香港首個總膳食研究：
丙烯酰胺

The First Hong Kong Total Diet Study:
Acrylamide

食物環境衞生署
Food and Environmental Hygiene Department

食物安全中心
Centre for Food Safety

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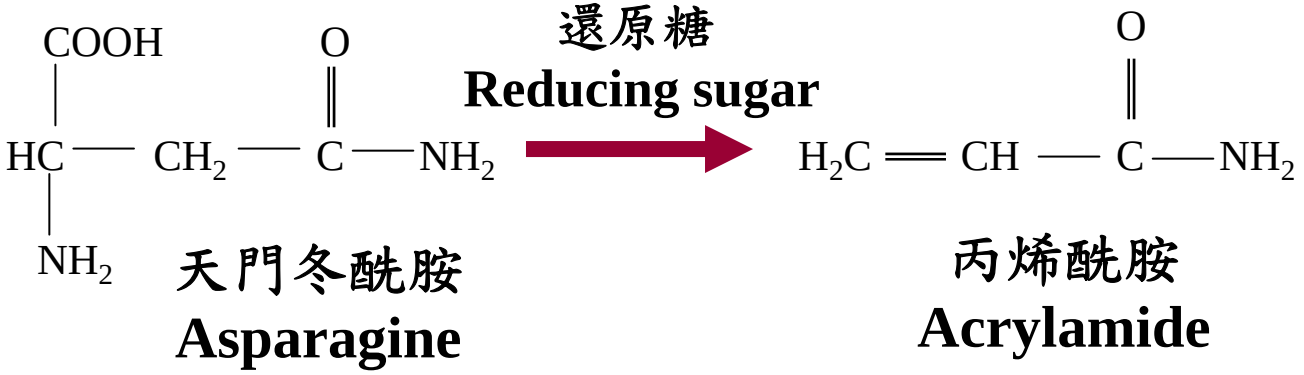
丙烯酰胺
Acrylamide

- **食物加工產生的污染物**
  - 2002年，瑞典研究人員首次報告
  - 油炸或烘焗食物會產生大量丙烯酰胺
- **工業化學物**
  - 自1950年代中以來，用以製造聚丙烯酰胺

- **A food processing contaminant**
  - First reported by Swedish researchers in 2002
  - High level was formed in food during frying or baking
- **An industrial chemical**
  - Used in the production of polyacrylamide since mid-1950s

丙烯酰胺在食物中的形成
Formation of acrylamide in food



- 在食物中形成的主要機制:
  - 食物經高溫(一般> 120°C)烹煮或加工而形成
  - 主要是通過美拉德反應 (褐化反應)
- 水煮的情況下沒有或只有微量形成
- **Major formation mechanism in food:**
  - Cook or process foods at high temperature (usually > 120°C)
  - Mainly via Maillard reactions
- **No acrylamide or only trace amounts can be formed by boiling**

食物內丙烯酰胺的情況
Acrylamide in food

- 含量較高的食物:
  - 薯片、薯條、脆麵包、餅乾
  - 可達毫克/公斤的水平

- **Foods with significant level:**
  - Potato crisps, French fries, crisp bread, biscuits and crackers
  - Up to mg/kg level

對健康的影響
Health effect

- **實驗動物的影響**
  - 神經系統毒性
  - 影響生殖和發育
- **人體的影響**
  - 攝入高劑量會產生神經系統毒性作用

- **Adverse effect to animals**
  - Toxic to the nervous system
  - Adverse reproductive and developmental effects
- **Adverse effect to humans**
  - Toxic to the nervous system at high doses

對健康的影響(二)
Health effect (2)

- 基因毒性
- 可引起齧齒動物多器官腫瘤
- 國際癌症研究機構(IARC)
  - 列為第2A組物質 (即可能令人類患癌的物質)
- 流行病學研究未能提供一致的證據
  - 證明人體從膳食攝入丙烯酰胺的水平與癌症發病率呈正相關
- **Genotoxic**
- **A multisite carcinogen in rodents**
- **International Agency for Research on Cancer (IARC)**
  - Group 2A agent (i.e. probably carcinogenic to humans)
- **Epidemiological studies do not provide any consistent evidence to show**
  - A positive correlation between the level of dietary exposure to acrylamide and the incidence of cancer in humans

基準劑量可信限下限 (BMDL)
Benchmark dose lower confidence limit (BMDL)

- **$BMDL_{10}$**
  - 基於誘發實驗動物腫瘤發病率增加10%
  - 兩個誘發實驗動物不同腫瘤的$BMDL_{10}$值
    - 為每日每公斤體重0.18毫克及0.31毫克

- **$BMDL_{10}$**
  - Based on a 10% extra risk of tumours
  - Two $BMDL_{10}$ values:
    - 0.18 and 0.31 mg/kg body weight (bw) /day

聯合國糧食及農業組織／世界衛生組織聯合食品添加劑專家委員會 (2010)

Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives (JECFA) (2010)

暴露限值 (MOE)
Margin of exposure (MOE)

$$MOE = \frac{BMDL_{10}}{\text{估計膳食攝入量 (Estimated Dietary Exposure)}}$$

- 評定對健康值得關注的程度 ，而不是真實地量化其對健康可能帶來的風險的高低
- **MOE的值越大 →顯示關注程度越低**
- 基因致癌物質
  - MOE > 10,000 →對公眾健康值得關注的程度不高
- 可作為釐定風險管理措施的優次

- **Provide an indication of the level of health concern without actually quantifying the risk**
- **The higher the MOE → the lower the health concern**
- **Genotoxic carcinogens:**
  - MOE > 10,000 → low public health concern
- **Use for priority setting for risk management actions**

過往本地研究
Previous local studies

- 食物含丙烯酰胺的情況 **(2003)**
- 油條含丙烯酰胺的情況 **(2003)**
- 測試油炸烤焗小食的致癌物--丙烯酰胺 **(2006)**
- 部分受歡迎食物的丙烯酰胺含量 **(2010)**
- 香港成年人從食物攝取丙烯酰胺的情況 **(2010)**

- Acrylamide in Food (2003)
- Acrylamide in Fried Fritters (2003)
- Acrylamide in Fried and Baked Food (2006)
- Acrylamide in Some Popular Foods (2010)
- Dietary Exposure to Acrylamide of Hong Kong Adult Population (2010)

過往本地研究 (二)
Previous local studies (2)

- **主要結果:**
  - 薯片和餅乾等零食中檢測到高水平的丙烯酰胺
  - 最近2010年的研究: 低 MOE值
    - MOE: 261-1385 < 10,000
    - 對健康影響的程度值得關注
- **Main findings:**
  - High levels of acrylamide were detected in snack foods such as potato chips and biscuits
  - Latest 2010 study: Low MOE values
    - MOE: 261 – 1385 < 10,000
    - May indicate human concern

香港首個總膳食研究
The First Hong Kong Total Diet Study

- 過往研究的限制
  - 主要針對已知含高丙烯酰胺的食物
- 再次進行研究
  - 全面評估了從膳食攝入丙烯酰胺的分量
- Limitation of previous studies
  - Focused on local food products reported to have higher acrylamide contents
- Re-examine the issue
  - To obtain a more accurate estimate of acrylamide dietary exposure from the whole diet

香港首個總膳食研究 (二)
The First Hong Kong Total Diet Study (2)

- **研究目的:**
  - 估計整體香港市民和不同人口組別從膳食攝入各種選定物質的分量
    - 包括污染物和營養素
  - 從而評估攝入這些物質對健康帶來的風險

- **Objectives:**
  - To estimate the dietary exposures of the HK population and population subgroups to a range of substances
    - including contaminants and nutrients
  - To assess any associated health risks

香港首個總膳食研究 (三)
The First Hong Kong Total Diet Study (3)

- **檢測超過130種物質**
  - 殘餘除害劑、持久性有機污染物、金屬污染物、黴菌毒素、營養素等
- **食物消費量數據來源**
  - 香港市民食物消費量調查
  - 根據市民食物消費量模式，選出150種食物

- **Analysis of over 130 substances**
  - Pesticide residues, persistent organic pollutants (POPs) , metallic contaminants, mycotoxins, nutrients, etc.
- **Food consumption data source**
  - Population-Based Food Consumption Survey (FCS)
  - Select 150 TDS food items, based on food consumption pattern

香港首個總膳食研究 (四)
The First Hong Kong Total Diet Study (4)

- **食物抽樣和處理**
  - 4次抽樣工作，共收集1 800個樣本，並合併為600個混合樣本
  - 把食物處理至可食用狀態
    - 例如，大部分葉菜都是經清洗和浸泡後再炒
      - 參考海外總膳食研究的一般食物處理程序，煎炒食物樣本時，不會加入食油
- **Food sampling and preparation**
  - 1800 samples were collected on 4 occasions and combined into 600 composite samples
  - Samples were prepared as consumed
    - e.g. most leafy vegetables were stir-fried after washing and soaking
      - With reference to overseas TDS on general food preparation procedures, no cooking oil was added during frying of food samples

香港首個總膳食研究 (五)
The First Hong Kong Total Diet Study (5)

- **丙烯酰胺的化驗分析**
  - 食物安全中心的食物研究化驗所進行
- **檢測丙烯酰胺的食物樣本**
  - 133種總膳食研究食物（17種屬水果組別的食物除外）
  - 共檢測532個混合樣本

- **Laboratory analysis for acrylamide**
  - Conduct by the Food Research Laboratory (FRL) of the CFS
- **Samples for acrylamide testing**
  - 133 TDS food items (17 items of food group “Fruits” were excluded)
  - 532 composite samples for acrylamide

研究結果
Results

含量最高的食物 (微克/公斤)
Food items with highest levels (μg/kg)

	本研究 Current study	其他地方 Other places	本地2010年研究 2010 Local study
薯片 Potato chip	**680**	399 – 1202	788
薯條 Fried potato	**390**	159 – 963	382
翠玉瓜 (炒) Zucchini (stir-fried)	**360**		

膳食攝入量
Dietary exposure

	每日膳食攝入量 (微克/每公斤體重) [MOE] Dietary exposure (μg /kg bw/day) [MOE]	
	一般人 Average	攝入量高的人 High consumer
本研究 Current study	0.21 [847 – 1459]	0.54 [334 – 576]
2010年研究 2010 Study	0.13 [1385]	0.69 [261]

- 兩個研究的MOE值均少於 10,000
- 顯示對本地市民健康影響的程度值得關注

- MOE < 10, 000 in both studies
- Indicate a health concern among the local population

跟其他地方研究比較
Comparison with other places

地方 Places	每日膳食攝入量 (微克/每公斤體重) Dietary exposure (μg /kg bw/day)	
	一般人 Average	攝入量高的人 High consumer
香港 Hong Kong (本研究) (Current study)	**0.21**	**0.54 (P95)**
中國內地 Mainland China	0.286	0.490 (P95)
英國 UK	0.3	0.6 (P97.5)
加拿大 Canada	0.3 – 0.4	
歐洲 Europe	0.31 – 1.1	0.58 – 2.3 (P95)
美國 US		
法國 Fra		
愛爾蘭		
新西蘭 New Zealand	0.84 (男25+, male 25+) 0.66 (女性25+, female 25+)	1.39 (男25+, male 25+) (P95) 1.15 (女性25+, female 25+) (P95)

- 與其他地方比較，香港市民的攝入量屬於低端
- Local data is ~ lower end of the range of those in other places

跟其他地方研究比較(二)
Comparison with other places (2)

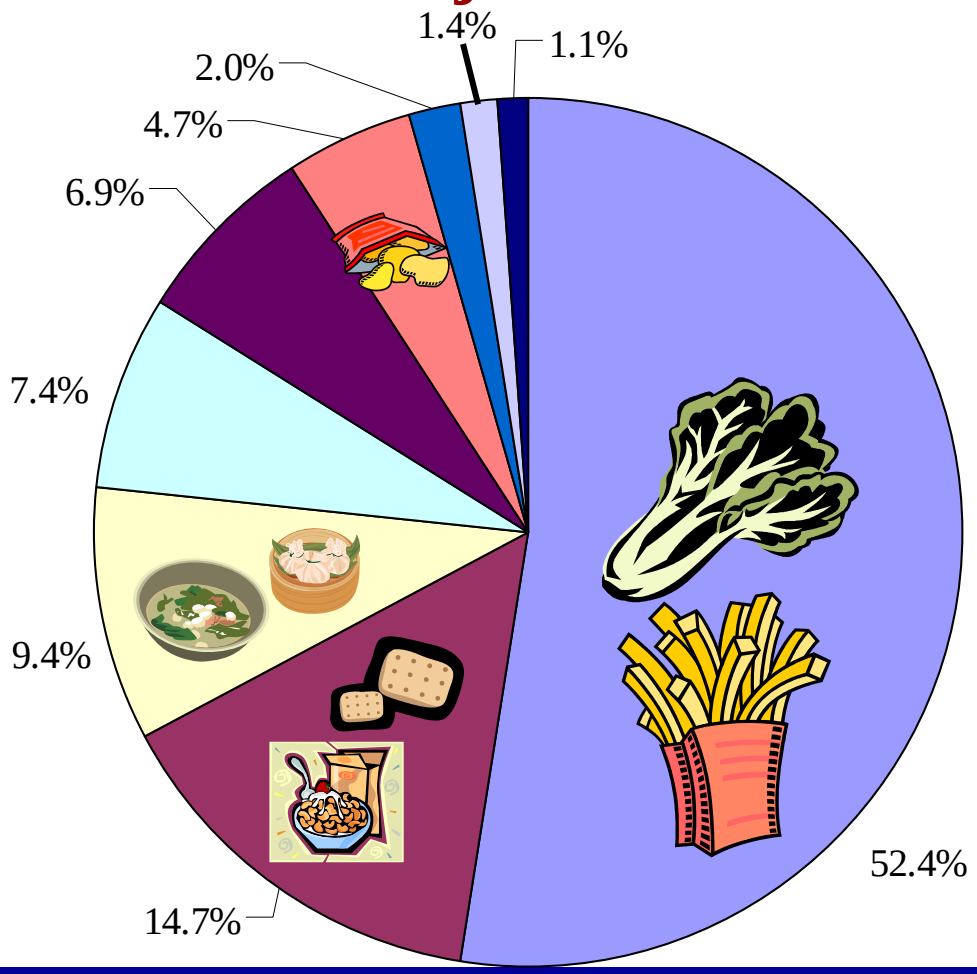
	每日膳食攝入量 (微克/每公斤體重) [MOE] Dietary exposure (μg /kg bw/day) [MOE]	
	一般人 Average	攝入量高的人 High consumer
香港 Hong Kong	0.21 [847 – 1459]	0.54 [334 – 576]
中國內地* Mainland China*	0.286 [621 – 1069]	0.490 [367 – 633]

- 香港市民的攝入量，與內地研究結果相若
- Dietary exposure of HK people is similar to that of Mainland China

* 資料來源 Source of Information

Zhou PP, et al. Biomedical and Environmental Sciences 2013, 26(6): 465-470.

主要的膳食來源
Major food contributors



- 蔬菜及蔬菜製品 Vegetables and their products
- 穀物及穀物製品 Cereals and their products
- 混合食品 Mixed dishes
- 豆類、堅果和種子及其製品 Legumes, nuts and seeds and their products
- 不含酒精飲品 Beverages, non-alcoholic
- 零食食品 Snack Foods
- 肉類、家禽和野味及其製品 Meat, poultry and game and their products
- 調味料、醬油及香草 Condiments, sauces and herbs
- 其他 Others

中國內地 Mainland China: 蔬菜 Vegetables (48.4%)

西方國家 Western countries: 薯條 French fries (10-60%), 薯片 potato chips (10-22%)

主要的膳食來源 (二)
Major food contributors (2)

- 炒菜
  - 佔總攝入量的44.9%
    - 炒的烹煮方法會促使丙烯酰胺的形成
    - 主要膳食來源

- **Stir-fried vegetables**
  - 44.9% of total exposure
    - Frying induces the formation of acrylamide
    - Major source of exposure

主要的膳食來源 (三)
Major food contributors (3)

- 炸薯和薯片、餅乾及穀類早餐
  - 亦是香港市民從膳食中攝入丙烯酰胺的重要來源
    - 由於該等食物含高水平的丙烯酰胺

- **Fried potato and potato chips, biscuit and breakfast cereal**
  - Also significant sources of exposure
    - due to the high level of acrylamide found in these food items

炒菜
Stir-frying vegetables

- **炒菜的丙烯酰胺含量較高** ：最高達360 微克/公斤
  - 例如：翠玉瓜、蘿菜、洋蔥
- **部分炒菜含量較低**：< 10微克/公斤
  - 例如：唐生菜、莧菜、菠菜、西洋菜
- **非炒(即生吃、水煮或蒸)的蔬菜則未有檢出丙烯酰胺**
  - 例如：西生菜、青瓜、節瓜

- **Stir-fried vegetables with relatively high acrylamide level**
  - Highest: 360 μg/kg
  - e.g. zucchini, water spinach, onion
- **Some stir-fried vegetables with low acrylamide level**
  - < 10 μg/kg
  - e.g. Chinese lettuce, Chinese spinach, spinach, watercress
- **Not detected in non-fried items (i.e. non-cooked, boiled or steamed)**
  - e.g. European lettuce, cucumber, hairy gourd

炒菜(二)
Stir-frying vegetables (2)

	平均含量(微克/公斤) Mean (µg/kg)
苦瓜、唐生菜、莧菜、菠菜、西洋菜 Bitter melon, Chinese lettuce, Chinese spinach, spinach, watercress	< 10
西蘭花、紹菜/黃芽白、菜心、椰菜、芽菜、白菜、番茄 Broccoli, Chinese cabbage, Chinese flowering cabbage, European variety cabbage, mung bean sprout, petiole Chinese cabbage, tomato	11 – 50
西芹、芥蘭、茄子、芥菜、絲瓜 Celery, Chinese kale, eggplant, leaf mustard, sponge gourd	51 – 100
蒜頭、洋葱、燈籠椒、蕹菜、翠玉瓜 Garlic, onion, sweet pepper, water spinach, zucchini	101 – 360

其他研究數據：經高溫烹煮除馬鈴薯外的蔬菜（如煎炸、燒烤和烘烤）：達數百微克/公斤的水平

Data from other studies: Vegetables other than potatoes cooked in high temperature (such as frying, grilling and baking): Up to several hundreds µg/kg

炒菜(三)
Stir-frying vegetables (3)

- **丙烯酰胺的產生受多種因素影響**
  - 例如，蔬菜是否含有天門冬酰胺和還原糖，以及烹煮食物的溫度和時間
- **這項研究的蔬菜樣本烹煮時並無加入食油**
  - 或許未能確切反映在家居煮食時炒菜的情況
  - 以致檢測結果可能存在偏差

- **Many factors affecting the formation of acrylamide**
  - **e.g.** Presence of asparagines and reducing sugars in vegetables, cooking temperature and time
- **TDS samples: Fried without cooking oil added**
  - → May not truly reflect the situation of domestic cooking
  - May introduce bias in the test results

炒菜(四)
Stir-frying vegetables (4)

- **進一步探討以不同烹煮的條件炒菜及食肆的炒菜對丙烯酰胺形成的影響**
  - 炒菜時溫度越高、時間越長，產生的丙烯酰胺會越多
  - 炒菜時加入食油與否對炒菜產生丙烯酰胺的影響
    - 實驗結果並未發現有明顯關聯

- **Further testing on the formation of acrylamide in stir-frying vegetables under different cooking conditions and stir-fried vegetables from restaurant**
  - More acrylamide was formed when frying at a higher temperature and for a longer time
  - Frying with or without cooking oil added
    - No obvious association

炒菜(五)
Stir-frying vegetables (5)

- 這些實驗和食肆抽取的炒菜樣本檢出的丙烯酰胺含量
  - 均低於總膳食研究的同類樣本
- 是次總膳食研究可能高估了市民從炒菜攝入丙烯酰胺的分量
- 許多變數都可影響丙烯酰胺的形成
  - 例如，批次、食品成分（例如還原糖和氨基酸的含量）和加工條件（例如烹調溫度和時間）等方面的差異

- **Lower acrylamide levels in the experiments and in the vegetables sampled from restaurants than TDS samples of the same kinds**
- **May overestimate exposure from stir-fried vegetables in the TDS**
- **Many variables may affect the formation of acrylamide**
  - e.g. batch to batch variation, food composition (e.g. contents of reducing sugars and amino acid), processing conditions (e.g. cooking temperature and time), etc

食肆的炒菜
Fried vegetables from restaurants

- **探討食肆炒菜的做法**
  - 在炒菜前，普遍會先灼菜1分鐘或以下
  - 基於有關結果，炒前灼菜是可助減低丙烯酰胺的形成
- **Further investigation on the frying vegetables in restaurants**
  - It is common to blanch leafy vegetables for about 1 minute or less before frying
  - Based on these findings, blanching vegetables may help to reduce the formation of acrylamide

減低風險的工作
Risk reduction

- 國際機構及多個國家機構致力探究減少食物中丙烯酰胺的方法
- 多個國家機構亦有推行監測計劃
- 食品法典委員會的實務守則(2009)
  - 在預防及減少薯類及穀物製品丙烯酰胺的形成方面，給國家機構和食品製造商提供指引
- **International bodies and many national authorities have made efforts to explore ways to reduce acrylamide in food**
- **Many national authorities are also implementing monitoring programme**
- **Codex Code of Practice (2009)**
  - Gives guidance to national authorities and manufacturers to prevent and reduce formation of acrylamide in potato products and cereal products

減低風險的工作 (二)
Risk reduction (2)

- 食物安全中心業界指引
  - 2011年發出
    - 提供建議協助業界減少在食物，特別是馬鈴薯和穀類製品中形成丙烯酰胺
  - 2013年更新
    - 加入有關烹煮蔬菜的建議

- **CFS Trade Guidelines**
  - **Issued in 2011**
    - Provide recommendations to help the trade minimise the formation of acrylamide in food, especially in potato and cereal based products
  - **Updated in 2013**
    - Incorporate advice on cooking vegetables

減低炒菜丙烯酰胺含量的具體方法
Specific ways to reduce acrylamide level in stir-fried vegetables

原材料	■ 考慮提供以水煮或蒸的蔬菜，甚或生吃的蔬菜。
配方	■ 研發配方，以水煮或蒸的方法烹煮含蔬菜的菜餚，而不用煎炒的方法。
食物加工方法	■ 在炒菜時，考慮在炒菜前先灼菜。 ■ 避免炒菜時間過長或溫度過高。

Raw materials	■ Consider serving vegetables prepared by boiling or steaming or vegetables that can be eaten raw.
Recipes	■ Develop recipes for vegetable containing dishes prepared by boiling or steaming, instead of frying.
Food processing conditions	■ For stir frying vegetables, consider blanching them first before frying. ■ Avoid frying vegetables for too long or at too high temperature.

減低風險的工作 (三)
Risk reduction (3)

- **自2003年以來，推出減少形成丙烯酰胺的措施**
  - 主要集中丙烯酰胺含量高的食物
  - 可有效減少部分個別人士或人群組別的攝入量
  - 但對大多數國家一般人群的攝入量只有輕微影響
- **JECFA建議**
  - 進一步努力發展及推行減少丙烯酰胺在食物形成的方法
- **Mitigation after 2003**
  - Mainly food with high acrylamide levels
  - Might significantly reduce the exposure for some individual or population subgroups
  - Little effect on the dietary exposure for the general population in many countries
- **JECFA recommended**
  - Further efforts on developing and implementing mitigation methods for acrylamide in foods

結論
Conclusion

- 丙烯酰胺的膳食攝入量
  - MOE < 10,000
  - 顯示對本地市民健康影響的程度值得關注
    - 流行病學研究未能提供一致的證據，證明從膳食攝入丙烯酰胺與患癌有關
- 應繼續致力減少本地食物丙烯酰胺的含量

- **Dietary exposure to acrylamide**
  - MOE < 10,000
  - **Indicate human health concern**
    - **No consistent evidence on the association between dietary exposure and cancer in humans from epidemiological studies**
- **Efforts should continue to be made in the interest of reducing acrylamide levels in food locally**

給業界的建議
Advice to trade

- 應設法減低食物的丙烯酰胺含量
- 選取原材料和制訂食譜及食品加工方法時，可參考有關的業界指引

- **Seek ways to reduce the level of acrylamide in food**
- **Make reference to the trade guidelines**
  - **during the selection of raw materials and the formulation of recipes and food processing conditions**

給市民的建議
Advice to public

- 應保持均衡及多元化的飲食
  - 每天應進食最少三份蔬菜
  - 不應進食過量薯片或炸薯等煎炸食物
- 市民不應烹煮食物時間過長或溫度過高

- **Have a balanced and varied diet**
  - Consume at least 3 servings of vegetables a day
  - Moderate the consumption of fried foods such as potato chips and fried potatoes
- **Not to cook food for too long or at too high a temperature**

給市民的建議(二)
Advice to public (2)

- 可考慮在炒菜前先灼菜，或以水煮或蒸的方法來烹煮蔬菜
  - 部分蔬菜可在清洗後生吃

- **Consider blanching the vegetables before frying, or cooking them by boiling or steaming**
  - Some vegetables may also be eaten raw after washing

公佈
Publicity

- **已於今年7月公佈有關研究結果**
  - 研究報告及業界指引(更新版)
    - 已上載食物安全中心網頁
- **其他總膳食研究報告**
  - 亦會陸續上載食物安全中心網頁
- **Study finding has been released in July 2013**
  - Study report and trade guidelines (updated version)
    - Uploaded in the webpage of CFS
- **Other TDS reports**
  - Will be released in phases and uploaded in the webpage of CFS

謝謝

Thank you

食物環境衞生署
Food and Environmental Hygiene Department

食物安全中心
Centre for Food Safety