 PUFA Low in saturates	+ Improved fatty acid profile, including ratio of *n*-6 to *n*-3 fatty acids + Expected to lower cholesterol ratio[c]
		(Palm and PK stearins) with high-oleic canola oil	High in MUFA Small amount of both *n*-6 and *n*-3 PUFA Low in saturates	+ Improved fatty acid profile + Expected to lower cholesterol ratio[c]
	Blending oils for solids and performance	Palm oil/palm stearins/fully hydrogenated oil + medium-stability vegetable oils	Moderate in MUFA Moderate in *n*-6 and *n*-3 PUFA Moderate to high in saturates	+ Better fatty acid profile than highly saturated oil shortening or animal fat + Expected to lower cholesterol ratio[c]
	Inter-esterified oils with vegetable oil	(Palm and PK stearins) with high-oleic canola oil	High in MUFA Small amount of both *n*-6 and *n*-3 PUFA Moderate to high in saturates	+ Better fatty acid profile than highly saturated oil shortening or animal fat + Expected to lower cholesterol ratio
		(Fully hydrogenated vegetable oils and liquid vegetable oils) with liquid vegetable oils[d]	High in MUFA Small amount of both *n*-6 and *n*-3 PUFA Moderate to high in saturates 2–4% *trans*	+ Better fatty acid profile than highly saturated oil shortening or animal fat + Expected to lower cholesterol ratio[c]
Bakery/food processor shortening spray/liquid	General vegetable oils	Canola or soya oils	High MUFA or *n*-6 PUFA High in *n*-3 PUFA Low in saturates Poor oxidative Stability	+ Improved fatty acid profile, including ratio of *n*-6 to *n*-3 fatty acids + May contribute to a diet which reduces CHD risk
	Medium- and high-stability vegetable oils	High-oleic canola oil High-oleic sunflower	High in MUFA Small amount of *n*-6 and *n*-3 PUFA Low in saturates Better oxidative stability than general vegetable oils	+ Improved fatty acid profile including ratio of *n*-6 to *n*-3 fatty acids + May contribute to a diet that reduces CHD risk
		Low-linolenic soya Mid-oleic sunflower	High in MUFA or *n*-6 PUFA Low in saturates Better oxidative stability than general vegetable oils	– Increased ratio of *n*-6 to *n*-3 fatty acids + May contribute to a diet that reduces CHD risk

Abbreviations: CHD, coronary heart disease; HDL, high-density lipoprotein; HDL-C, high-density lipoprotein cholesterol; LDL, low-density lipoprotein; MUFA, monounsaturated fatty acid; PK, palm kernel; PUFA, polyunsaturated fatty acid; TFA, *trans*-fatty acid.
[a]From Appendix 14 of the Report of the Canadian *Trans* Fat Task Force, 'Transforming the food supply' (Trans Fat Task Force, 2006).
[b]Criteria were used to assess healthier alternatives to partially hydrogenated oils. Screen criteria (health implications and availability) had to be met; other criteria (functionality and cost), although considered, were not deemed essential in determining suitable alternatives for TFA replacement.
[c]Comments on health effects are made in comparison to similar products made with partially hydrogenated oils.
[d]Indicate secondary alternatives that contain 2–4% *trans* fat.

In all the food categories targeted, a number of food manufacturers successfully reduced the level of *trans* fat in their products to levels below those recommended by the *Trans* Fat Task Force. The data indicated that progress has been made in all food categories examined since the Task Force work began and mandatory nutrition labelling regulations for prepackaged foods came into effect in 2005 (Table 3). For example, by the fall of 2006, 60% of cookies, 85% of crackers, 83% of frozen chicken products and 75% of frozen potato products contained $<5\%$ *trans* fats. In a separate study focussing on margarines, by 2005, 71% of the top-selling brands contained no TFAs, and saturated fats were also fairly low (Ratnayake *et al.*, 2007). Among restaurants and fast food products sampled during the spring of 2007, 78% of chicken strips/nuggets, 83% of fish products, 75% of onion rings and 60% of miscellaneous fast foods met the 5% limit. The data also indicated that reformulations were being introduced each year; for example, none of the fast food French fries met the limit in 2006, compared with 73% in 2007; for chicken strips/nuggets, the figures were 29 and 78% for 2006 and 2007, respectively (Table 3). The data also showed that, in many cases, these reductions were much lower than the 5% limit and that the reductions were achieved by using healthier alternatives and not by increasing the levels of saturated fat.

Evidence is already available that the *trans* reduction strategy is having the desired effect in Canada. In a convenience sample of women in Vancouver, the proportion

Table 3 Percentage of Canadian foods meeting the 2 and 5% *trans* fat of total fat limit recommended by the Canadian *Trans* Fat Task Force[a]

Food category	*2005*	*2006*	*2007*
Prepackaged foods from grocery stores			
Cookies	33%	60%	—
Crackers	59%	85%	—
Frozen chicken products (chicken strips/ nuggets)	—	83%	—
Frozen potato products	—	75%	—
Granola bars	78%		—
Foods from fast food and restaurant establishments			
Chicken strips/nuggets	—	29%	78%
Donuts	—	34%	—
Fish products	—	—	83%
French fries	—	0%	73%
Miscellaneous fast foods	—	—	60%
Muffins	—	84%	—
Onion rings	—	—	75%

— Indicates food group was not sampled that year.
[a]Data calculated from the Canadian *Trans* Fat Monitoring Program (Health Canada, 2007b).

of TFAs in human milk (a biomarker of dietary consumption of TFAs) decreased from 6.2 to 5.3 to 4.6% over three consecutive 5-month periods from November 2004 to January 2006 (Friesen and Innis, 2006). TFA labelling of foods became mandatory in Canada in December 2005. These researchers used the relation between breast milk and dietary TFAs to predict that TFA intake of women in their study decreased from 3.4 to 2.7 to 2.2 g/day during the corresponding time periods. Results from the Canadian study suggest that mandatory labelling and the publicity regarding the harmful effects of *trans* fat had an immediate effect on the amount of TFAs in the food supply, and hence in the breast milk samples.

Local and regional initiatives: The New York City approach

Throughout Canada and the United States, a number of municipalities and states or provinces have announced, or are considering, a variety of measures to reduce *trans* fats in restaurants and food services. Some include ban of foods containing high levels of TFAs from school cafeterias, hospitals, day care centres and other institutions under local jurisdiction. Among these, the example from New York City (NYC) is probably the most well known and will be briefly described.

On 5 December 2006, the NYC Board of Health approved an amendment to their Health Code to phase out artificial (i.e., IP) *trans* fat in all NYC restaurants and other food service establishments. Full details of their proposal can be found on their website entitled, 'Healthy Heart—Avoid *Trans* Fat' (New York City Department of Health and Mental Hygiene, 2007a). The phase-out of artificial *trans* fat in restaurant foods is happening in two stages. By 1 July 2007, all restaurants had to ensure that all oils, shortening and margarines, containing artificial *trans* fat used for frying or for spreads, contained <0.5 g of *trans* fat per serving. Oils and shortening used to deep fry yeast dough and cake batter were not included in the first deadline. In the second phase, by 1 July 2008, all foods sold in restaurants must have <0.5 g of *trans* fat per serving. Packaged foods served in the manufacturer's original packaging were exempted from the NYC health code.

The NYC Department of Health and Mental Hygiene prepared a number of informative materials to assist restaurants in reformulating products to comply with the new regulations. For example, a *Trans* Fat Help Centre was set up to aid food service establishments by providing them with information on how to replace *trans* fat, including products and prices for *trans*-free frying oils, margarines and shortenings (New York City Department of Health and Mental Hygiene, 2007b). In addition, they have prepared a variety of informative materials such as how to choose and use healthier oils, what to look for in mixes and pre-made items, and questions and answers, etc. Recognizing that restaurants are often multi-ethnic in nature, information is available in a variety of languages including English, Spanish, Arabic, Bengali, Chinese, Korean and Russian.

Although implementation of the new Health Code phasing out *trans* fats from restaurants and other food service establishments in NYC is still underway, and an evaluation of the full results of the NYC amendments have yet to be published, NYC staff plan to publish further details in the near future (Dr Sonia Angell, personal communication).

Control of TFA industrial production: the Argentinean experience

In the winter of 1990, the Program for Infarct Prevention in Argentina was established by La Plata National University, the Buenos Aires Scientific Investigations Commission and the Buenos Aires Health Ministry, based on the model from the North Karelia Project (which served as a demonstration project for Finland as a whole). Balcarce City, situated in Buenos Aires province, was selected as a national Demonstration Area (Tavella and Spadafora, 1997; Tavella *et al.*, 2001). As part of the baseline food consumption evaluation, the lipid composition of commonly consumed foods was analysed (Tavella *et al.*, 2000), and consumption data were validated by analysing the fatty acid composition of adipose tissue samples (Debeza *et al.*, 1999). The findings were surprising. Almost all of the common foods contained TFAs, whereas omega-3 fatty acids were practically absent. For example, elaidic acid (*trans*-18:1 *n*-9) was present in most sweet or salty solid snack foods, such as cookies and crackers. Nearly all cookies, for which Argentina is a major consumer, contained elaidic acid and even apparently healthy choices, such as cereal bars, contained partially hydrogenated vegetable oils (Peterson *et al.*, 2004).

This scientific investigation was the starting point for the planning of intervention strategies needed to modify the situation observed in Balcarce City. The first step was to assess whether the agricultural production and the fats and

oils industry could provide sufficient quantities of healthy fats and oils to replace TFAs. In 2001, La Plata National University and Dow Agrosciences signed a cooperative agreement to join efforts for this purpose. As a result, 4 years later, a great variety of TFA-free sunflower oils with high oleic acid content were readily available on the Argentinean market. The properties of these oils, including very high heat resistance and relatively low price, were extremely important in allowing the food industry to replace partially hydrogenated oils (Valenzuela *et al*., 2004).

The replacement process began with a small cookie factory in La Plata City. Very soon, the largest companies turned their attention towards the reformulation of their products. The press played an important role in disseminating scientific and practical information to the public, so that the industry saw the reformulation of high *trans* processed foods as a potential business opportunity. The systematic media coverage of TFA reduction through the press and on television was an important catalyst for change, for example, companies saw '*trans* free' as a commercial advantage for their products. A 'domino effect' became evident, with Granix, la Cooperativa Obrera de Bahía Blanca, Fargo, McCain, Arcor, Pepsico, Kraft, General Mils, McDonalds, Nestlé and Unilever, among others, all replacing their TFAs containing fats with high oleic sunflower oil. The impact of this replacement seems to be substantial: in a very short time, Argentina was able to replace approximately 40% of the 30 000 metric tons of TFAs that were produced annually with other fats. In addition, the Mercosur (the South American Common Market integrated by Argentina, Brazil, Paraguay and Uruguay) recently established that all food labels must include information on their *trans* content (since July 2007).

The success in the area of TFA reduction encouraged Argentina to consider further efforts in addressing not only basic and applied research on TFAs but also in establishing public policies that could motivate the food industry to introduce healthy changes. For instance, the La Plata National University recently signed an agreement with Advanta Company to conduct studies related to the use of tristearic acid-rich oil sources, particularly in the production of foods requiring a solid fat content. Additionally, the Senators chamber of Buenos Aires province has approved a bill that reduces provincial taxes to those food companies that have removed TFAs from their products.

As a result of this success in Argentina, in 2005, the Food and Nutrition Program of the United Nations University for Latin America requested that Argentina develop a proposal for a project to evaluate the impact of these interventions on promoting healthier fats initiated in Argentina and adopted by several other countries. This work has now integrated Uruguay, Chile, Mexico and the Central America countries (through the Institute of Nutrition of Central America and Panama (INCAP)). Presently, the group is evaluating the effects of removing TFAs in several countries in the region, considering the major role of the quality of the fat supply on the incidence of coronary heart disease, in accordance with the implementation of the Global Strategy on Diet, Physical Activity and Health approved in 2004 (WHO, 2004).

In 2006, as part of the United Nations University Food and Nutrition Program regional Latin American project, the first course on Nutrition, Fat and Oils entitled, 'Implications in human health and food industry' was held in Cuernavaca city, Mexico. The main objective was to enhance knowledge on the significance of the quality of fat supply on the health and well-being of populations; the programme also included the analysis of local strategies to control TFA consumption in the region. The course was designed for consumer organizations, food industry representatives and academics. This activity will be offered periodically to other Latin-American countries. To strengthen the efforts to remove TFA from the food supply in the Americas, PAHO/WHO established the 'Americas *Trans* Fat Free' Working Group in 2007 (PAHO/WHO Task Force, 2007).

The complexity involved in the design and implementation of TFA replacement programmes makes it absolutely necessary that the effort include the health, agriculture and business sectors working between and across disciplines. Some may consider the problem to be basically a medical concern; however, the effective reduction of TFAs in foods involves the participation of multiple other sectors. The experiences in Argentina indicate that the greatest success is achieved when all sectors work collaboratively, orientating actions and searching for solutions in a coordinated manner to address this risk factor for human health.

Challenges in reducing TFAs in the food supply: an Indian perspective

The challenges in India and in other developing countries in reducing TFAs are different in a number of ways, compared with that in North American or European countries. First, India suffers from the consequences of the double burden of (1) chronic energy (calorie) deficiency, associated with low intakes of total fat, *n*-3 polyunsaturated fatty acids and micronutrients, and (2) diet-related chronic diseases related to excessive intakes of energy and other nutrients. In addition, cost, availability and stability of oils, which are often stored without refrigeration, are important considerations in much of the developing world.

Vegetable oils—availability, demand and imports. Oilseeds occupy a prominent place in the national economy of India, next only to cereals. Despite impressive achievements in vegetable oil production, the current vegetable oil production in India (12 metric tons in 2005–2006) is not adequate to meet demands, and approximately 40% of the annual requirement is met from imports. The demand for edible oils is expected to further increase to 15.6 metric tons by 2010 (Srinivasan, 2005; Mehta, 2007). The per capita consumption of edible oils in India has increased from 6 kg/year in

1985–1986 to 11 kg/year in 2005–2006 but is still far below the average consumption of vegetable oils in developed countries (20 kg/year) or of the world average (15 kg/year). Increases in population, urbanization and income levels due to overall development programmes launched in the country have resulted in a significant rise in the consumption of fats and oils (Srinivasan, 2005; Mehta, 2007; Solvent Extractors Association, 2007).

Unlike most of the other oilseed-producing countries, India grows a wide range of oil-producing crops. The annual oilseed crops include groundnut, rapeseed/mustard, soybean, sunflower, sesame, safflower, cottonseed, niger, linseed and castor seed; the last two crops being non-edible industrial oilseeds (Table 4). Vegetable oils are also obtained from several unconventional items, including rice bran and cottonseed. In the tree species, coconut and palm oil are the major sources of edible oils. The tree-borne seeds (sal, mango, neem, karanja, mahua, etc.) also contribute to overall oilseed production and edible oil availability. Both price advantage and acceptability contribute to the preference for the import of palm oil (70% of imports); soybean oil accounts for 20% and sunflower and rapeseed together constitute 10% of the total imports (Table 4).

Partially hydrogenated vegetable oils and TFAs. Vegetable oil products such as vanaspati, bakery fats and shortening made by partial hydrogenation entered India about 50 years ago. The composition of vanaspati, promoted as a substitute for ghee (anhydrous butter), is shown in Table 5. TFA contents are generally quite high. The production of vanaspati increased from 0.87 million tonnes in 1985–1986 to 1.35 in 2005–2006 and accounts for approximately 10% of the total production of edible oils (Solvent Extractors Association, 2005a; Mehta, 2007). Currently, the Indian partial hydrogenation oil industry is suffering from underutilization of capacity. The choice of oil used for vanaspati varies with domestic availability and imports. To increase oilseed utilization and production, the Government of India subsidizes the price of minor and unconventional oils used for the manufacture of vanaspati. In the manufacturing of vanaspati, approximately 25% indigenous oils and approximately 75% imported oils have been used; but in 2003, the Government of India reduced the permissible levels of indigenous oils to 12%. Palm oil and its fractions constitute a major proportion of imported oils used in the manufacture of vanaspati.

Currently, under the Prevention of Food Adultration (fourth amendment) Rules 2003, specifications have not been given for TFA limits in vegetable oil products. The limited data on fatty acid composition of currently sold vanaspati across the country show wide variations in total TFA content (ranging from 4 to 65% of total fatty acids), with elaidic acid being the major *trans* isomer (Table 5). The lower TFA levels in some brands/batches reflect the use of a higher proportion of palm oil in the mixture of feed oils used for hydrogenation.

Table 4 Vegetable oil production in India[a]

Name of oil	*2004–2005 ($\times 10^3$ tonnes[b])*	*2005–2006 ($\times 10^3$ tonnes[b])*
(A) *Primary source*		
Groundnut	1558	1838
Rapeseed/mustard	2354	2521
Soybean	1100	1324
Sunflower	392	475
Sesame	209	199
Niger seed	34	32
Safflower seed	52	69
Castor	317	396
Linseed	51	52
Subtotal (A)	6067	6906
(B) *Secondary source*		
Coconut	550	420
Cotton seed	430	570
Rice bran	620	680
Solvent extracted	350	430
Tree and forest origin	80	130
Subtotal (B)	2030	2230
Total (A + B)	8097	9136
(C) Less export and industrial use	850	820
(D) Net domestic availability of edible oils	7247	8316
(E) Import of edible oils[c]	4542	4288
(F) Total availability Consumption of edible oils from domestic and import sources	11 189	12 604

[a]Source: Solvent Extractors Association News Circular Vol X, Issue 7, October 2007.
[b]Converted to ($\times 10^3$ tonnes) from the traditional unit of quantity used in India (lakh tonnes) which equals tonnes $\times 10^5$, as reported in the source publication.
[c]Imported oils are mainly palm oil and soybean oil.

Vegetable oil requirements. The fat intake in the Indian population is highly income dependent and therefore highly skewed, the intake being low in rural and urban poor income groups (Table 6). The daily visible fat intake in rural and urban low income groups is low (<13 g/person) as compared with that in the urban middle and high income groups (30–50 g/person). Although vegetable oil is the major visible fat used in cooking, there are strong regional preferences for the type of vegetable oil consumed (Achaya, 1987; Ghafoorunissa, 1996). However, both cost and advertisements of the cholesterol-lowering potential of different oils seem to influence the regional choice of cooking oils. In India, a major priority is to increase vegetable oil consumption to increase the calorie density of the predominantly cereal-based diets of the majority of the population, particularly that of the lower income groups. The daily visible fat requirement for Indians (depending on physical activity and physiological status) is estimated to be between 20 and 50 g per person. The vegetable oil intake (Table 6) therefore

Table 5 Fatty acid composition of vanaspati (% of total fatty acids)

Fatty acids	*Study (number of samples)*				
	Ghafoorunissa et al. (22)[a,b]		*Kheiri (21)*[c]	*Bunge, India (116)*[d]	*Jeyarani (9)*[e]
	Mean	*Range*	*Mean*	*Mean (Range)*	*Range*
			% of total fatty acids		
16:0	41.2	16.8–54.5	14.8		
18:0	5.5	3.5–10	8.1		
Total SFA	46	34–58	24		
18:1 *cis*	31.9	8.6–45.3	18.8		
18:1 *trans*	17.5	5.0–38.1	43.2	19 (4–65)	6–30
18:2 *n*-6	4.4	5.0–83	3.4		
18:2tt, 18:2ct + 18:2tc + 20:0	—	—	9.8		
SFA + TFA	63.6	46.4–82.5	87.5		

Abbreviations: SFA, saturated fatty acid; TFA, *trans*-fatty acid.
[a]Ghafoorunissa, Natarajan and Ibrahim; analyses done in 2000–2002 (unpublished).
[b]Fatty acid methyl esters analysed by gas chromatography using SP-2330 capillary column (30 × 0.25 mm id, Supelco, USA).
[c]Source: Kheiri, 1982.
[d]Bunge India Limited, personal communication.
[e]Jeyarani and Reddy, 2005.

Table 6 Intakes of visible and invisible fat in India

(A) *Daily visible fat—intake versus requirement in India*

	Recommendations[a] *(energy %)*		*Visible fat intake (g/person/day)*	
	Total fat	*LA (n-6)*	*Requirement*	*Intake (adults)*
Adults	20–30	3.0	20–50	Rural <12
Pregnancy	20	4.5	30	
Lactation	20	6.0	40	Urban high income group >40
Young children	25	3.0	25	

(B) *Invisible fat in India—from all foods except visible fat (energy %)*

	Fat	*SFA*	*MUFA*	*LA (n-6)*	*ALNA (n-3)*
Rural	7	2	2.2	2	0.2
Urban	14	6.6	4.2	2	0.2

Abbreviations: ALNA, alpha-linolenic acid; LA, linoleic acid; MUFA, monounsaturated fatty acid; SFA, saturated fatty acid.
[a]Source: FAO, 1994.

needs to be increased from the present daily consumption level of <13 g per person to combat the widespread energy deficiency in poor income groups (Ghafoorunissa, 1996, 1998). As a complete dependence on any one vegetable oil does not ensure optimal intakes of various fatty acids, use of two or more oils is recommended (Ghafoorunissa, 1998; Ghafoorunissa *et al.*, 2002), optimally including oils that contain the *n*-3 polyunsaturated fatty acid alpha-linolenic acid (Table 7). Thus, the goal to reduce TFA consumption by reducing the consumption of, or the TFA content of, vanaspati must be balanced against the current insufficient total fat intake among much of the population.

Estimates of TFA intakes in India. During the past 2 decades, the per capita availability of vanaspati ranged between 1.0 and 1.3 kg/year (Solvent Extractors Association, 2005b). Estimates of TFA based on edible fats and oil supplies that were available in India in the 1980s (approximately 0.8 million tonnes), and the population over which they were spread, showed an average availability of vanaspati of 3g/person/day (Achaya, 1987). In north India, where vanaspati is used for cooking, maximum consumption can be ~20 g/person/day. In Delhi, which is a multicentric market, 37% of the fats and oils market is for vanaspati (Singh and Mulukutla, 1996). In all parts of the country, vanaspati is used as a substitute for ghee in various preparations. In the bakery industry, vanaspati, butter and specialty fats (margarines, shortenings, gel) account for 60, 20 and 10%, respectively, of total fat usage. Vanaspati is widely used in the preparation of commercially fried, processed, ready to eat and street foods, and for the preparation of Indian snacks, sweets and savoury items, frozen foods, packaged foods and premixed foods. The indirect consumption of vanaspati through foods purchased at these outlets is not, however, reflected in the National Sample Survey 1999–2000 data; monthly per capita consumption range between 0.01

Table 7 Recommended oil combinations for India[a]

Decrease LA (n-6) and increase ALNA (n-3)	*Decrease LA (n-6)*
Groundnut/sesame/rice bran/cotton seed + mustard	Sunflower/safflower + palmolein
Groundnut/sesame/rice bran/cotton seed + canola	Safflower/sunflower + groundnut/sesame/rice bran/cotton seed
Groundnut/sesame/rice bran/cotton seed + soybean	
Palm/palmolein + soybean	
Safflower/sunflower + palmolein + mustard	

Abbreviations: ALNA, alpha-linolenic acid; LA, linoleic acid.
Note: Additional advantage other than tocopherols and phytosterols: sesame—lignans (essamol, sesamin and sesamolin); rice bran—tocotrienols and oryzanol; red palm oil/palmolein—carotenes and/tocotrienols; soyabean—lignans.
[a]Source: Ghafoorunissa, 1998.

and 0.45 kg (average, rural 0.06, urban 0.04). The National Sample Survey 1999–2000 data indicated that vanaspati consumption as cooking oil is confined mainly to four states: Haryana, Punjab, Uttar Pradesh and Himachal Pradesh (National Sample Survey, 2001; Srinivasan, 2005). The limited data obtained in various types of biscuits showed that TFAs ranged between 30 and 40% of total fatty acids (National Institute of Nutrition, 2000). The consumption of foods containing vanaspati has increased in recent years. This high intake of TFAs may be part of several changes in dietary and other life style patterns among urban middle and high-income groups contributing to the present day high prevalence of diet-related chronic diseases.

Studies on health effects of TFA from vanaspati. In a case–control study in two major Indian cities, an inverse association between mustard oil consumption and IHD risk was seen, whereas a somewhat elevated risk with vanaspati consumption was observed (Rastogi *et al.*, 2004). As a large proportion of the Indian population is predisposed to insulin resistance and the prevalence of diabetes and coronary heart disease is high, reduction of TFAs from hydrogenated oils and foods consumed in India, along with other dietary and life style changes, needs to be actively pursued.

Recommendations for reducing TFAs in edible oils and foods consumed in India. A number of approaches could be considered in India to achieve lower limits for TFA and saturated fatty acid (SFA) content in vegetable oil products, refined oils and processed foods. A regulatory framework, for example, under the Prevention of Food Regulation Act could be provided for effective enforcement of such measures.

Edible oils. The edible oil and food industry in India should be encouraged to achieve lower TFA levels by using blends of vegetable oils with lower levels of unsaturation, and hence requiring less hydrogenation, and to use fractions high in solids derived from natural oils such as palm, palm kernel and coconut.

Within a feasible stipulated timeframe, the edible oil industry should replace hydrogenation technology with newer technologies that are being developed (both in India and other parts of the world) to produce zero *trans* fats with desired functionality for various food applications. However, before investing in new technologies, it is necessary to establish that the new products have health benefits than does vanaspati in Indian subjects. The edible oil industry would therefore need support, investment and incentives to develop, set up and operate new technologies.

For refined vegetable oils, quality parameters should include TFA limits. It may be necessary to generate data on the TFA content of refined oils, and if the data show high TFAs, modifications in the deodorization step should be considered to ensure that TFAs are within minimal specified limits.

Food industry. The food processing industry should use blends of natural vegetable oils that furnish higher stability to products wherever feasible (Table 7). For food technological applications that necessarily require solid fats, palm oil and its fractions, and coconut oil (an indigenous oil that may have specific positive health benefits) would have to be substituted for hydrogenated fats.

Nutrient label. The labels on processed foods should not give misleading messages. To give consumers a choice, the label on hydrogenated oils and processed foods should give the contents of TFAs and SFAs separately and state the optimal recommended ranges.

Restaurants and fast food outlets. Steps should be initiated for restaurants to disclose the use of partially hydrogenated oils in menu options. Programmes would also be needed to encourage and insist that in restaurants, fast food outlets and even in domestic frying, blends of vegetable oils without TFAs, which furnish higher thermal stability, should be used (Table 7).

Increase public industry and political awareness. Most producers and consumers in India lack awareness regarding the negative health impact of TFAs. In the Indian food-based dietary guidelines, guidelines for reducing TFAs would need to be included. These guidelines would have to emphasize combinations of indigenous vegetable oils, and take into

consideration the imported oils, growth of the global fast food industry and possible increases in SFA due to substitution of palm oil and coconut oil for vanaspati. In fact, a balance between medium chain (coconut, palm kernel oils, butter, ghee) and long chain SFAs (all vegetable oils and invisible fats) may be desirable. Alongside key messages on the negative health effects of TFAs, information on products, which contain high SFA and TFA, should be prepared. With the increase in the use of processed, premixed and ready to eat foods, there is a need for educating the consumer to read and understand food labels.

A multi-pronged approach is required to reduce the burden of diet-related chronic diseases by reducing TFAs in Indian diets. In brief, this should include guidelines for industry, an effective regulatory framework for the enforcement of guidelines, and consumer education to reduce the intake of foods containing TFAs and to avoid hydrogenated vegetable oils such as vanaspati for cooking food in the home.

Conclusions

A number of successful approaches have been used globally to reduce the TFA content of foods and hence the intakes of TFAs. Among the examples reviewed in this paper, several common features can be highlighted, which appear to be central to implementing successful approaches to reducing TFAs. First is science, or expert national panels, which reviewed the situation regarding TFA consumption in their respective jurisdiction and made concrete recommendations for their reduction, which were appropriate to the local environment. Second, the role and importance of the media in facilitating change cannot be overlooked. Active interest by the media in increasing consumer awareness of, and pressurizing industry to meet the challenges associated with reducing the TFA content of foods was a central aspect of the TFA reduction activities in Denmark, Canada, NYC and in Argentina. This awareness stimulated and sustained consumer demand, industry action and, in many cases, government involvement to ensure continued product reformulation by the industry. Governments have approached the problem through a variety of measures, reflective of local circumstances, but all programmes have exhibited a degree of government involvement, which has ranged from the introduction of regulatory limits, for example, Denmark or NYC, to the introduction of agricultural and tax measures to support the production of healthy alternatives, for example, Argentina, to setting concrete objectives, coupled with active monitoring, and publishing industry progress over a defined time interval to sustain the voluntary commitments by industry to reformulate, for example, Canada. Thus, the complexity involved in TFA reduction and replacement throughout the food supply makes it absolutely necessary for all sectors (government, industry, public health and academics) to work collaboratively to reach TFA reduction/elimination goals. These actions also need to be supported by both media and consumer awareness of the health concerns associated with TFA intakes to be successfully implemented.

Conflict of interest

During the preparation and peer review of this paper in 2007, the authors and peer-reviewers declared the following interests.

Dr Mary L'Abbé: None declared. Professor Steen Stender: Shares in Novozymes (enzymes for various processes, including interesterification). Professor Murray Skeaff: Led a research project that tested the effects of a plant sterol-enriched fat spread on blood cholesterol concentrations; costs of the research partially funded by Unilever Research and Development (2003–2004); participated in a subcontract to conduct a randomized controlled trial of a milk product enriched with an antioxidant extract from vegetables, which was partially funded by Fonterra, a milk company in New Zealand (2005–2007). All industry-supported research projects were organized and administered through the University of Otago Research and Enterprise Unit. Dr Ghafoorunissa: Chairperson of the Edible Oils and Fats Subcommittee PFA, Central Committee of Foods Standards (Ministry of Health and FW, Government of India) (2000–2008); Member of the Nutrition Advisory Council for the Malaysian Palm Oil Promotion Council (2004–2005); Consultant in the area of 'heart health' for Hindustan Unilever Limited (2006–2008); Life Member of the Nutrition Society of India. Professor Marcelo Tavella: Scientific advice provided to Dow Agrosciences, Argentina (current).

Peer-reviewers: Dr Dariush Mozaffarian: None declared. Dr Srinath Reddy: None declared. Professor Ricardo Uauy: Scientific Advisor to Unilever and Wyeth (*ad hoc* basis); Scientific Advisor to Knowles and Bolton, Danone, DSM and Kellogg's (*ad hoc* basis).

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