Trans fatty acid content of margarines, oils and blended spreads available in New Zealand

Madeleine J. Ball, Dean Hackett, Ashley Duncan

Department of Human Nutrition, University of Otago, Dunedin, New Zealand.

Concern has been expressed about the possible adverse effects of high intakes of trans fatty acids on coronary heart disease risk. Data on New Zealand foods was very sparse. The fatty acid composition of New Zealand margarines, cooking oils, blended spreads and dairy products has thus been analysed using a methodology that determines the percentage of trans fatty acids. The C18:1 trans content of the margarines varied between 4.8% and 11.3% of the total fatty acids, and there was less than 0.7% C18:2 trans. The total trans fatty acid content of the oils analysed was less than 1%. The amount of trans fatty acids in readily available margarines, blended spreads and oils in New Zealand appears lower than for many other countries, and the intake of these products is relatively small. Most of the products also have a high linoleic acid content, which may modify any potential adverse effects of trans fatty acids on plasma lipoproteins. Replacement of products high in C12, C14 and C16 saturated fatty acids in the diet with these margarines need not be discouraged, although manufacturers should probably be encouraged to further reduce the content of trans fatty acids of some products and the increased use of partially hydrogenated fats in fast food restaurants should be examined.

Introduction

Small amounts of unsaturated fatty acids in the trans configuration are found in nature in dairy products and beef[1]. However, the major source in the average person's diet is margarines and shortenings made from hydrogenated plant oils, and in many countries these are important components of the diet. Hydrogenation converts liquid vegetable oil to solid fats, which protects the fats from becoming oxidized and rancid and adds texture to the foods. The principle fatty acid in most vegetable oils used for hydrogenation is linoleic acid, C18:2, and the hydrogenation produces oleic acid (C18:1 n-9 – a cis fatty acid), stearic acid (C18:0) and elaidic acid (C18:1 n-9 – a trans fatty acid). Other trans fatty acids may also be formed by movement of the double bond along the carbon chain.

A number of studies in animals and man have indicated a possible relationship between trans fatty acid intake and coronary heart disease (CHD)[2,3,4]. Swine fed hydrogenated fat developed accelerated atherosclerosis[2], and Royce[5] observed reduced prostacyclin synthesis, suggesting that trans fatty acids may influence thrombosis. Thomas[4] found that people who died of CHD had a higher adipose tissue trans fatty acid content, although the study design did not allow for control of other risk factors. More importantly, a recently published epidemiological study of women in the United States[6] showed a relationship between estimated dietary trans fatty acid intake in 1980, particularly that from vegetable sources, and subsequent death from CHD. Although the relative risk was small, the relationship remained after controlling for other dietary factors considered to influence CHD risk. The relationship was also stronger for the 69 000 women whose margarine consumption had been stable from 1970–80, although it was not linear: the relative risk of eating 2–3 teaspoons per day being no more than consuming <1 per month, and a higher risk only really existing with a high consumption of <20 mls per day.

Possible mechanisms for an association of trans fatty acids with CHD risk may be via an effect on plasma lipids and/or haemostasis. An increase in low density lipoprotein cholesterol (LDL-C) and a reduction in HDL-C has been found when normocholesterolaemic subjects are fed diets rich in elaidic acid trans. C18:1 n-9[7,8]. This pattern of lipoprotein change would be expected to be associated with an increased CHD risk. Furthermore, levels of lipoprotein Lp(a), which also appear to be positively associated with CHD risk, may also be increased by trans fatty acids[9,10] Vergroesen[7] found the change in serum cholesterol induced by elaidic acid to be intermediate between that of saturated and cis monounsaturated fatty acids. Mensink & Katan found that when normocholesterolaemic subjects were fed diets containing 10–11% total energy as trans isomers of oleic acid, or this amount as additional oleic acid or saturated fatty acids (principally lauric and palmitic) respectively, they had higher LDL-C on the trans fatty acid diet than on the cis oleic acid diet and similar levels on the

Correspondence address: Dr M.J. Ball, Senior Lecturer, Department of Human Nutrition, University of Otago, PO Box 56, Dunedin, New Zealand.

saturated fat diet; and in addition HDL-C was lower. Zoch & Katan also found diets containing 7.7% trans fatty acids resulted in higher LDL-C and lower HDL-C levels than those containing a similar amount of linoleic acid.

Trans fatty acids can be incorporated into biomembrane phospholipids[12-14] in a manner which depends on their double bond configuration and position[13], and the dietary linoleic acid[15]. This may influence membrane properties and hence haemostatic and/or vascular function. Trans fatty acids cause less inhibition of platelet aggregation than cis fatty acids[16], and some can influence eicosanoid metabolism and arachidonic acid availability[17].

In the United States, intake of trans fatty acids has been relatively high, and some hardened US and Canadian baking and frying fats contained 30–50% trans fatty acids[18,19]. Very little hard margarine is available in New Zealand, and butter consumption still outweighs that of soft margarines[20]. However, the current pressure to reduce saturated fat intake is probably increasing the consumption of trans fatty acids by promoting the use of partially hydrogenated vegetable fats and margarines. It is therefore important to have data on the trans fatty acid content of the margarines and oils being used.

This study was therefore performed to provide some preliminary data on the fatty acid content of New Zealand margarines, butters, blended vegetable oil/butter spreads, soft cheese and cooking oils.

Methods

Branded varieties of margarines, oils, butters, blended spreads and soft cheeses, were obtained from local grocery stores in Dunedin. These included brands widely used by New Zealand consumers.

A sample was taken from one or two tubs of each product. The lipid material was extracted from the food specimens using the Folch method[21], and this extraction was in duplicate. The samples were then dissolved in chloroform/methanol (2:1) and methylated with methanolic H_2SO_4 (6%) overnight at 80°C, after which they were dissolved in hexane/water (2:1) and centrifuged. The upper phase containing the fatty acids was evaporated to dryness and the methylated fatty acids separated by thin layer chromatography using hexane/ether/acetic acid (85:15:1). After location the fatty acid methyl ester band was reconstituted in methanol/hexane

Table 1. Trans and cis fatty acid composition of the products (as % total fatty acids). Mean of duplicate analyses.

	C16:0	C16:1	C18:0	C18:1 n9 cis	C18: trans	C18:2 n6 cis	C18:2 n6 trans
Margarines							
Brand A	15.8	0	7.2	23.4	7.3	35.3	0.5
Brand B	17.7	0.2	6.9	21.9	7.8	37.8	0.5
Brand C	19.0	0	6.7	20.8	9.2	39.4	0.4
Brand D	15.9	0.1	7.6	22.3	8.5	37.9	0.5
Brand E	11.7	0.2	4.8	42.7	7.3	19.8	0.7
Brand F	17.1	0.3	9.7	20.8	8.1	38.0	0.3
Brand G	16.5	0	6.1	21.2	8.6	37.1	0.6
Brand H	17.6	0	6.0	21.6	7.0	37.4	0.6
Fat Reduced Margarine/Blends*							
Brand A	18.1	0	5.7	19.7	10.5	34.9	0.5
Brand B	17.2	0	6.8	18.9	10.8	39.3	0.4
Brand C	17.0	0	6.7	20.1	7.5	41.7	0.4
Brand D	18.6	0	8.0	25.5	11.3	28.6	0.5
Butters							
Semisoft	36.9	0.6	14.3	13.7	2.8	0.8	0.4
Clarified	30.0	0.5	13.6	19.3	1.6	1.0	0.2
Blends							
A	16.3	0.1	7.4	20.0	6.2	36.8	0.5
B	26.7	0.7	8.4	19.6	5.8	19.0	0.5
C	25.1	0.4	7.4	19.9	4.8	20.2	0.6
Oils							
Rapeseed	7.4	0	2.3	57.2	0.6	19.3	0.3
Safflower	8.9	0.1	2.7	11.7	0.1	72.9	0.3
Soya	15.4	0	4.1	23.2	0.4	30.3	0.2
Corn Oil	14.5	0.1	2.7	32.5	0.6	41.8	0.5
Others							
Beef Fat	28.3	2.9	17.4	29.3	1.4	0.5	0.3
Cheeses							
Cottage Cheese	43.3	0.8	10.6	15.2	0.8	1.3	0.1
Cream Cheeses:							
Brand A	30.5	1.1	13.3	19.7	2.2	0.6	0.2
Brand B	38.2	1.4	9.9	16.8	1.2	0.5	0

* Fat content at least 30% below that of the standard product on a g/100 g basis (20% below for brand D).

and centrifuged. The upper hexane phase containing the fatty acids was removed and stored at −4°C. The individual fatty acids were then identified by gas liquid chromatography on a Hewlett Packard Series II gas chromatograph (GC) isothermally at 180° C using a BPX 70 polar capillary column (SGE, Australia), which is a fully cross-linked highly polar stationary phase of 70% cyanopropylsiloxane whose polarity has been optimized to resolve C18:1 cis and trans fatty acids. The fatty acid standards, which included C18:1 n9t, C18:1 n12t and C18:2 n6t (trans trans), were obtained from Nu Chek Prep Inc. Elysian, Minnesota, USA. The analysis was performed in duplicate for each specimen. For one specimen extraction and chromatography was performed ten times and the coefficient of variation of the individual fatty acids was calculated.

Four margarines whose trans fatty acid content was relatively high by the above GC analysis were also analysed by infrared spectroscopy using the American Oil Chemists method[22].

Results

Table 1 shows the fatty acid composition of the selected products, expressed as a percentage of the total fatty acids. The results are the mean of duplicate determinations; the duplicates results usually being within 1% for the trans fatty acids. The trans fatty acid content varied from less than 1% to 11.8% of the total fatty acids, but many of the margarines had a similar content of 7–9% and a high content of cis unsaturated fatty acids. Most of the products with a trans fatty acid content greater than 7% also had a high content of linoleic acid (C18:2 n-6 cis) of greater than 35%, with the exception of Brand E margarine which had a high oleic acid (C18:1 n-9 cis) content.

Infrared spectroscopic analysis on four margarines revealed the percentage of C18 trans fatty acids as 11%, 15%, 10% and 9% of the total fatty acids, compared to values of 9.2%, 8%, 10.5% and 8.5% obtained by GC.

The separation of the cis and trans isomers appeared quite good. Using C18:1 n-12 trans and C18:1 n-9 trans standards to identify retention times and spiking the extracts with standards to enhance particular peaks it appeared that the two could be separated, although other trans isomers run with similar retention times to the n-12t fatty acid. At the time we were unable to obtain commercial standards for other isomers to provide complete quantitative data on the individual positional isomers. The peaks identified as C18:1 n-9t in the products varied between 0% and 4% of the total fatty acids. In the butters, the percentage of trans fatty acids was low, and appeared to be predominantly the n=9t isomer (constituting about 1% total fatty acids), as in the soft cheeses and beef fat. The polyunsaturated fat content was low and the percentage of saturated fatty acids C16 and C14 (latter not shown) was high.

In the oils analysed, ie rapeseed, safflower, soya and corn oil, the percentage of trans fatty acids was very low, with the trans C18:1 being less than 0.5% of the total fatty acids and the trans C18:2 n-6 less than 0.4%. The coefficients of variation for the individual fatty acids (calculated from the results of 10 extractions) were as follows: C16:0 3.8%, C18:0 3.8%, C18:1 cis 2.1%, C18:1 trans 3.6%, C18:1 n-9 trans 3.1%, C18:2 n-6 cis 2.5%, C18:2 n-6 trans 3.1%.

Discussion

New Zealanders traditionally have a high intake of dairy products and meat, and obtain a high percentage of their energy from saturated fat[23]. Milk and dairy products contain small amounts of trans fatty acids (about 5% of dairy and beef fat formed by bacterial bio-hydrogenation. The major source of trans fatty acids[1] in the diet in many countries is, however, margarines and shortenings made from hydrogenated plant oils. The use of margarines in New Zealand is relatively recent, as they were not permitted until the Margarine Act was passed in 1972. Since then only soft margarines have been readily available as spreads, and have provided a high polyunsaturated, low saturated fat alternative to butter. Small amounts of hard margarines with a higher content of trans fatty acids, and thus a higher melting point, such as those widely used in the US and Europe for many decades, have only recently been imported from Australia. Consumption of vegetable oils and polyunsaturated fats in New Zealand remains the lowest of any OECD (Organisation for Economic Co-operation and Development) country, and the butter consumption remains one of the highest[20]. The recommendations of the New Zealand Taskforce[24] and health organizations in many countries are to reduce saturated fat intake with some substitution of polyunsaturated and monounsaturated fats. As data on the trans fatty acid content of many unsaturated fats and high-fat foods is sparse, this study was performed to obtain some information on New Zealand products. The trans fatty acids were measured using a GC method with a column that allows quantitation of several different trans isomers, as this provides more information than infrared spectroscopy which only quantitates the total monoenoeic or dienoeic trans fatty acids. The results were, however, similar for margarines with a high concentration. The highest trans fatty acid content in the products analysed was 11.8% total fatty acids.

In the United States the average daily intake of trans fatty acids has been estimated to be 8–10 g, or 5–8% of total daily fat consumption, although Enig suggests a much higher intake of between 11.1 g and 27.6 g per day[27]. In the Netherlands mean intake is estimated at 17 g per day[28] and in Britain as 4 – 5.6 g per day[29]. Thus total intake for many people is not dissimilar to the 7.7% energy intake Zoch found to alter lipoprotein levels[11], and individuals eating large amounts of hydrogenated fats and fried foods may well exceed this.

The food sources of the trans fatty acids are likely to vary considerably. Chemically analysed duplicate diets from eight adolescent US teenagers revealed 13% of their trans fatty acid intake came from margarines and a third from biscuits, cakes and baked products[30]. Hunter[26] estimated about a quarter of the US intake came from margarines and spreads. The pressure to reduce the use of saturated fats, such as palm oil and butter, may be increasing the consumption of partially hydrogenated vegetable oils containing trans fatty acids because they are a good alternative for the production of semi-solid and solid fats. Some of these baking and frying

fats used in the US and exported to other countries contain 25–40% trans fatty acids and only small amounts of linoleic acid, and the increased use of partially hydrogenated fats in 'fast food' outlets might also be of concern, even if they replace saturated fats.

Margarines and many oils available in New Zealand appear to have a relatively low percentage of trans fatty acids. Individual intake will vary considerably, but preliminary calculations from data on the percentage fat supplied by margarine from the Life in New Zealand Survey[30] indicate that the average intake from margarines as spreads would be less than 0.5 g per day, as these constitute only 5–9% of the average fat intake. This would be only a fraction of the trans fatty acids provided by 20 ml of the types of US margarines used in 1980[6]. In order to calculate the total intake of trans fatty acids we would need more data, particularly on the fat used in baked products, both commercial and home made, as such foods provide a significant additional fat intake for many New Zealanders. Total intake is, however, likely to be lower than that in many 'western' countries. The fatty acid composition of the New Zealand margarines may also be preferable, as the linoleic acid content is high (>7%), in contrast to the low linoleic acid in some hardened US and Canadian margarines, including those likely to have been consumed in 1980. A high linoleic acid content may counteract any adverse effect of the trans fatty acids[15], particularly on lipoprotein levels. Nestel et al.[31] showed no increase in LDL-C when volunteers ate semi-hardened edible oil blends containing 16% trans fatty acids but more linoleic acid and less palmitic acid than a control blend.

Further analytical studies are needed and then the additional of the data to a food composition database to allow calculation of usual dietary intake. Further clinical studies are also needed as the full effects of the trans fatty acids, and of different mixtures of fatty acids in the overall diet, on health are not known. In the light of current knowledge most of the soft margarines and oils available in New Zealand are probably suitable to replace fats with a high content of C12, C14 and C16 saturated fatty acids as spreads, particularly given the low overall intake of unsaturated fats in the diet. Moves to further reduce the trans fatty acid content of some margarines would, however, seem prudent, and there is a need for on-going monitoring of intake.

Acknowledgement — Dr M. Skeaff kindly provided discussion on technical aspects of the analytical work.

References

1 Parodi PW. Distribution of isomeric cis and trans fatty acids in milk fat. J Dairy Sci 1976; 50: 1870–73
2 Kummerow FA. Lipids in atherosclerosis. J Food Sci 1975; 40:12–17.
3 Kritchkevsky D. Trans fatty acid effects in experimental atherosclerosis. Federation Proc 1982; 41:2813–16.
4 Thomas L, Winter J, Scott R. Concentration of 18:1 and 16:1 transunsaturated fatty acids in the adipose body tissue of decedents dying of ischemic heart disease compared with controls: analysis by gas liquid chromatography. J Epidemiol Comm Health 1983; 37:16–21.
5 Royce S, Holmes R, Takagi T, Kummerow F. The influence of dietary isomeric and saturated fatty acids on atherosclerosis and eicosanoid synthesis in swine. Am J Clin Nutr 1984; 39:215–224.
6 Willett W, Stampfer M, Manson J et al. Intake of trans-fatty acids and risk of coronary heart disease among women. Lancet 1993; 341: 581–5.
7 Vergroesen A, Gottenbas J. The role of fats in human nutrition: an introduction. In 'The role of fats in Human Nutrition'. Vergroesen AJ. Ed New York: Academic Press, 1975: 1–41.
8 Mensink R, Katan M. Effect of dietary trans-fatty acids on high density and low density lipoprotein cholesterol levels in healthy subjects. N Engl J Med 1990; 323:439–45.
9 Nestel P, Noakes M, Belling B. Plasma Lipoprotein and Lp (a) changes with substitution of elaidic acid for oleic acid in the diet, J Lipid Res 1992; 22:1029–36.
10 Mensink R, Zock P, Katan M, Hornstra G. The effect of dietary cis and trans fatty acids on serum lipoprotein (a) levels in humans. J Lipid Res 1992; 33:1493–1501.
11 Zock P, Katan M. The effects of trans fatty acids and stearic acid versus linoleic acid on serum lipids in humans. J Lipid Research 1992; 33:399–410.
12 Emken E, Adlof R, Rohwedder W, Gully R. Incorporation of deuterium-labelled trans- and cis- B octadecanoic acids in human plasma lipids. J Lipid Res 1983; 24:34–45.
13 Moore C, Alfin-Slater R, Aftergood L. Incorporation and disappearance of trans-fatty acids in rat tissues. Am J Clin Nutr 1980; 33:2318–23.
14 Ostlund-Lingvist A, Albanus L, Croon L. Effect of dietary trans-fatty acids on microsomal enzymes and membranes. Lipids 1985 20:620–4.
15 Zevenberger J, Houtsmuller U, Gottenbos J. Linoleic acid requirement of rats fed trans-fatty acids. Lipids 1988; 23:178–86.
16 Peacock L, Wahl K. Isomeric cis and trans fatty acids and porcine platelet reactivity to collagen in vitro. Biochem Soc Trans 1988; 16:291.
17 Kinsella J, Bruckner G, Mai J, Shimp J. Metabolism of trans fatty acids emphasis on the effects of trans-octadecadienoate on lipid composition, essential fatty acids and prostglandins: an overview. Am J Clin Nutr 1981; 34:2307–18.
18 Enig M, Atal S, Keeney M, Sampugna J. Isomeric trans-fatty acids in the US diet. J Am Coll Nutr 1990; 9:471–86.
19 Beare Rogers J, Gray L, Hollywood R. The linoleic acid and trans fatty acids of margarines. Am J Clin Nutr 1979; 32:1805–9.
20 Laugesten M. Fats in the food supply, coronary and all-cause mortality in 22 OEDC countries including New Zealand, 1955 1988. Proceedings Nutr Soc NZ 1992; 18: 173–185.
21 Folch J, Lees JM, Sloane-Stanley GM. A simple method for isolation and purification of total lipids from animal tissue. Biol Chem 1957; 226: 497–509.
22 OAAC – 12th Edition. Horwitz W. Ed. Wisconsin: George Banta Co. Inc, 1975.
23 Life in New Zealand Survey. Commission Report 1991. Wellington, New Zealand.
24 Nutrition Taskforce. Food for Health. Report of the Nutrition Taskforce to the Department of Health. Department of Health, Wellington, NZ.
25 Senti FR. Health aspects of dietary trans fatty-acids; Federation of American Societies for Experimental Biology, 1988.
26 Hunter J, Applewhite T. Reassessment of trans-fatty acid availability in the US diet. Am J Clin Nutr 1991; 54:363–9.
27 Enig M, Pallarisch L, Sampugna J, Keeney M. Fatty acid composition of the fat in selected food items with emphasis on trans components. J Am Oil Chem Soc 1983; 60:1788–94.
28 Brussard J. Hoeveel transvetzuren bevat de Nederlandse Voeding? Voeding 1986; 47:108–11.
29 Gregory J, Foster K, Tyler H, Wiseman M. The Dietary

and Nutritional Survey of British Adults. London: HMSO, 1990.
30 Van der Reek M, Craig Schmidt M, Weete J, Clarke A. Fat in the diets of adolescent girls with emphasis on isomeric fatty acids. Am J Clin Nutr 1986; 43:530–7.
31 Nestel P, Noakes M, Belling G, McArthur R, Clifton P, Abbey M. Plasma cholesterol-lowering potential of edible-oil blends suitable for commercial use. Am J Clin Nutr 1992; 55:46–50.

Trans fatty acid content of margarines, oils and blended spreads available in New Zealand

Madeleine J. Ball, Dean Hackett, Ashley Duncan

Asia Pacific Journal of Clinical Nutrition 1993; 2:165–169

紐西蘭人造黃油，烹調用油與黃油植物油混合油 (blended spreads) 中的反式脂肪酸含量

摘要

己有報導多吃反式脂肪酸對冠心病危險可能產生有害的作用。紐西蘭食物中，這些數據是很少的。因而用一種測定反式脂肪酸百分數的方法，去分析紐西蘭的人造黃油，烹調用油，黃油植物油混合油和奶制品的反式脂肪酸組成。人造黃油的反式 C18:1含量占總脂肪酸量的 4.8-11.3%，而反式 C18:2 則少於0.7%，烹調用油的總反式脂肪酸含量少於1%。

紐西蘭的人造黃油，黃油植物油混合油，和烹調用油中所含的反式脂肪酸量較許多國家低，并進食這些產品相對較少。絶大多數產品含有較高的亞油酸，這可能改變反式脂肪酸對血漿脂旦白的有害作用。雖然在快餐店增用不完全氫化脂肪尚待驗證，但用這些人造黃油在膳食中代替含 C12, C14 和 C16 飽和脂肪酸高的產品是鼓勵的。