

trans Fatty acids in the Canadian food supply: an updated analysis^{1–3}

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ABSTRACT

Background: Dietary *trans* fatty acids (TFAs) increase the risk of heart disease. In 2007, Canada set voluntary TFA limits for industrial TFAs added to food and encouraged substitution of TFAs with unsaturated fats during reformulation. No longitudinal follow-up assessment of TFA amounts in foods has occurred in Canada since termination of a government-led Trans Fat Monitoring Program (TFMP).

Objective: The objective was to conduct an updated assessment and longitudinally evaluate TFA amounts in the food supply and to determine whether saturated fats have replaced TFAs in reformulation.

Design: This was a cross-sectional study that used 3 databases: TFMP (Health Canada, 2005–2009; $n = 921$), the University of Toronto Food Label Information Program (2010–2011; $n = 5544$), and the Restaurant Database (2010; $n = 4272$). Outcomes were TFAs as a percentage of fat, proportion of foods meeting TFA limits, and saturated fat amounts in foods with high or low TFAs.

Results: The proportion of foods meeting TFA limits improved from 75% in 2005–2009 to 97% in 2010–2011, particularly in the following packaged foods: croissants (25% to 100%), pies (36% to 98%), cakes (43% to 90%), and garlic spreads (33% to 100%). Most restaurant categories assessed by the TFMP had 100% of foods meeting TFA limits. Some categories had a large proportion that exceeded TFA limits: dairy-free cheeses (100%), frosting (72.0%), lard and shortening (66.7%), coffee whiteners (66.7%), and restaurant-prepared biscuits and scones (47.4%). Saturated fat amounts were significantly higher ($P < 0.05$) among some foods with the lowest TFAs, such as cookies, brownies and squares, cakes with pudding/mousse, dessert toppings, and lard and shortening.

Conclusions: There has been an impressive improvement in TFA amounts in the Canadian food supply since the termination of the TFMP. However, action by the food industry is required to reduce TFAs in foods that exceed the recommended TFA limits and to minimize the use of saturated fats in replacing TFAs during reformulation. *Am J Clin Nutr* 2014;100:1116–23.

INTRODUCTION

The consumption of industrial *trans* fatty acids (TFAs)⁴, produced through the partial hydrogenation of vegetable oils, increases the risk of heart disease and causes multiple cardiovascular disease risk factors, which are effects that occur even at low intakes (1–3% of total energy) (1, 2). Because cardiovascular disease risk increases incrementally with increasing TFA consumption, there is no Estimated Average Requirement, Adequate Intake, or Tolerable Upper Intake Level of consumption

(3). The WHO recommends that <1% of total energy should come from TFAs (4). In the 1990s Canada had the highest TFA intakes in the world, consuming an average of 8.4 g/d (3.7% of total energy) (5), leading to the mandatory declaration of TFAs on the Nutrition Facts table (NfT) for all foods containing ≥ 0.2 g/serving (6). The primary dietary sources of TFAs were crackers, margarines, shortenings, doughnuts, cookies, pie shells, breaded chicken, cake mixes, fries, and sauces and gravies (7). Lower amounts of TFAs are found naturally in ruminant sources (2–5% of total fat content) (5); however, these contribute a small amount to total dietary TFAs and are not associated with adverse health outcomes (8).

A recent United Nations high-level meeting emphasized the importance of policies to reduce and/or eliminate TFAs in the food supply (9). The US Food and Drug Administration also recently released a proposal to limit TFAs in foods by considering partially hydrogenated oils as not “generally recognized as safe” for use in food (10). In 2005, the Canadian government assembled a multistakeholder Trans Fat Task Force to develop recommendations to reduce TFAs in Canadian foods to the lowest amounts possible (to <2% of total fat for fats and oils and <5% of total fat for all other foods) (11). This included a recommendation to replace TFAs with unsaturated fats, rather than with saturated fats, during reformulation. Although the task force recommended implementing regulations, the government opted for a voluntary approach in 2007 with the option for regulatory measures after 2 y if industry did not respond (5). The Trans Fat Monitoring Program (TFMP) was established, which, between 2006 and 2009, conducted planned twice-yearly

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⁴ Abbreviations used: NfT, Nutrition Facts table; TFA, *trans* fatty acid; TFMP, Trans Fat Monitoring Program.

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monitoring and reporting of TFA amounts in foods (by product and brand name). By 2009, 76% of Canadian packaged, restaurant, and institutional foods had TFA amounts that fell within the recommended limits (12). Intake estimates of TFAs were reduced by 30%, from 4.9 g/d (2.0% of total energy) in 2004 to 3.4 g/d (1.4% of total energy) in 2008 (12). On termination of the TFMP in 2009, the federal government did not implement the proposed regulations, despite 24% of foods having unacceptably high amounts of TFAs and mean population intakes exceeding recommended amounts (5, 12).

There has been no assessment of TFA amounts in the food supply since the termination of the TFMP; thus, it is unknown if the food industry has made additional progress in further reducing or eliminating industrial TFAs. The objective of this study was to conduct a detailed, updated assessment of TFA amounts in the Canadian packaged (grocery) and restaurant food supply and to assess changes in the proportion of foods that meet the recommended TFA limits. In addition, this study assessed whether saturated fat was substituted for TFAs during reformulation.

METHODS

Packaged grocery foods

The University of Toronto Food Label Information Program, a database containing information on Canadian food and beverages in the marketplace, was used to assess TFA amounts in packaged food. This database has previously been described in detail (13, 14). Briefly, the data, collected in 2010–2011, included the nutritional and food label information for 10,487 national and private-label food and beverages from 4 major Canadian grocers that represented ~60% of the Canadian grocery market share (15). Data were collected from 3 of the grocery stores in Toronto, Ontario, and one grocery store in Calgary, Alberta. The NfT information, company, brand, container size, price, date and location of acquisition, and nutrition marketing information (eg, nutrient content claims, health claims) were entered into the database.

Food and beverages were classified according to the Food and Drug Regulations (6). Further classifications for the analysis of TFAs were guided by categories that Health Canada developed for the TFMP and for monitoring other nutrients in the food supply (16).

Restaurant foods

Data on foods served in sit-down and quick-service/fast-food restaurants were derived from the University of Toronto Restaurant Database. This database contains the reported nutritional composition and menu information on 9201 food and beverages, collected in 2010, from 85 Canadian restaurant franchises with >20 outlets nationally. A detailed description of this database has been published (17–19).

TFMP

The TFMP, operated by Health Canada between 2006 and 2009, analyzed the TFA content of foods known to contribute the highest TFA amounts in the Canadian diet (12). The assessment was based on chemical analysis and food label reporting of TFAs, as previously described (12). The TFMP assessed packaged,

restaurant, and institutional foods. Product categories were chosen if they were significant sources of dietary industrial TFAs (ie, foods high in TFAs or foods with moderate TFAs that were consumed in large quantities). Packaged products were tested if they represented >80% of the market share within that food category. Restaurant foods were sampled from national chains. The data on institutional foods were not used in this analysis. Because not every food category was analyzed each year of the TFMP, and data on TFAs were also collected in 2005, the present study uses the cumulative packaged and restaurant data from 2005 to 2009 (Table 1) (12).

Data analysis

Food categories in which a main ingredient contributed ruminant TFAs were excluded from the primary analysis. Mixed restaurant dishes containing a main ingredient with ruminant TFAs were included but are presented separately from those foods containing solely industrial TFAs. Individual foods missing information on TFAs and food categories that were low fat with a mean total fat content of ≤ 1 g/NfT serving were excluded, except for seasoning mixes and cooking sprays, which may contain TFAs. The percentage of contribution of TFAs (g) to total fat (g) was calculated to determine the number of items that did not meet the recommended TFA limits, defined as <2% of total fat for fats and oils and <5% of total fat for all other foods. Data from sit-down and quick-service/fast-food restaurants were pooled for this analysis. For food subcategories that had either 10 single foods or 10% of foods exceeding the recommended TFA limits, the Wilcoxon signed rank test was used to determine any differences in TFAs and saturated fat between foods that met and exceeded the TFA limits. Only food subcategories that had >5 products were included in this analysis. Continuous variables are presented as means and SDs and categorical variables as frequencies and percentages. Data are presented per NfT serving. A *P* value of <0.05 was considered significant. Statistical analyses were performed by using SAS version 9.2 (SAS Institute).

RESULTS

Included in the analysis were 5544 packaged foods and 4272 restaurant foods. Data from 21 (22.1%) restaurants and 37 (0.4%) packaged foods were excluded because they did not report TFA information (see Supplemental Table S1 under “Supplemental data” in the online issue). Overall, 95.4% of packaged foods and 96.1% of restaurant foods contained TFA amounts that fell within the recommended limits. Among restaurant foods that solely contained industrial TFAs, 91.3% ($n = 616$ of 675) of foods met the recommended limits. However, in restaurant foods with a main ingredient containing ruminant TFAs (eg, cheese), 97.1% ($n = 3492$ of 3597) of foods met the recommended limits.

Analysis of products exceeding recommended TFA limits

The highest proportion of products that exceeded the recommended TFA limits was observed among dairy-free cheeses (100%), frosting (72.0%), coffee whiteners (66.7%), Mexican meal kits (62.5%), lard and shortening (55.5%), shortbread cookies (41.7%), and refrigerated dough (50%) (Table 2 and Supplemental Table S2 under “Supplemental data” in the online



TABLE 1Comparison of foods meeting the recommended TFA limits: TFMP (2005–2009) compared with the University of Toronto FLIP/RD (2010–2011)¹

	Health Canada TFMP ²				Cumulative 2005–2009 meeting TFA limits ³	FLIP/RD
	2005	2006	2007	2008/2009		2010–2011 meeting TFA limits ³
Packaged grocery foods						
Breads and buns	—	—	100 (20/20)	—	100 (20/20)	100 (345/345)
Brownies	—	—	—	45 (5/11)	45 (5/11)	79 (23/29)
Cakes	—	—	—	43 (6/14)	43 (6/14)	90 (100/111)
Cookies	33 (5/15)	60 (9/15)	—	65 (48/74)	68 (54/80)	88 (272/309)
Crackers	59 (13/22)	85 (17/20)	—	86 (44/51)	94 (60/64)	98 (263/268)
Croissants	—	—	—	25 (4/16)	25 (4/16)	100 (2/2)
Danishes	—	—	—	45 (5/11)	45 (5/11)	—
Garlic bread and bread with additions	—	—	55 (6/11)	—	55 (6/11)	91 (21/23)
Granola bars	83 (19/23)	—	100 (8/8)	—	80 (16/20)	99 (171/172)
Muffins and quick breads	—	100 (2/2)	—	—	100 (2/2)	100 (60/60)
Pies	—	—	—	36 (4/11)	36 (4/11)	98 (58/59)
Tarts	—	—	—	67 (10/15)	67 (10/15)	100 (22/22)
Breaded chicken, frozen	—	83 (5/6)	—	—	83 (5/6)	94 (50/53)
Coffee whiteners	—	—	—	53 (9/17)	53 (9/17)	33 (2/6)
Garlic spreads	—	—	33 (2/6)	—	33 (2/6)	100 (3/3)
Margarines	52 (15/29)	—	59 (20/34)	—	53 (23/43)	85 (44/52)
Noodles, instant	—	—	—	86 (19/22)	86 (19/22)	100 (17/17)
Potato products, prefried, frozen	—	75 (9/12)	—	91 (10/11)	90 (19/23)	98 (45/46)
Vegetable shortenings	—	—	50 (2/4)	—	50 (2/4)	40 (2/5)
Lard shortenings	—	—	100 (4/4)	—	100 (4/4)	75 (3/4)
Snacks	—	—	—	92 (85/92)	92 (85/92)	99 (305/306)
Snack puddings	—	—	—	78 (21/27)	78 (21/27)	100 (54/54)
Popcorn	—	—	—	82 (18/22)	82 (18/22)	88 (51/58)
Fast foods from restaurants						
Chicken products	—	29 (4/14)	76 (13/17)	85 (60/71)	79 (75/95)	100 (128/128)
Doughnuts	—	35 (15/43)	23 (6/26)	57 (17/30)	29 (10/35)	100 (92/92)
Fish products	—	—	86 (6/7)	76 (19/25)	83 (19/25)	100 (26/26)
French fries	—	0 (0/5)	68 (15/22)	81 (58/71)	79 (71/90)	100 (35/35)
Muffins	—	—	—	89 (25/28)	89 (25/28)	95 (81/85)
Miscellaneous	—	—	78 (11/14)	50 (11/22)	82 (9/11)	—
Onion rings	—	—	60 (6/10)	83 (5/6)	75 (9/12)	100 (10/10)
Pizzas	—	—	100 (13/13)	—	100 (13/13)	100 (396/396)
Pizza dipping sauces	—	—	—	100 (8/8)	100 (8/8)	—
Ethnic foods	—	—	—	89 (56/63)	89 (56/63)	—
Total products	58 (52/89)	52 (61/117)	67 (132/196)	76 (547/718)	75 (694/921)	97 (2681/2776)

¹ All values are percentages; number of products meeting TFA limits/total number of products evaluated in parentheses. FLIP/RD, Food Label Information Program/Restaurant Database; TFA, *trans* fatty acid; TFMP, Trans Fat Monitoring Program; —, no data.

² Data from reference 12.

³ Recommended TFA limits are <2% of total fat for fats and oils and <5% of total fat for all other foods.

issue). Significantly lower amounts of TFAs were found in most foods that met the TFA limits. However, many packaged foods that exceeded the TFA limits contained very high amounts of TFAs, compared with similar products that met the TFA limits (Table 2). These included coffee whiteners ($38.3 \pm 32.7\%$ of total fat from TFAs, $13.1 \pm 10.9\%$ of energy), yeast doughnuts ($35.0 \pm 0.0\%$ of total fat from TFAs, $12.6 \pm 0.0\%$ of energy), popcorn ($33.9 \pm 12.7\%$ of total fat from TFAs, $17.4 \pm 8.7\%$ of energy), frosting ($28.6 \pm 9.0\%$ of total fat from TFAs, $10.1 \pm 3.7\%$ of energy), cake doughnuts ($27.7 \pm 21.5\%$ of total fat from TFAs, $14.5 \pm 11.4\%$ of energy), dairy-free cheese and spreads ($27.5 \pm 12.4\%$ of total fat from TFAs, $20.8 \pm 9.0\%$ of energy), and sugar wafer cookies ($25.0 \pm 0.0\%$ of total fat from TFAs, $12.9 \pm 0.0\%$ of energy).

Among restaurant foods, biscuits and scones (47.4%) and cookies (14.7%) were categories with the highest proportion of

foods exceeding the TFA limits (Table 2 and Supplemental Table S3 under “Supplemental data” in the online issue). Cookies ($21.8 \pm 7.5\%$ of total fat from TFAs, $8.6 \pm 2.9\%$ of energy) and biscuits/scones ($20.8 \pm 4.1\%$ of total fat from TFAs, $5.6 \pm 0.7\%$ of energy) contributed the most TFAs (as a percentage of fat and energy from TFAs). In categories that contained some ingredients with ruminant TFAs (eg, cheese), the greatest proportion of foods exceeding TFA limits were bread (27.6%), nachos (22.0%), fries with toppings (16.7%), kids’ desserts (14.3%), and other entrées (13.8%).

Comparison with the TFMP

In a comparative analysis with the TFMP, there was an overall improvement in the proportion of foods meeting the TFA limits, from 75% of foods in 2005–2009 to 97% of foods in 2010–2011



TABLE 2

Comparison of TFA and SFA amounts between foods meeting and exceeding recommended TFA limits¹

	Total no. of products (%)	Fat	SFAs	TFAs + SFAs	TFAs	Percentage of energy from TFAs	P	
							TFAs	SFAs
		% of food weight	% of total fat	% of total fat	% of total fat	%		
Grocery foods								
Dairy-free cheese and spreads	6 (100.0)	23.9 ± 5.7	26.3 ± 10.7	53.8 ± 22.0	27.5 ± 12.4	20.8 ± 9.0	—	—
Frosting							<0.001	0.195
<5% TFAs	7 (28.0)	15.9 ± 1.5	31.0 ± 5.3	31.0 ± 5.3	0.0 ± 0.0	0.0 ± 0.0		
≥5% TFA	18 (72.0)	14.9 ± 3.6	28.4 ± 6.7	57.0 ± 7.3	28.6 ± 9.0	10.1 ± 3.7		
Coffee whiteners							0.090	0.475
<5% TFAs	2 (33.3)	6.7 ± 4.7	70.0 ± 42.4	70.0 ± 42.4	0.0 ± 0.0	0.0 ± 0.0		
≥5% TFAs	4 (66.7)	8.3 ± 1.9	38.3 ± 13.5	76.7 ± 19.2	38.3 ± 32.7	13.1 ± 10.9		
Lard and shortening							0.023	0.037
<2% TFAs	4 (44.4)	100.0 ± 0.0	40.0 ± 0.0	41.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0		
≥2% TFAs	5 (55.5)	100.0 ± 0.0	27.5 ± 6.1	48.3 ± 16.3	20.8 ± 16.2	20.9 ± 16.1		
Mexican kit							0.036	0.230
<5% TFAs	3 (37.5)	8.5 ± 0.3	41.4 ± 7.1	43.2 ± 4.5	1.8 ± 2.6	0.7 ± 1.1		
≥5% TFAs	5 (62.5)	8.1 ± 2.2	34.1 ± 9.5	41.7 ± 8.7	7.6 ± 1.8	2.9 ± 0.6		
Refrigerated dough							0.001	0.672
<5% TFAs	5 (50.0)	7.3 ± 7.1	18.9 ± 25.9	19.3 ± 26.5	0.4 ± 1.0	0.2 ± 0.4		
≥5% TFAs	5 (50.0)	12.7 ± 7.6	26.3 ± 9.2	48.2 ± 9.4	21.9 ± 14.0	7.6 ± 5.6		
Shortbread cookies							0.006	0.507
<5% TFAs	7 (58.3)	27.8 ± 3.0	58.3 ± 12.8	60.6 ± 13.2	2.3 ± 1.6	1.1 ± 0.8		
≥5% TFAs	5 (41.7)	25.9 ± 4.3	52.8 ± 16.7	62.4 ± 9.6	9.5 ± 8.7	4.0 ± 3.1		
Toaster pastries							0.001	0.004
<5% TFAs	8 (66.7)	10.5 ± 0.9	30.8 ± 1.5	30.8 ± 1.5	0.0 ± 0.0	0.0 ± 0.0		
≥5% TFAs	4 (33.3)	13.0 ± 0.0	42.9 ± 0.0	50.0 ± 0.0	7.1 ± 0.0	2.5 ± 0.0		
Doughnuts, yeast							—	—
<5% TFAs	2 (66.7)	19.6 ± 0.0	50.0 ± 0.0	53.7 ± 0.5	3.7 ± 0.5	1.6 ± 0.2		
≥5% TFAs	1 (33.3)	12.0 ± 0.0	25.0 ± 0.0	60.0 ± 0.0	35.0 ± 0.0	12.6 ± 0.0		
Bacon bits							—	—
<5% TFAs	3 (75.0)	20.2 ± 5.5	19.4 ± 17.3	19.4 ± 17.3	0.0 ± 0.0	0.0 ± 0.0		
≥5% TFAs	1 (25.0)	21.4 ± 0.0	13.3 ± 0.0	26.7 ± 0.0	13.3 ± 0.0	6.0 ± 0.0		
Frozen grain/potato sides							—	—
<5% TFAs	3 (75.0)	8.0 ± 2.2	41.9 ± 12.9	41.9 ± 12.9	0.0 ± 0.0	0.0 ± 0.0		
≥5% TFAs	1 (25.0)	12.8 ± 0.0	33.3 ± 0.0	45.8 ± 0.0	12.5 ± 0.0	6.4 ± 0.0		
Cakes with pudding/mousse							0.014	0.014
<5% TFAs	10 (76.9)	17.9 ± 3.8	57.8 ± 9.0	60.0 ± 9.1	2.2 ± 1.1	1.1 ± 0.5		
≥5% TFAs	3 (23.1)	2.4 ± 0.2	28.9 ± 7.7	46.7 ± 5.8	17.8 ± 1.9	2.9 ± 0.2		
Doughnuts, cake							0.055	0.184
<5% TFAs	7 (77.8)	19.5 ± 5.4	41.8 ± 10.7	43.4 ± 10.3	1.7 ± 1.0	0.7 ± 0.4		
≥5% TFAs	2 (22.2)	24.3 ± 1.0	33.0 ± 6.3	60.7 ± 15.2	27.7 ± 21.5	14.5 ± 11.4		
Dry mashed or scalloped potatoes							<0.001	0.736
<5% TFAs	24 (80.0)	4.2 ± 2.1	23.6 ± 9.4	23.8 ± 9.3	0.2 ± 0.6	0.1 ± 0.2		
≥5% TFAs	6 (20.0)	2.9 ± 0.9	22.6 ± 5.3	37.9 ± 18.7	15.3 ± 17.1	4.8 ± 5.9		
Vegetable dishes							0.027	0.399
<5% TFAs	8 (80.0)	2.4 ± 0.6	23.6 ± 13.4	24.3 ± 14.3	0.7 ± 1.3	0.1 ± 0.3		
≥5% TFAs	2 (20.0)	8.0 ± 9.9	58.0 ± 1.2	63.8 ± 1.3	5.8 ± 0.1	2.0 ± 2.2		
Brownies and other squares							<0.001	0.006
<5% TFAs	31 (83.8)	17.8 ± 6.2	34.5 ± 16.7	35.4 ± 16.3	0.9 ± 1.3	0.4 ± 0.6		
≥5% TFAs	6 (16.2)	13.6 ± 5.2	14.6 ± 9.7	24.1 ± 14.6	9.6 ± 5.4	3.1 ± 0.8		
Sandwich cookies							<0.001	0.025
<5% TFAs	32 (84.2)	20.1 ± 4.1	42.5 ± 15.4	43.0 ± 15.8	0.5 ± 1.0	0.2 ± 0.4		
≥5% TFAs	6 (15.8)	20.8 ± 2.6	25.9 ± 6.2	47.3 ± 7.0	21.4 ± 9.6	8.3 ± 4.2		
Dessert toppings							0.004	0.033
<5% TFAs	16 (84.2)	15.8 ± 9.2	87.3 ± 15.3	88.4 ± 14.4	1.1 ± 1.5	0.8 ± 1.1		
≥5% TFAs	3 (15.8)	10.0 ± 0.0	66.7 ± 0.0	73.3 ± 0.0	6.7 ± 0.0	3.0 ± 0.0		

(Continued)

TABLE 2 (Continued)

	Total no. of products (%)	Fat	SFAs	TFAs + SFAs	TFAs	Percentage of energy from TFAs	P	
							TFAs	SFAs
Margarine							<0.001	0.031
<2% TFAs	44 (84.6)	70.3 ± 15.8	15.7 ± 7.8	16.2 ± 7.9	0.3 ± 0.5	0.3 ± 0.6		
≥2% TFAs	8 (15.4)	67.5 ± 17.5	21.1 ± 4.2	37.0 ± 9.4	15.9 ± 11.9	16.3 ± 12.1		
Chocolate chip cookies							<0.001	0.020
<5% TFAs	39 (84.8)	20.8 ± 4.3	43.7 ± 13.0	44.4 ± 13.4	0.7 ± 1.0	0.3 ± 0.5		
≥5% TFAs	7 (15.8)	21.6 ± 2.1	32.8 ± 6.2	47.7 ± 5.7	15.0 ± 5.2	6.2 ± 0.3		
Stuffing mixes							<0.001	0.028
<5% TFAs	12 (85.7)	7.8 ± 2.2	23.0 ± 13.3	24.3 ± 12.7	1.3 ± 1.4	0.5 ± 0.6		
≥5% TFAs	2 (14.3)	10.1 ± 0.0	56.4 ± 0.0	61.5 ± 0.0	5.1 ± 0.0	2.1 ± 0.0		
Sugar wafer cookies							—	0.445
<5% TFAs	6 (85.7)	21.0 ± 7.6	56.1 ± 18.0	56.4 ± 18.0	0.3 ± 0.7	0.1 ± 0.3		
≥5% TFAs	1 (14.3)	32.0 ± 0.0	37.5 ± 0.0	62.5 ± 0.0	25.0 ± 0.0	12.9 ± 0.0		
Appetizers								
Pastry							<0.001	0.756
<5% TFAs	42 (87.5)	11.5 ± 5.5	28.9 ± 15.3	30.0 ± 16.2	1.2 ± 1.3	0.6 ± 0.7		
≥5% TFAs	6 (12.5)	15.6 ± 5.2	31.5 ± 14.3	40.6 ± 14.0	9.1 ± 4.0	4.4 ± 0.6		
Sausage rolls							—	0.409
<5% TFAs	7 (87.5)	17.8 ± 4.3	38.4 ± 5.0	39.3 ± 4.7	0.9 ± 0.7	0.5 ± 0.3		
≥5% TFAs	1 (12.5)	16.0 ± 0.0	31.3 ± 0.0	45.0 ± 0.0	13.8 ± 0.0	7.1 ± 0.0		
Popcorn							<0.001	0.079
<5% TFAs	51 (87.9)	18.1 ± 11.4	34.1 ± 16.6	34.5 ± 16.7	0.4 ± 0.6	0.2 ± 0.3		
≥5% TFAs	7 (12.1)	27.2 ± 10.0	21.1 ± 4.5	55.1 ± 11.3	33.9 ± 12.7	17.4 ± 8.7		
Other cookies							<0.001	0.020
<5% TFAs	87 (89.7)	17.6 ± 6.5	36.8 ± 23.8	37.4 ± 24.2	0.6 ± 1.1	0.2 ± 0.5		
≥5% TFAs	10 (10.3)	18.2 ± 4.2	57.2 ± 23.4	67.6 ± 17.5	10.4 ± 6.3	3.9 ± 2.6		
Chocolate-covered cookies							<0.001	0.003
<5% TFAs	44 (66.7)	28.1 ± 6.4	59.8 ± 9.9	60.6 ± 9.8	0.7 ± 1.0	0.3 ± 0.5		
≥5% TFAs	5 (33.3)	26.8 ± 4.5	45.3 ± 5.2	64.3 ± 7.3	19.1 ± 6.3	8.7 ± 2.9		
Pasta and noodles with sauce, canned and dry							<0.001	<0.001
<5% TFAs	162 (91.5)	4.2 ± 3.4	25.1 ± 13.4	25.6 ± 14.0	0.5 ± 1.3	0.2 ± 0.4		
≥5% TFAs	15 (8.5)	3.5 ± 1.4	38.1 ± 8.8	44.9 ± 7.7	6.7 ± 2.2	2.1 ± 1.1		
Restaurant foods								
Desserts and other baked goods							<0.001	<0.001
<5% TFAs	125 (89.9)	14.8 ± 7.7	42.4 ± 16.0	43.8 ± 16.3	1.1 ± 1.1	0.5 ± 0.5		
≥5% TFAs	14 (10.0)	14.3 ± 9.4	26.7 ± 15.2	37.2 ± 17.5	10.4 ± 5.1	4.3 ± 3.3		
Biscuits/scones							<0.001	0.167
<5% TFAs	10 (52.6)	9.5 ± 0.7	22.4 ± 4.2	23.1 ± 4.0	0.8 ± 0.9	0.3 ± 0.4		
≥5% TFAs	9 (47.4)	8.4 ± 3.5	27.5 ± 9.4	47.9 ± 9.0	20.8 ± 4.1	5.6 ± 0.7		
Cookies							<0.001	<0.001
<5% TFAs	52 (85.3)	22.0 ± 3.6	49.0 ± 11.8	49.7 ± 3.9	0.6 ± 0.7	0.3 ± 0.3		
≥5% TFAs	9 (14.7)	30.8 ± 21.1	25.8 ± 7.3	47.5 ± 8.6	21.8 ± 7.5	8.6 ± 2.9		
Rice							<0.001	0.175
<5% TFAs	17 (89.5)	3.0 ± 3.6	16.6 ± 18.2	16.7 ± 18.2	0.1 ± 0.4	0.0 ± 0.1		
≥5% TFAs	2 (10.5)	2.0 ± 0.3	41.7 ± 35.3	51.7 ± 30.6	10.0 ± 4.7	1.2 ± 0.4		

¹ All values are means ± SDs unless otherwise indicated. Comparisons were made between foods in the same category that met the limits recommended by the Canadian Trans Fat Task Force and used for the Trans Fat Monitoring Program (<2% total fat for fats and oils and <5% total fat for all other categories) (12). $P < 0.05$ was considered significant as determined by the Wilcoxon signed rank test. TFA, *trans* fatty acid.

(Table 1 and Figure 1). Packaged food categories with the greatest improvements (2005–2009 to 2010–2011) in meeting the TFA limits were croissants (25% to 100%), pies (36% to 98%), cakes (43% to 90%), garlic spreads (33% to 100%), and garlic bread (55% to 91%). Furthermore, many food categories such as bread and buns, croissants, muffins and quick breads, tarts, garlic spreads, instant noodles, and snack puddings had 100% of products meeting the recommended TFA limits in

2010–2011. However, 2 product categories had decreases in the number of products meeting the TFA limits (2005–2009 to 2010–2011): coffee whiteners (53% to 33%) and lard (100% to 75%) and vegetable (50% to 40%) shortenings.

Restaurant foods also showed significant improvements in the number of foods meeting the TFA limits (Table 1 and Supplemental Table S3 under “Supplemental data” in the online issue). By 2010, every food category among those assessed by the



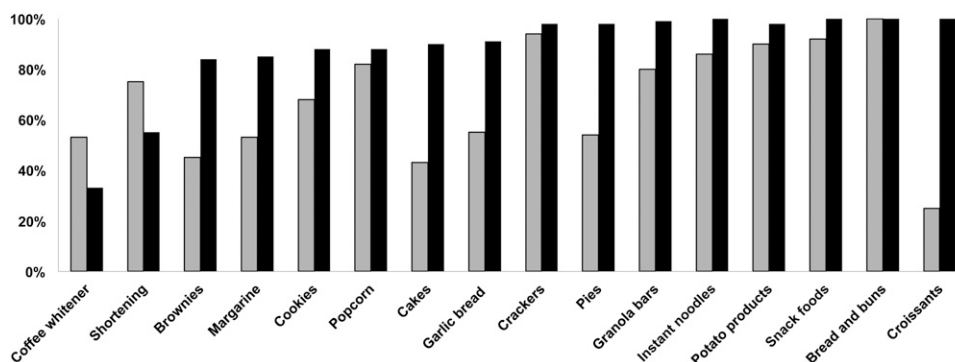


FIGURE 1. Summary of the proportion of packaged foods meeting Health Canada's recommended *trans* fat limits: 2005–2009 (gray bars) compared with 2010–2011 (black bars). Data are from the Trans Fat Monitoring Program (2005–2009) and the Food Label Information Program (2010–2011). Full data and sample sizes are shown in Table 2.

TFMP, except for muffins, had 100% of foods meeting TFA limits in the restaurant database.

Saturated fat amounts in products with high or low TFA amounts

Most food categories showed no increase in saturated fat amounts between foods that were lower in TFAs (ie, met the TFA limits) and those higher in TFAs (ie, exceeded the TFA limits) (Table 2). However, among packaged foods, significantly higher saturated fat amounts were seen in some foods with lower TFA amounts: chocolate chip cookies ($43.7 \pm 13.0\%$ compared with $32.8 \pm 6.2\%$, $P = 0.020$), chocolate-covered cookies ($59.8 \pm 9.9\%$ compared with $45.3 \pm 5.2\%$, $P = 0.003$), sandwich cookies ($42.5 \pm 15.4\%$ compared with $25.9 \pm 6.2\%$, $P = 0.025$), brownies and squares ($34.5 \pm 16.7\%$ compared with $14.6 \pm 9.7\%$, $P = 0.006$), cakes with pudding/mousse ($57.8 \pm 9.0\%$ compared with $28.9 \pm 7.7\%$, $P = 0.014$), dessert toppings ($87.3 \pm 15.3\%$ compared with $66.7 \pm 0.0\%$, $P = 0.033$), and lard and shortening ($40.0 \pm 0.0\%$ compared with $27.5 \pm 6.1\%$, $P = 0.037$). Among restaurant foods, cookies ($49.0 \pm 11.8\%$ compared with $25.8 \pm 7.3\%$, $P < 0.001$) and desserts and other baked goods ($42.4 \pm 16.0\%$ compared with $26.7 \pm 15.2\%$, $P < 0.001$) had significantly higher saturated fat amounts in products that were lower in TFAs.

DISCUSSION

This study provides a detailed assessment of TFAs in the Canadian food supply by analyzing >10,000 packaged and restaurant foods and by uniquely describing changes in TFA amounts after termination of the government-led TFMP. This analysis found that 95% of packaged foods and 96% of restaurant foods, overall, had TFA amounts that fell within the recommended limits. When examining the top contributors of industrial TFAs to the Canadian diet, there was a striking improvement in the proportion of foods meeting the recommended limits, increasing from 75% in 2005–2009 to 97% in 2010–2011. These data are surprising because virtually no government monitoring or education programs have been directed toward TFAs since 2009. The data also highlight the food industry's commitment in voluntarily reducing the amount of TFAs in foods. However, areas of concern were identified. First, more

than half of packaged dairy-free cheeses, frostings, coffee whiteners, Mexican meal kits, refrigerated packaged dough products, and restaurant-prepared biscuits and scones had TFA amounts that exceeded recommended limits. Second, among foods that exceed the TFA limits, many contain very high amounts of TFAs (eg, coffee whiteners, doughnuts, dairy-free cheese, refrigerated dough). Many of these were in food categories that contained a large proportion of products that meet the TFA limits, which suggests that technologies clearly exist for reformulation. Third, in 8 subcategories (eg, varieties of cookies, cakes, dessert toppings), there were significantly higher saturated fat amounts among foods with the lowest TFA amounts, an unintended side effect of reformulation that is contrary to earlier Canadian reports (20). Indeed, many of the foods evaluated in this study are produced by multinational food companies and thus available across North America. Therefore, it is considered reasonable that these data may be generalizable to the United States and other countries.

Canada, along with Denmark, emerged as an early global leader in implementing a coordinated national strategy for reducing and eliminating industrial TFAs in the food supply (21). Although Denmark legislated limits of industrial TFAs in foods to $\leq 2\%$ TFAs of total fat, which resulted in rapid and dramatic reductions in TFAs in the food supply and in TFA intakes (22), the Canadian government adopted a voluntary approach in addition to the earlier mandatory requirement to declare the TFA content of all foods containing ≥ 0.2 g/serving on the NfT. Although the results in Canada took longer to achieve than did Denmark's approach, the present study shows that not only was Health Canada's strategy effective in reducing TFA amounts in the food supply, it was also sustainable and improved in subsequent years (12). There has been a 19% increase in the number of foods that meet the recommended TFA limits since termination of the TFMP, from 75% in 2005–2009 to 97% in 2010–2011. However, attention is required on those foods that continue to contain unacceptable amounts of TFAs to ensure low TFA amounts in all foods for equitable and maximal health benefits for all Canadians. This is relevant because TFA intake patterns vary across the population (ie, 14- to 18-y-old males have the highest intakes) (12, 23), and addressing such foods would reduce exposure to TFAs in population subgroups at risk of excess intakes. Indeed, this study showed that some single-food items can contribute substantial amounts of and calories from TFAs;

thus, on a daily basis, some individuals could consume amounts that exceed the daily recommendation of <1% of total energy from TFAs.

The effectiveness of policies to reduce and eliminate industrial TFAs has been evaluated (24). In 1999–2002, the US population consumed an average of 2.3% of total energy from TFAs (23). In 2006, New York City banned industrial TFAs in food service establishments and TFA amounts in the average lunchtime meal was reduced from 2.91 g/serving in 2007 to 0.5 g/serving in 2009 (25). Also in the United States, where TFA labeling on packaged foods was mandated in 2006, a 49% reduction (1.9 to 0.9 g/serving) in the TFA content was reported in an assessment of 360 packaged foods between 2007 and 2011 (26). Some products (eg, doughnuts, French fries) were reformulated much more rapidly compared with other categories (eg, popcorn) (26). A study in European countries, which described high and variable TFA amounts in foods, found significantly reduced TFA amounts over time, although TFA amounts in products in some eastern European countries remain high (27). Most of these reductions in TFAs in the food supply were reflected in biomarkers of TFA intake (28–30).

Substituting saturated fats for TFAs would counteract the health benefits of removing TFAs; therefore, it is recommended that unsaturated fats be substituted for TFAs during reformulation. Among a relatively small number of Canadian foods reformulated to be lower in TFAs, Ratnayake et al (20) observed an increase in PUFAs and MUFAs and no increase in SFAs. In contrast, the present study found that some cookie and cake varieties, brownies and squares, dessert toppings, and lard and shortenings had higher amounts of saturated fat in products with low amounts of TFAs, which suggests the likely addition of saturated fats during reformulation. This finding is similar to other countries, where higher saturated fat amounts were found in reformulated cookies (31, 32) and microwave popcorn (31). To ensure that the beneficial health effects of TFA reduction are not negated with the addition of unhealthy saturated fats to foods during reformulation, governments and researchers should continue to evaluate such unintended consequences as foods are reformulated to contain reduced TFAs or be free of TFAs.

This analysis has limitations. First, there were differences between the TFMP database and the 2010–2011 University of Toronto databases. However data from the 2010–2011 databases provided a market-wide perspective and thus include a representative assessment of all foods in the categories of interest. Second, TFA intake resulting from food supply changes was not assessed, although most intakes will likely be extremely low in TFAs, with the exception of those individuals who regularly consume the few products that have high amounts. Third, our data may not provide an accurate assessment of TFAs in restaurant foods because we only included chain restaurants with >20 outlets and because a large number of franchises did not report the amount of TFAs in foods served. This analysis also relied on the NfT and reported menu information from food manufacturers, which makes an assumption that these data are accurate. Canadian laboratory analysis show that there is a high degree of accuracy with regard to the TFA reported on the NfT (33), which is reported for all foods containing ≥ 0.2 g TFAs/serving in Canada. Finally, our comparison of saturated fat amounts among products meeting and exceeding the recommended TFA limits included a comparison of group means, and

product variations may account for observed differences in saturated fat. The strength of this analysis, however, is that differences in saturated fat were evaluated across a large number of food subcategories.

This study, which uniquely conducted a broad and detailed assessment of TFA amounts in >10,000 Canadian packaged and restaurant foods, highlights the success of both the Canadian government and food industry in achieving and sustaining lower TFA amounts in the food supply. However, this study also highlights 3 areas that require action: 1) entire food categories that have a large proportion of food items that exceed the TFA limits; 2) individual foods that contain very high amounts of TFAs, even though the large majority of products in that food category are meeting the TFA limits; and 3) those foods that appear to be reformulated with saturated fat, rather than unsaturated fats. Addressing these challenges would ensure equitable and maximal health benefits for all segments of the population. Although the food industry has made great progress in reducing and eliminating TFAs, governments should invoke strict monitoring programs until such changes are implemented in all foods or take necessary regulatory action, as proposed in the United States, to ensure that all foods produced would have industrialized TFAs reduced or eliminated to safer limits.

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