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Industrially produced *trans* fatty acids: major potential sources in Malaysian diet

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Abstract

This study was conducted to determine the major potential sources of industrially produced *trans* fatty acids (IP-TFAs) in Malaysian diet. Levels of IP-TFAs were initially determined in samples (n = 136) collected from 8 food groups (baked products, snacks, dairy products, breakfast cereals, fast foods, semisolid fats and cooking oils, and fried foods). A survey was carried out to 105 subjects aged 19-59 years old to determine the intake of IP-TFAs using Food Frequency Questionnaire (FFQ). The IP-TFAs range from 0-5.79% of food, with the highest found in semisolid fats and cooking oils (0.1-5.79%), followed by fast foods (0.04-0.86%), baked products (0.01-0.29%), breakfast cereals (0.06-0.45%), snacks (0.03-0.26%), dairy products (0-0.26%), and fried foods (0.002-0.06%). A Spearman's Rho rank test showed that there were significant correlations ($p < 0.05$) between 4 of the food groups (semisolid fats and cooking oils, fast foods, fried foods, and baked products), with the total IP-TFA intakes of subjects. In general, total IP-TFAs intakes of subjects were < 1% of subjects' diet (0.067%-0.91% of subjects' total calorie intakes). This indicate that high fat foods (semisolid fats and cooking oils, fast foods, fried foods, and baked products) were the main contributor of IP-TFAs in Malaysian diet, despite the low proportion of *trans* fatty acids, following their high frequency of daily intake.

Introduction

In most countries, fast foods, bakery products, packaged snacks, and margarines, had became among the common sources of industrially produced *trans* fatty acids (IP-TFAs). IP-TFAs are *trans* fat produced when oils containing unsaturated fatty acids are hydrogenated in the presence of catalyst (Sundram and Basiron, 2008). Most of commercial hydrogenation are typically partial, in order to obtain a malleable mixture of fats that is solid at room temperature, but melts upon baking or consumption (Mahan and Stump, 2008). The process changes the consistency of the fatty acid and makes it less prone to rancidity, therefore increase the shelf life and flavor stability of foods that contain these fats. The *trans* fats also are produced in rumen of animals by bio-hydrogenation and are found in milk, milk-products and various animal-based processed foods (Turpeinen *et al.*, 2002; Kuhnt *et al.*, 2006; Mosley *et al.*, 2006).

According to Margaret and Schmidt (2006), the predominant *trans* isomer in ruminant fats is vaccenic acid (C18:1, t11) in contrast to IP-TFAs, in which the predominant isomers are elaidic acid (C18:1, t9), and linoelaidic acid (C18:2 t9, 12). For that reason, a combination of all common isomers found in foods is required in order to obtain total trans fatty acids (TFA) in samples. The concern about IP-TFAs and the intake arise since they were reported in many studies as components that contribute to chronic diseases such as coronary heart disease (CHD), cancer, diabetes, as well as many other serious diseases (Nicole *et al.*, 2001; Sarah *et al.*, 2007; Steen *et al.*, 2009).

For similar reason, western countries had begun advocating a reduction in IP-TFA's intake by introducing regulation concerning it. Denmark, for example, has prohibited the use of oils/ fats containing more than 2 g *trans* fats/100 g fat (or 5 g *trans* fats when the fat is used as food ingredient)

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(Stender and Dyaberg, 2003). In addition, Canada (Regulations Amending the Foods and Drugs Regulations, 2003) and USA (CFR/FDA, 2003), are requiring the IP-TFA's content exceeding 0.2 g and 0.5 g per serving, respectively to be displayed on the product information. In Malaysia as well, a guideline was made for trans content in foods to be labeled as 'Low in *Trans* Fats' (<1.5% of 100 g food or <0.75 g of 100 ml liquid) and 'Trans Fat Free' (<0.1 g of 100 g food or 100 ml liquid) (MOH, 2010). However, there is no either legislation or guidelines regarding IP-TFA's level in the diet that are being constituted to date.

Therefore, the purpose of this study was to obtain a general picture of the IP-TFA situation (amount and intake) in the country as to observe if there is/are significance(s) that should be concerned in regards to it. This paper reports on the frequency of intake, and the estimation of actual intake of selected foods and food products that are identified as major potential sources of IP-TFA in the diet of Malaysian.

Materials and Methods

Selection of food samples and preparation

Food samples were collected from 8 food groups, which had been identified as potentially containing IP-TFA. The food groups were baked products, snacks, dairy products, breakfast cereals, fast foods, semisolid fats and cooking oils, and fried foods. A total of 136 food items categorized under these food groups were selected for analysis. The selection of food samples was made based on Food Consumption Statistics of Malaysia 2003 (2006) that are common in the Malaysian diets. Fried food samples were purchased from night markets and small hawkers in 3 different areas (Kajang, Bangi, and Putrajaya). Baked products, snacks, dairy products, breakfast cereals, fast foods, and semisolid fats and cooking oils were purchased randomly from bakery shops, groceries, food stalls, and hypermarkets in Klang Valley areas. The purchasing, processing and analysis of food samples were made gradually from March 2009 to June 2010. The solid food samples for each food group were grinded homogenously, dried in oven at 50^{o}C. Preparations of samples were according to protocol suggested by Codex Alimentarius (1999). The grinded, dried samples were packed into PE covered cup, and stored at -20^{o}C before analysis. Sampling method used for this study was convenience sampling, and analyses were made in triplicate.

Extraction of fat

Three replicates of sample were analyzed for gas chromatography (GC) analysis. Extraction of lipid from solid samples followed Soxhlet extraction method (AOAC, 1990) using petroleum ether b.p 40°C -60°C (Fisher Scientific, UK) as the extracting solvent; through a Soxhlet extractor apparatus (Electrothermal, Barnstead, US). Chloroform-methanol mixture of 1:2 v/v (Grey and Hughes, 2006; Kirk and Sawyer 1991; Bligh and Dyer, 1959) was used for extraction of fat from liquid samples. Solvents for both methods 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, cool in desiccator, and weight. Fats extracted were stored into 10 ml capped glass bottles after flushed with N_2, and stored at (-20°C).

Preparation of standards

Five single IP-TFA standards were purchased from Supelco, Bellefonte, USA. The IP-TFA standards comprised of C16:1 9t, C18:1 6t, C18:1 9t, C18:1 11t, and C18:2 9t 12t. All standards were readily FAME's. A mix standard was prepared for simultaneous identification. An internal standard (C13:0) was used to quantify the TFA in the samples.

Trans fatty acids analysis

Preparation of fatty acid methyl esters: The fats extracted from the samples were weight to about 0.02 g, into screw capped test tubes for methylation, and added with 1 ml internal standard solution (0.1% g/v tridecanoic in heptane). Later, 3 ml of BF_3 (12% v/v) was added into the tube, before being incubated for 1.5 h, at 55°C (the tube was hand-shook vigorously for 5 sec. every 20 min. for homogenization). After that, about 2 ml of $NaHCO_3$ (R&M Merkery, Essex, UK) and 2 ml heptanes were added. The mixture was then vortexed for a few seconds to ensure mixing before being centrifuged at 3600 rpm at 25°C, for 15 min. After centrifugation, the heptane layer containing FAME was transferred into 2 ml GC vials and kept in -20°C before analysis. The preparation of methyl esters procedures were conducted in the fume hood up till centrifugation.

Instrumentation: Gas Chromatography HP6890 (Agilent Technology, USA) equipped with a flame-ionization detector and a polar HP88 capillary column (100 m x 0.32 mm i.d. with 0.25 mm film thickness and 0.25 mm internal diameter; Supelco, Sigma-Aldrich Co., USA).

Separation/Determination using GC system: Helium at a constant flow-rate 1 ml/min was used as a carrier for the GC analysis. The column temperature was programmed to 40°C, held for 0.5 mins, then increased at 5°C per min to 230°C, and finally held for 15 min. Sample (5 μlL) was injected into the splitless mode system with the injector temperature set at 250°C. The running time of each sample was about 40 min. *Trans* fatty acid methyl esters were identified by comparing retention data of sample with that of authentic standards and quantified by peak area comparison.

Subjects

The sample size of subjects for dietary intake study was calculated using the prevalence of IP-TFA intake in Singapore. Assuming that the dietary pattern of Singaporean is not much different with Malaysian, the calculation of sample size was made based on the prevalence of IP-TFA intake in Singapore (National Nutrition Survey of Singapore, 2004); since Malaysia has not been established on such data. Sampling method used was simple random sampling and the survey was conducted at Universiti Putra Malaysia, Serdang, from April to October 2010. A formal letter was initially sent to Dean of Faculties, to seek permission for interviewers to approach staffs and students. Brief information regarding the survey was advertised at the faculties prior to data collection besides distribution of information letters. A total of 105 subjects consist of students and staffs from 9 faculties, who fit the criteria, and interested to participate were selected. All subjects provided written informed consent and were given some honorarium for their commitment in the survey. The methodology employed in the study was evaluated and approved by the Ethics Committee of Faculty of Medicine and Health Sciences, Universiti Putra Malaysia

Dietary assessment

The instrument used for the dietary assessment of subjects was Food Frequency Questionnaire (FFQ). A set of questionnaire was developed by adopting and modifying from Malaysian Adult Nutrition Survey 2002/2003. The questionnaire was consisted of 4 sections; socio-demographic, health status, lifestyle, and the food intake frequency of the 8 food groups potentially containing IP-TFAs. Answers for the food intake frequency were either per day/week/month/year, or never. All subjects were asked to complete the face to face interview of the FFQ, which was conducted by a few trained researchers.

Data analysis

The data obtained were processed and given a score of 1 to 9 based on frequency; 1 = never, 2 = ≤1/mo, 3 = 2-3/mo, 4 = 1/wk, 5 = 2-3/wk, 6 = ≥4/wk, 7 = 1/d, 8 = 2-3/d, 9 = ≥4/d (Hazizi, 2006; Reaburn *et al.* 1979) before being recorded into Microsoft Excels (2007). For the intake of IP-TFA in gram, conversion was made by multiplying the standard serving size of each food (in gram) as specified in the FFQ with the following values for each frequency option: Never=0; ≤1/mo=0.03; 2-3/mo=0.07; 1/wk=0.14; 2-3/wk=0.43; ≥4/wk=0.57; 1/d=1; 2-3/d=2.5; and ≥4/d=4 (Marks *et al.*, 2006). Values obtained were multiplied with the IP-TFAs content of each food, for each particular serving size. Total IP-TFAs intake was the sum of IP-TFAs of all food items from all 8 food groups. The data was then analyzed using Statistical Package for the Social Science software (SPSS Inc. Version 16, 2008) for windows, to estimate the major sources of IP-TFAs from foods. Spearman rho correlation coefficient was used to observe relationship between food intake frequency and total TFA intake by subjects. Variables with p value of less than 0.05 were considered statistically significant.

Results and Discussions

The age of subjects ranges from 18-59 years old (Table 1). From a total of 105 subjects, 54.3% were students, while 45.7% were staffs. Majority of them are female (61.9%) and age between 21-29 years old (74.3%). The subjects were mainly Malay (80%), followed by Indian (10%), and Chinese (8%), while another 2% are Sarawak *Bumiputera* (Iban). Most of the subjects are Muslims, followed by Hindu, Buddha, Christian, and others; 81%, 7.6%, 6.7%, 2.9%, and 1.9%, respectively.

Table 1. Respondents characteristics (n=105)

Factors	Student (n = 57)	Staff (n = 48)	Total (n = 105)
	N (%)	N (%)	N (%)
Gender			
Male	23 (21.9)	17 (16.2)	40 (38.1)
Female	34 (32.4)	31 (29.5)	65 (61.9)
Age (years old)			
≤ 20	5 (4.8)	-	5 (4.8)
21 – 29	52 (49.5)	26 (24.8)	78 (74.3)
30 – 39	-	5 (4.8)	5 (4.8)
40 – 49	-	7 (6.7)	7 (6.7)
≥ 50	-	10 (9.5)	10 (9.5)
Ethnicity			
Malay	42 (40)	42 (40)	84 (80)
Chinese	5 (4.8)	3 (2.9)	8 (7.6)
Indian	7 (6.7)	3 (2.9)	10 (9.5)
Others*	3 (2.9)	-	3 (2.9)
Religion			
Muslim	43 (41)	42 (40)	85 (81)
Buddha	4 (3.8)	3 (2.9)	7 (6.7)
Hindu	5 (4.8)	3 (2.9)	8 (7.6)
Christian	3 (2.9)	-	3 (2.9)
Others**	2 (1.9)	-	2 (1.9)

*Sarawak *Bumiputera.*

The lists of food samples, serving sizes, weight of medium serving sizes (gram), as well as the IP-TFAs content of the food samples are presented in Table 2. A total of 136 food samples were analyzed and total

Table 2. Mean, median, maximum value, minimum value, and standard error of mean of total energy intake, and total IP-TFA intake of subjects (n = 102)

	Total Energy Intake (Kcal)	Total IP-TFA Intake (g/day)	Total IP-TFA Intake (%)
Mean ± SD	1655.80 ± 472.72	0.71 ± 0.42	0.399 ± 0.22
Minimum Value	843.72	0.10	0.07
Maximum Value	2998.31	3.02	0.91
SEM	46.81	0.04	0.021

*SEM; standard error of mean

IP-TFAs content in food were estimated based on medium serving size (assumption: foods consumed in medium serving by all subjects). The IP-TFA contents are presented in percent of food (g/100 gram food). From all the 8 food groups analyzed, IP-TFA content was highest in semisolid fats and cooking oil, followed by fast foods, baked products, breakfast cereals, snacks, dairy products, miscellaneous, and fried foods, in descending order. The broadest range of IP-TFA content was observed in semisolid fat and cooking oils (0.11-5.79%). Vegetable cooking oils were doubled in IP-TFA content compared to semisolid fats; led by high polyunsaturated fatty acids oils; soy oil (5.79 ± 1.99%), blended oil (4.06 ±1.99%), and corn oil (2.13 ± 1.99%), as compared to palm oil and olive oil, having 1.79 ± 2.0% and 0.79 ± 1.99 %, respectively (< 2% of total fat). The observed trend is similar with study by Tang (2002), where the non-palm based cooking oils had 0.46-3.83% IP-TFA; also highest in soybean oil (n = 4) and corn oil (n = 4), with high level of IP-TFA (1.63-3.83%, and 1.13-1.96%, respectively). The high level of IP-TFA obtained in this study is expected, since soybean oil is well known for its high content of linoleic (35.2-64.8%) and linolenic acids (1.7-19%) (Hammond *et al*., 2005). Large variation in the values may be influenced by both different treatments during processing prior to packaging, and ingredients used.

Fast foods on the other hands contained between 0.04-0.86% IP-TFA, with deep fried fast foods having higher range of IP-TFA (0.18-0.86%) than burgers (0.04-0.67%). Fast foods are common sources of IP-TFA in many countries (Stender *et al*., 2006; Aro *et al*., 1998; Poppel *et al*., 1998) especially in French fries and nuggets. Therefore the highest level of IP-TFA in the studied French fries (0.18 ± 0.16%) and nuggets (0.86 ± 0.97%) compared to other fast food sample are expected. However, the wide range of IP-TFA contents of fast foods among different countries is due to different ingredients and fats used. As for baked products, the range was 0.01-0.29%, specifically highest in cakes (0.01-0.29%), compared to bread (0.01-0.14%), doughnuts (0.02-0.12%), biscuits (0.01-0.05%), and pastries (0.02-0.04%). The IP-TFA's in baked products are contributed by the use of baking ingredients like shortening and margarine; which might have been partially hydrogenated (Lee *et al*., 2008).

The least containing IP-TFA was fried foods, where the ranges were about 0.002-0.06% and 0.003-0.03% for fried *kuih* and fried balls, respectively. Most of the fried *kuih* and balls selected were readily low in fat (Huda *et al*., 2000; Tee *et al*., 1997) prior to frying, therefore the IP-TFA level are expected to be low. In addition, despite that those foods were prepared by deep frying, Malaysian foods as mentioned earlier, are commonly prepared using palm oil. Palm oils are generally low in IP-TFA. Other than that, palm oil is also known for its stability due to the balanced ratio of fatty acids; as well as high amount of β-Carotene, and vitamin E (Edem, 2002). Hence isomerization-forming IP-TFA could be minimal, unless in repeatedly used deep frying oil.

The exposure to IP-TFA was observed by considering frequency of intake of the selected studied foods. The highest mean of TFA intake (by food group) was 0.314g daily, contributed through intake of food containing palm oil. Even though the level of IP-TFA in palm oil was less than 2% (safe level) of fat (Stender and Dyaberg, 2003), however the high consumption of palm oil among Malaysian cannot be ignored. The Food Balance Sheets for Malaysia also indicated that the per capita palm oil consumption approximates at 17 g/head/day which is probably the highest for palm oil in the world (Malaysian RNI, 2005). Therefore, it can be concluded that the association between IP-TFA level in foods and its daily intake must be considered, besides the level of IP-TFA in a particular food. Other food that showed noticeable amount of IP-TFA intake include chicken burger (0.07 g/d), French fries (0.05 g/d), full cream milk (0.02 g/d), chocolate bun (0.01 g/d), and ice cream (0.01 g/d).

In order to obtain total IP-TFA intake of subjects, IP-TFAs in all food eaten by subjects was total up for each respondent. Generally, for all subjects (n = 105), the range of TFA intake is 0.22 g/day-4.09 g/day. Three out of 105 subjects (3%) however were found to have exceptionally high IP-TFA intake at 1.07%, 2.24%, and 2.35% of total energy intake. The high IP-TFA intake in these subjects was related to high intake of fast foods (0.46 g/day-0.91 g/day), and semisolid fats and cooking oils (0.69 g/day-1.71 g/day). Among the fast foods, the IP-TFA intake of these subjects was high for nugget (0.46 g/day), French fries (0.63 g/day), chicken burger (0.84 g/day), and fried chicken (0.91 g/day). While for semisolid fats and cooking oils intake, high IP-TFA was from palm oil (0.69 g/day) and blended oil (1.71 g/day).

Table 2 shows the majority of subjects (97%, n = 102) had intakes ranging from 0.104 g/day to 3.02 g/day (0.07%-0.91% of total energy intake), with mean of 0.71 ± 0.42 g/day (0.399 ± 0.22%). Intake of IP-TFA of these subjects was largely contributed by intake of fast foods (0-0.20 g/day for nuggets, 0-0.27 g/day for French fries, 0-0.36 g/day for chicken burger, and 0-0.52 g/day for fried chicken), and semisolid fats and cooking oils (0-0.67 g/day for palm oil and 0-0.56 g/day for blended oils). It can be observed that the majority of the studied subjects had 0.06%-0.91% IP-TFA intake, still less than the recommended upper intake limit of 1% kcal of the diet for TFA (FAO/WHO, 2008). This however may increase with times, and require close monitoring and controlled of IP-TFA in foods.

When compared to intake of IP-TFA from other countries, the mean intake of 0.10-3.02 g/day (n = 102) can be considered low. IP-TFA intake of North America was reported at 3-4 g/day, while in Italy, Portugal, Greece and Spain, the daily intakes were 1.4-2.1 g/day. Greater values for Germany, Finland, Denmark, Sweden, France, United Kingdom, Belgium, Norway, Netherlands, and Iceland were reported (2.1–5.4 g/day) (Margaret and Schmidt, 2006).

Table 3 shows *trans* fatty acids in 100 gram food, mean TFA intake and the relationship between the score of frequency intake of foods, and the total IP-TFA intake of the subjects. A scatterplot (not shown) between frequency of intake and exposure to IP-TFA indicate a linear relationship exist where the higher the frequency of intake result to the larger contribution to IP-TFA intake of subjects. Besides that, exposure to IP-TFA also depends on the actual content of IP-TFA in a particular food.

According to the Spearman's rho, there were significant relationships ($p < 0.05$) between the frequency of intake and total IP-TFA intake in 4 of the 8 food groups studied; semisolid fats and cooking oils ($r_s[9] = 0.481$), fast foods ($r_s[19] = 0.384$,), fried foods($r_s[33] = 0.274$,) and baked products ($r_s[33] = 0.264$). For semisolid fats and cooking oils, palm oil was the major contributor to the total IP-TFA intake of subjects, following the amount available in the oil and its high frequency of intake. According to Tang (2002), crude palm oil is preliminarily free of *trans* fatty acids, but variability in deodorization process of the oil may cause isomerization of fatty acids in the refined products. Therefore the intake of food high in refined palm oil should be controlled and monitored. As for fast foods, fried chicken ($r_s[5] = 0.462$, $p < 0.05$), chicken nugget ($r_s[3] = 0.317$, $p < 0.05$), and French fries ($r_s[3] = 0.239$, $p < 0.05$), were moderate to lowly correlated with total TFA intake of subjects. This could be related to the use of oil in deep frying of food which can be repeatedly used by the fast food producers. Similarly, significant relationships were observed in 5 of the fried foods; banana fritter ($r_s[3]= 0.284$), fried yam ($r_s[3]= 0.212$), *keropok lekor* ($r_s[3]= 0.276$), chicken ball ($r_s[3]= 0.205$), and cuttlefish ball ($r_s[3]= 0.196$). The fried foods were collected from night market and street hawkers were also fried using oil that could be repeatedly used. Trans polyunsaturated fatty acids are present in the frying palm oil as a result of high heat treatment. Both linoleic and linolenic acids can undergo trans isomerization during frying (Romero *et al*., 2000). Generally, deep fried foods are more likely to have higher level of TFA (National Heart Foundation of Australia, 2009). In Malaysia, during the last decade, the demand for fast foods has increased tremendously following the 'westernization' of global eating habit (Ismail *et al*., 2002). Among the baked products, 2 type of foods showed significant relationships with subjects' total TFA intake, which are cream crackers ($r_s[4] = 0.239$), and whole grain bread ($r_s[2] = 0.245$). The actual amounts of IP-TFA in both foods are low; cream crackers (0.05 ± 0.02 g/100 g food) and whole grain bread (0.07 ± 0.01 g/100 g food), but the high frequency of intake of both cream crackers (once a week) and whole grain (2-3 times per month) contributed to IP-TFA in the diet. Based on the above discussion, it is reasonable to emphasize the importance of frequency of intake to IP-TFA in a diet.

Overall results of this study concluded that the major dietary sources of trans fats were contributed from semisolid fats and cooking oils, fast foods, fried foods, and selected baked products. Besides, low level of IP-TFA in food may not guarantee low exposure of IP-TFA in the diet as frequencies of intake also determine the exposure. Generally, the percentage of TFA intake for Malaysia is low (0.07%-0.91% of total calorie), but the figure may increase with times thus require close monitoring of IP-TFA level in foods. Future study is recommended to use a large sample size to give a better picture of IP-TFA in the Malaysian diet.

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Table 3. Total *trans* fatty acids content in 100 g food, mean TFA intake, and relationship between score of frequency intake and total IP-TFA intake of subjects

Food (N=136)	Serving Size[a]	Weight (g)	IP-TFA (g/100 g Food)	Range of IP-TFA (g/100 g Food)	Mean TFA Intake of Individual Food (g/day)[b] n=105	Score of Frequency Intake (Mean ± SD) n=105	r_s
Baked Products						2.11 ± 0.54	0.264*
Baked Products subgroups:							
Group 1: Biscuits						3.10 ± 1.26	0.228*
Cream Crackers	3 pcs	21	0.05 ± 0.02	0.01-0.05	5.45 ± 0.01	3.95 ± 2.10	0.239*
(chocolate)	3 pcs	29.4	0.01 ± 0.01		0.22 ± 0.00	2.26 ± 1.36	0.005
Group 2: Cakes						1.93 ± 0.62	0.105
Fruit	1 slice	116	0.18 ± 0.13		5.77 ± 0.01	1.76 ± 0.56	0.089
Swiss Roll	1 slice	10	0.01 ± 0.13	0.01-0.29	0.05 ± 0.05	1.82 ± 1.07	0.118
Butter	1 slice (medium)	72	0.26 ± 0.13		5.53 ± 0.02	1.60 ± 0.80	0.030
Chocolate	2 slices (small)	32	0.29 ± 0.13		4.26 ± 0.01	2.06 ± 1.00	0.043
Group 3: Doughnut						2.15 ± 0.83	0.030
Doughnut (Sugary)	1 pcs	54	0.02 ± 0.01	0.02-0.12	0.90 ± 0.00	2.19 ± 1.32	0.059
Doughnut (Cream)	1 pcs	84	0.12 ± 0.01		3.26 ± 0.00	1.82 ± 0.74	-0.020
Group 4: Pastries						2.13 ± 0.76	0.132
Croissant (plain)	1 pcs	50	0.04 ± 0.01	0.02-0.04	0.29 ± 0.00	1.25 ± 0.70	0.149
Curry Puff (chicken)	1 pcs	48	0.02 ± 0.00		1.24 ± 0.00	2.83 ± 1.60	-0.027
Group 5: Bread						2.08 ± 0.91	0.187
Whole Grain Bread	1 slice	30	0.07 ± 0.01	0.01-0.14	3.24 ± 0.01	1.86 ± 1.36	0.245*
Chocolate Bun	1 pcs	60	0.14 ± 0.14		12.4 ± 0.04	2.34 ± 1.65	0.124
Pizza (Chicken Flavor)	1 slice	94	0.01 ± 0.01		0.37 ± 0.00	2.02 ± 0.53	-0.007
Snacks						2.05 ± 0.78	0.054
Potato Chips	1 cup	15	0.26 ± 0.28	0.03-0.26	2.73 ± 0.01	2.26 ± 1.16	-0.024
Milk Chocolate	6 cubes	27	0.05 ± 0.05		1.49 ± 0.00	2.25 ± 1.31	-0.025
Chocolate Wafer	2 pcs	21	0.03 ± 0.05		0.19 ± 0.00	1.65 ± 0.90	0.119
Dairy Products						1.99 ± 0.91	0.135
Cheese	2 slices	32	0.06± 0.05		0.92 ± 0.01	1.60 ± 1.05	0.036
Yoghurt (Low Fat)	1 cup	129	ND	0-0.26	NA	2.09 ± 1.07	0.046
Fresh Milk	1 glass (360 ml)	250	0.01 ± 0.01		0.96 ± 0.00	1.80 ± 1.35	-0.064
Powder Milk Full Cream	4 dessert spoon heap	29	0.26 ± 0.11		21.4 ± 0.05	2.50 ± 2.31	0.308*
Powder Milk Low Fat	4 dessert spoon heap	32	ND		NA	2.21 ± 2.20	-0.049
Breakfast Cereals						1.89 ± 0.81	0.166
Flavored	1 cup	42	0.27 ± 0.11		8.45 ± 0.02	1.88 ± 1.46	0.116
Honey Flavored	1 cup	40	0.12 ± 0.11	0.06-0.45	2.60 ± 0.01	1.63 ± 1.32	-0.084
Corn Flakes	2 cup	40	0.06 ± 0.11		0.69 ± 0.00	1.51 ± 0.99	-0.165
3 in 1 Oat	1 packet	28	0.45 ± 0.21		19.9 ± 0.03	2.57 ± 1.98	0.014
Fast Foods						2.10 ± 0.66	0.384*
Fast Foods subgroups:							
Group 1: Deep Fried						2.61 ± 1.06	0.489*
Fried Chicken	1 pcs	120	0.76 ± 0.73	0.18-0.86	121.0 ± 0.19	2.90 ± 1.46	0.462*
Nugget	3 pcs	54	0.86 ± 0.97		34.1 ± 0.07	2.24 ± 1.21	0.317*
Fench Fries	1 cup (medium)	349	0.18 ± 0.16		54.0 ± 0.10	2.53 ± 1.12	0.239*
Group 2: Burgers						1.75 ± 0.54	0.252*
Beef Burger	1 pcs (medium)	125	0.08 ± 0.11		3.4 ± 0.00	1.89 ± 0.69	0.022
Chicken Burger	1 pcs (medium)	125	0.67 ± 0.25	0.04-0.67	66.5 ± 0.13	2.30 ± 1.15	0.190
Fish Burger	1 pcs (medium)	75	0.08 ± 0.11		0.018 ± 0.01	1.38 ± 0.68	0.135
Cheese Burger	1 pcs (medium)	114	0.04 ± 0.05		1.2 ± 0.01	1.41 ± 0.93	0.073
Semisolid Fats and Cooking Oils						2.15 ± 0.60	0.481*
Semisolid Fats and Cooking Oils subgroups:							
Group 1: Semisolid Fats						1.74 ± 0.78	0.147
Shortenings	1 tablespoon	12	2.5 ± 0.00	0.11-2.5	1.5 ± 0.00	1.14 ± 0.37	0.117
Mayonnaise	1 teaspoon, heap	7	0.11 ± 0.19		0.7 ± 0.00	2.30 ± 1.47	0.108
Group 2: Cooking Oils						2.30 ± 0.60	0.709*
Blended Oils	1 tablespoon	14	4.06 ± 1.99		25.8 ± 0.18	1.25 ± 1.03	0.133
Corn Oil	1 tablespoon	14	2.13 ± 1.99	0.79-5.79	12.6 ± 0.05	1.45 ± 1.18	0.334*
Olive Oil	1 tablespoon	14	0.79 ± 1.99		2.6 ± 0.01	1.26 ± 0.92	0.122
Palm Oil	1 tablespoon	13	1.79 ± 2.00		314 ± 0.25	6.43 ± 1.90	0.591*
Soy Oil	1 tablespoon	14	5.79 ± 1.99		16.2 ± 0.11	1.14 ± 0.84	0.189
Fried Foods						1.95 ± 0.61	0.274*
Fried Foods subgroups:							
Group 1: Fried Kuih						2.33 ± 0.83	0.377*
Banana Fritter	3 pcs	66	0.002 ± 0.00		2.4 ± 0.00	3.34 ± 1.55	0.284*
Keropok Lekor	3 pcs	42	0.01± 0.01	0.002-0.06	0.6 ± 0.00	2.93 ± 1.63	0.276*
Peneram	1 pcs (medium)	55	0.04 ± 0.04		0.4 ± 0.00	1.45 ± 0.64	-0.085
Cakoi	1 pcs (medium)	46	0.06 ± 0.09		1.4 ± 0.00	1.86 ± 1.18	0.003
Group 2: Fried Balls						1.53 ± 0.57	0.140
Fish Ball	10 pcs	54	0.02 ± 0.03		0.2 ± 0.00	1.65 ± 0.72	0.121
Crab Ball	6 pcs (2 sticks)	70	0.02± 0.03	0.003-0.03	0.2 ± 0.00	1.44 ± 0.52	0.168
Prawn Ball	6 pcs (2 sticks)	75	0.003 ± 0.00		0.03 ± 0.00	1.46 ± 0.54	0.156
Cuttlefish Ball	6 pcs (2 sticks)	70	0.03 ± 0.03		0.4 ± 0.00	1.50 ± 0.75	0.196*
Chicken Ball	6 pcs (2 sticks)	70	0.03 ± 0.05		0.7 ± 0.00	1.64 ± 0.88	0.205*
Miscellaneous						2.67 ± 0.91	0.147
Roti Canai	1 pcs	84	0.01 ± 0.00		1.2 ± 0.00	3.37 ± 1.48	0.142
Chappati	2 pcs	64	0.01 ± 0.00		0.06 ± 0.00	1.9 ± 1.43	-0.038
Dhosai	1 pcs	114	0.01 ± 0.00	0.01-0.15	0.06 ± 0.00	1.85 ± 1.37	-0.111
Sweetened Milk, Condensed	3 dessert spoon, level	27	0.03 ± 0.01		3.0 ± 0.01	3.50 ± 2.14	0.205*
Ice Cream Vanilla-Chocolate	1 stick	65	0.15 ± 0.148		11.6 ± 0.02	2.77 ± 1.35	0.042

[a]Serving size was based on medium serving of the particular food; [b]presented as (x 10^{-3}) formula; r_s = Spearman Rho Value; r_s^* indicate statistical significance $p < \alpha$ (Significant level was set at 0.05). Subjects (n=10)

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