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The *Trans* Fatty Acids Content of Selected Foods in Malaysia

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ABSTRACT

Introduction: There is a lack of information on the *trans* fatty acid (TFA) content in Malaysian foods. The objective of this study is to determine the TFA content of bakery products, snacks, dairy products, fast foods, cooking oils and semisolid fats, and breakfast cereals and Malaysian fast foods. This study also estimated the quantity of each isomer in the foods assayed. **Methods**: The *trans* fatty acid content of each food sample was assessed in duplicate by separating the fatty acid methyl esters (FAME) in a gas chromatography system equipped with HP-88 column (USA: split ratio 10: 1) for *cis/trans* separation. Five major TFA isomers, palmitoelaidic acid (16: 1*t*9), petroselaidic acid (18:1*t*6), elaidic acid (18:1*t*9), vaccenic acid (18: 1*t*11) and linoelaidic acid (18:2*t*9, 12), were measured using gas chromatography (GC) and the data were expressed in unit values of g/100 g lipid or g/100 g food. **Results**: The total TFA contents in the studied foods were <0.001 g-8.77 g/100 g lipid or <0.001 g-5.79 g/100 g foods. This value falls within the standard and international recommendation level for TFA. The measured range of specific TFA isomers were as follows: palmitoelaidic acid (<0.001 g-0.26 g/100 g lipid), petroselaidic acid (<0.001 g – 3.09 g/100 g lipid), elaidic acid (<0.001 g-0.87 g/100 g lipid), vaccenic acid (<0.001 g-0.41 g/100 g lipid) and linoelaidic acid (<0.001 g-6.60 g/100 g lipid). **Conclusion**: These data indicate that most of the tested foods have low TFA contents (<1 g/100 g lipid).

Keywords: Malaysian foods, *trans* fatty acids (TFA), isomers of TFA, palmitoelaidic, linoelaidic, elaidic, vaccenic and palm oil

INTRODUCTION

Trans fatty acid (TFA) intake is associated with negative effects on human health (Mozaffarian *et al*., 2006), such as increased levels of total cholesterol and low-density lipoprotein (LDL) and the development of allergies. TFA is mainly produced by a partial hydrogenation process during the production of foods such as bakery items and snacks (Hamilton, 2008). Dairy and animal fats can also contain TFAs that are produced naturally by a bio-hydrogenation process in ruminants (Craig-Schmidt, 2006). The deodorisation process during food frying operations is another significant source of TFA production (Martin *et al*., 2005). Due to the adverse effects of TFA, many countries, including the USA and Canada, have banned the sale of food products containing more than 2 g TFA/100 g lipid (Food Safety Authority of Ireland, 2008).

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In Australia and New Zealand, TFA content must be displayed on food packaging; this rule was introduced as a strategy to reduce TFA intake among the population in the country. To replace or reduce TFA levels in foods, manufacturers have adopted alternative technologies, such as modified hydrogenation, inter-esterfication and the use of oil fractions with high solid fat contents. In Malaysia, however, there is yet to be any mandatory legislation of TFA levels. TFAs are not listed along with other nutrients in the Malaysian Food Composition Database, an indication of how little data on TFA levels in Malaysian foods is available. Thus, the objective of this study is to provide preliminary information on TFA content in Malaysian food markets. Because this study is the first serious effort to compile comprehensive data on TFAs in Malaysia, it is designed to serve as the basis for future data collection on TFA content in Malaysian food.

METHODS

Sample selection and preparation

Ninety-two (92) food samples were purchased gradually from different hypermarkets (Giant, Carrefour and Tesco), fast foods restaurants, small bakery stores and grocery shops in the area of Bandar Baru Bangi, Selangor, Malaysia, between June 2008 and January 2009. Purposive sampling was used during sample collection. Different popular brands of a product were coded by letter (e.g., A, B, C, D and E). The analysis was carried out in triplicate. The samples were grouped into 7 food groups, namely, bakery products (n=19), snacks (n=15), breakfast cereals (n=5), semisolid fats and cooking oils (n=9), milk and dairy products (n=21), fast food (n=19) and Malaysian fast foods (n=4). The selection of the food group is based on previous studies that have shown these food groups to contain high TFA concentration (Wagner *et al.,* 2008). The details of food samples for each food groups are listed below:

- Bakery products: cakes (n=4, including filled cream, fruit, chocolate and butter cake), doughnuts (n=4, including sugary and chocolate cream), croissants (n=3, including sweet and savory types), white bread (n=1), whole grain bread (n=2), pizza (n=2, including cheese and lean meat toppings) and chocolate buns (n=3).
- Snacks: cream crackers (n=3, including sugary and plain), chocolate biscuits (n=3), potato chips (n=3), chocolate bars (n=3, combination of vegetable oils and milk cream), chocolate wafers (n=3, combination of butter, milk powder and vegetable oil).
- Breakfast cereals: (n=5, including honey, chocolate, corn, whole-grain varieties and cereal drink, 2 in 1 premixed).
- Cooking oil and semisolid fats: mayonnaise (n=3), palm oil, olive oil, soybean oil, corn oil and blended oil (combination of canola, soy and olive oil).
- Milk and dairy products: cheese (n=3, including low- and high-fat types), yogurt (n=3, including low- and high-fat types), fresh milk (n=7, including pasteurised fresh milk, chocolate-flavored, low-fat and full cream), powdered milk (n=4, including low-fat and full cream), sweetened milk (n=2) and ice cream (n=2)
- Fast foods: fried chicken (n=5), chicken nugget (n=3), fries (n=3), beef burger (n=2), chicken burger (n=2), cheeseburger (n=2) and fish burger (n=2).
- Malaysian fast foods: *roti canai* (n=2), chapatti (n=1) and *thosai* (n=1).

Food samples were homogenised immediately after purchase using a macerator jar and kept in sealed plastic or capped bottles, labeled and stored at -80 °C until analysis. Homogenised portions of bakery products, snacks, breakfast cereals, fast food items, *roti canai*, chapatti and *thosai* were dried at 102 ± 2 °C for several hours until two consecutive weighings differed by less than 0.1% (AOAC, 1985).

Quantification of *trans* fatty acid

Fat extraction

The Soxhlet method (AOAC, 1985) was used to extract the lipids from solid bakery products, snacks, breakfast cereals, fast foods, *roti canai*, *chapatti* and *thosai*. Ten grams of dried food samples were weighed into a pre-dried extraction thimble. Then, 250 ml of petroleum ether (Chemar®, Geneva) was added to a round bottle flask and used to extract the lipid from the food matrix for 8 hours. For semisolid and liquid foods such as milk, dairy products, shortening and mayonnaise, the Blight and Dyer method, with slight modifications as described by Hughes (2006), was used to extract the lipid. The sample was macerated with chloroform and methanol to allow the separation of the lipid fraction. After the filtration of solids and separation of the fat layer, the lipid fraction was collected.

Solvents were removed by evaporation using Rotary Evaporator (Büchi Rotavapor R-200, Switzerland) and the flask was dried in an air-oven at 40-60 °C for 1 h, cooled in a desiccator, and weighed. The collected part was used in the analysis of fatty acid methyl esters (FAME). Cooking oil was directly aliquoted and converted to FAME for GC analysis. For each food brand, two aliquot lipid samples (0.5 g each) were taken and placed in 1.5 ml capacity rubber septa-capped amber glass vials and analysed separately. Approximately 0.5 ml of 0.0005% butylhydroxytoluene (BHT) (Sigma-Aldrich, USA) in n-hexane was added to each aliquot to prevent the oxidation of the fatty acids, and the vial was streamed under nitrogen gas for several seconds before sealing. Then, the vial was kept at -80 °C before analysis.

Fatty acid methyl ester (FAME) preparation

The conversion of lipids into FAME can be achieved through boron trifluoride (BF_3) *trans*-esterification (Wagner *et al.*, 2008). A 2 ml aliquot of 12% BF_3 (Acros, Belgium) in methanol and 1 ml of an internal standard (tridecanoic acid 13:0, 0.01 g/100 ml heptanes) were added to 20 µl (0.02 g lipid) aliquots of fats extracted from each sample. The mixture was incubated for 1.5 h at 55 °C and shaken vigorously every 20 min to allow complete *trans*-esterification. To terminate the process, 2 ml of anhydrous sodium carbonate (8.5 g/100 ml distilled water) was added. An additional 1.98 ml heptane was added, and the solution was centrifuged at 3600 rpm for 15 min. A heptane layer containing FAME was collected for GC analysis.

Gas chromatography-flame ionization detector (GC-FID) analysis

The *trans* fatty acid content was assessed in duplicate by separating the FAME in a gas chromatography system (Hewlett Packard HP 6890 Network GC-systems, USA) equipped with a 100 m × 250 µm × 0.2 µm (film thickness) HP-88 column (USA: split ratio 10:1) for *cis/trans* separation. Helium was used as a carrier gas with a flow rate 1.0 ml/min and a total flow of 13 ml/min. The temperature programme was as follows: 0.50 min at 40 °C, increase by 25 °C/min up to 192 °C, 25 min at 192 °C, increase by 15 °C/min up to 205 °C, 3 min at 205 °C, increase by 10 °C/min up to 230 °C, 20 min at 230 °C. The total time was 57.87 min. *Trans* fatty acid methyl esters were identified with the HP ChemStation Software from Hewlett Packard (California, USA) and *trans* fatty acids isomers including palmitoelaidic acid (16:1*t*9), petroselaidic acid (18:1*t*6), elaidic acid (18:1*t*9), vaccenic acid (18:1*t*11) and linoelaidic acid (18: 2*t*9,12) were identified by comparing retention times with the authentic standards (>98% purity, Sigma-Aldrich, USA). Each TFA isomer was analysed according to the following formula AOAC (2000):

TFA isomers (g/100 g lipid)

$$= \frac{\text{Area}_{\text{FA isomers}} \times \text{Conc.}_{\text{IS}} \times \text{RRF}_{\text{FA isomers}}}{\text{Area}_{\text{IS}} \times \text{Conc.}_{\text{fat}} \times 1.04}$$

where 1.04 is the conversion factor from methyl ester to fatty acid. The RRF (relative response factor) is obtained from an injection of TFA isomers standard, and IS (internal standard) refers to 0.001 g of Tridecanoic acid (13:0). The RRF was determined as follows:

$$\text{RRF}_{\text{TFA isomers}} = \frac{\text{Area}_{\text{IS}} \times \text{Conc.}_{\text{FA}}\ \text{isomers}}{\text{Area}_{\text{FA isomers}} \times \text{Conc.}_{\text{IS}}}$$

Statistical analysis

The TFA value obtained from this food analysis was of univariate type. This univariate data were expressed as ranges of g/100 g lipid or g/100 g food.

RESULTS AND DISCUSSION

The total TFA is defined as the sum of five TFA isomers namely, palmitoelaidic acid (16:1*t*9), petroselaidic acid (18:1*t*6), elaidic acid (18:1*t*9), vaccenic acid (18:1*t*11) and linoelaidic acid (18:2*t*9, 12). The range of the total TFA and isomer contents in each type of bakery products, snacks, breakfast cereals, cooking oil and semisolid fats, milk and dairy products, Western and Malaysian fast foods assayed are reported in Table 1. The percentage contributions of total TFA and isomers from the seven food groups are shown in Figure 1, while Figure 2 shows the overall percentages (%) of TFA isomers found in all the food items assayed. The total TFA contents in the samples analysed were below 10 g/100 g lipid. This indicates that the usage of partially hydrogenated fats is low in Malaysia.

Bakery products are represented by cakes, doughnuts, croissants, white bread, whole-grain bread, buns and pizzas. The highest TFA values were found in white bread (3.17 g/100 g lipid) and whole-grain bread brand B (3.10 g/100 g lipid). Fortunately, these products contain only small amounts of fat, so TFA provided only 0.08 g/100 g and 0.14 g/100 g of the food, respectively. This is considered low based on the U.S Food and Drug Administration (FDA) regulations, which state that any food product with less than 0.5 g TFA per serving is allowed to claim '0 *trans* fat' on the food label. Such claims were found in the labeling for both of these products. The other bakery products such as cake, doughnuts and croissants also showed TFA values of less than 2 g/100 g lipid. However, the TFA value for pizza in this study is higher than that of pizza from Ireland (Food Safety Authority of Ireland, 2008), Australia (McCarthy, Barr & Sinclair, 2008) and Austria (Wagner *et al.*, 2008). The Food Safety Authority of Ireland (2008) reported that Irish foods contain low TFA due to efforts by food manufacturers to maintain the lowest TFA content possible. Australia and Austria also restrict industrially produced TFA (Danish Veterinary and Food Administration, 2011).

The TFA content in the tested snacks which included cream crackers, chocolate biscuits, potato chips, chocolate bars and wafer chocolate ranged from <0.001-1.89 g/100 g lipid. The highest amount of TFA was found in potato chips (brand B). All investigated cream crackers contained between 0.12-0.35 g a TFA/100 g lipid which is considered an appropriate amount (less than 2 g/100 g lipid). The values are also lower than those observed in crackers from Australia (McCarthy *et al.*, 2008) and Korea (Lee *et al.*, 2010). This finding is further supported by earlier studies by Neo, Tan & Ariffin (2007) and Norhayati *et al*. (2011) who stated that the content of TFA in both branded and non-branded biscuits in Malaysia was considerably low. Similar findings were also found for chocolate bars and chocolate wafers, for which the values were lower than those reported in China (Fu *et al.*, 2008), Australia (McCarthy *et al.*, 2008) and Switzerland (Richter *et al.*, 2009). The usage of palm oil or palm kernel oil as a raw

Table 1. Absolute total *trans* fatty acid (TFA) and *trans* fatty acid (TFA) isomers content in all food groups

Food groups	*n*	*Total TFA g/100 g food*	*Total TFA g/100 g lipid acid (16:1t9)*	*TFA-isomers g/100 g lipid* Palmitoelaidic acid (18:1t6)	Petroselaidic acid (18:1t9)	Elaidic (18:1t11)	Vaccenic acid (18:2t9,12)	Linoelaidic
Bakery products	19	<0.001-0.28	<0.001-3.17	<0.001-0.17	<0.001-3.09	<0.001-0.02	<0.001-0.11	<0.001-3.12
Cakes	4	0.01-0.27	0.10-0.91	0.04-0.12	<0.001-0.60	<0.001	<0.001-0.08	<0.001
Doughnuts	4	0.01-0.13	0.06-0.70	<0.001-0.06	<0.001-0.67	<0.001	<0.001-0.09	<0.001
Croissants	3	0.03-0.05	0.14-0.23	0.08-0.17	<0.001-0.15	<0.001-0.02	<0.001	<0.001
White bread	1	0.08	3.17	<0.001	<0.001	<0.001	<0.001	3.12
Whole-grain bread	2	<0.001-0.14	<0.001-3.10	<0.001	<0.001-3.09	<0.001	<0.001	<0.001
Buns	3	0.01-0.28	0.11-1.23	0.02-0.11	<0.001-0.67	<0.001	<0.001	<0.001-1.21
Pizza	2	0.00-0.01	0.03-0.19	<0.001-0.08	<0.001	<0.001	<0.001-0.11	<0.001-0.03
Snack	15	<0.001-0.57	<0.001-1.89	<0.001-0.21	<0.001-0.27	<0.001-0.87	<0.001-0.08	<0.001-1.02
Cream crackers	3	0.03-0.07	0.12-0.35	<0.001	<0.001-0.18	<0.001-0.33	<0.001-0.08	<0.001
Chocolate biscuits	3	0.00-0.01	0.06-0.29	<0.001-0.02	<0.001-0.27	<0.001	<0.001-0.04	<0.001-0.02
Potato chips	3	0.02-0.57	0.06-1.89	<0.001-0.06	<0.001	<0.001-0.87	<0.001	<0.001-1.02
Chocolate bars	3	<0.001-0.10	<0.001-0.75	<0.001-0.21	<0.001	<0.001	<0.001	<0.001-0.54
Chocolate wafers	3	0.00-0.09	0.02-0.38	<0.001-0.02	<0.001	<0.001-0.38	<0.001	<0.001
Milk and dairy products	21	<0.001-0.34	<0.001-3.84	<0.001-0.26	<0.001	<0.001-1.36	<0.001-0.41	<0.001-3.84
Cheese	3	<0.001-0.10	<0.001-0.67	<0.001	<0.001	<0.001-0.67	<0.001	<0.001
Yogurt	3	<0.001-0.00	<0.001 -3.84	<0.001	<0.001	<0.001-0.76	<0.001	<0.001-3.84
Fresh milk	7	0.00-0.01	0.09-0.95	0.04-0.26	<0.001	<0.001	<0.001-0.41	<0.001-0.47
Powdered milk	4	<0.001-0.34	<0.001-3.30	<0.001	<0.001	<0.001-1.36	<0.001	<0.001-1.94
Sweetened milk	2	0.02-0.04	0.16-0.64	0.01	<0.001	<0.001	<0.001	0.14-0.64
Ice cream	2	0.25-0.40	0.26-0.92	0.01-0.08	<0.001	<0.001-0.18	<0.001	0.07-0.83
Fast food	19	<0.001-1.97	<0.001-8.77	<0.001-0.14	<0.001	<0.001-4.80	<0.001	<0.001-4.48
Fried chicken	5	0.16-1.96	0.10-8.49	<0.001	<0.001	<0.001-4.80	<0.001	<0.001-3.69
Chicken nuggets	3	0.22-1.97	1.22-8.77	<0.001	<0.001	1.22-4.27	<0.001	<0.001-4.48

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Table1. Continued from previous page

Fries	3	<0.001-0.31	<0.001-1.88	<0.001	<0.001	<0.001-1.88	<0.001	<0.001
Beef burger	2	<0.001-0.16	<0.001-0.61	<0.001-0.14	<0.001	<0.001	<0.001	<0.001-0.47
Chicken burger	2	0.49-0.85	2.44-5.73	<0.001	<0.001	1.00-1.82	<0.001	1.44-3.92
Cheese burger	2	<0.001-0.07	<0.001-0.42	<0.001	<0.001	<0.001-0.42	<0.001	<0.001
Fish burger	2	<0.001-0.15	<0.001-0.10	<0.001	<0.001	<0.001-0.10	<0.001	<0.001
Cooking oil and semisolid fats	9	<0.001-5.79	<0.001-5.79	<0.001	<0.001	<0.001-2.13	<0.001	<0.001-4.03
Olive oil	1	0.79	0.79	<0.001	<0.001	0.79	<0.001	<0.001
Blended oil (canola, soybean and olive)	1	4.06	4.06	<0.001	<0.001	0.82	<0.001	3.24
Soybean oil	1	5.79	5.79	<0.001	<0.001	1.76	<0.001	4.06
Palm oil	1	1.79	1.79	<0.001	<0.001	1.79	<0.001	<0.001
Corn oil	1	2.13	2.13	<0.001	<0.001	<0.001	<0.001	2.13
Mayonnaise	3	<0.001-0.33	<0.001-0.65	<0.001	<0.001	<0.001	<0.001	<0.001-0.65
Shortening	1	2.50	2.19	<0.001	<0.001	<0.001	<0.001	<0.001-2.19
Breakfast cereal	5	0.06-0.59	1.57-6.60	<0.001	<0.001	<0.001-1.57	<0.001	<0.001-4.82
Coco-coated cereal	1	0.27	1.57	<0.001	<0.001	1.57	<0.001	<0.001
Honey-coated cereal	1	0.12	1.76	<0.001	<0.001	<0.001	<0.001	1.76
Corn cereal	1	0.06	4.82	<0.001	<0.001	<0.001	<0.001	4.82
Cereal beverages	2	0.30-0.59	4.74-6.60	<0.001	<0.001	<0.001	<0.001	<0.001-6.60
Malaysian fast food	4	0.00-0.62	0.03-6.60	<0.001-0.01	<0.001	<0.001-3.71	<0.001	<0.001-6.60
Roti canai	2	0.00-0.62	0.03-5.70	<0.001	<0.001	<0.001-3.53	<0.001	<0.001
Chapatti	1	0.32	3.71	<0.001	<0.001	3.71	<0.001	<0.001
Thosai	1	0.00	0.08	<0.001	<0.001	1.51	<0.001	<0.001

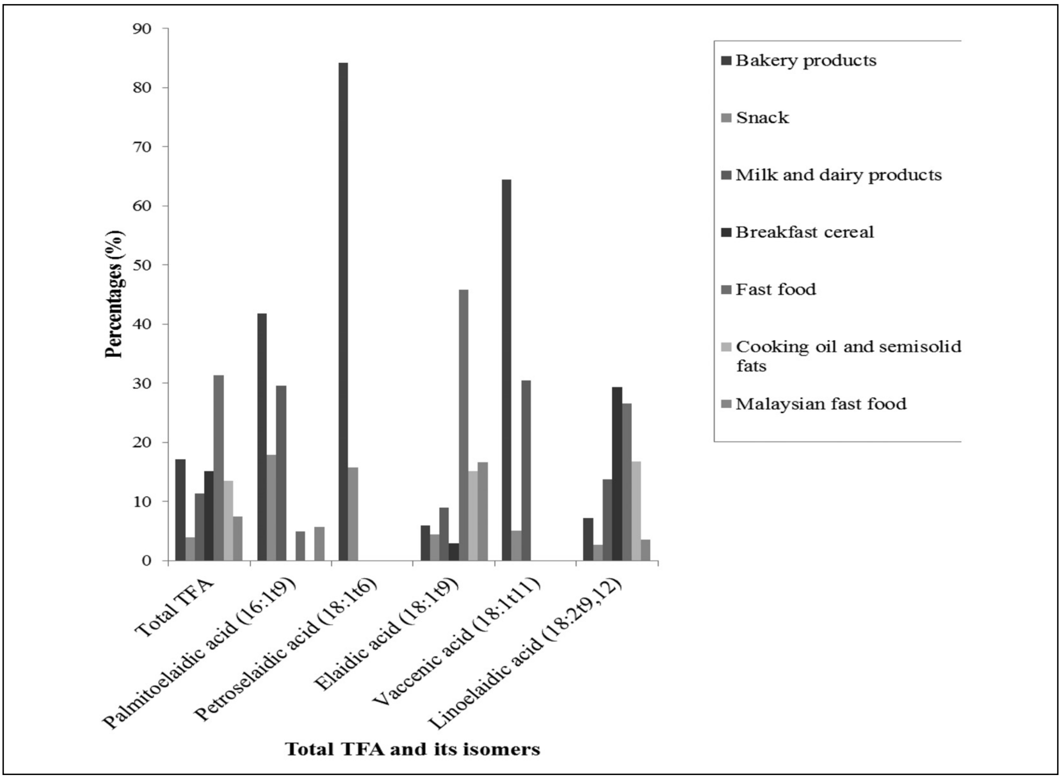

Figure 1. Percentages (%) of total *trans* fatty acid (TFA) and *trans* fatty acid (TFA) isomers in each food group.

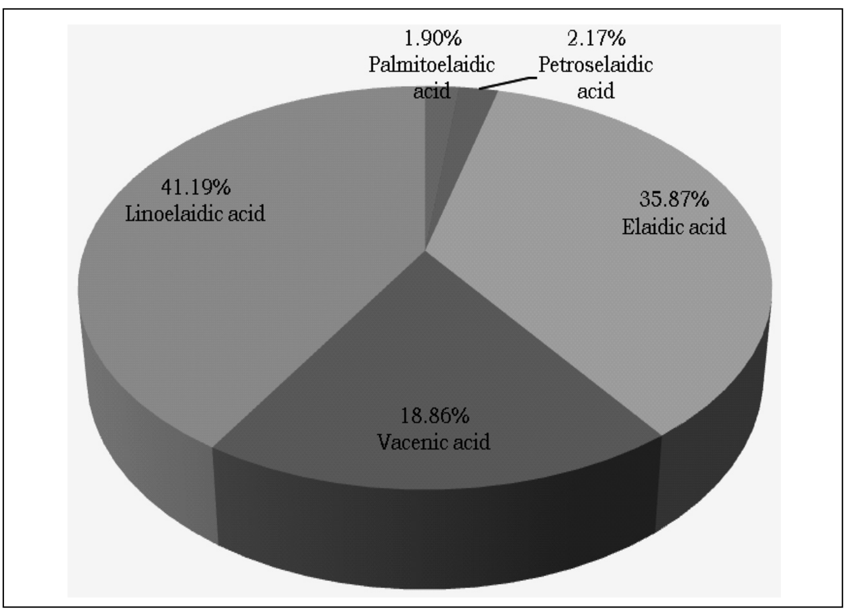

Figure 2. Overall percentages (%) of *trans* fatty acid (TFA) isomers in all studied food

material for chocolate production in Malaysia may have helped to reduce the TFA levels in the foods studied.

Generally, fast food items contained the most TFA in this study, ranging from <0.001-8.49 g/100 g lipid. The highest TFA amounts were found in chicken nuggets (brand B) followed by fried chicken (brand C) and chicken burgers (brand A). However, these values were lower than the TFA levels observed in Swiss fast food (Richter *et al.*, 2009). Due to its high degree of saturation, palm oil is not as easily isomerised to TFA during frying as other cooking oils (Neo *et al*, 2007), which may explain this observation. The TFA content of fish burgers in this study was also found to be lower than that reported in Ireland, but the TFA content of chicken burgers in Malaysia seemed to be higher than that reported in Ireland (Food Safety Authority of Ireland, 2008). The TFA content of fries and fried chicken was higher in our study compared to Korean data (0.07 g and 0.14 g/100 g food, respectively) (Lee *et al*., 2010) but was much lower compared to China (8.81 g/100 g lipid for fries) (Fu *et al.*, 2008).

For cooking oils, the Swiss reported a lower range of TFA (Richter *et al.*, 2009) than was observed in our data. The manipulation of hydrogenation process, including increased pressure, catalyst concentration and agitation or other hydrogenation techniques such as supercritical fluid state can also reduce TFA content (Food Safety Authority of Ireland, 2008). However, the TFA values measured here were much lower than the TFA contents in commercially available Iranian edible oils (0.9-35.2%) (Asgary *et al*., 2009).

Breakfast cereals including cereal beverages showed a wide range of TFA values, from 1.57-6.60 g/100 g lipid. Among the three breakfast cereals studied, corn cereal had the highest TFA value (4.82 g/100 g lipid), but due to its low overall fat content, the amount of TFA per 100 g food was only 0.06 g/100 g food. Cereal beverages also had high TFA levels, more than 2 g/100 g lipid. This might be due to the use of corn and soybean as the main ingredients (as stated in food labeling). Corn and soybeans are both major sources of PUFAs. TFAs can be formed by the heat isomerisation processes during food manufacturing, and PUFAs are more susceptible to this process (Neo *et al*., 2007). For the honey-coated and chocolate-coated breakfast cereals, which contained lower TFA, no ingredients that contained high PUFA were listed on the food labels. The value of TFA in all breakfast cereals studied was higher than the data obtained from Austria (Wagner *et al*., 2008) and Korea (0.005 g/100 g food) (Lee *et al.*, 2010). The lower concentration of TFA may be attributed to the usage of new technologies, including vegetable oil interesterification in certain countries (Castro *et al.*, 2009).

Among the Malaysian fast foods tested, *roti canai* was found to have a high amount of TFA (0.03-5.70 g/100 g lipid or 0.00-0.62 g/100 g food). This could be because a large amount of margarine is often added to this food to increase its crispness. The difference of the TFA contents between the two *roti canai* samples studied was also large. This could have occurred if softer margarine was used to prepare *roti canai 1* and harder margarine was used to prepare *roti canai 2*. In addition to margarines, vanaspati also can be used to increase the palatability of the food. Vanaspati is normally used as an animal fat substitute to prepare meals such as *chapatti* (Agrawal *et al.*, 2008). This might explain why a high amount of TFA (>2 g/100 g lipid) was found in *chapatti.*

Throughout the sample analysis, the high variability of TFA content among samples can be clearly observed in the lipid composition of the food. Several factors can explain this variability. Differences in cooking methods could be one source of TFA content variability among food samples. Fast food preparation typically involves deep-frying, which contributes to a high level of

TFA by exposing more of the food surface area for fat absorption (Food Safety Authority of Ireland, 2008). A second factor is the type of vegetable oil used for food preparation. Vegetable oils such as soybean, palm oil, olive oil and corn oil undergo bleaching and deodorising to produce the cooking substance. However, under certain conditions, this process can produce high TFA. The degree of TFA production depends on the degree of saturation of the fatty acids in the oil (Innis, Green & Halsey, 1999). High TFA can be found in oils with low fatty acid saturation, such as soybean oil. In this study, soybean oil showed the highest value of TFA, approximately 5.79%. Furthermore, palm oil and olive oil meet the TFA Canada and Denmark official legislation for oils and fats (<2 g/100 g lipid) (McCarthy *et al.*, 2008) because both of these vegetable oils have a high degree of saturation, especially in comparison with soybean and corn oil.

TFA isomers

Recent evidence has suggested that different individual isomers from different food sources may elicit distinct favorable or adverse effects (Food Safety Authority of Ireland, 2008). For example, industrially produced TFA isomers such as elaidic acid (18:1*t*9) and linoelaidic acid (18:2*t*9, 12) may increase the risk of cardiovascular disease (Richter *et al.*, 2009). In contrast, natural TFAs such as vaccenic acid (18:1*t*11) have antiatherosclerotic and antidiabetic effects (Prandini, Sigolo & Piva, 2011) and could be beneficial. However, vaccenic acid can cause rendering of the milk fat in human (breast) milk, reducing the energy density available for breastfed infants (Khor & Norhaizan 2008). Therefore, it is important to differentiate between TFA isomers and identify their food sources.

Palmitoelaidic acid (16:1*t*9) and vaccenic acid (18:1*t*11) are predominantly found in bakery, milk and dairy products (Figure 1). Both of these isomers originate from bio-hydrogenation process in ruminants and deposits in animal fats (Cattlemen's Beef Board and National Cattlemen's Beef Association, 2011). Most bakeries use fat from animal sources like eggs and skim milk as the main ingredients. This might explain the presence of these isomers in bakery products. However, these isomers contributed to only a small percentage of total TFA in all food samples tested (Figure 2).

Petroselaidic acid (18:1*t*6) was only found in bakery products and snacks. In contrast, elaidic acid (18:1*t*9) and linoelaidic acid (18:2*t*9, 12) were present in all tested food groups (Figure 1). This could be the reason as to why both of these isomers contributed to the highest proportion (> 30%) of total TFA in all food studied (Figure 2). Fast foods contain predominantly elaidic acid (18:1*t*9), whereas linoelaidic acid (18:2*t*9, 12) is the major isomer in breakfast cereal. The Cattlemen's Beef Board and National Cattlemen's Beef Association (2011) have suggested that 18:1*t*9 becomes a major source in hydrogenated cooking oil. Furthermore, Wagner *et al.* (2008) have reported that 18:1*t* (*trans*-MUFA) is the predominant isomer that accounts for more than half of total TFA in fast food.

Based on the scientific evidence presented earlier, elaidic acid (18:1*t*9) is a well-known cause of many human health problems. Our findings show that fast food is a major food source of elaidic acid (18:1*t*9) in Malaysia. Further identifying and classifying food sources according to their TFA isomer contents could help the public manage their food intake and maintain better health.

Recommendations and legislations on TFA

Recommendations and regulations have been made to monitor TFA intake among the populations of certain countries. Each country regulates TFA content to a certain level. Based on Table 2, the Malaysian Ministry of Health recommends that solid foodstuffs can be claimed as low TFA if the

Table 2. The food samples according to *trans* fatty acid (TFA) regulations recommendation

	Description	*Number of tested products*
Malaysian recommendations		
Solid foodstuff	Low TFA(<1.5 g/100 g of food) Free TFA (<0.1 g/100 g of food)	25/69 solid foodstuffs 42/69 solid foodstuffs
Indian recommendations		
Solid foodstuff	Very low TFA (<1.0 g/100 g lipid) Low TFA (1.5-4.9 g/100 g lipid) Medium TFA(5-10 g/100 g lipid) High TFA (>10 g/100 g lipid)	46/69 solid foodstuffs 18/69 solid foodstuffs 5/69 solid foodstuffs 0/69 solid foodstuffs
Denmark regulations		
Oils only	Prohibited to sell if TFA contain >2 g/100 g lipid	3/5 cooking oil
Foodstuffs containing oils, fats and other ingredients	Prohibited to sell if TFA contain >5 g/100 g lipid	4/87 foodstuffs (excluding cooking oils)

TFA amount does not exceed 1.5 g/100 g lipid (Ministry of Health Malaysia, 2011). Moreover, if the TFA amount is less than 0.1 g/100 g food, the food can be labeled as TFA-free. Based on the Malaysian recommendations, 25 and 42 of the 69 solid food products tested can claim to be low-TFA and TFA-free, respectively.

Based on the Indian recommendations (Agrawal *et al.*, 2008), 46 out of 69 studied solid foods have very low TFA, 18 out of 69 studied solid foods have low TFA and 18 out of 69 studied solid foods are defined as medium TFA. None of the solid foods studied contain high TFA.

Denmark and Canada prohibit the sale of oils and fats with TFA levels above 2 g/ 100 g lipid (Food Safety Authority of Ireland, 2008). Based on this regulation, 3 out of 5 cooking oils would not be permitted to be sold, with the exceptions being palm oil and olive oil. However, only 4 out of 87 foodstuffs would be prohibited for sale in the market. Although different TFA level cutoffs are used by these countries, an agreement among countries' recommendations and legislation can be observed in the sense that most of the studied foods have appropriate levels of TFA.

One of the possible reasons why the TFA content in this study is relatively low is the extensive use of palm oil in Malaysia. Palm oil has a natural solid structure that is able to prevent TFA formation during the food production process. It has been used extensively in the local Malaysian food supply, and furthermore, Malaysia is becoming a major exporter in the global palm oil market (Malaysia Palm Oil Industry, 2011). Labels such as 'palm kernel oils', 'vegetable palm oil' and 'palm olein' can also be found in the packaging of most tested products, indicating that palm oil is used as an ingredient in most food products.

This study, however, only investigated a subset of the wide variety of foods available in Malaysian markets. Most of the selected food products were labeled as 'vegetable palm' or 'no *Trans*' on their packaging, which may be a source of bias and one reason for the low TFA content observed in the current study. Furthermore, TFA contents were measured only once for each sample; thus, the current data are not comprehensive. Precautionary steps are therefore needed because the TFA compositions of a variety of foods remain questionable. Another issue is that even though low amounts of TFA were found in the food items studied, the consumption patterns of those food items remain unknown. For example, if a person eats five food items with each containing 0.4 grams of TFA, the person will exceed the limit in that day unexpectedly. Further investigations should be performed to address this issue.

CONCLUSIONS

Most of the tested products have very low TFA contents (<1 g/100 g lipid). The extensive use of palm oil might be one reason for the low TFA content observed. Nevertheless, a substantial number of products did contain significant amounts of TFA. Deep-fried products from fast food restaurants also seemed to have high elaidic isomer contents, and elaidic acid is commonly associated with increased low-density lipoprotein cholesterol (LDL-C) and lowered high-density lipoprotein cholesterol (HDL-C) levels.

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