

Risk Assessment Studies

Report No. 72

**Industrially-Produced Trans Fatty Acids Content
in Prepackaged and Non-Prepackaged Food**

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Centre for Food Safety
Food and Environmental Hygiene Department
The Government of the Hong Kong Special Administrative Region

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Executive Summary

Increased intake of trans fatty acids (TFAs) is associated with increased risk of coronary heart disease. TFAs can be produced industrially or at lower levels naturally found in ruminant fats. Industrially-produced trans fatty acids (IP-TFAs) are the predominant source of dietary TFAs and WHO has therefore launched a REPLACE action package aiming to eliminate IP-TFAs from the global food supply by 2023. To this end, Hong Kong has introduced a ban on partially hydrogenated oils (PHOs) (the main source of IP-TFAs) by specifying PHO as a prohibited substance in food under the Harmful Substances in Food Regulation. The relevant provisions will come into force on 1st December 2023.

Before the new requirement comes into effect, the Centre for Food Safety conducted this risk assessment study on IP-TFAs content in 149 prepackaged and non-prepackaged food items from five food categories, namely fats and oils, margarines and spreads, prepackaged foods, ready-to-eat foods and miscellaneous local specialities. Results revealed that out of the 149 food samples, the levels of IP-TFA in 143 samples (96%), were below the WHO guidance level of 2 g per 100 g total fat; only six out of the 149 samples (4%) contained IP-TFA greater than the WHO guidance level of 2 g IP-TFAs /100 g of total fat, ranging from 2.2 to 6.7 g/ 100g of total fat. These samples were egg tart, Chinese dough sticks, puff pastry of soup, fried soybean roll and pickled vegetables sauce for fish soup base.

We further looked into the six cases with IP-TFA greater than 2 g /100 g of total fat with a view to consider if the samples contained PHOs by assessing the trans fatty acids isomers profiles of the food samples, level of IP-TFAs detected and information from food manufacturers/suppliers. Three (2%) samples were compatible with containing PHOs. Relevant food outlets have adopted the recommendations from CFS and reformulated their recipes to reduce IP-TFA level to under the WHO guidance level of 2 g IP-TFAs/100 g of total fat.

Comparing the result of this study with that of 2019 of similar coverage, there has been a significant decrease in percentage of food samples with IP-TFAs > 2g/100 g fat and the IP-TPAs levels in the same types of food items have decreased.

From 1 December 2023 onwards, the trade has to ensure that their food products do not contain PHOs.

1. Objectives

The objectives of this risk assessment study are:

- i) to establish a baseline of industrially-produced trans fatty acids (IP-TFAs) content in prepackaged and non-prepackaged foods in Hong Kong for future comparison; and
- ii) to arouse public and trade attention on IP-TFAs and the importance of replacing partially hydrogenated oils (PHOs) with healthier fats/oils.

2. Background

2. Trans fatty acids (TFAs) in food can be divided into two main groups, IP-TFAs and naturally occurring TFAs from ruminant animals. Partially hydrogenated oils (PHOs) are the main source of IP-TFAs.¹ PHOs are edible fats and oils (vegetable oils in general) which have undergone the industrial process of hydrogenation.² The production process of PHOs can however result in a considerable amount of IP-TFAs ranging from 10% to 60% of the oil.^{2,3} PHOs are solid at room temperature and can prolong the shelf life of food products. They are mainly used for fried and baked foods.³ Besides PHOs, a small amount of IP-TFAs can be inadvertently created during industrial refinement of vegetable oils, and when fats/oils are heated and reheated, such as during frying and baking at high temperatures.¹ IP-TFAs from oil refinement cannot be fully eliminated but the content does not usually exceed 2%.⁴ Heating and frying may increase TFAs concentration by approximately 3%.³

3. According to the World Health Organization (WHO), trans fat intake is responsible for approximately 500,000 premature deaths from coronary heart disease each year around the world.⁵ In Hong Kong, heart diseases are the third leading causes of death in 2020, and coronary heart disease (CHD) constitutes a major portion of the mortality.^{6,7} Dietary TFAs increase low-density lipoprotein (“bad” cholesterol) and decreased high-density lipoprotein (“good” cholesterol) levels, both associated with increased risk of coronary heart disease.⁸ WHO recommends limiting TFAs intake to less than 1% of total energy, which equals to less than 2.2 g/day in a 2000-calorie diet.⁹

4. To meet the WHO's goal of eliminating IP-TFAs from the global food supply by

2023, and in line with one of the key measures under “Towards 2025: Strategy and Action Plan to Prevent and Control Non-Communicable Disease” in Hong Kong announced by the Government in 2018,¹⁰ Hong Kong has introduced a ban on the use of partially hydrogenated oils (PHOs) (the main source of IP-TFAs) by specifying PHO as a prohibited substance in food under the Harmful Substances in Food Regulation. The relevant provisions will come into force on 1 December 2023.¹¹

5. The Centre for Food Safety (CFS) has conducted a number of studies of TFA in foods since 2007.^{12,13,14} These studies covered mainly locally manufactured non-prepackaged baked and fried foods available at consumer level. The 2012 TFA study showed a decrease in TFA content in foods when compare to that of 2008, but the study conducted in 2019 reflected no obvious downward trend of IP-TFA/total fat (%) content compared to that of 2012.¹³ To prepare for the upcoming prohibition of PHOs in the food supply, this study, with a focus on food items potentially contain PHOs, covered a wide range of food products including ghee and shortenings, margarine and spreads, fried or baked prepackaged and ready-to-eat foods, as well as local specialities.

3. Scope of Study

6. This study examined five categories (25 subcategories) of foods which could possibly contain IP-TFAs, four of which included subcategories of food samples suggested by the WHO’s “Global protocol for measuring fatty acid profiles of foods, with emphasis on monitoring trans-fatty acids originating from partially hydrogenated oils” (“the WHO Global protocol”).¹⁵ In addition to the four categories suggested in the WHO Global protocol, a fifth category was added to cover miscellaneous local specialities suspected to contain IP-TFAs, based on their ingredients (i.e. oil-based) and/or preparing methods (i.e. fried and baked foods). The five categories and 25 subcategories are listed below:

I. Fats and oils

- | | |
|---------|----------------|
| 1. Ghee | 2. Shortenings |
|---------|----------------|

II. Margarines and spreads from grocery stores

- | | |
|---------------|------------------|
| 3. Margarines | 4. Other spreads |
|---------------|------------------|

III. Prepackaged foods from grocery stores

- | | |
|----------------------------|-----------------------------|
| 5. Biscuits | 6. Breads |
| 7. Cookies | 8. Potato chips/other chips |
| 9. Sliced cakes/mini cakes | 10. Pizzas (frozen) |

11. Croissants/puff pastries (frozen)
- IV. **Ready-to-eat foods** from food outlets
- | | |
|---|--|
| 12. Pound cakes /Swiss rolls | 13. Chinese/sweet pastries |
| 14. Eggrolls/phoenix rolls | 15. Croissants/Danish/puffs |
| 16. Cocktail buns/cream-filled buns | 17. Sweet pies/tarts |
| 18. Meat pies | 19. Puff pastries of soups |
| 20. French fries /hash browns | 21. Fried doughnuts/Ox-tongue pastries
/Chinese dough sticks (deep-fried) |
| 22. Samosas /meat stuffed pastry
rolls | |
- V. **Miscellaneous**
- | | |
|---|-----------------------------------|
| 23. Fried bean curds/fried bean curd
sticks/ fried soybean rolls | 24. Hotpot soup bases (oil-based) |
| 25. Oil-based sauces | |

4. Methodology and Laboratory Analysis

Sampling

7. This study analysed 149 samples including 94 prepackaged foods and 55 non-prepackaged foods. Samples were collected between 22 November and 31 December 2021.

8. For prepackaged samples under categories I, II, III and V, the 6 brands per each subcategory were collected from two or more different major supermarkets and convenience stores. Five instead of six shortenings samples were purchased due to the lack of brand variety in the local market. The 6 food items per subcategory from category IV were collected from six popular food outlets. Owing to low market availability or take-away restriction on certain food items (e.g. soup with puff pastry), some flexibility was allowed but no more than two food items should be collected from the same food outlet/chained store/ brand.

9. To include foods more likely to contain IP-TFAs, food items previously found to contain considerable levels of TFAs or IP-TFAs or with higher local consumption rate have been accorded priority in the sampling plan. References included previous studies¹², the Nutrient Information Inquiry System (NIIS)¹⁶ of CFS and the Second Hong Kong population-based food consumption survey.¹⁷

Lab testing and IP-TFAs estimation

10. There is no direct chemical testing method for the level of IP-TFAs in food. The basic principle to estimate IP-TFAs content is by subtracting the amount of ruminant fats from that of total TFA. In this study, the IP-TFAs content in food samples were estimated using the EU approach, through a decision making algorithm with reference to the “Analytical approach for checking the compliance of fats and oils against the regulated limit for industrial trans fatty acids (Commission Regulation (EU) 2019/649)”¹⁸ published by the Joint Research Centre, the European Commission’s science and knowledge service (“The JRC Report”). Chemical tests were conducted by the Food Research Laboratory (FRL) of the CFS and the fatty acids profiles of all food samples were analyzed. In house method with reference to AOAC 996.06 was used for the determination of TFA content. The amounts (g/100 g fat) of total TFA (sum of TFA with at least one non-conjugated carbon-carbon double bond), butyric acid (BA, from milk fat) and conjugated linoleic acid (CLA (*c9, t11-18:2*), from ruminant body fat) were then used to estimate IP-TFAs in food items. The relevant limit of detection (LOD) and limit of quantitation (LOQ) are listed in **Annex**.

11. Depends on the fatty acid profiles of individual sample, IP-TFAs in a food sample were estimated by Equation 1, 2 or 3:

- i. When the food item contained detectable amount of BA (or both BA and CLA), *Equation 1* was applied to estimate the amount of IP-TFAs.

$$\text{Equation 1: } IP-TFA = total\ TFA - 1.76 * BA$$

- ii. When the food item contained detectable amount of CLA but not BA, *Equation 2* was applied to estimate the amount of IP-TFAs.

$$\text{Equation 2: } IP-TFA = total\ TFA - 6.67 * CLA$$

- iii. If the food item contained no detectable amount of BA and CLA, then *Equation 3* was applied to calculate the amount of IP-TFAs.

$$\text{Equation 3: } IP-TFA = total\ TFA$$

5. Results and Discussion

5.1 IP-TFA content in food items

12. In this study, out of 149 samples, 6 food items (4%) contained greater than the WHO guidance level of 2 g IP-TFA per 100 g of total fat, 90 food items (60%) contained > 0 - 2 g IP-TFA per 100 g of total fat and 53 food items (36%) contained no detectable amount of IP-TFA (see **Figure 1**). For those food items with IP-TFAs greater than the WHO guidance level of 2 g/100 g total fat, four of them were under the “Ready-to-eat” category and two under the “Miscellaneous” category.

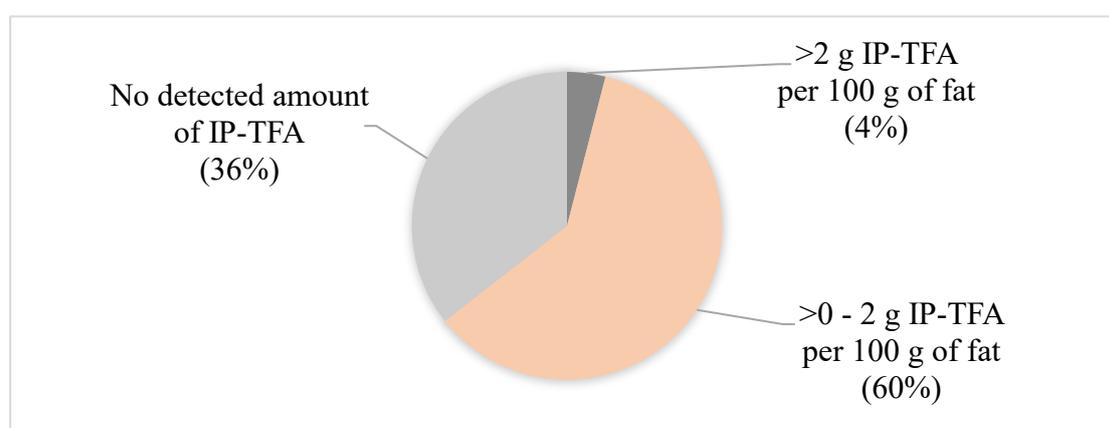


Figure 1: Proportions of IP-TFA levels in food samples

13. Distribution of IP-TFA mean content of the five food categories is presented in **Figure 2**, details of IP-TFAs mean value and range of values per subcategory can be found in **Table 1**. Among the 25 subcategories, only the “puff pastries of soups” subcategory has mean value going over 2 g IP-TFA per 100 g of total fat.

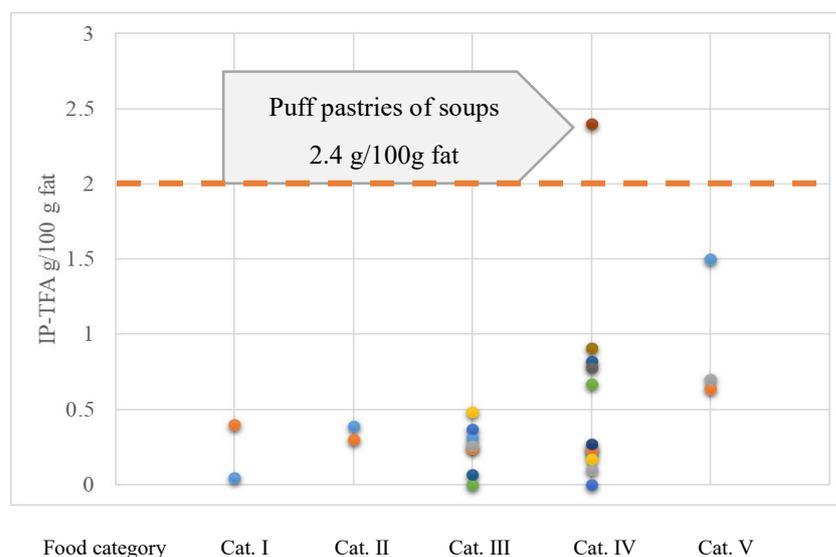


Figure 2: Distribution of IP-TFA mean levels in the five food categories

Table 1: Levels of total fat, saturated fat, TFA and IP-TFA in food samples

Category	Subcategory [#]	Mean Total fat [^] [Range of values] (g/100 g food)	Mean Saturated fat [^] [Range of values] (g/100 g food)	Mean TFA [^] [Range of values] (g/100 g fat)	Mean IP-TFA ^{^^} [Range of values] (g/100 g fat)
I. Fats and oils	1. Ghee	100 [99-100]	63 [52-76]	0.44 [0.15-0.80]	0.048 [0-0.19]
	2. Shortenings	100 [99-100]	41 [27-55]	0.47 [0.11-0.66]	0.40 [0.057-0.63]
II. Margarines and spreads	3. Margarines	70 [59-81]	27 [9.0-74]	0.49 [0.30-0.72]	0.39 [0-0.68]
	4. Other spreads	50 [34-71]	12 [4.5-33]	0.32 [0.070-1.1]	0.30 [0.070-1.1]
III. Prepackaged foods	5. Biscuits	27 [14-42]	14 [6.5-23]	0.52 [0.23-1.1]	0.31 [0-0.52]
	6. Breads	6.7 [1.3-13]	1.9 [0.24-4.4]	0.34 [0-0.94]	0.24 [0-0.61]
	7. Cookies	28 [17-42]	13 [6.8 -17]	1.3 [0.45-3.1]	0.26 [0-1.2]
	8. Potato chips /other chips	28 [24-32]	9.2 [2.0-27]	0.49 [0.30-0.74]	0.48 [0.30-0.74]
	9. Sliced cakes /mini cakes	20 [15-26]	9.2 [3-15]	1.2 [0.51-2.3]	0.37 [0-1.2]
	10. Pizzas (frozen)	9.3 [6.3-12]	3.5 [2.4-5]	0.93 [0.76-1.2]	0 [0]
	11. Croissants /Puff pastries (Frozen)	21 [16-24]	11 [9.0-13]	1.2 [0.41-1.6]	0.068 [0-0.41]
IV. Ready-to-eat foods (Baked foods)	12. Pound cakes /Swiss rolls	24 [19-28]	9.5 [6.1-13]	1.2 [0.64-2.0]	0.22 [0-0.64]
	13. Chinese/ Sweet Pastries	23 [16-38]	9.5 [4-20]	1.0 [0.29-2.3]	0.23 [0-0.48]
	14. Eggrolls/ Phoenix rolls	31 [30-31]	16 [14-21]	1.4 [0.28-2.9]	0.10 [0-0.32]
	15. Croissants/ Danish/ Puffs	24 [20-27]	13 [11-15]	1.1 [0.34-2.1]	0.17 [0-0.39]
	16. Cocktail buns/ Cream-filled buns	22 [19-25]	13 [10-15]	1.4 [0.81-2.1]	0 [0]
	17. Sweet pies/ tarts	16 [9.7-27]	7.9 [5.3-17]	0.97 [0.42-2.3]	0.67 [0-2.2]
	18. Meat Pies	22 [18-24]	8.4 [7.1-10]	1.0 [0.48-2.2]	0.82 [0-2.0]
	19. Puff pastries of soups (pastry)	25 [22-28]	13 [9.5-15]	2.5 [0.21-6.7]	2.4 [0.14-6.7]
IV. Ready-to-eat foods	20. French fries /hash browns	20 [10-35]	4.4 [1.6-13]	0.78 [0.32-1.2]	0.78 [0.32-1.2]

Category	Subcategory [#]	Mean Total fat [^] [Range of values] (g/100 g food)	Mean Saturated fat [^] [Range of values] (g/100 g food)	Mean TFA [^] [Range of values] (g/100 g fat)	Mean IP-TFA ^{^^} [Range of values] (g/100 g fat)
(Fried foods)	21. Fried Doughnuts/ Ox-Tongue Pastries /Chinese dough sticks (deep-fried)	17 [11-25]	4.4 [0.97-9.7]	1.0 [0.19-2.6]	0.91 [0.10-2.6]
IV. Ready-to-eat foods (Fried/baked foods)	22. Samosas /Meat stuffed pastry rolls	23 [16-32]	12 [6.9-17]	0.49 [0.40-0.57]	0.27 [0-0.53]
V. Miscellaneous (Fried foods)	23. Fried bean curds/Fried bean curd sticks/ Fried soybean rolls	81 [67-86]	15 [6.2-23]	1.5 [0.81-3.1]	1.5 [0.81-3.1]
V. Miscellaneous (Semi-liquid oil-based foods)	24. Hotpot soup bases (oil-based)	7.7 [0-32]	1.3 [0-4.9]	0.64 [0-2.2]	0.64 [0-2.2]
	25. Oil-based Sauces	26 [13-43]	3.5 [0.94-6.7]	0.73 [0.34-1.5]	0.70 [0.25-1.5]

Remarks:

[^] “Zero” fat or TFA means the fat or TFA amount in food sample were below the detection limits.

^{^^} “Zero” IP-TFA means either the IP-TFAs amount in food sample were less than the detection limits or a replacement of IP-TFAs amount in negative values after deduction of ruminant fats.

[#] Six samples were collected per subcategory except shortenings. Five samples were collected for shortenings due to lack of brand variety in local market.

5.2 Assessment on food items with IP-TFA greater than 2 g/100 g fat

14. Since small amount (usually less than 2%) of IP-TFAs can be produced in the manufacturing processes of refined oils and fully hydrogenated oils,⁴ therefore evaluating foods samples with IP-TFAs greater than the WHO guidance level of 2 g/100 g fat could act as a pointer on the use of PHOs as a primary ingredient.¹⁹ Based on the aforesaid assumption, food items with IP-TFAs greater than the WHO guidance level of 2 g/100 g fat were further investigated to find out the possibility of including PHOs as ingredients in this study.

Table 2: Food items with IP-TFA greater than 2 g/100 g fat (WHO guidance level)

No	Subcategory	Sample description	Type of oil use*	Major trans isomers	IP-TFA (g/100g fat)
IV. Ready-to-eat foods					
1.	Sweet pies/tarts	Egg Tart	Tart pastry: margarine	C18:1	2.2
2.	Fried Doughnuts/Ox-Tongue Pastries /Chinese dough sticks (deep-fried)	Chinese dough sticks	Frying oil: refined soybean oil	C18:2 & C18:3	2.6
3.	Puff pastries of soups	Puff pastry of mushroom soup	Pastry: margarine (vegetable oils)	C18:1	6.5^ Pastry
4.	Puff pastries of soups	Puff pastry of borsch	Pastry: margarine (vegetable oils)	C18:1	6.7^ Pastry
V. Miscellaneous (local specialities)					
5.	Fried bean curds/Fried bean curd sticks/ Fried soybean rolls	Fried soybean roll	A blend of non-hydrogenated rapeseed oil, soybean oil and olive oil	C18:2 & C18:3	3.1
6.	Hotpot soup bases (oil-based)	Pickled Vegetables Sauce for fish soup	Non-hydrogenated soybean oil	C18:2 & C18:3	2.2
*Information provided by food outlets or suppliers ^Food item no. 3 and 4 were collected from the same food outlet and the pastries were from the same source upon further verification.					

15. The JRC report stated that trans fatty acids in physically refined vegetable oils comprise mostly trans isomers of linoleic (C18:2) and linolenic acid (C18:3), while those in PHOs comprise mostly trans isomers of oleic acid (C18:1).¹⁸ Since sample 1

(Egg tart), sample 3 (puff pastry of mushroom soup) and sample 4 (puff pastry of borsch) contained mostly trans isomers of oleic acid (C18:1), they had a higher chance of containing PHOs (see **Table 2**). While for items 2 (Chinese dough sticks), 5 (Fried soybean roll) and 6 (Pickled Vegetables Sauce for fish soup), they contained mostly trans isomers of linoleic (C18:2) and linolenic acid (C18:3). Hence, the IP-TFAs in these items were more likely related to the use of refined and/or reheated oils.

16. To investigate the possibility of including PHOs as ingredients, the relevant food outlets and suppliers were interviewed and additional samples of those ready-to-eat food items were collected for further analysis. Information collected from the food outlets/suppliers and chemical test results of follow-up samples supported the initial inference made in para. 15. CFS strongly recommended the representatives of the relevant food outlets to reformulate their food products. IP-TFAs results of the further follow-up samples of egg tart and puff pastry of soup showed that the food outlets have successfully reduced IP-TFAs content in the reformulated samples to below 2 g/100 g fat. Therefore, PHOs should not be a major ingredient in the concerned food samples.

5.3 Comparison with previous studies

17. CFS has studied TFAs in foods since 2007 and two previous studies (2019 and 2020) have included the analysis of IP-TFAs content. The 2019 RA study examined IP-TFAs in non-prepackaged local foods and the 2020 RA study focused on IP-TFAs in non-prepackaged cakes available in local market. Comparing the percentage of samples with IP-TFAs > 2 g/100 g fat of current study with that of 2019, which likewise covered a variety of local foods, a substantial decrease from 25% to 4% is observed (see **Table 3**). If just comparing the results of non-prepackaged foods, the percentage of samples with IP-TFAs > 2g/100g lowered to 7%. This indicates the trade have made effort to reduce IP-TFAs level in the food supply.

Table 3: Percentage of food samples with IP-TFA >2 g/100 g fat in 2019 and this risk assessment studies

Risk Assessment Study	Year	Percentage of food samples with IP-TFA > 2 g/100 g fat
Industrially-produced Trans Fatty Acids Content in Local Foods	2019	25%
Industrially-Produced Trans Fatty Acids Content in Prepackaged and Non-Prepackaged Food (This study)	2022	4% (all samples), (7% non-prepackaged food)

18. When looking into IP-TFAs levels of individual subcategory, it is noted that there is a decrease in IP-TFAs levels in puff pastries of soups, chicken pie, samosas/meat stuffed pastry rolls, cakes, Chinese/sweet pastries and cookies over the years (see **Figure 3**).¹² This implies the trade has used ingredients with lower IP-TFAs content for product reformulation.

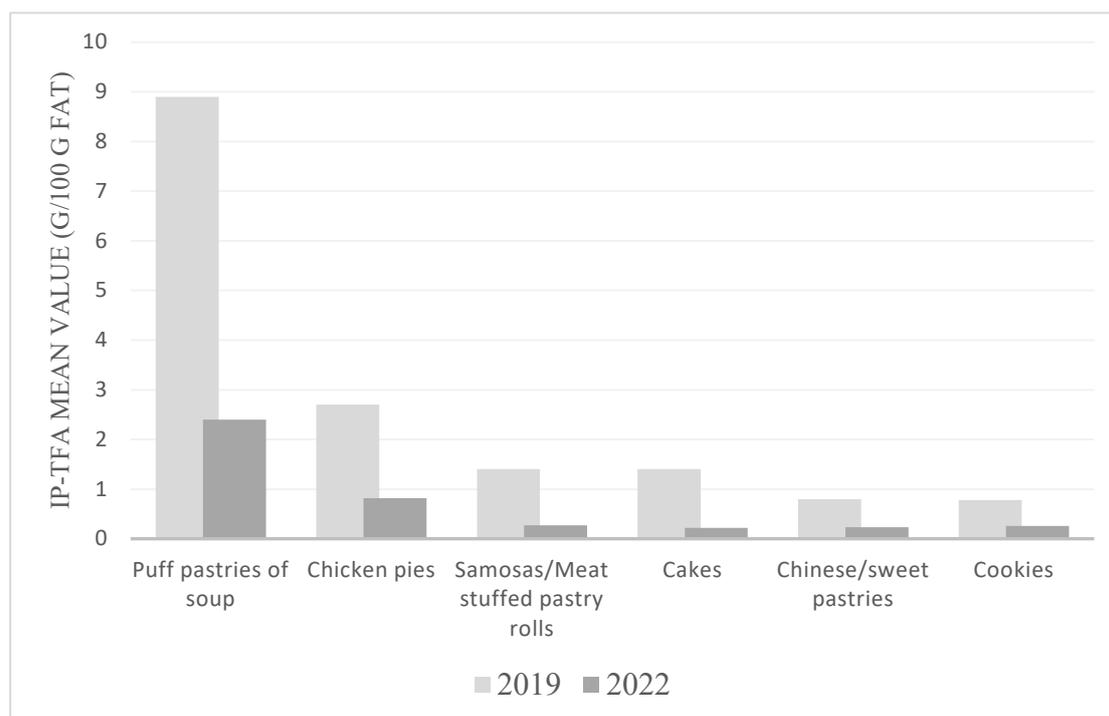


Figure 3: IP-TFAs mean value of certain food items in 2019 and 2022 studies

6. Conclusions and Recommendations

6.1 Conclusions

19. Among the 149 food items, six samples (4%) contained IP-TFA greater than 2 g per 100 g of total fat. These samples were egg tart, Chinese dough sticks, puff pastry of soup, fried soybean roll and pickled vegetables sauce for fish soup base. They were under the “ready-to-eat” category or the “miscellaneous” category. The IP-TFA levels in these samples were between 2.2 and 6.7 g per 100 g of total fat. Among these, it was possible that 3 samples (2%), the egg tart and two puff pastries of soups, might contain PHOs in their compositions after further investigation. Accepting the recommendations from CFS, the food outlets of egg tarts and puff pastries of soup have successfully

reformulated their recipes to not using PHOs as an ingredient so as to reduce IP-TFAs levels in the food. When comparing the result of this study with that of 2019 with similar coverage, there is a significant decrease in percentage of food samples with IP-TFAs greater than WHO guidance level of 2g/100 g fat and the IP-TFAs levels in certain food items have been lowered. This indicated the majority of trade may have reformulated their food products to minimize IP-TFAs in the food supply.

6.2 Advice to Trade

20. To prepare for the upcoming prohibition of PHOs and labelling requirement of fully hydrogenated oil on 1 December 2023, the trade has to ensure that their food products do not contain PHOs and keep proper supporting documentation, and label prepackaged foods properly if they contain fully hydrogenated oils as ingredients.

6.3 Advice to Consumers

21. Members of the public shall pay attention to the level of TFAs on nutrition labels when purchasing prepacked foods. WHO recommends limiting TFAs intake to less than 1% of total energy, which equals to less than 2.2 g/day in a 2000-calorie diet.

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Annex: LOD and LOQ for determining fatty acids in food

Fatty acids	Limit of detection (g/100g or g/100mL)	Limit of quantification (g/100g or g/100mL)
C4:0	0.0005	0.002
C6:0	0.004	0.01
C8:0	0.005	0.02
C10:0	0.002	0.006
C12:0	0.001	0.003
C14:0	0.002	0.006
C15:0	0.002	0.006
C16:0	0.002	0.005
C17:0	0.002	0.005
C18:0	0.002	0.006
C20:0	0.001	0.004
C22:0	0.002	0.007
C24:0	0.002	0.008
All <i>trans</i> fatty acids (except C _{18:3T} (Total))	0.004	0.01
C _{18:3T} (Total)	0.01	0.03