Trans fatty acids in a range of UK processed foods

Mark Roe a,⁎, Hannah Pinchen a, Susan Church b, Selvarani Elahi c, Margaret Walker d, Melanie Farron-Wilson e, Judith Buttriss f, Paul Finglas a

a Institute of Food Research, Norwich Research Park, Norwich NR4 7UA, UK
b Department of Health, Wellington House, 133-155 Waterloo Road, London SE1 8UG, UK
c Eurofins Food Testing UK Ltd., Valiant Way, Wolverhampton WV9 5GB, UK
d Scottish Government, Edinburgh, EH9 3FF, UK
e LGC Ltd., Queens Road, Teddington TW11 0LY, UK
f British Nutrition Foundation, 52-54 High Holburn, London WC1V 6RQ, UK

⁎ Corresponding author. Tel.: +44 1603 255191.
E-mail address: mark.roe@ifr.ac.uk (M. Roe).

1. Introduction

Trans fatty acids (TFA) (geometrical isomers of monounsaturated and polyunsaturated fatty acids having non-conjugated, interrupted by at least one methylene group, carbon–carbon double bonds in the trans configuration, Codex Alimentarius, 1985), have been present in the diet in small quantities ever since humans began consuming food from animal origin. Consumption of TFA increased during the 20th century when oils began to be hardened by a process of hydrogenation that adds hydrogen to double bonds within unsaturated fatty acids (Korver & Katan, 2006). High levels of TFA in the diet originate mainly from the use of partially hydrogenated oils (Wolff, 1994). TFA isomers differ between the industrial TFA (I-TFA) and ruminant TFA (R-TFA), with elaidic acid (9-C18:1) predominant in I-TFA and vaccenic acid (11-C18:1) predominant in R-TFA (Scientific Advisory Committee on Nutrition, 2007).

Health concerns began to arise in the 1990s following reports that diets high in total TFA were associated with increased risk of coronary heart disease through increases in serum LDL cholesterol and decreases in HDL cholesterol (Willet et al., 1993). A recent systematic review and meta-analysis of cohort studies showed that increased total TFA intake, ranging from 2.8 to 10 g per day, was associated with a 22% increase in risk of CHD events with a similar increased risk of fatal CHD (Bendsen, Christensen, Bartels, & Astrup, 2011). Studies comparing the health effects of I-TFA and R-TFA are limited but I-TFA has consistently been associated with increased risk markers for CHD whereas R-TFA intake does not appear to affect CHD risk (Bendsen et al., 2011). The lack of effect of R-TFA may be due to the relatively low levels of intake or may be related to endogenous conversion of vaccenic acid to conjugated linoleic acid (CLA) (Turpeinen et al., 2002) which may have positive health benefits.

In 1994 the UK Department of Health (DH) recommended that TFA consumption should not increase beyond the then current estimated UK intake of 5 g/day or 2% of food energy, and that consideration should be given to ways of reducing the TFA in the diet (Department of Health, 1994). The TRANSFAIR study of European intakes in 1995/96 estimated that average consumption of TFA in 14 countries was 0.5–2.1% of total energy intake in men and 0.8–1.9% in women (Hulshof et al., 1999). While average population intakes were below or close to recommended intake limits the concern that significant proportions of the population may have been consuming high quantities of TFA led to interventions to reduce intake in some countries (L’Abbe, Stender, Skeaff, Ghafoorunissa, & Tavella, 2009).
In 2007 the UK Food Standards Agency (FSA), in response to a request from the Secretary of State for Health, asked the Scientific Advisory Committee on Nutrition (SACN) to review recent data on the health effects of trans fatty acids (SACN, 2007). Following this review, the FSA concluded that voluntary reformulation by the food industry in the UK had reduced TFA in vegetable oils used in UK food production to a minimum (<1%) and that action to introduce mandatory restrictions would formalise existing practices among the UK producers, but would be unlikely to offer an additional public health benefit (Food Standards Agency, 2007a). Processes have been developed to produce oils that are both low in TFA and also saturated fatty acids and are based on use of blends of oils, including palm oil and liquid seed oils such as sunflower seed oil or rapeseed oil, with processes including combinations of fractionation (crystallisation of solid fat molecules and separation from liquid molecules), interesterification (rearrangement of the structure of the fat molecules to make the fat more solid) and full hydrogenation of liquid oils. The Dietary and Nutritional Survey of Adults (Gregory, Foster, Tyler, & Wiseman, 1990) showed that average TFA intakes were 2.2% of food energy in 1986/87 but had reduced to 1.2% of food energy by 2000/2001 (Henderson, Gregory, Irving & Swan, 2003) with an estimated 55–65% of TFA intake derived from processing of vegetable oils (SACN, 2007). Intake estimates were based on UK food composition data available at the time and on existing TFA values, which do not include industry reformulations that have taken place in recent years and are likely to have lead to an overestimate of intake. A 2007 re-estimation of intake based on industry data showed product reformulation had reduced average population intakes of TFA to 1% of food energy (Food Standards Agency, 2007b). The Food Standards Agency therefore commissioned an analytical survey of foods that may contain I-TFA to update food composition data used in the National Diet and Nutrition Survey (NDNS) and for publication in the McCance and Widdowson's The Composition of Foods series of publications. This survey was part of the UK Food Composition project originally funded by FSA with responsibility for nutrition in the UK transferring from FSA to DH in October 2010.

2. Materials and methods

2.1. Sampling

Samples to be analysed were selected by reviewing existing data on the contribution of processed foods to intakes of TFA in the UK. The main data sources were the UK Composition of Foods Integrated Dataset (FSA, 2008) for composition data and results from year 1 of the NDNS rolling programme for information on consumption and the main contributors to TFA intakes. Information obtained from the food industry on reformulation activity to reduce the levels of TFA in manufactured foods was also considered. Composite samples were analysed to produce a single, robust set of nutrient values to be derived for each product type, covering an appropriate cross-section of products available. The list of 62 composite samples was finalised following consultation with the UK food composition project's Expert User Group which included representatives from the food industry, academia, catering suppliers, nutritionists and dietitians. Market share information was used, where available, and industry consulted, to determine products and brands to make up the sub-samples included within each composite sample. Each composite sample consisted of between 5 and 12 sub-samples that were purchased and prepared for analysis between January and April 2010 (Department of Health, 2011a). The majority of samples were purchased from supermarkets, independent retailers and takeaway outlets in the Norwich area although takeaway products were also sampled from London, Leeds and Wolverhampton. Survey samples included pizza, garlic bread, breakfast cereals, quiche, fat spreads, cooking fats and oils, chicken products (retail and takeaway), meat pies, fish products and chips (retail and takeaway), coleslaw, crisps and savoury snacks, confectionery, chocolate spread, soup, mayonnaise, baby rusk and ice cream. Biscuits, buns, cakes and pastries were not included in the survey because they had been surveyed in 2009 (Department of Health, 2011b).

2.2. Sample preparation

All purchased samples were stored according to label recommendations and ready to eat takeaway products were refrigerated and frozen as soon as possible. Sub-samples requiring preparation/cooking were prepared in accordance with manufacturers' instructions and using normal domestic practices. Sub-samples were homogenised and combined into composite samples for analysis on an equal weight basis and were stored frozen at −40 °C until required for analysis.

2.3. Total fat and fatty acid analysis

Total fat and fatty acids were analysed by Eurofins Laboratories, Wolverhampton, UK, between March and April 2010. Lipid fractions from dairy samples were extracted using the Rose Gottlieb procedure (International Standard 1D, 1996) and the Bligh & Dyer procedure (Bligh & Dyer, 1959) was used for all other samples. The isolated fat was trans-esterified using 200 μL of 2 M methanolic sodium methoxide to form fatty acid methyl esters (FAME). The FAME profile was determined using a capillary gas chromatograph equipped with a 100 m × 0.25 mm × 0.2 μm column (Supelco SP 2560 (Metlab, Deeside, UK) split ratio 50:1, injector temperature 250 °C) and a flame ionisation detector (hydrogen 30 ml/minute, air 400 ml/minute, temperature 260 °C) with helium used as a carrier gas (43.51 PSI at 170 °C). The temperature program was 40 °C for 2 min, increased by 3 °C/min to 215 °C and held for a further 33 min. Quantification and identification of the individual FAME was achieved by the use of external standards (qualitative and quantitative (FAME multi-standard C4–C25 (Eurofins, in house composite of individual FAME standards),) and an analytical quality control (AQC) sample (anhydrous milk fat spiked with cod liver oil (Eurofins, in house preparation)). The Limit of Quantification for each fatty acid was 0.02% (normalised as a percentage of the total peak area).

Total TFA was calculated as the sum of r7-C18:1 (trans-7-octadecenoic acid), r9-C18:1(trans elaidic acid), t11-C18:1(trans vaccenic acid), t12-C18:1(trans-12-octadecenoic acid) and r9,t12-C18:2 (trans linolelaidic acid).

3. Results and discussion

Data for total fat (g/100 g food) and TFA (g/100 g FAME) for composite samples analysed are provided in Table 1. TFA were detected in all samples with total TFA ranging from 0.04% to 2.40% of FAME. The highest TFA concentrations were found in cod in batter and potato chips from fish and chip shops, dairy ice cream, garlic and herb baguette, spreadable butter and pizza. The cod fried in batter and potato chip composite samples both contained approximately equal quantities of vaccenic acid and elaidic acid reflecting the use of either beef fat or vegetable oil for frying sub-samples collected from different regions of the UK. Dairy ice cream, garlic and herb butter, spreadable butter and pizza contained mainly vaccenic acid from dairy ingredients included in the products with detectable quantities of elaidic acid and trans-7-octadecenoic acid.
Table 1

<table>
<thead>
<tr>
<th>Product</th>
<th>n°</th>
<th>Total fat (g/100 g food)</th>
<th>12-Octadecenoic acid (g/100 g FAME)</th>
<th>Vaccenic acid (g/100 g FAME)</th>
<th>Elaidic acid (g/100 g FAME)</th>
<th>Octadecenoic acid (g/100 g FAME)</th>
<th>Vaccenic acid (g/100 g FAME)</th>
<th>Elaidic acid (g/100 g FAME)</th>
<th>Total TFA (g/100 g FAME)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pizza, cheese and tomato</td>
<td>1</td>
<td>9.8</td>
<td>&lt;0.02</td>
<td>0.93</td>
<td>0.17</td>
<td>0.12</td>
<td>0.47</td>
<td>1.22</td>
<td></td>
</tr>
<tr>
<td>Garlic and herb baguette, baked</td>
<td>1</td>
<td>16.7</td>
<td>0.15</td>
<td>1.53</td>
<td>0.16</td>
<td>0.11</td>
<td>0.56</td>
<td>1.93</td>
<td></td>
</tr>
<tr>
<td>Breakfast cereal products¹</td>
<td>2</td>
<td>16.1 (11.6–20.5)</td>
<td>&lt;0.02</td>
<td>&lt;0.02</td>
<td>0.03 (&lt;0.02–0.05)</td>
<td>&lt;0.02</td>
<td>&lt;0.02</td>
<td>0.05(0.04–0.06)</td>
<td></td>
</tr>
<tr>
<td>Quiche Lorraine</td>
<td>1</td>
<td>17.6</td>
<td>&lt;0.02</td>
<td>0.87</td>
<td>0.20</td>
<td>&lt;0.02</td>
<td>0.40</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>Fat spread (26–39% fat)²</td>
<td>3</td>
<td>38.3 (36.9–39.0)</td>
<td>&lt;0.02</td>
<td>0.13 (0.05–0.25)</td>
<td>0.90 (0.06–0.15)</td>
<td>0.07 (&lt;0.02–0.15)</td>
<td>0.07 (0.05–0.08)</td>
<td>0.28 (0.15–0.38)</td>
<td></td>
</tr>
<tr>
<td>Fat spread (41–62% fat)³</td>
<td>3</td>
<td>59.6 (59.1–60.6)</td>
<td>&lt;0.02</td>
<td>0.11 (0.05–0.14)</td>
<td>0.11 (0.09–0.14)</td>
<td>&lt;0.02</td>
<td>0.04 (0.03–0.04)</td>
<td>0.22 (0.19–0.25)</td>
<td></td>
</tr>
<tr>
<td>Fat spread (62–75% fat, not polyunsaturated)</td>
<td>1</td>
<td>73.2</td>
<td>&lt;0.02</td>
<td>0.13</td>
<td>0.07</td>
<td>&lt;0.02</td>
<td>0.06</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

¹ Polyunsaturated, not polyunsaturated including dairy, not polyunsaturated including olive oil.

² Polyunsaturated, not polyunsaturated, not polyunsaturated with olive oil.

³ Polyunsaturated, not polyunsaturated, not polyunsaturated with nuts.

⁴ Takeaway pieces deep fried, takeaway pieces, baked chicken/turkey burger, oven cooked breaded/battered chicken/turkey pieces, baked chicken breast/steak.

⁵ Large beef pie large, individual beef pie, Cornish pasty, pork pie, sausage roll (ready to eat), chicken/turkey slices in pastry.

⁶ Breaded/crumb-coated products, breaded/crumb-coated products.

⁷ Vanilla soft scoop, chocolate/ chocolate and mint cone with nuts, luxury choc ice.

⁸ Vanilla soft scoop, luxury ice cream with chocolate/caramel.

⁹ Spreadable (75–80% fat), spreadable light (60% fat).

with trans-12-octadecenoic detectable in dairy ice cream, garlic and herb butter and spreadable butter.

The content of elaidic acid was less than 0.3% of FAME in all samples with the exception of three deep fried products (cod in batter, potato chips and deep fried chicken pieces) purchased from takeaway outlets.

In 17 of the 29 product types listed in Table 1, vaccenic acid made up a significant proportion (46–100%) of TFA. 15 of these product types also contained a proportion (0.04–0.56% of FAME) of c9,t11-conjugated linoleic acid (CLA) which comes from ruminant origin and indicates that the TFA in these products is mainly R-TFA (Fig. 1).
Fig. 2 shows a comparison between total TFA from this survey and previous existing analytical data held for comparable foods. Direct comparison is not possible for all food products because in some cases sub-sample composition was different or formulations are known to differ with regard to fat content or type of fat used. The results show that levels of I-TFA in processed foods have reduced considerably compared with previous analyses of similar foods carried out over the last 20–30 years. In most cases previous analyses only reported values for total TFA and not individual trans isomers so I-TFA and R-TFA cannot be compared but since meat and dairy contents of the products are similar the reduction in total TFA can be assumed to be a result of lower levels of I-TFA in fats and oils used during processing.

The 2008 UK survey of buns, biscuits, cakes and pastries reported levels of total TFA in the 62 composite samples analysed (Department of Health, 2011b) that were similar to those found in this survey. TFA concentration ranged from <0.05 to 2.73/100 g FAME with the higher concentrations found in products that included dairy ingredients, with vaccenic acid the predominant isomer. Elaidic acid was the predominant isomer in only one sample (plain scones) with a relatively high total TFA content (1.81/100 g FAME total TFA and 1.40/100 g FAME t9-C18:1).

Total TFA concentrations in this survey are lower than concentrations previously reported in similar European surveys carried out prior to widespread industry reformulation. A survey undertaken in 2005/2006 in Austria reported TFA levels of 0.2–13.8% of total fatty acids with elaidic acid concentrations between 0.02% and 6.53% of total fatty acids (Wagner, Plasser, Proell, & Kanzler, 2008). A Swiss survey in 2006/2007 (Richter, Shawish, Scheeder, & Colombani, 2009) showed a similar range of total TFA levels (0.03–22.9% of FAME).

This survey forms part of the Department of Health’s rolling programme of nutrient analysis, the results of which are incorporated into the Department’s nutrient databanks which support the National Diet and Nutrition Survey Rolling Programme (NDNS RP) and other national dietary surveys. Data from this particular survey were incorporated for year 3 of the NDNS RP onwards. However, prior to this, results from years 1 and 2 (2008–2010) of the NDNS RP (Department of Health, 2011c) showed that mean TFA intakes were less than 2 g per day for all age groups, representing 0.7–0.9% of food energy, and were lower than in previous surveys for all age groups and also lower than the 2007 re-estimated value of 1.0%. TFA intakes of the upper 2.5 percentile were lower than the population target average of <2% of food energy and ranged between 1.2% of food energy in children and 1.7% in the over 65 age group. Major contributors to trans fatty acid intake were meat and meat products, milk and milk products and cereal and cereal products. Results showed that the relative contribution to TFA from cereal and cereal products was lower, and meat and meat products and milk and milk products higher, than previous surveys reflecting a reduction in the levels of I-TFA compared with R-TFA.

4. Conclusion

The results from this survey provide up-to-date data that will be incorporated into the Department of Health’s nutrient databanks which support the NDNS and other national dietary surveys. The results will also be incorporated into future publications in the McCance and Widdowson’s The Composition of Foods series. This survey determined the TFA content of a range of processed foods that are potential sources of artificial TFA in the UK diet. The results confirmed information provided by the food industry in 2007 on the levels of TFA in key processed food sectors, as part of a review of the evidence of the health impacts of TFA (Food Standards Agency, 2007b). Industry reformulations have significantly reduced the total TFA content of processed foods in the UK, with vaccenic acid from ruminant sources being the major contributor in
the majority of foods analysed with higher levels of TFA. The health implications of R-TFA compared with I-TFA are not clear but the low levels found in this survey are unlikely to be associated with increased risk of CHD (Bendsen et al., 2011). Looking at the general population as a whole, average intake of TFA is well below the recommended maximum, and intake at the upper end of the distribution (97.5 percentile) also falls within the recommendation.

Acknowledgments

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References


