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# *Trans* Fatty Acids in Canadian Margarines: Recent Trends

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**ABSTRACT:** The fatty acid composition and the *trans* fatty acid content of the top-selling 109 Canadian margarines were determined by a combined capillary gas–liquid chromatography/infrared spectroscopy method. The 109 brands accounted for 68% of the margarine brands sold in Canada and represented 74% of the market share. The mean level of total *trans* content in tub margarines ($n = 79$) was 18.8% (g/100 g fatty acids) and ranged from 0.9 to 46.4%. The most frequent occurrence of *trans* in tub margarines was in the 15–20% range; 48 of the 79 tub brands were in this range but seven brands contained more than 40% *trans*. The *trans* content of hard margarines ($n = 30$) ranged from 16.3 to 43.7% and the mean value was 34.3%. In 20 of the 109 brands, the levels of *trans,trans* isomers of linoleic acid exceeded the maximum level of 1% recommended for Canadian margarines. The levels of *cis,trans/trans,cis* isomers of linoleic acid were also high; 78 brands contained more than 1% and in 16 brands, the levels were in the 6–7% range. Linoleic acid content in the 109 brands ranged from 1.0 to 45.2% and averaged 18.3%. In 33 samples, linoleic acid was below the level of 5% recommended by an *ad hoc* committee of Health Canada. Moreover, in these, the total *trans* content exceeded 30%, and *trans* polyunsaturated fatty acid level was greater than 5%. There were eight margarines prepared from nonhydrogenated fat and their total *trans* content was below 2.5%. From the *trans* content and market share of each of the margarine brands, the average intake of *trans* fatty acids from margarine was estimated as 0.96 g/person/d. The intake of *trans* fatty acids in Canada from various sources was previously estimated by us as 8.4 g/person/d. Thus it is suggested that only 11% of the dietary *trans* fatty acids are supplied by margarines and the majority of *trans* fatty acids in the Canadian diet is derived from hidden fats in fast foods and bakery products.
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**KEY WORDS:** Fatty acids, gas chromatography, hydrogenated vegetable oils, *cis-trans* isomers, linoleic acid, α-linolenic acid, margarine.

There is now convincing evidence that dietary *trans* fatty acids (TFA) raise plasma low-density lipoprotein-cholesterol (LDL-C) and lipoprotein (a) [Lp(a)] and lower plasma high-density lipoprotein cholesterol (HDL-C) (1–7). High LDL-C, high Lp(a) and low HDL-C are considered lipid risk factors for cardiovascular disease. In addition, there are concerns about recent suggestions that TFA may affect human fetal growth and infant development (8–11). The high levels of TFA in Canadian breast milk are also a concern (12–14).

Margarines are an important source of both essential fatty acids (EFA) and TFA in the Canadian diet. The levels of these fatty acids in Canadian margarines have been determined on a regular basis (15–19) and the last such analysis was performed in 1990 (19). The current publicity about health concerns of TFA seems to have influenced margarine manufacturers to reduce the TFA content in their products. Several margarine brands prepared without hydrogenated fats are also now available to Canadians. Because of these new developments, the TFA content and the fatty acid composition of current Canadian margarines were determined. Such data may be valuable to health professionals for recommending the most suitable types of margarine to the public. The margarine brands in this study were selected on the basis of their national market share, which allowed us to make a good estimate of the contribution of margarine to the total TFA content in the Canadian diet.

## EXPERIMENTAL PROCEDURES

*Sample selection.* National market share data for margarines were purchased from a marketing research organization in Canada. The information included the sales volume generated at retail during the 24-wk period between May 29, 1994, and November 13, 1994. The market data showed the availability of 160 different brands of margarines in Canada. Of these, the top 109 best-selling brands (79 tub and 30 print), which represented 74% of the market share, were selected for analysis. Six samples from each brand were purchased during March and April 1995 from six regions of Canada (Maritime, Quebec, Ontario, Manitoba-Saskatchewan, Alberta, and British Columbia).

*Analysis.* Analyses were performed in three Health Protection Branch (HPB) laboratories. The top 40 best-selling margarine brands were analyzed at the HPB Ottawa Laboratory. Of the remainder, 40 (all collected from the Ontario, Manitoba-Saskatchewan, Alberta, and British Columbia regions) were analyzed in the HPB Regional Laboratory in Winnipeg and the other 29 (collected from the eastern regions) in the HPB Atlantic Regional Laboratory in Dartmouth. All three laboratories followed the same standard protocol for sample handling, storage, and fatty acid analysis.

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A central plug (1 g) from each of the six samples of the same brand was taken and homogenized. Approximately 200 mg of the homogenized sample was directly converted to fatty acid methyl esters (without prior extraction of fat) by initial treatment with 1.5 mL 0.5 NaOH in methanol at 100°C for 5 min followed by further treatment of the mixture with 2 mL of 14% $BF_3$-methanol at 100˚C for 30 min. The fatty acid methyl esters were recovered with hexane and analyzed using an SP-2560 (100 m × 0.25 mm i.d. 20 µm thickness, Supelco, Bellefonte, PA) capillary column in a Hewlett-Packard (Palo Alto, CA) 5890 Series II gas chromatograph (GC) equipped with a Hewlett-Packard GC Chemstation. The column oven temperature was initially held at 165°C for 75 min and then programmed at 7°C/min to a final temperature of 210°C, and held at this temperature for 30 min. Fatty acid identification was based on authentic reference standards and by comparison with GC traces previously published by us (20,21). This single-step direct GC analysis was satisfactory for samples containing less than 5% *trans* 18:1 fatty acids (*t*-18:1). However, in samples containing more than 5% *t*-18:1, the 12*t* to 16*t*-18:1 isomers eluted with *cis*-18:1 (*c*-18:1) isomers. The *t*-18:1 content of these samples was determined using the additional step of total *trans* measurement by infrared spectroscopy (IR) and correction for the *cis-trans* overlaps by combining the IR and GC results as outlined by Ratnayake (21) and AOAC official method 994.15 (22).

## RESULTS

The relative amounts (% of total fatty acids) of total TFA, *t*-18:1, *trans,cis/cis,trans*-18:2 (*ct*-18:2), *trans,trans*-18:2 (*tt*-18:2), *trans*-18:3 (*t*-18:3), total saturated fatty acids (SFA), *c*-18:1 (all isomers), *cis*-18:2n-6 (linoleic acid) and *cis*-18:3n-3 (α-linolenic acid) of the 79 tub (T) and 30 print (P) brands are provided in Table 1. The coding of the brands was based on their market share rankings, and in Table 1 they are arranged according to descending order of the market share.

The distribution of the total TFA content, which includes all types of *trans* fatty acids, is shown in Figure 1. The print margarines as expected generally contained higher TFA content (average 34.3%; range 16.3 to 43.7%) than the tub margarines (average 18.8%; range 0.9 to 46.4%). The most frequent occurrence of *trans* was in the 15–20% range, and 48 of the 79 tub brands were in this range. It is noteworthy that in seven tub brands the TFA content exceeded 40%. The labels of eight brands indicated that they contained no hydrogenated fat (termed as zero-*trans* margarines), and their TFA content was less than 2.5%.

As expected, *t*-18:1 was the major *trans* group in all the margarines prepared from partially hydrogenated vegetable oils (Table 1). Also, all the margarines showed varying levels of several *tt*, *ct*, or *tc*-18:2 isomers. In some margarines up to 15 different isomers were detected. In 1980, an *ad hoc* committee of Health Canada recommended that the *tt*-18:2 content in Canadian margarines should be kept below 1% of total fatty acids (23). Twenty margarines of the present study (eight tub and 12 print brands) contained more than 1% *tt*-18:2. Moreover, in nine brands (# 21-T, 33-T, 66-T, 73-T, 77-T, 79-T, 86-T, 87-T, and 49-P in Table 1) the level exceeded 2%. The *ct* or *tc*-18:2 isomers are always the major *trans*-polyunsaturated fatty acid (PUFA) isomer group in partially hydrogenated vegetable oils. This group is comprised of 7 to 9 different isomers. The most predominant ones are 9*c*,13*t*-18:2; 9*c*,12*t*-18:2; and 9*t*,12*c*-18:2 (20). In the present study, 75 brands contained more than 1% *ct*-18:2. In the nine brands with the highest *tt*-18:2 levels mentioned earlier, the level of *ct*-18:2 was also extremely high and exceeded 5% of the total fatty acids. Moreover, in these the total amount of EFA (sum of linoleic and α-linolenic acids) was lower than total *trans*-18:2 content (sum of *tt*-, *ct*-, and *tc*-18:2 isomers) (Table 1).

A wide range in the linoleic acid concentration occurred in both the tub margarines (2.3 to 44.6%) and print margarines (1.0 to 32.8%). The average was 22.7 and 6.7% for tub and print margarines, respectively. Thirty-one brands (11 tub and 20 print) contained less than 5% linoleic acid, which is the minimum level recommended for Canadian margarines. In a few brands (56-P, 58-P, and 82-P in Table 1), linoleic acid level was just above 1%. α-Linolenic acid content was generally higher in the tub margarines (average 4.6%; range 0.5 to 8.2%) than in print margarines (average 1.6%; range 0.1 to 5%).

The relationships in Figure 2 demonstrate that the high level of TFA is associated with low levels of linoleic and α-linolenic acids. The inverse correlation was particularly strong for α-linolenic acid. There was no correlation between TFA and total saturated fatty acids.

The scatter plot in Figure 3 shows that TFA content has no correlation with market share rankings of the various margarine brands. The levels of linoleic, α-linolenic, and saturated fatty acids also showed no relationship with the market share (scatter plots are not shown).

## DISCUSSION

The 1990 Nutrition Recommendations of Health Canada specified that n-6 fatty acids in the Canadian diet should be at least 3% of dietary energy and n-3 fatty acids at least 0.5% of dietary energy, with a ratio of n-6 to n-3 fatty acids in the range of 4:1 to 10:1 (24). Furthermore, because of the potential adverse effects of TFA, it was recommended not to increase the levels of this class of fatty acids in the Canadian diet. The n-6 and n-3 fatty acids are present at various levels in a variety of natural and processed foods in the Canadian diet. Margarine is one of the convenient and readily available sources of both linoleic and α-linolenic acids. However, the probable presence of large amounts of TFA in margarine is a drawback. Because of these dual features, the fatty acid profile of Canadian margarines had been examined from time to time at Health Canada (15,16,18,19) and Agriculture Canada (17).

Comparison of the data presented in this study with previous Canadian data (15–19) shows an overall improvement in the fatty acid profile of present-day margarines. Specifically, a large number of current margarines display significantly

**TABLE 1**
**Fatty Acid Compositions (g/100 g fatty acids) of Canadian Margarines**

| Sample ID (rank[a] and type[b]) | Total *trans* | *t*-18:1 | *ct*-18:2 | *tt*-18:2 | *t*-18:3 | SFA | c-18:1 | 18:2n-6 | 18:3n-3 |
|---|---|---|---|---|---|---|---|---|---|
| 1-T | 1.1 | 0.2 | 0.4 | 0 | 0.5 | 14.5 | 41.3 | 33.8 | 6.4 |
| 2-T | 16.9 | 15.4 | 1.1 | 0 | 0.4 | 18.9 | 25.4 | 33.1 | 5.1 |
| 3-T | 10.5 | 9.7 | 0.5 | 0 | 0.3 | 13.0 | 51.4 | 15.4 | 7.0 |
| 4-P | 33.4 | 30.2 | 3.0 | 0 | 0.2 | 17.9 | 31.3 | 14.6 | 2.1 |
| 5-T | 16.8 | 15.5 | 1.0 | 0.1 | 0.3 | 17.8 | 22.2 | 37.1 | 5.5 |
| 6-P | 41.5 | 37.3 | 3.6 | 0.4 | 0.2 | 16.3 | 34.1 | 6.0 | 1.1 |
| 7-T | 18.4 | 16.9 | 0.9 | 0 | 0.6 | 12.4 | 48.5 | 13.2 | 5.2 |
| 8-T | 0.9 | 0.2 | 0.3 | 0 | 0.4 | 18.2 | 45.9 | 25.7 | 6.1 |
| 9-T | 21.4 | 19.4 | 0.9 | 0.6 | 0.5 | 15.3 | 33.6 | 22.3 | 5.7 |
| 10-T | 13.5 | 11.7 | 1.3 | 0 | 0.5 | 14.3 | 46.9 | 16.3 | 6.3 |
| 11-T | 20.2 | 18.5 | 1.1 | 0 | 0.6 | 12.1 | 48.1 | 12.1 | 5.2 |
| 12-P | 41.8 | 37.2 | 4.0 | 0.5 | 0.1 | 16.2 | 33.9 | 5.6 | 1.0 |
| 13-T | 17.4 | 15.9 | 1.2 | 0 | 0.3 | 18.8 | 25.9 | 32.0 | 4.9 |
| 14-T | 16.0 | 14.9 | 0.8 | 0 | 0.3 | 18.2 | 23.8 | 35.4 | 5.9 |
| 15-T | 17.6 | 16.1 | 0.8 | 0 | 0.6 | 18.6 | 25.3 | 33.1 | 4.8 |
| 16-T | 11.6 | 10.8 | 0.4 | 0 | 0.3 | 15.0 | 33.7 | 27.6 | 6.7 |
| 17-T | 16.3 | 14.8 | 1.1 | 0.1 | 0.3 | 17.9 | 21.9 | 37.2 | 5.9 |
| 18-T | 13.6 | 12.6 | 0.6 | 0 | 0.4 | 18.5 | 21.3 | 39.6 | 6.4 |
| 19-T | 18.3 | 16.9 | 1.1 | 0 | 0.4 | 17.9 | 25.2 | 32.7 | 5.1 |
| 20-P | 31.4 | 30.4 | 0.6 | 0 | 0.4 | 12.4 | 41.7 | 11.3 | 4.9 |
| 21-T | 37.0 | 27.1 | 6.4 | 2.1 | 1.4 | 11.7 | 43.8 | 4.0 | 0.6 |
| 22-P | 40.4 | 33.3 | 4.8 | 0.4 | 1.0 | 16.5 | 37.1 | 3.5 | 0.8 |
| 23-T | 0.9 | 0.3 | 0.3 | 0 | 0.3 | 18.3 | 44.8 | 28.0 | 6.1 |
| 24-T | 18.7 | 17.1 | 1.2 | 0 | 0.4 | 17.6 | 27.0 | 31.0 | 4.9 |
| 25-P | 37.1 | 34.4 | 2.5 | 0 | 0.1 | 18.1 | 38.0 | 5.0 | 0.5 |
| 26-T | 16.9 | 15.4 | 1.1 | 0 | 0.4 | 18.2 | 23.9 | 34.6 | 5.4 |
| 27-T | 17.3 | 16.4 | 1.0 | 0 | 0.3 | 18.0 | 26.4 | 32.5 | 4.8 |
| 28-T | 13.2 | 12.5 | 0.3 | 0 | 0.4 | 12.3 | 48.4 | 16.1 | 7.5 |
| 29-T | 17.4 | 16.3 | 0.9 | 0 | 0.2 | 18.0 | 19.7 | 34.7 | 5.1 |
| 30-T | 14.7 | 13.1 | 0.9 | 0.3 | 0.5 | 13.6 | 37.5 | 23.1 | 4.4 |
| 31-T | 18.0 | 16.9 | 0.7 | 0.1 | 0.4 | 20.0 | 22.8 | 33.3 | 5.3 |
| 32-T | 19.1 | 14.5 | 2.4 | 0.7 | 1.3 | 16.6 | 47.0 | 10.7 | 3.0 |
| 33-T | 45.6 | 35.0 | 6.7 | 2.8 | 1.1 | 10.9 | 36.2 | 3.1 | 0.6 |
| 34-T | 1.3 | 0.3 | 0.2 | 0 | 0.8 | 18.0 | 53.4 | 17.4 | 7.4 |
| 35-T | 20.1 | 17.8 | 1.3 | 0.2 | 1.0 | 14.6 | 35.1 | 18.3 | 5.4 |
| 36-T | 18.1 | 16.2 | 0.7 | 0.2 | 0.6 | 15.1 | 46.6 | 13.6 | 5.9 |
| 37-T | 18.5 | 17.3 | 0.7 | 0 | 0.5 | 17.9 | 25.4 | 32.5 | 5.1 |
| 38-T | 17.0 | 15.2 | 1.0 | 0.1 | 0.5 | 18.1 | 26.1 | 33.3 | 5.0 |
| 39-T | 5.0 | 2.8 | 0.7 | 0 | 1.0 | 21.6 | 41.5 | 24.0 | 6.9 |
| 40-T | 16.5 | 14.9 | 1.0 | 0.1 | 0.3 | 19.5 | 25.2 | 33.0 | 5.3 |
| 41-T | 17.9 | 16.7 | 0.8 | 0.2 | 0.2 | 19.7 | 23.4 | 32.6 | 5.8 |
| 42-T | 17.0 | 14.3 | 0.9 | 0 | 1.6 | 19.1 | 21.2 | 37.0 | 5.0 |
| 43-T | 17.8 | 16.4 | 1.0 | 0.7 | 0.3 | 19.3 | 24.6 | 32.5 | 5.2 |
| 44-P | 33.6 | 29.4 | 2.7 | 0.8 | 0.5 | 20.9 | 38.3 | 3.5 | 1.6 |
| 45-T | 19.6 | 17.9 | 1.2 | 0 | 0.5 | 18.4 | 26.8 | 30.4 | 4.1 |
| 46-T | 16.7 | 15.6 | 0.6 | 0 | 0.5 | 18.5 | 24.6 | 34.5 | 4.9 |
| 47-T | 2.7 | 2.0 | 0.3 | 0 | 0.4 | 21.0 | 41.7 | 25.8 | 8.2 |
| 48-T | 18.4 | 16.8 | 0.9 | 0.1 | 0.7 | 18.5 | 23.8 | 33.9 | 4.7 |
| 49-P | 41.8 | 31.5 | 6.3 | 2.4 | 1.1 | 11.4 | 38.5 | 3.6 | 0.6 |
| 50-T | 18.2 | 16.7 | 0.8 | 0.2 | 0.3 | 19.7 | 23.6 | 32.4 | 5.8 |
| 51-P | 36.2 | 32.4 | 2.3 | 0.7 | 0.4 | 17.2 | 38.7 | 4.7 | 1.6 |
| 52-P | 17.2 | 15.4 | 0.9 | 0.1 | 0.5 | 18.5 | 26.0 | 32.8 | 5.0 |
| 53-T | 16.6 | 13.8 | 2.4 | 0.1 | 0.2 | 19.1 | 18.4 | 44.6 | 0.4 |
| 54-P | 28.9 | 26.3 | 1.5 | 0.3 | 0.5 | 23.8 | 23.9 | 24.3 | 4.2 |
| 55-P | 42.9 | 35.8 | 4.2 | 1.8 | 0.8 | 16.2 | 34.3 | 3.3 | 0.8 |
| 56-P | 35.3 | 31.4 | 2.7 | 0.6 | 0.5 | 17.6 | 43.6 | 1.0 | 0.9 |
| 57-T | 19.0 | 17.2 | 0.8 | 0.3 | 0.4 | 11.7 | 46.4 | 13.5 | 7.9 |
| 58-P | 39.0 | 33.4 | 3.5 | 1.6 | 0.4 | 23.0 | 34.0 | 1.8 | 0.1 |
| 59-T | 19.7 | 17.9 | 1.1 | 0.1 | 0.4 | 18.2 | 28.3 | 28.5 | 4.7 |
| 60-T | 19.5 | 17.8 | 0.9 | 0.1 | 0.4 | 17.1 | 32.5 | 25.1 | 5.2 |

(*continued*)

**TABLE 1**
**(*Continued*)**

| Sample ID (rank[a] and type[b]) | Total *trans* | *t*-18:1 | *ct*-18:2 | *tt*-18:2 | *t*-18:3 | SFA | *c*-18:1 | 18:2n-6 | 18:3n-3 |
|---|---|---|---|---|---|---|---|---|---|
| 61-P | 37.3 | 34.5 | 2.5 | 0.1 | 0.2 | 18.8 | 35.6 | 6.1 | 1.0 |
| 62-T | 3.7 | 1.5 | 0.6 | 0 | 1.0 | 21.8 | 44.1 | 22.5 | 7.2 |
| 63-P | 37.3 | 33.7 | 2.7 | 0.4 | 0.4 | 19.0 | 36.2 | 5.0 | 0.9 |
| 64-T | 17.9 | 15.2 | 1.3 | 0.4 | 1.1 | 18.2 | 45.3 | 11.7 | 4.6 |
| 65-T | 38.4 | 34.4 | 3.1 | 0.4 | 0.4 | 18.1 | 38.7 | 4.2 | 0.8 |
| 66-T | 44.8 | 34.8 | 6.2 | 2.5 | 0.9 | 11.0 | 35.3 | 2.9 | 0.5 |
| 67-T | 43.7 | 36.9 | 4.1 | 1.6 | 0.8 | 16.1 | 32.9 | 3.2 | 0.8 |
| 68-T | 19.4 | 17.7 | 0.8 | 0 | 0.9 | 18.2 | 24.6 | 32.3 | 4.8 |
| 69-T | 1.7 | 0.9 | 0.2 | 0 | 0.7 | 15.2 | 53.9 | 18.5 | 8.2 |
| 70-T | 15.7 | 15.1 | 0.6 | 0 | 0.1 | 19.3 | 24.0 | 39.5 | 1.1 |
| 71-T | 23.1 | 19.4 | 1.7 | 0.9 | 1.2 | 15.8 | 44.1 | 10.4 | 4.2 |
| 72-P | 37.8 | 32.0 | 3.4 | 1.7 | 0.6 | 21.5 | 35.2 | 2.8 | 0.6 |
| 73-T | 46.4 | 35.3 | 6.6 | 3.0 | 1.1 | 10.7 | 35.0 | 3.3 | 0.6 |
| 74-T | 19.9 | 16.9 | 1.4 | 0.6 | 1.1 | 18.1 | 44.5 | 11.0 | 4.3 |
| 75-T | 18.1 | 16.6 | 1.4 | 0 | 0 | 18.9 | 21.4 | 40.7 | 0.5 |
| 76-T | 18.6 | 16.2 | 1.3 | 0.3 | 1.2 | 18.2 | 44.9 | 11.4 | 4.3 |
| 77-T | 41.1 | 31.4 | 6.3 | 2.0 | 1.0 | 11.5 | 39.5 | 3.7 | 0.6 |
| 78-T | 21.4 | 17.5 | 1.6 | 0.8 | 1.3 | 18.1 | 43.2 | 11.0 | 3.8 |
| 79-T | 45.8 | 35.2 | 6.5 | 2.7 | 1.0 | 11.4 | 35.5 | 2.9 | 0.6 |
| 80-P | 41.9 | 35.0 | 4.2 | 1.7 | 0.7 | 17.3 | 33.9 | 3.6 | 0.8 |
| 81-P | 42.1 | 35.2 | 4.2 | 1.7 | 0.7 | 17.3 | 33.5 | 3.6 | 0.8 |
| 82-P | 38.7 | 33.3 | 3.3 | 1.5 | 0.4 | 23.1 | 34.3 | 1.7 | 0.1 |
| 83-P | 38.4 | 32.8 | 3.5 | 1.6 | 0.5 | 22.5 | 34.5 | 2.1 | 0.3 |
| 84-P | 18.1 | 15.1 | 1.2 | 0.6 | 1.2 | 16.9 | 45.1 | 12.6 | 4.8 |
| 85-P | 17.8 | 14.9 | 1.2 | 0.5 | 1.2 | 16.6 | 45.5 | 12.7 | 4.9 |
| 86-T | 42.5 | 32.9 | 6.0 | 2.4 | 0.9 | 11.6 | 37.7 | 2.9 | 0.5 |
| 87-T | 41.0 | 31.7 | 5.9 | 2.1 | 1.0 | 11.8 | 38.8 | 3.7 | 0.7 |
| 88-T | 15.6 | 14.4 | 1.0 | 0 | 0.2 | 20.1 | 23.8 | 34.4 | 5.5 |
| 89-T | 16.6 | 15.0 | 1.2 | 0 | 0.4 | 18.7 | 25.9 | 3.2 | 4.8 |
| 90-T | 14.5 | 13.5 | 0.8 | 0 | 0.1 | 17.3 | 25.1 | 42.1 | 0.8 |
| 91-T | 16.3 | 16.3 | 1.2 | 0 | 0.4 | 17.6 | 26.4 | 32.3 | 5.0 |
| 92-P | 34.9 | 30.2 | 2.9 | 0.9 | 0.6 | 22.4 | 37.5 | 2.5 | 1.1 |
| 93-T | 17.8 | 14.8 | 1.1 | 0.5 | 0.8 | 17.6 | 44.5 | 13.3 | 5.8 |
| 94-T | 16.0 | 13.1 | 1.1 | 0.4 | 0.8 | 18.1 | 45.4 | 13.4 | 6.0 |
| 95-T | 17.0 | 14.5 | 1.7 | 0.1 | 17.5 | 19.2 | 45.2 | 45.2 | 0.8 |
| 96-T | 19.5 | 16.6 | 1.2 | 0.3 | 0.8 | 18.1 | 45.0 | 11.2 | 5.4 |
| 97-P | 33.7 | 28.2 | 3.1 | 1.2 | 0.7 | 22.0 | 38.3 | 3.6 | 1.4 |
| 98-T | 20.2 | 15.6 | 1.4 | 0.3 | 1.7 | 14.1 | 47.3 | 12.5 | 5.0 |
| 99-P | 33.4 | 28.2 | 3.3 | 1.1 | 0.4 | 23.6 | 38.2 | 2.4 | 1.1 |
| 100-T | 38.4 | 31.8 | 4. | 1.4 | 0.8 | 19.1 | 37.2 | 2.3 | 1.1 |
| 101-T | 18.4 | 15.2 | 1.3 | 0.5 | 0.8 | 18.4 | 45.5 | 11.3 | 5.3 |
| 102-T | 18.1 | 14.9 | 1.4 | 0.5 | 0.8 | 18.0 | 46.0 | 11.3 | 5.4 |
| 103-P | 32.5 | 27.0 | 3.0 | 1.3 | 0.7 | 22.1 | 38.8 | 3.7 | 1.4 |
| 104-P | 34.5 | 30.0 | 3.2 | 0.7 | 0.3 | 18.3 | 35.2 | 8.9 | 1.6 |
| 105-T | 19.6 | 15.9 | 1.6 | 0.6 | 1.0 | 17.1 | 45.2 | 11.5 | 5.4 |
| 106-T | 18.4 | 16.6 | 1.0 | 0.1 | 0.4 | 18.7 | 26.3 | 31.2 | 4.9 |
| 107-P | 36.6 | 32.7 | 2.3 | 0.7 | 0.5 | 17.2 | 38.3 | 4.9 | 1.6 |
| 108-T | 18.0 | 16.5 | 1.2 | 0 | 0.4 | 18.8 | 24.1 | 33.2 | 5.2 |
| 109-T | 18.7 | 15.1 | 1.8 | 0.5 | 1.4 | 14.2 | 48.6 | 11.7 | 3.8 |

[a]Margarine brands are identified according to their market share and arranged in the descending order of market share. Rank 1 is the top selling brand.
[b]T, tub margarine; P, print margarine; *t, trans; c, cis;* SFA, saturated fatty acids.

lower levels of TFA. For example, the most frequent occurrence of TFA in margarines of the present study was 15–20%, and 48% of the samples were in this range. Furthermore, only 35% of the samples analyzed contained more than 25% TFA. In contrast, the most frequent occurrence of TFA in 1990 margarines was in the 20–25% range (19); only 20% of the samples were in this range and 61% contained more than 25% TFA. In margarines produced in 1977 (16) and 1982–1983 (18), the most frequent occurrence of TFA was in the 30–35% range. These data suggest that over the last two decades margarine manufacturers have taken measures to gradually lower the TFA content in their products. This trend is most likely a result of the public pressure on margarine producers to reduce TFA in their products. Similar reductions in TFA in margarines in recent years have been noted in Denmark (25) and France (26).

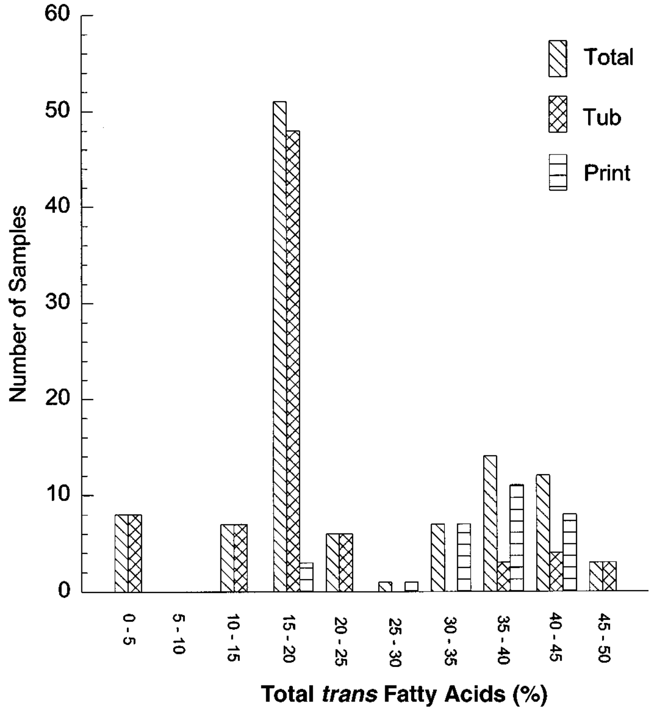


**FIG. 1.** Distribution of *trans* fatty acids in margarines.

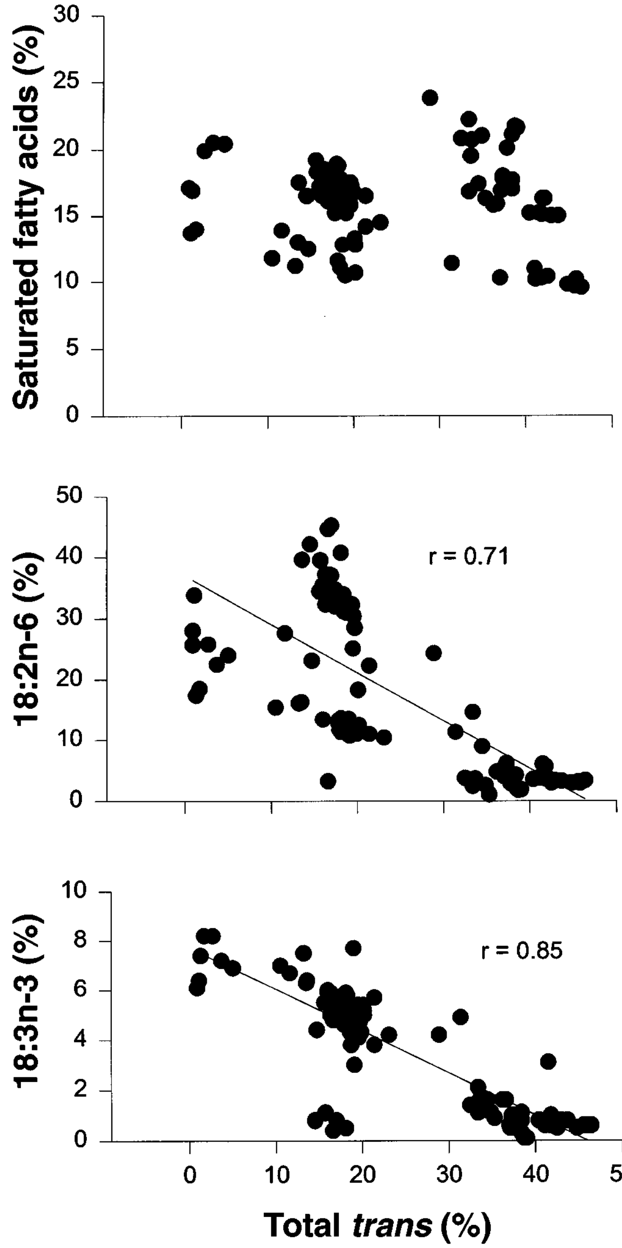


**FIG. 2.** Relationship of α-linolenic, linoleic, and total saturated fatty acids with *trans* fatty acids in margarines

Although the TFA content of a large proportion of margarines is in the moderate range of 15–20%, the 109 different margarines analyzed in the present study have a mean TFA level of 23.6%. This is because a fair number of margarines, including some tub margarines and top-selling brands, are still made with highly hydrogenated fats. The mean TFA value of 23.6% for Canadian margarines is unsatisfactory compared to recent margarine results for Australia (13.1%) (27), Denmark (3.0%) (25), France (3.8%) (26), Greece (10%) (28), and New Zealand (16.2%) (29). However, margarines from Austria (22.9%) (30) and the United States (22.6%) (31) contain TFA levels similar to those found in Canadian margarines.

The average content of total EFA for the 109 margarines of this study was 22.1%, which is similar to the average EFA value reported for 1990 margarines (19). However, the current margarines contain slightly higher levels of α-linolenic acid (mean value 3.8 vs. 2.5%) and lower levels of linoleic acid (mean value 18.3 vs. 19.6%) than the 1990 margarines. This slightly increased availability of α-linolenic acid in relation to linoleic acid in current margarines is good news because it is widely accepted that North Americans consume more than the required amount of n-6 fatty acids but not enough n-3 (32). It has been estimated that North Americans are eating one-tenth of the amount of n-3 fatty acids required for normal functioning (33). In this context it is noteworthy that Canadian tub margarines could be an important source of α-linolenic acid. Almost all of the 30 best-selling margarine brands, which hold approximately 60% of the market share, contained more than 5% α-linolenic acid. In some tub brands α-linolenic acid content was about 7–8%. This is closer to the level normally seen in unhydrogenated canola oil, which is the primary oil used in Canadian margarines. A 10 g serving of a top-selling tub margarines could provide at least 0.4 g of α-linolenic acid, which is equivalent to one-fourth of the recommended daily intake of n-3 fatty acids for adult Canadians (24).

Although the fatty acid profile of the majority of margarines in the present study is satisfactory, a disturbing feature is the combination of high levels of TFA, particularly *trans*-18:2 isomers, and extremely lower levels of EFA in a substantial number of margarines. These margarines would not supply the necessary daily requirement of EFA. In terms of health effects, high TFA/low EFA is an unacceptable dietary fatty acid profile. Considering the recent clinical findings on TFA (1–7), such a fatty acid profile could be expected to produce unfavorable serum lipoprotein profiles. In addi-

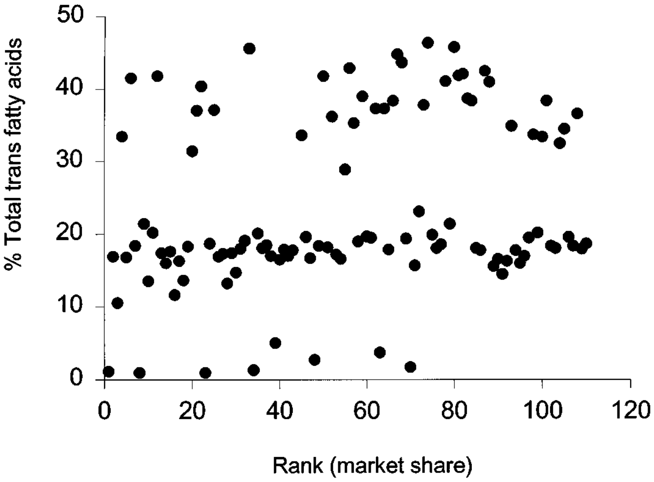


**FIG. 3.** Relationship between market share ranking and *trans* fatty acids in margarines.

tion, diets high in TFA and low in EFA have been shown to result in deficiencies of n-6 and n-3-PUFA metabolites and eicosanoids, and in formation of unusual $C_{20}$ *trans*-PUFA metabolites in animal models (34–41). Thus, overall there appears to be no justification for producing high-*trans*/low EFA margarines. Unfortunately, five such margarines are among the 30 top-selling margarines in Canada (6-P, 12-P, 21-T, 22-P, and 25-T).

A noteworthy observation in the present study is the occurrence of eight brands of margarine with less than 2.5% TFA. These margarines are generally termed as zero-*trans* margarines and are prepared using nonhydrogenated liquid oils. In contrast to products made from partially hydrogenated oils, the zero-*trans* margarines contain almost no *t*-18:1. In these the main *trans* fatty acid components are the geometrical isomers of linoleic (9*c*,12*t*-18:2 and 9*t*,12*c*-18:2) and α-linolenic acids (mainly 9*c*,12*c*,15*t*-18:3 and 9*t*,12*c*,15*c*-18:3). The levels and types of these *trans*-PUFA isomers are typical of those found in refined, unhydrogenated canola or soybean oils found in Canadian retail stores (unpublished data). Deodorization and physical refining, which involve exposure of oil to high temperatures, are known to generate small amounts of *trans*-geometrical isomers of linoleic and α-linolenic acids (42). Out of the eight zero-*trans* margarines in this study, one is the most popular margarine in Canada and another is among the 10 best-selling brands. In contrast to the current situation, there was only one zero-*trans* margarine brand in 1990 (19) and there were none prior to 1990 (15,17,18). An exception was in 1977 where there was one brand with less than 5% TFA (16), however, that was prepared with lard and consequently contained a high proportion of SFA.

The SFA content of the zero-*trans* margarines in the present study was about 14–18%, which is comparable to the levels seen in margarines prepared using partially hydrogenated oils. In addition, the proportions of oleic and α-linolenic acids are generally higher in zero-*trans* margarines. Oleic acid (9*c*-18:1) neither raises nor lowers the serum cholesterol level, and thus has been called "neutral" in its action on serum cholesterol (43). The margarines prepared from partially hydrogenated oils also contain a large amount of oleic acid, but in addition they contain some unusual *cis*-positional isomers of oleic acid (the individual isomer proportions are not shown in Table 1). There is very little information on the biological activity of oleic acid positional isomers, but a preliminary report from the United States suggested a possible influence of *c*-18:1 isomers on the growth of infants (11). This study found that both cord blood triglyceride *trans* and *cis* 18:1 positional isomers were inversely related to cord blood docosahexaenoic acid (DHA), but only the *cis* isomers were related to arachidonic acid (AA). DHA and AA, which are the major PUFA metabolites of α-linolenic and linoleic acids, respectively, play a key role in the development of the central nervous system in infants (see review chapters in ref. 44 for up-to-date information on this subject). The zero-*trans* margarines do not contain any *cis*-oleic acid isomers. Thus, overall zero- *trans* margarines offer an excellent fatty acid profile with regard to the established pathological and physiological aspects of dietary fats in human nutrition. The zero-*trans* margarine industry is gradually evolving in Canada. A recent (February 1998) casual survey of several major retail stores in Ottawa showed that at present there are at least 15 different brands of zero-*trans* margarines in Canada.

Based on the market share (data not shown) and the total TFA content of each of the margarines in the present study, the average TFA content in Canadian margarines could be estimated as 12.1% of TFA. The total retail margarine sales in Canada in 1995 were 84.6 million kg (45) and, using these data, the availability of TFA from margarine could be estimated as 0.96 g per person per day. In a previous study by members of our research group (13) using TFA data for 198 human milk samples from across Canada, the intake of TFA in Canada from various dietary sources was estimated as 8.4 g per person per day. This shows that only 11% of TFA in the Canadian diet is derived from margarines. Evidently, the majority of TFA enters the diet as "hidden" fat in bakery products such as breads, biscuits, cakes, crackers, cookies, french fries, doughnuts etc. Very few of these are made with unhydrogenated oils (46). It is thus apparent that the reduction of TFA in the Canadian diet from the current high level of 8.4 g per day would require support from the manufacturers of bakery products, since only a limited reduction could be achieved by further manipulation of the fatty acid profile of margarines.

The amounts of SFA, *cis*-monounsaturated fatty acids, and PUFA (sum of n-6 and n-3 fatty acids) are generally listed on the labels of almost all the processed food products sold in Canada. Although the content of TFA is not declared on product labels, very often information regarding the possible presence of hydrogenated oils is found in the ingredient list. Despite this, the sale of margarines in Canada is not related to the quality of their fatty acid profiles. The reason for this is not known, but probably price and loyalty to a certain brand or manufacturer could be the key factors that dictate the sale of foods. Lack of knowledge about nutrition could be another important contributory factor. According to national surveys conducted by the Canadian National Institute of Nutrition, nearly two-thirds of Canadians do not rate themselves as particularly knowledgeable about nutrition and many acknowledge they do not know the many nutritional terms or some diet and disease relationships (47). Since many Canadian consumers cannot be expected to make informed food choices, it is up to the food manufacturers to take the initiative of reducing the *trans* content in the Canadian diet.

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