Original Article

Trans Fatty Acid Levels in Foods and Intakes among Population Aged 3 Years and above in Beijing and Guangzhou Cities, China

LIU Ai Dong[1,2], LI Jian Wen[1,2], LIU Zhao Ping[1,2], ZHOU Ping Ping[1,2], MAO Wei Feng[1,2], LI Ning[1,2], and ZHANG Lei[1,2,#]

1. Key Laboratory of Food Safety Risk Assessment, Ministry of Health, Beijing 100021, China; 2. China National Center for Food Safety Risk Assessment, Beijing 100022, China

Abstract

Objective To understand the dietary intake levels of trans fatty acids (TFA) in a Chinese population and establish a basis for health risk assessment of trans fatty acids.

Methods The TFA contents data of 2613 food items and food consumption data of 10,533 people aged 3 years and above in two large cities in China were matched and a simple assessment method was used to estimate the distribution of dietary TFA intake.

Results The mean content of TFA was highest in margarine (1.68±0.83 g/100g), followed by chocolate and candy (0.89±2.68 g/100g), edible vegetable oils (0.86±0.82 g/100g), milk (0.83±1.56 g/100g), and bakery foods (0.41±0.91 g/100g). TFA intake accounted for 0.34%, 0.30%, 0.32%, and 0.29% of the total energy intake in the 3-6, 7-12, 13-17, and ≥18 year age groups, respectively. Of the populations studied, 0.42% demonstrated TFA intakes (as percentage of energy intake) greater than 1%. The main sources of dietary TFA intake were edible vegetable oils, milk, mutton, and beef, and baked foods, which accounted for 49.8%, 16.56%, 12.21%, and 8.87%, respectively.

Conclusion The current intake of TFA among people in two cities did not appear to be of major health concern regarding the threshold of TFA intake as the percentage of total energy recommended by the World Health Organization. Because most TFA were derived from industrially processed foods, the government should reinforce nutrition labeling and regulate food producers to further reduce TFA in food and to provide scientific instruction for consumers to make sound choices.

Key words: Trans fatty acid; Intake; Food sources; China

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INTRODUCTION

Trans fatty acids (TFA) is the general name of unsaturated fats with at least one double bond in the trans configuration[1]. TFA in food are usually derived from three main sources, including (i) partial catalytic hydrogenation of oils and fats, which is often used in industrial process; (ii) biotransformation by bacteria in the stomach of a ruminant animal, resulting in the natural presence of TFA in milk, milk products, and meat from these animals; and (iii) heat treatments such as commercial refinement and cooking (e.g., deep frying) at high temperatures[2]. Hydrogenation has been widely used in food manufacturing to facilitate the conversion of vegetable oils to solid or semi-solid products (e.g., margarines). Therefore, TFA may be present in various manufactured foods

[#]Correspondence should be addressed to ZHANG Lei, E-mail: zhanglei@cfsa.net.cn

Biographical note of the first author: LIU Ai Dong, Associate Professor, majoring in nutrition and food safety risk assessment.

to which partially hydrogenated oils or their products were added. Partially hydrogenated oils contain up to 30%-50% TFA, which may account for the presence of TFA in certain food categories and result in significant TFA intake in populations[3-4]. Substantial evidence indicates that the consumption of TFA is associated with coronary heart disease (CHD)[5-8], which may be related to increased serum levels of total cholesterol (TC) and low density lipoprotein cholesterol (LDL-C), and decreased high density lipoprotein cholesterol (HDL-C)[9-18]. It has been estimated that 72,000 cardiovascular disease-related deaths per year could be averted by a 1% reduction in industrially produced TFA intake[19]. In addition, some studies suggested that TFA intake is associated with the development of diabetes[6] and breast cancer[20]; however, these associations have not been confirmed by other studies[7-8,21]. Although the results varied, TFA are considered a general health risk factor. The World Health Organization (WHO) recommended that the TFA intake should be limited to less than 1% of the total energy intake[22]. Some European countries and the United States also provided similar recommendations of less than 1%[23], or less than 2%[24-26], or an intake as low as possible[27-28].

The attention paid to the intake and related adverse health effects of TFA[3-4] has resulted in a series of legislations to limit TFA contents in manufactured foods in many counties. Meanwhile, dietary guidelines and recommendations aimed at reducing TFA consumption have been established[26-28]. However, limited information is available regarding TFA intake and its subsequent health risks in a Chinese population. Lack of substantial data of TFA contents in ordinary industrial and natural food consumed by Chinese people was the key barrier to TFA risk assessment in this population. In addition, previous studies assessing the intake of TFA were usually limited by restricted food items[29] such as edible oil, bakery foods, and/or small TFA-containing food consumption survey data[30]. Therefore, previous reports were insufficient to illustrate the real status of intake of TFA in the Chinese population. To address this situation, the China National Food Safety Assessment Expert Committee initiated the assessment of dietary intake and risk assessment of trans fatty acid in the Chinese population as well as a special study of TFA in usual TFA-containing foods, and food consumption surveys in two large cities were conducted. In this study, we aimed to examine the current status of TFA in the food supply to establish a basis for an assessment of the risks to public health.

MATERIALS AND METHODS

TFA-Containing Food Consumption Survey

In 2011, to estimate the dietary intake of TFA, a specific consumption survey was conducted among populations aged 3 years and above in Beijing and Guangzhou, which are the biggest cities with large populations in northern and southern China, respectively. The multi-stage cluster sampling method and proportionate to population size sampling technique were applied to select a representative population from two cities. The information regarding the population size of all city districts and communities in each district were collected before conducting the sampling. Subsequently, four districts were sampled from each of the two cities, and six communities were selected from within each district. Finally, a total of 10,533 people in these communities were selected as participants. With written informed consent, they were interviewed by trained nutrition professionals at home from May to October 2011. For children aged 3-12 years, the parents or diet providers were permitted to assist them during the interview; the adult then signed the consent form for the child. Individual food consumption was assessed by using three consecutive 24-h food recalls, including the categories and amount of foods as well as their cooking methods. To consider daily variations in the food intake, the participants were interviewed on consecutive two weekdays and one weekend day. In addition, the food records and weighing were applied to collect family edible oil consumption data in the same 3 consecutive days as that of a 24-h recall, and the total edible oil consumed by the whole family during 3 interview days was calculated. Next, individual edible oil consumption was obtained by reallocating the total family oil consumption to each family member based on their eating times within the family and their individual dietary energy intake.

Digital food weighing scales (RCS-160, with an accuracy of 0.1 g) allocated by the Survey Quality Control group were used to facilitate food weighing in the household. Meanwhile, individual body weight was measured with an accuracy of 0.1 kg.

TFA Contents of Foods

The TFA content of foods used in this

assessment was derived from two sources. The primary data source was direct chemical analysis conducted by qualified laboratories in three authorized institutes (i.e., China Center for Disease Control and Prevention, National Food Quality Supervision and Inspection Center, and Beijing Nutrition Resources Institute) and two universities (i.e., Jiangnan University and Nanchang University). Food samples were collected from supermarkets in five cities located in different provinces in China. All the food samples were homogenized, frozen, and stored at -20 °C before being transported to qualified laboratories. The fats were extracted by the hydrolytic method (AOAC Official Method 996.06)[31] or the Soxhlet extraction method[32], and then the extracted fat residue was dissolved in chloroform and diethyl ether[31] or in sodium hydroxide (NaOH)-methanol (AOCS Official Method Ce 2-66)[33], then methylated to fatty acid methyl esters (FAMEs) using boron trifluoride in methanol according to AOAC 996.06 or the equivalent method[31,33]. The FAMEs were subsequently analyzed and TFA were quantitatively determined by capillary gas chromatography. Quality controls were conducted by using CP-Sil 88 (100 m × 0.25 mm × 0.2 μm) chromatographic column and fatty acid methyl ester mixed standards allocated uniformly as well as by the periodic determination of a quality control substance. In addition, a comparison of the results among the five laboratories was conducted to ensure the accuracy of the detection results. Finally, about 1681 TFA content data were obtained. Another data source was the dataset of 932 TFA-containing food items contributed by other research institutes, enterprises, and associations, which included edible oil, biscuits, cake, and potato chips. The mean TFA contents of each food category derived from two data sources were compared by the *t* test, and there were no statistical differences ($P<0.05$). A total of 2613 TFA content data was used in this assessment.

Assessment of TFA Intake

Fifteen food categories including 28 subgroups (e.g., milk, yogurt, fresh beef, fresh mutton, chocolate) were established on the basis of the 3-day food consumption survey results. Individual food consumption of each subgroup was matched with the TFA content data of the same food subgroup. Subsequently, the TFA intake from all the subgroups of foods was calculated as an individual intake of dietary TFA. Meanwhile, the quintiles of the TFA intake from the 50th to 97.5th in population were also calculated. The individual TFA intake was calculated as the percentage of total energy using the following formula:

$$E\% = \frac{DI \times 9}{DE} \times 100 \quad (1)$$

E% was the individual TFA intake as the percentage of total energy. *DI* was the individual TFA intake per day (g/day). *DE* was the individual total dietary energy intake (kcal). The energy transfer index of TFA was 9 kcal/g.

Statistical Analyses

Descriptive statistics including percentiles, means, and standard deviations were calculated for the TFA contents of different food categories, TFA intake, and TFA intake as the percentage of the total energy intake. One-way analysis of variance (ANOVA) was used to examine statistically significant differences in the TFA intake as the percentages of the total energy intake among age- and gender-specified groups. All statistical analyses were conducted using the Statistical Analysis Software (SAS) version 9.1.3 (SAS Institute Inc.). A value of $P<0.05$ was considered statistically significant.

RESULTS

TFA Contents of 15 Food Groups

TFA contents were determined in all of the 15 food categories. Margarine has the highest TFA content at 1.68 g/100g. The contents of chocolate and candy, edible vegetable oils, and bakery products were 0.89 g/100g, 0.86 g/100g, and 0.41 g/100g, respectively. Other food categories contained the contents of TFA from 0.35 g/100g to 0.09 g/100g (Table 1).

Estimation of TFA Intake in Absolute Amounts and as Percentage of Energy Intake among Participants

A total of 10,533 participants representing people aged 3 years and above, and living in two major cities in China, participated in this study. The participants were categorized into four age groups (e.g., 3-6 years, 7-12 years, 13-17 years, and ≥18 years) (Table 2).

The mean and median estimated intakes of TFA in the study population were 0.55 g/day and 0.46 g/day respectively; moreover, the 97.5th percentile of intake was 1.45 g/d (Table.3). In all age groups, male subjects had higher intake than female subjects

at both mean and high percentile (P97.5) levels. The range of TFA intake from the 50th (0.42-0.49 g/d) to 97.5th (1.23-1.51 g/d) quintile varied by approximately 2- to 3-fold in different age groups. Adolescents aged 13-17 years, particularly male adolescents, had the highest mean intake of TFA compared with other age groups. TFA as the percentage of the total energy intake of the population was 0.30% in general (Table 2). Approximately 97.5% of the population's intake of TFA as the percentage of energy is less than 0.72%. Similarly, there were 0.42% of the subjects who have taken more TFA as the percentage of the total energy than 1% (Figure 1).

Table 1. Contents of TFA in Food Categories[1]

Food	*n*	TFA (g/100g)		
		Mean[2]	Median	Max
Margarine	116	1.68±2.05	0.84	10.34
Chocolate &candy	135	0.89±2.68	0.16	15.60
Vegetable edible oil	451	0.86±0.82	0.65	4.68
Bakery food (biscuit, bread)	682	0.41±0.91	0.11	8.64
Condiments (pastries)	98	0.35±0.71	0.05	4.12
Deep-fried stick	42	0.31±0.65	0.13	3.64
Mutton &beef	92	0.30±0.43	0 .11	2.14
Solid beverages	115	0.25±0.54	0.07	3.42
Snacks	86	0.24±0.37	0.12	2.74
Puffing foods	224	0.16±0.62	0.04	7.01
Milk&yogurt	146	0.16±0.21	0.08	1.68
Poultry and products	53	0.16±0.29	0.07	1.86
Fast foods	274	0.11±0.29	0.04	3.92
Ice creams	99	0.09±0.10	0.05	0.53
Pork products	16	0.04±0.01	0.05	0.10

Note. [1]All of the 2613 food items are classified into 15 categories. [2]Data are means±SD of all food categories. TFA, trans fatty acid.

Table 2. TFA Intake and TFA as % energy of Participants in Beijing and Guangzhou Cities[1]

Age Group (years)	*n*	Trans Fatty Acid (g/d)						Trans Fatty Acid (% energy)					
		Mean[2]	P5	P50	P90	P95	P97.5	Mean[2]	P5	P50	P90	P95	P97.5
Males	5204	0.58±0.40	0.18	0.49	1.04	1.28	1.53	0.30±0.17	0.10	0.29	0.53	0.62	0.73
3-6	1008	0.51±0.29‡	0.19	0.43	0.85	1.06	1.23	0.34±0.17	0.14	0.32	0.56	0.66	0.80
7-12	1165	0.58±0.37§‡	0.22	0.5	1.00	1.23	1.44	0.32±0.18§‡	0.12	0.30	0.55	0.66	0.79
13-17	958	0.64±0.45§‡	0.21	0.52	1.16	1.43	1.82	0.31±0.17§	0.11	0.30	0.54	0.64	0.80
≥18	2073	0.59±0.44§‡	0.15	0.49	1.07	1.31	1.57	0.28±0.15§	0.09	0.26	0.49	0.58	0.65
Females	5329	0.52±0.36	0.17	0.44	0.93	1.17	1.39	0.30±0.16	0.10	0.28	0.53	0.62	0.72
3-6	942	0.47±0.25‡	0.20	0.42	0.77	0.93	1.24	0.33±0.16	0.14	0.33	0.55	0.67	0.75
7-12	1029	0.51±0.32§‡	0.21	0.43	0.90	1.08	1.32	0.29±0.17§	0.11	0.27	0.53	0.62	0.74
13-17	1007	0.57±0.40§‡	0.23	0.46	1.04	1.27	1.54	0.32±0.18§	0.11	0.29	0.56	0.68	0.80
≥18	2351	0.53±0.39§‡	0.14	0.44	0.94	1.24	1.46	0.29±0.15§	0.09	0.27	0.49	0.56	0.65
Total	10533	0.55±0.38	0.18	0.46	0.99	1.23	1.45	0.30±0.17	0.10	0.28	0.53	0.62	0.72
3-6	1950	0.49±0.27	0.19	0.43	0.82	0.99	1.23	0.34±0.17	0.14	0.33	0.56	0.67	0.79
7-12	2194	0.54±0.35†	0.21	0.47	0.96	1.16	1.41	0.30±0.17†	0.11	0.28	0.54	0.63	0.78
13-17	1965	0.61±0.42†	0.22	0.49	1.10	1.38	1.65	0.32±0.18†	0.11	0.30	0.55	0.66	0.80
≥18	4424	0.56±0.41†	0.14	0.46	1.02	1.28	1.51	0.29±0.15†	0.09	0.26	0.49	0.57	0.65

Note. [1]Values are means or percentiles. [2]Data are means±SD. TFA, trans fatty acid. §Comparison among different age but same gender group population. Others age group values were compared with that of 3-6 age group, $P<0.05$. ‡Comparison between different gender but same age group population, $P<0.05$. †Comparison among different age group population without consideration of gender, $P<0.05$.

Major Food Group Contributors to TFA Intake in Different Population Groups

An assessment was conducted to estimate the percentage contribution of different categories of food to the total TFA intake (Table 3). The major source of dietary TFA in the population of two cities was edible oils, accounting for approximately 49.81% of the total TFA intake, followed by milk and yogurt (16.56%), and mutton and beef (11.79%). Bakery foods contributed 8.87% to the total TFA intake, and approximately 12% of the TFA intake was derived

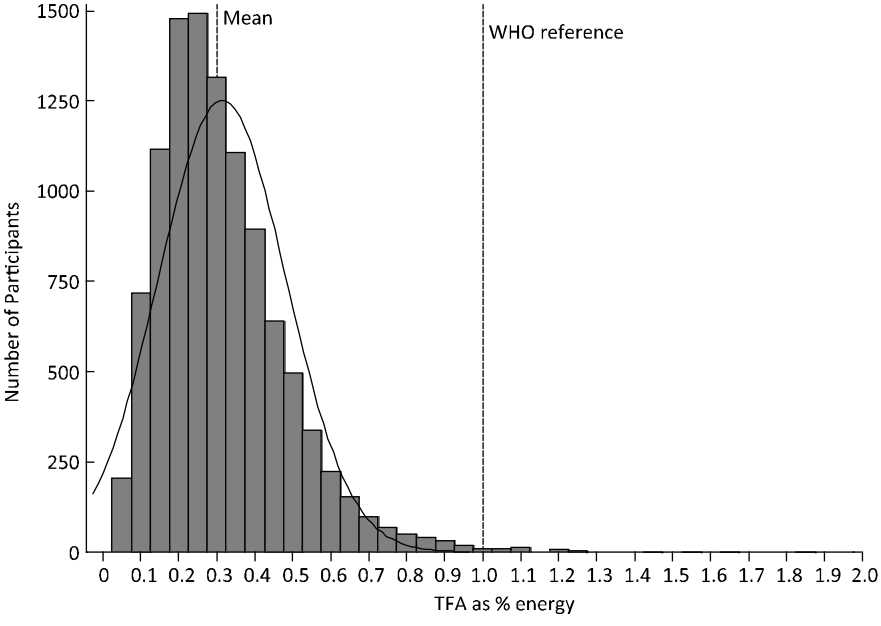

Figure 1. Distribution of population TFA intake as % of total energy. WHO, World Health Organization; TFA, trans fatty acid. *n*=10533 for all of the participants. 0.42% of participants intake TFA as % energy surpass World Health Organization reference.

Table 3. Contribution of Food Categories to TFA Intake among Participants in Beijing and Guangzhou Cities[1]

All, ≥3 Years		3-6 Years		7-12 Years		13-17 Years		≥18 Years	
Food Item[2]	%Total TFA	Food Item[2]	%Total TFA	Food Item[2]	%Total TFA	Food Item[2]	%Total TFA	Food Item[2]	%Total TFA
Edible oil	49.81	Edible oil	45.47	Edible oil	48.54	Edible oil	44.60	Edible oil	54.64
Milk&yogurt	16.56	Milk&yogurt	28.92	Milk&yogurt	18.20	Milk&yogurt	14.81	Mutton&beef	13.32
Mutton&beef	11.79	Bakery foods	12.10	Mutton&beef	12.02	Mutton&beef	12.58	Milk&yogurt	11.81
Bakery foods	8.87	Mutton&beef	6.59	Bakery foods	8.98	Bakery foods	9.11	Bakery foods	7.47
Fast foods	4.19	Fast foods	1.66	Fast foods	4.55	Fast foods	7.79	Deep-fried stick	3.40
Deep-fried stick	2.36	Chocolate&Cand	1.40	Deep-fried stick	1.72	Deep-fried stick	2.45	Fast foods	3.25
Snacks	1.51	Ice creams	0.81	Chocolate&Can	1.27	Chocolate&Cand	1.93	Snacks	2.13
Chocolate&Cand	1.19	Puffing foods	0.69	Ice creams	1.18	Snacks	1.74	Poultry products	0.75
Ice creams	0.85	Snacks	0.53	Snacks	0.78	Ice creams	1.23	Chocolate&Candy	0.71
Poultry products	0.68	Poultry products	0.44	Poultry products	0.6	Poultry products	0.83	Condiments	0.67
Margarine	0.48	Deep-fried stick	0.41	Margarine	0.55	Solid beverage	0.83	Ice creams	0.52
Condiments	0.44	Margarine	0.39	Pork products	0.49	Puffing foods	0.75	Margarine	0.5
Puffing foods	0.43	Condiments	0.25	Puffing foods	0.44	Pork products	0.57	Pork products	0.39
Pork products	0.42	Pork products	0.21	Solid beverage	0.41	Margarine	0.45	Solid beverage	0.29
Solid beverage	0.42	Solid beverage	0.13	Condiments	0.25	Condiments	0.33	Puffing foods	0.16

Note. [1] *n*=10533. 1950, 2194, 1965, and 4424 for 3-6, 7-12, 13-17, and ≥18 years old groups participants respectively. [2] Food categories are sorted by decrease of their contribution of total TFA. TFA, trans fatty acid.

from other foods including fast foods, fried noodle, snacks, chocolate, and candy. In relation to TFA-containing food sources, the contributions from manufactured and natural foods were 71.17% and 28.83%, respectively.

DISCUSSION

The mean TFA intake of children and adults above 3 years of age in Beijing and Guangzhou cities was 0.49-0.61 g/d, thus accounting for 0.29%-0.34% of their daily energy intake in different age groups. These were all less than half of the limit of 1% recommended by the WHO[19]. Furthermore, the 97.5th quintiles of TFA intake as the percentage of energy, which varied 0.65%-0.80% across age groups, were still under this level. In contrast, the mean TFA intakes (1.2 to 7.8 g/d) and TFA intake as the percentage of the total energy of people in Japan and some western counties were 3- to 14-fold and 2- to 14-fold, respectively, greater than that found in our study[3-4,35-40]. Moreover, our results indicated that people whose TFA intake as the percentage of the total energy was over 1% only accounted for 0.42% of the whole population. These results indicated that the intake of dietary TFA in the Chinese population generally remained at a relatively lower level when compared to that of people among other counties and the WHO's reference. Chinese traditional dietary patterns, which primarily consist of more family-produced foods (cereals, vegetables, etc.) and fewer industrial TFA-containing foods, may contribute to this rather low level of TFA intake. However, these results do not necessary indicate that the TFA intake in China is less problematic than that in other countries, because the reasons behind this discrepancy have not been fully elucidated. One potential cause could be the diversity of food categories and risk assessment methods; however, the difference may be due to diverse databases of TFA contents and food consumption adopted by different countries[41].

We also found age-specific intakes of TFA in our study. Adolescents aged 13-17 years have the greatest mean TFA intake as g/d, as well as the largest variation of the intake of TFA from median to 97.5$^{\#}$ quintile, both of which were observed in other studies as well[42-43]. This could be partly explained by studies suggesting that adolescents, particularly middle school students, were the major consumers of high TFA-containing foods such as pastries, chocolate, milk, and milk products during the past 10 years in China[44]. Evidence suggested that people of this age group are more likely to be attracted by new manufactured food advertisements and altered their food choices[45], subsequently, this could contribute to relative higher consumption of TFA contained foods. Therefore, individuals of this age group may potentially put themselves at high risk from the intake of TFA.

Our study indicated that edible vegetable oil, milk, and fresh livestock meat contributed nearly to 3/4th of the total dietary TFA intake. Similarly, New Zealanders also consumed large amounts of fats and oil (30%-44%), dairy products (19%-21%), and cereal and cereal-based products (9%-10%), which are the top three contributors to their intake of TFA. However, among the U.S. population, the major TFA sources are bakery foods such as cakes, cookies, pies, and pastries[42], as well as confectionaries[41]. In our study, edible vegetable oil was the largest contributor and accounted for almost half of the total dietary TFA among different population groups studied. The significant proportion of edible oil TFA is linked to the high contents of TFA in partially hydrogenated edible oils and could be attributed to the widespread usage of edible oil in traditional cooking practices, in which edible oils have always been widely used. According to the Chinese Dietary Recommendation (2007), no more than 25 g/d edible oil is recommended for Chinese residents. However, the Chinese Nutrition and Health Survey in 2002 and our TFA-Containing Food Consumption Survey suggested that the mean consumption of vegetable oils were 31.3 g/d and 30.9 g/d, respectively[46]. Our results indicate that considerable improvement in decreasing the TFA intake from industrially produced edible oils can be achieved by decreasing their consumption. Milk was the second largest contributor to the TFA intake for teenagers younger than 18 years old. Milk is also the second largest source of TFA for children, particularly young children aged 3-6 years, in whose diets milk accounted for 29.3% of the total TFA intake. Among the adult population, ruminant meat was the second largest contributor, with 13.32% of the dietary TFA arising from meat consumption. It is important to note that the contributions from milk and ruminant meat do not relate to their high TFA contents but rather to how the amounts of these products are being consumed[43,46]. In addition, although margarine and butter, as well as chocolate and candy, contain large amounts of TFA, these foods contribute to only a small proportion of the

total TFA as compared to the studies in western countries, primarily because of the low consumption of such food items in the typical Chinese diet.

Because of the differences in isomer distributions between TFA that originate from industrially produced as opposed to ruminant foods, there has been debate on whether they have similar harmful effects, particularly related to the risk of CHD. Some results from experiments using animal models have indicated that industrial TFA can induce pro-inflammatory responses and atherogenic lipoprotein profiles[47-48]; however, other studies suggested that the TFA vaccenic acid limits inflammation in obese rats[49] and improves atherogenic lipid profiles[50]. Two recent system reviews reported that industrial TFA may be positively related with the risk of CHD, whereas ruminant TFA is not[51-52]. In addition, ruminant TFA have no adverse effects on the key cardiovascular risk factors such as TC:HDL-C and LDL-C:HDL-C ratios, at least at the intake levels up to 4.19% of the daily energy intake[52]. While the effects of ruminant TFA on the risk of CHD remain unclear, the deleterious effects of industrial TFA are generally accepted. In our study, over 70% of the total intake of dietary TFA was derived from industrial foods, and this figure increased with the growth of the age among participants. In contrast, this proportion ranged from 23% to 74% in other countries[3,36,39-40,53]. Obviously, although the Chinese intake of dietary TFA remained at relatively low levels, we have a high proportion of industrial TFA, which can increase health risks. Another important point that must be emphasized was that many of these TFA-containing foods also provided a large quantity of SFA and calories[42], all of which may increase the health risk of chronic diseases such as obesity, hypertension, and hyperlipidemia. Thus, reducing these foods would not only decrease TFA but also SFA and excess dietary energy.

Legislative strategies may be an effective approach for facilitating control over TFA intake. A legislation on the limits of the TFA content in food in Denmark and ban on the use of fats and oils containing TFA in some US states and cities for reducing dietary TFA intake has been proven to be successful[54-56]. Nutrition labeling was enacted in many countries, including China, to display the information on the TFA content of the packaged food items. However, with respect to those foods produced in small food workshops, fast food stalls, or other facilities, this regulation would not be effective because the foods usually have no package or labeling information[43].

A limitation of this study is that although we sampled 2986 foods, they may not cover all of the TFA-containing foods consumed daily. Another limitation is that some foods consumed by participants lack TFA content values, and we integrated these foods into other food subgroups before the mean consumption calculation. Therefore, this study may have statistically overestimated the TFA intake. Finally, we assumed that participants sampled from two modern cities, Beijing and Guangzhou, represented a generalized profile of food consumers in China, but this may not be strictly true in real situations because of different consumption habits in various areas in China. However, despite these limitations, to the best of our knowledge, this study is the first authoritative assessment of TFA intake in China and provides useful information on the TFA intake and food sources in large cities in China. In addition, the results of this study offered scientific evidence for the modification of the present legislation or ban on TFA in food, as well as the dietary guideline on selecting food wisely.

In conclusion, our study indicated that there was a relatively low concern of health risk among residents in large cities when their dietary TFA intake and TFA as the percentage of the total energy was compared with other counties and the WHO reference. However, the high proportion of TFA from industrial food sources remains a concern. Thus, further concerted efforts, including production technology improvements, nutritional labeling reinforcement, and health knowledge education should be encouraged to further reduce the TFA intake in Chinese dietary patterns.

AUTHOR CONTRIBUTIONS

LI Ning and LIU Zhao Ping designed the research; LIU Ai Dong, LI Jian Wen, ZHANG Lei, ZHOU Ping Ping, and MAO Wei Feng conducted the research; LIU Ai Dong performed statistical analysis and wrote the paper; LI Ning revised the manuscript, and ZHANG Lei had primary responsibility for final content. All authors have read and approved the final manuscript.

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