Risk Assessment Studies
Report No. 43

# Dietary Exposure to Acrylamide of Hong Kong Adult Population

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Centre for Food Safety
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## Abstract

Acrylamide is a probable carcinogen that is found in many types of food, especially carbohydrate-containing foods that receive high-temperature treatment. The Centre for Food Safety had conducted a joint study with the Consumer Council and a risk assessment study for a snapshot of the current acrylamide levels in foods that were more likely to contain acrylamide in order to assess the latest situation in Hong Kong. Ninety individual and five composite samples were analysed. The mean acrylamide levels in "potato chips" and "other snack type biscuits" were higher than other food categories, with mean levels of 788 and 1 115 μg/kg respectively. "Rice crackers" had the lowest mean acrylamide level of 20 μg/kg. The highest levels were detected in a potato chip sample (3 000 μg/kg) and a snack type biscuit sample (2 100 μg/kg). The dietary exposure to acrylamide in the average local population and high consumers (97.5$^{th}$ percentile) was 0.13 μg/kg body weight/day and 0.69 μg/kg body weight/day respectively. Their respective margins of exposure (MOE) were 1 385 and 261 suggesting health concerns regarding acrylamide exposure of the local population. Members of the public should maintain a balanced diet, consume more fruits and vegetables, avoid burnt foods and reduce consumption of carbohydrate-rich foods that have undergone

high-heat treatment including deep-frying and baking. Foods should not be cooked excessively, i.e. for too long or at too high temperature. Members of the food trade should seek ways to reduce the level of acrylamide in food, while not compromising the safety and nutrition value of the products.

Risk Assessment Studies –

# *Dietary Exposure to Acrylamide of Hong Kong Adult Population*

*A follow-up investigation of acrylamide in Food available in Hong Kong*

## OBJECTIVES

The Centre for Food Safety (CFS) of the Food and Environmental Hygiene Department (FEHD) conducted a risk assessment study on the dietary exposure of acrylamide in Hong Kong adults, in parallel with the joint Consumer Council (CC) study titled "Acrylamide in Some Popular Foods" in 2010. This study was based on the Hong Kong Population-based Food Consumption Survey 2005 – 2007 data and the analysis of some food products that were more likely to have higher acrylamide contents and/or popular in Hong Kong. The health risk from acrylamide exposure was also estimated.

## BACKGROUND

2. In April 2002, the Swedish National Food Administration (NFA) and researchers from Stockholm University released study findings that acrylamide was detected in starchy foods like potato chips and French fries. It subsequently raised public health concerns in many countries, because acrylamide is a probable human carcinogen and genotoxicant.

3. In view of the findings, an expert consultation was convened jointly by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) in June 2002[1]. The Consultation recognised that the issue was a major concern and acknowledged the potential link between acrylamide and asparagine-rich foods cooked at high temperature.

4. The FEHD thus considered that there was a need to conduct a study to determine the acrylamide levels in foods of our local diets, including Asian

foods (e.g. fried rice, fried noodles, fried dim sum (點心) and yau-hei (油器) (i.e. deep-fried dough) etc.). Local food items were analysed for acrylamide and two risk assessment studies, titled "Acrylamide in Food" and "Acrylamide in Fried Fritters", were released in December 2003 as a result. The studies found that the levels of acrylamide in the commonly consumed foods such as rice, noodles, bakery and batter-based products were generally low, while higher levels were present in snack foods such as biscuits, chips and crisps. Dietary exposure to acrylamide in the local population, based on both Hong Kong Adult Dietary Survey 1995 and the Food Consumption Survey for Secondary School Students 2000, was on the low side when compared with dietary exposure of acrylamide in western diet. The acrylamide levels in fried fritters were found to increase with both frying temperature and time, whereas battering could help reducing the acrylamide level in deep-fried food.

5. Furthermore, a joint CC study on "Acrylamide in Fried and Baked Food" was released in October 2006. The acrylamide levels in snack foods and traditional local foods were analysed and methods were explored to reduce acrylamide formation in deep fried taro pieces. This study found that level of acrylamide was higher in potato chips, potato crisps and biscuits, whereas some wheat based, rice based, soy based foods, nuts and coffee were generally found to contain lower amount of acrylamide. The experiment with deep-fried taro pieces showed that the acrylamide level increased with time and frying temperature and applying batter on taro pieces could help lowering the acrylamide level.

6. In 2010, the CFS conducted another joint CC study on "Acrylamide in Some Popular Foods". In connection with the above study, this risk assessment (RA) study was also conducted to estimate the dietary exposure to acrylamide of the population. The RA study aimed to obtain a snapshot of current acrylamide levels in locally available foods that were more likely to contain higher levels of acrylamide and popular in Hong Kong, as well as to estimate the exposure level with reference to the latest food consumption data from the Hong Kong Population-Based Food Consumption Survey 2005-2007[2].

## Acrylamide

7. Acrylamide is an odourless, white, crystalline organic solid with melting point of 84-86°C[3]. It readily undergoes polymerisation to form

polyacrylamide, which is a highly cross-linked gel polymer with many uses in industry. Polyacrylamides are used as a coagulant aid in the treatment of drinking water[4]. It is also used in paper, textile and plastic industries, and synthesis of dyes, as a grouting agent in the construction of dam foundation, tunnels and sewers.

## Source of exposure

8. The major exposure route to acrylamide for the general population is the exposure through ingestion of food. Inhalation of acrylamide from industrial emissions, skin absorption via consumer products and drinking water are other possible minor exposure routes. On the other hand, higher occupational exposure in laboratories, and among manufacturing and grouting workers are possible[5]. Polyacrylamide is sometimes used as a coagulant aid in drinking water treatment and trace amount of non-polymerised acrylamides may present in drinking water. The WHO Guidelines for Drinking Water Quality has established a guideline value of 0.5 μg/litre for acrylamide in drinking water[6]. Residual acrylamide from packaging material contributes a negligible exposure[7]. The current major contributors of dietary exposure are foods that contain free asparagine and reducing sugars and undergone high heat treatment in excess of 120°C, like French fries, potato chips, coffee, pastry and cookies, bread and rolls/toasts etc[4].

## Metabolism and health implications of acrylamide

9. Ingested acrylamide is readily absorbed from the gastrointestinal tract and distributed widely to tissues. It is rapidly excreted via urine[4].

10. In animal studies, single oral doses produced acute toxic effects only at doses above 100 mg/kg body weight and the $LD_{50}$ reported are generally above 150 mg/kg body weight[4]. However, acute toxicity caused by acrylamide is rarely encountered in humans[5]. The main site of acrylamide toxicity is the nervous system in animal studies. Continued dosing with acrylamide had been shown to induce nerve terminal degeneration in brain areas for learning, memory and other cognitive functions. The "no-observed-effect level" (NOEL) for morphological changes in nerves was 0.2 mg/kg body weight/day in rat study. In reproduction studies, an oral dose of more than 7 mg/kg body weight/day showed reduced fertility, dominant

lethal effects and adverse effect on sperm count and morphology in male rodents. No adverse effects on fertility or reproduction have been observed in female rodents except for the oral "lowest-observable-effect-level" (LOEL) of 2.5 mg/kg body weight/day from slight reduction in rat offspring body weight. The overall NOEL for reproductive and developmental effects was 2 mg/kg body weight/day[4].

11. Acrylamide is clastogenic and genotoxic both *in vivo* and *in vitro*[4]. Acrylamide induces chromosomal aberrations in germ cells of mice and rats *in vivo* and can cause gene mutations and chromosomal aberrations *in vitro*[8].

12. Acrylamide is carcinogenic in animal experiments. It produces increased incidences of peritoneal mesotheliomas in testis, follicular adenomas of thyroid, tumours in mammary gland, central nervous system and it is also an initiating agent for skin carcinogenesis in various animals. Acrylamide also increased the incidence and multiplicity of lung tumours in mice in screening bioassays.

13. In 1994, International Agency for Research on Cancer (IARC) evaluated acrylamide and considered that there was sufficient evidence of carcinogenicity in experimental animals but inadequate evidence of carcinogenicity in humans. IARC classified acrylamide as Group 2A (probably carcinogenic to humans) [8].

14. As acrylamide is a genotoxic carcinogen, no safety reference value can be established. In order to reduce the health risk, the exposure to acrylamide should be reduced to as low as reasonably achievable. JECFA had used the margin of exposure (MOE) approach to estimate the human health risk. MOE is a quotient of the lower limit at which adverse effects were observed, over the estimated exposure from food. The lower the value, the greater is the possible effect on public health. With mean acrylamide exposure 0.001 mg/kg body weight/day and high exposure of 0.004 mg/kg body weight/day (based on the national intake data), the JECFA had established MOEs for acrylamide as follows[9] (Table 1):

**Table 1: Summary of toxicological evaluations for acrylamide by JECFA**

| Effect on animals | No-observed-adverse-effect-level (NOAEL) or Lower limit on the benchmark dose for a 10% response ($BMDL_{10}$) (mg/kg body weight/day) | MOE at mean dietary exposure | MOE at high dietary exposure | Conclusion / comments |
|---|---|---|---|---|
| Morphological Changes in nerves in rats | 0.2 (NOAEL) | 200 | 50 | JECFA noted that while adverse neurological effects are unlikely at the estimated average exposure, morphological changes in nerves cannot be excluded for individuals with a high dietary exposure to acrylamide. |
| Mammary tumours in rats | 0.31 ($BMDL_{10}$) | 310 | 78 | JECFA considered that for a compound that is both genotoxic and carcinogenic, these MOEs indicate a health concern |
| Harderian gland tumours in mice | 0.18 ($BMDL_{10}$) | 180 | 45 | |

JECFA considered the above MOEs indicated a health concern[9].

15. As a comparison, Table 2 includes the results of the JECFA evaluation on other harmful chemicals produced during processing:

**Table 2: Margin of exposure for polycyclic aromatic hydrocarbons and ethyl carbamate by JECFA**

| Chemical | Food that commonly contain this chemical | MOE at mean dietary exposure | MOE at high dietary exposure | Concern |
|---|---|---|---|---|
| Polycyclic aromatic hydrocarbons (PAHs) | Roasted meat | 25 000 | 10 000 | Low* |

| | | | | |
|---|---|---|---|---|
| Ethyl carbamate | Fermented food like bread, cheese, soy sauce & alcoholic beverages | 20 000 | 3 800 | Low* |

* This does not mean that PAHs and ethyl carbamate are of low toxicity or not of concern. It means that acrylamide is of more health concern in terms of MOE.

### Formation of acrylamide in food

16. Research findings revealed that raw food and foodstuffs that are prepared by boiling do not contain appreciable levels of acrylamide[10]. Acrylamide is formed when foods, particularly those rich in the amino acid asparagine, are cooked at high temperature (120°C or above) in the presence of reducing sugars especially glucose and fructose in Maillard (browning) reaction. Cooking methods like deep-frying and baking can often reach in excess of 120°C. The formation of acrylamide is also affected by pH, temperature, heating time and the presence of certain ingredients in the product[11].

### Regulatory control

17. Like other countries, there is currently no specific regulatory control for controlling the level of acrylamide in food in Hong Kong. In order to help the trade minimise the formation of acrylamide in food, especially potato and cereal based products, the CFS has drafted a set of Trade Guidelines on Reducing Acrylamide in Food with reference to the Codex Code of Practice for the Reduction of Acrylamide in Foods (CAC/RCP 67-2009). After consulting with the trade, the Trade Guidelines has been distributed and uploaded to the CFS website for reference.

## SCOPE OF STUDY

18. To estimate the dietary exposure of acrylamide for Hong Kong adults through analysis of selected local foods that are more likely to contain higher levels of acrylamide and are popular in Hong Kong.

# METHODS

## Sampling

19. A range of locally-available carbohydrate-rich food, which might have undergone high heat treatments, was taken for acrylamide analysis in this study. These foods might be subject to high-temperature cooking or processing in excess of 120°C like baking and deep-frying. Crispy snacks, biscuits, French fries and waffle fries, baked potatoes, breakfast cereals, coated peanuts, deep-fried dim-sum and chocolate powder for preparing chocolate drinks were included. The samples were taken either in form of ready-to-eat food or need mixing with hot water; they were either pre-packaged food or restaurant dishes. Food samples were purchased from various restaurants, supermarkets and other retailers in Hong Kong.

20. The likelihood of containing higher levels of acrylamide, commonality and availability of the food/products formed the major selection criteria. 90 individually analysed food samples in 21 food groups that were shared with the CC study, together with five composite samples (composing of 22 individual samples) were used in the present RA study. Please refer to Table 3 for details.

## Laboratory analysis

21. Laboratory analyses were conducted by the Food Research Laboratory (FRL) of the CFS.

22. The edible portion of the food sample was homogenised and an appropriate test portion (1 - 4 g) was taken. The acrylamide in the test portion was extracted by water and then, cleaned up by solid phase extraction, and subsequently determined by Liquid Chromatograph-Tandem Mass Spectrometry (LC-MS/MS) technique[12]. D3-Acrylamide was used as an internal reference (surrogate) for the analysis. The test method was validated by single-laboratory validation against certified reference materials. The limit of detection and the limit of quantification were 3 μg/kg and 10 μg/kg respectively.

## Food consumption data

23. The food consumption data from the Hong Kong Population-based Food Consumption Survey 2005-2007[2] was extracted and used for this study. The survey collected the food consumption data, such as types of food intake, amounts of food intake and dietary practices of about 5 000 Hong Kong adults aged 20 to 84 years. They were selected through an anonymous and scientific household address sampling procedure. The food consumption data were collected through food behaviour questionnaire (FBQ), food frequency questionnaire (FFQ) and 24-hour dietary recalls (24-hr recalls) in two non-consecutive days, through face-to-face and telephone interviews. The consumption and FBQ data had been age- and gender- weighted to represent the general adult population of Hong Kong aged 20 to 84.

## Estimation of dietary exposure

24. Dietary exposure of acrylamide from each food item was obtained by combining the weighted population mean consumption data from 24-hr recalls and the mean acrylamide level of that food group. Total exposure for an individual was obtained by summing acrylamide exposures from all food items investigated. When an exact match in food consumption data was not available for the foods sampled, the consumption data of a similar item was used instead to estimate the exposure (Please see Annex for details). The mean and 97.5$^{th}$ percentile exposure data were used to represent the average and high consumers respectively.

# RESULTS AND DISCUSSION

## Acrylamide levels

25. Results of 90 individual food samples and additional five composite samples were collected. The results, which were grouped under 26 food groups, were as follows (Table 3):

## Table 3: Food groups and results of acrylamide analysis

| Individual Analysis (from the Consumer Council study) | | | | |
|---|---|---|---|---|
| Food Group | Number of Samples | Acrylamide Level (µg/kg) | | |
| | | Mean | Median | Minimum – Maximum |
| **Crispy Snacks** | | | | |
| Potato chips | 12 | 788 | 595 | 160 – 3 000 |
| Taro chips | 3 | 191 | 92 | 11 – 470 |
| Prawn crackers | 6 | 152 | 123 | ND* – 330 |
| Snack noodles | 2 | 78 | 78 | 35 – 120 |
| Corn chips | 6 | 179 | 139 | 16 – 480 |
| Rice crackers | 3 | 20 | 14 | 6 – 39 |
| Banana chips | 3 | 115 | 81 | 74 – 190 |
| **Fried and Baked Potatoes** | | | | |
| French fries and waffle fries | 7 | 382 | 370 | 74 – 890 |
| Baked potatoes | 3 | 82 | 71 | 15 – 160 |
| **Biscuits** | | | | |
| Cheese crackers | 2 | 255 | 255 | 150 – 360 |
| Digestive biscuits | 3 | 217 | 230 | 170 – 250 |
| Cookies | 6 | 115 | 83 | 42 – 250 |
| Soda crackers | 5 | 96 | 68 | 39 – 200 |
| Chocolate-coated biscuits | 5 | 157 | 110 | 47 – 370 |
| Wafers | 5 | 144 | 150 | 53 – 280 |
| Sandwich crackers | 4 | 305 | 325 | 61 – 510 |
| Wheat crackers | 5 | 203 | 140 | 87 – 390 |
| Biscuit sticks | 2 | 196 | 196 | 32 – 360 |
| Other snack type biscuits | 2 | 1115 | 1115 | 130 – 2 100 |
| **Breakfast Cereals** | | | | |
| Corn flakes | 3 | 56 | 69 | 29 – 70 |
| Bran cereals | 3 | 240 | 200 | 59 – 460 |
| **Composite Analysis (Risk Assessment Study exclusive)** | | | | |
| **Food Group** | **Number of Samples** | **Acrylamide Level (µg/kg)** | | |
| Coated peanuts (脆皮花生) | 3 | 83 | | |
| Ma-fa (脆麻花) | 8 | 40 | | |
| Fried fritters (油條) | 3 | 58 | | |
| Deep fried taro dumplings (芋角) | 5 | 210 | | |
| Chocolate powder (for chocolate drinks) | 3 | ND* (in ready-to-drink form) | | |

* ND = Non-detect = <3 µg/kg. 1/2 LOD (i.e. 1.5 µg/kg) was assigned to the ND samples for the calculation of median and mean levels for

individual analysis. One analysis for each sample under "Individual Analysis", and only one analysis was conducted for each food group under "Composite Analysis".

26. On the whole, vast majority of the high-temperature treated carbohydrate-rich foods analysed contained acrylamide. Some of the items (40% of the analytical results) contained relatively little (less than 100 μg/kg) acrylamide while some (3.2% of the analytical results) contained higher levels (above 1 000 μg/kg).

27. For potato chips, the mean acrylamide level was 788 μg/kg and the range was 160 to 3 000 μg/kg, which was the widest range among the food groups in this study. Two of the potato chip samples contained in excess of 1 000 μg/kg (1 300 and 3 000 μg/kg) and the 3 000 μg/kg level was the highest acrylamide level found among samples in all FEHD and CFS studies so far. Potato chips were either made from sliced potatoes or potato flour/starch. Different varieties of potatoes contained different amount of asparagine and reducing sugars. Furthermore, refrigeration of potato at low temperature would also increase the amount of reducing sugars. Researches suggested that by selecting potato varieties with lower asparagine and reducing sugars levels, avoiding storing potatoes at lower than 6°C, adjustment of cooking time and temperature to achieve a light golden colour, as well as removal of chips that are too dark in colour can help to lower the acrylamide level. For potato chips that were prepared from potato flour/starch, partial replacement with ingredients with lower levels of asparagine and reducing sugars can also reduce acrylamide level. If asparagine was present, the use of the enzyme asparaginase could breakdown asparagine[13].

28. For French fries and waffle fries (mean 382 μg/kg, range 74 to 890), other than the level of asparagine and reducing sugars and the processing conditions, the cutting style of the potato could also affect the acrylamide level. In theory, the thicker the cut, the lower the acrylamide level when compared with thinner cuts because of the less surface area [13].

29. For taro chips, the mean level was 191 μg/kg with a range of 11 to 470 μg/kg. Similar to potato, taro also contains asparagine and reducing sugars. The 2006 joint CC study on "Acrylamide in Fried and Baked Food" found that by battering the taro pieces before deep-frying, the acrylamide level could be reduced because the batter protects the taro from water loss and

therefore surface browning and acrylamide formation. Reduction of cooking time and temperature could also help.

30. The mean levels of acrylamide in some commonly consumed products were relatively low. They included prawn crackers (mean 152 μg/kg, range not detected to 330 μg/kg), snack noodles (mean 78 μg/kg, range 35 to 120 μg/kg), rice crackers (mean 20 μg/kg, range 6 to 39 μg/kg), soda crackers (mean 96 μg/kg, range 39 to 200 μg/kg), baked potatoes (mean 82 μg/kg, range 15 to 160 μg/kg), corn flakes (mean 56 μg/kg, range 29 to 70 μg/kg) and chocolate powder for preparing chocolate drinks (not detected in ready to drink form). One sample of prawn crackers and the composite chocolate drink sample contained no detectable amount (i.e. less than 3 μg/kg) of acrylamide. The ingredient list of the concerned prawn cracker sample showed that unlike most other food samples, which contained potato, corn or wheat as the main ingredient, it used tapioca starch. It was possible that the tapioca starch contained very little asparagine and reducing sugars and therefore did not support acrylamide formation in the product. For the chocolate drink powder, acrylamide could be formed during the processing because of the heat treatment involved during the preparation of the chocolate powder and the possible presence of asparagine and reducing sugars. If the asparagine and reducing sugar levels were kept low during the processing of chocolate drink powder, the resulting mix would contain little acrylamide even if it underwent heat treatments. The preparation of ready-to-drink chocolate drinks from chocolate powder might caused a reduction in acrylamide level to non-detectable level because of the dilution. Similarly, even though the snack noodles, soda crackers were made with wheat, and corn flakes with corn, which might contain similar levels of asparagine and reducing sugars and therefore be able to have higher acrylamide levels, the level could be kept relatively low if there was a limiting factor for acrylamide formation, e.g. low asparagine level, low reducing sugars levels or processing at lower temperatures. All three rice crackers samples contained less than 100 μg/kg acrylamide, possibly due to the low level of asparagine in rice, which limited the formation of acrylamide. For baked potatoes, the acrylamide level was known to be lower than that of the fried potatoes (i.e. French fries and waffle fries).

31. Corn chips (mean 179 μg/kg, range 16 to 480) consisted mainly of corn flour and had similar levels of asparagine as in wheat flour (70 – 3 000 mg/kg in maize vs. 75 – 2 200 mg/kg in wheat)[13]. Therefore, its acrylamide

level could be similar to that of wheat products. Banana chips (mean 115 µg/kg, range 74 to 190) were also known to naturally contain asparagine and rich in reducing sugars like glucose and fructose. Acrylamide could be produced during the drying process with temperature over 120°C. Some of the bran cereals (mean 240 µg/kg, range 59 to 460) contained higher level of acrylamide than the corn flakes. The use of honey, which contained reducing sugars as an ingredient, in one bran cereal sample, plus favourable processing conditions could increase the acrylamide level.

32. For biscuits and crackers, the range of acrylamide level was wide. The acrylamide level ranged from 32 in a biscuit stick to 2 100 µg/kg in a snack type biscuit sample. This was mainly due to the variations in food processing conditions used among different products, as it was known that acrylamide formation depended on the exact time and temperature condition used to process a food. The higher amount of free asparagine and reducing sugars in the ingredients could also increase the acrylamide level in these products[4]. Furthermore, the use of the raising agent ammonium bicarbonate was known to increase the acrylamide levels. On the other hand, the use of yeast or other non-ammonium raising agents could help to lower the acrylamide level[13].

33. For the coated peanuts (83 µg/kg) and Chinese dim sums like ma-fa (40 µg/kg), fried fritters (58 µg/kg) and deep fried taro dumplings, the results varied. The composite analyses showed that the levels for the first three items were below 100 µg/kg, while the deep fried taro dumplings contained 210 µg/kg of acrylamide. The carbohydrate-rich taro dumplings had a fluffy surface with larger surface area and were prepared by deep-frying. This created a favourable environment for acrylamide formation in terms of temperature, chemical precursors and surface area. Similarly, the mean acrylamide for taro chips, which were also deep-fried, was 191 µg/kg.

34. The local results on maximum levels for biscuits, breakfast cereals, French fries and potato chips were generally within the ranges reported by European countries[14, 15] (Table 4).

**Table 4: Comparison of maximum acrylamide levels in certain foods in EU and Hong Kong**

| Food Product | EU (2003-2006) | EU (2007) | EU (2008) | Hong Kong (2010) |
|---|---|---|---|---|

| | Maximum µg/kg | Maximum µg/kg | Maximum µg/kg | Maximum µg/kg |
|---|---|---|---|---|
| Biscuits | 3 324 | 4 200 | - | - |
| ● Crackers | - | - | 1 042 | 2 100 |
| ● Wafers | - | - | 2 353 | 280 |
| Breakfast cereals | 846 | 1 600 | 2 072 | 460 |
| French fries | 3 428 | 2 668 | 2 466 | 890 |
| Potato chips | 4 215 | 4 180 | 4 382 | 3 000 |

## Local dietary exposure and comparison against other countries

35. The result of the estimation revealed that dietary exposure to acrylamide of an average adult consumers in Hong Kong (body weight 61.22 kg, number of consumers: weighted = 2 407 746 and unweighted = 2 151.) was about 0.13 µg/kg body weight/day (about 8.1 µg/day) for average consumers and 0.69 µg/kg body weight/day (about 42 µg/day) for high consumers ($97.5^{th}$ percentile). Please refer to Annex for details of the dietary exposures.

36. Both the average and high consumers fell within or below the range of dietary exposure of acrylamide in western diet (i.e. 0.3 to 0.8 µg/kg body weight/day) as estimated by the WHO at the expert consultation meeting in June 2002[16]. The estimated mean dietary exposure was 0.5 µg/kg body weight/day and 1.5 µg/kg body weight/day for high consumers in Australia in 2004. For New Zealand, the 2006 exposure data indicated a dietary exposure between 0.9 to 2.4 µg/kg body weight/day[17]. For United States, the Food and Drug Administration estimated the mean exposure level in 2006 to be 0.4 µg/kg body weight/day[18], while Health Canada reported in 2009 that the estimated mean exposure level for Canadian adults to be between 0.3 and 0.4 µg/kg body weight/day[19]. The European Food Safety Authority estimated that the mean exposure level for EU member states was 20 µg/day in 2007 and 30 µg/day in 2003 – 2006 respectively[14]. Therefore, the local mean dietary intake of acrylamide was not particularly high when compared with the above countries.

37. During the calculation of exposure, the categories of the food sampled were matched against consumption data in the Hong Kong Population-based Food Consumption Survey 2005-2007. If no exact match was available, the consumption data of the next-closest food category would be used for estimation. For example, the consumption data of “Snack foods (item not

specified)", "Taro" and "Cornnuts (脆烤粟米小食)" were used for the food categories "snack noodles", "taro chips" and "corn chips" respectively (See Annex). Furthermore, the consumption data of fried fritters in "rice-roll with fried fritters" was combined with "fried fritters" to obtain the total consumption amount for "fried fritters".

### Margin of exposure and local health concerns

38. The MOE obtained from this study, based on the most sensitive lower limit from the Harderian gland tumours in mice, were 1 385 for the average adult and 261 for high consumers, which might indicate human health concern because of the relatively low figures. This implied that locally the effort to reduce acrylamide level in food should continue.

## LIMITATIONS

39. Although more accuracy and precision in exposure estimation could be achieved with more samples analysed, compromises had to be made in relation to the use of finite laboratory resources. With the shared use of 90 individual analyses with the CC study and five extra composite samples were added for the RA study. As only 95 analyses were conducted, not all foods that contain acrylamide were included. Only popular local food items or food that were more likely to contain significant amount of acrylamide were sampled. On the other hand, food consumption data were not available for all foods sampled. Some approximations were necessary to estimate the consumption and exposure. For the non-detected analytical results, a conservative approach of using 1/2(LOD) for non-detect was adopted for calculations as recommended by JECFA under FAO and WHO. However, the net result of these factors on over-estimation or under-estimation was not known.

40. Furthermore, as the batch-to-batch variations in acrylamide levels were known to fluctuate greatly even for the same product, the results of this study represented only a partial snapshot of the acrylamide levels in certain local foods. A more realistic picture on local dietary acrylamide intake will be obtained through the upcoming local total diet study, where analysis will be conducted on replicates of complete local diets with seasonal variations taken

into account. The overall acrylamide intake estimate will be closer to the reality.

## CONCLUSIONS AND RECOMMENDATIONS

41. Acrylamide is found in carbohydrate-rich foods that receive high heat treatment such as those prepared by baking and deep-frying. The levels vary with the ingredients used and processing conditions. The study on some popular locally-available foods in Hong Kong showed that the levels of acrylamide were present in most food-types sampled, and that "potato chips", and "other snack type biscuits" contained relatively higher mean levels of acrylamide. Dietary exposure to acrylamide in the local adults was comparable or on the low side when compared with dietary exposure of acrylamide in some developed countries. The MOE analysis suggested that there were possible concerns from the dietary acrylamide exposure, especially for the high consumers based on the currently available exposure data. Efforts in reducing arcylamide levels in local foods should continue.

42. At present, the current data on acrylamide are not sufficient to warrant changes in basic dietary advice on healthy eating, i.e., have a balanced diet, eat more fruits and vegetables, avoid burnt foods and reduce consumption of high-heat treated carbohydrate-rich foods, including deep-frying and baking.

### Advice to public

43. To minimise the risk of acrylamide in food, food should not be cooked excessively, i.e. for too long or at too high temperature. However, all foods, particularly meat and meat products, should be cooked thoroughly to destroy foodborne pathogens.

### Advice to trade

44. Members of the food trade are advised to seek ways to reduce the level of acrylamide in food, while not compromising the safety and nutrition value of the products. Members of the trade can make reference to the guidelines on reduction in acrylamide level to be published by CFS.

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**Annex**

## The Average Dietary Exposure to Acrylamide in Hong Kong Adults

| Food Group | Average Exposure[a] (ug/kg body weight/day) | % Contribution of Total Exposure |
|---|---|---|
| Biscuits sticks and other snack type biscuits[b] | 0.0392 | 29.65% |
| French fries and waffle fries | 0.0339 | 25.60% |
| Potato chips | 0.0186 | 14.08% |
| Baked potatoes[c] | 0.0110 | 8.33% |
| Soda crackers | 0.0046 | 3.47% |
| Sandwich crackers | 0.0041 | 3.08% |
| Taro chips[d] | 0.0039 | 2.94% |
| Coated peanuts[e] | 0.0031 | 2.34% |
| Cookies | 0.0027 | 2.04% |
| Cheese crackers | 0.0020 | 1.49% |
| Digestive biscuits | 0.0018 | 1.35% |
| Wheat crackers | 0.0016 | 1.24% |
| Chocolate coated biscuits[f] | 0.0014 | 1.06% |
| Fried fritters | 0.0012 | 0.88% |
| Corn flakes | 0.0008 | 0.61% |
| Prawn crackers | 0.0006 | 0.46% |
| Wafers | 0.0006 | 0.43% |
| Bran cereals | 0.0004 | 0.27% |
| Deep fried taro dumpling | 0.0003 | 0.24% |
| Corn chips[g] | 0.0002 | 0.16% |
| Chocolate drinks prepared from chocolate powder[h] | 0.0002 | 0.13% |
| Snack noodles[i] | 0.0001 | 0.08% |
| Rice crackers | 0.0001 | 0.05% |
| Banana chips | 0.0000 | 0.02% |
| "Ma Fa" (a type of Chinese pastry) | 0.0000 | 0.01% |
| **Total:** | **0.1324** | **100.00%** |

* Figures may not add up to total due to rounding. For non-detect samples (<3 µg/kg), 1/2 LOD (i.e. 1.5 µg/kg) was assigned for calculations.

[a] The average exposure data were age- and gender- weighted.
[b] The average food consumption data of food group "Crackers (item not specified)" was used.
[c] The average food consumption data of food group "Potato" was used.
[d] The average food consumption data of food group "Taro" was used.
[e] The average food consumption data of food group "Peanut" was used.
[f] The average food consumption data of food group "Chocolate coated crackers" and "Chocolate flavoured crackers" were used.
[g] The average food consumption data of food group "Cornnuts" was used.
[h] The average food consumption data of food group "Chocolate drink" was used.
[i] The average food consumption data of food group "Snack foods (item not specified)" was used.