Pesticide residues in food

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Pesticides and Food

What is a pest?

- Pests are living organisms that occur where they are not wanted or that cause damage to crops or humans or other animals. Examples include:
  - insects,
  - mice and other animals,
  - unwanted plants (weeds),
  - fungi,
  - microorganisms such as bacteria and viruses, and
  - Prions.

Chemical Pesticides

Organophosphate Pesticides - These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (they were used in World War II as nerve agents). However, they usually are not persistent in the environment.

Carbamate Pesticides affect the nervous system by disupting an enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates.

Organochlorine Insecticides were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence (e.g. DDT and chlordane).

Pyrethroid Pesticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system.

U.S. Environmental Protection Agency

Biopesticides

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. Eg: canola oil and baking soda; At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products.

Three major classes:

(1) **Microbial pesticides** consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds, and other fungi that kill specific insects. The most widely used microbial pesticides are subspecies and strains of Bacillus thuringiensis, or Bt.

(2) **Plant-Incorporated-Protectants (PIPs)** are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein, and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

(3) **Biochemical pesticides** are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances, such as insect sex pheromones, that interfere with mating, as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.

U.S. Environmental Protection Agency

Pesticide Ordinance in Hong Kong defines "pesticide“ as -

(a) any **insecticide**, **fungicide**, **herbicide**, **acaricide** or any **substance** (whether organic or inorganic) or mixture of substances used or intended to be used for **preventing, destroying, repelling, attracting, inhibiting or controlling** any **insect, rodent, bird, nematode, bacterium, fungus, weed or other form of plant or animal life or any virus**, which is a pest; or

(b) any substance or mixture of substances used or intended to be used as a **plant growth regulator, defoliant or desiccant**,

but does not include any purely mechanical device for trapping or catching insects, rodents or other animals; any purely electromagnetic or ultrasonic device for the control of mosquitoes, rodents or other pests; any antiseptic, disinfecting solution or preparation in clinical or sanitary applications; and any pharmaceutical product within the meaning of section 2 of the Pharmacy and Poisons Ordinance (Cap 138)

Pesticide

- "Pesticide" means any substance intended for **preventing, destroying, attracting, repelling, or controlling** any pest including unwanted species of plants or animals during the production, storage, transport, distribution, and processing of food, agricultural commodities, or animal feeds or which may be administered to animals for the control of ectoparasites.

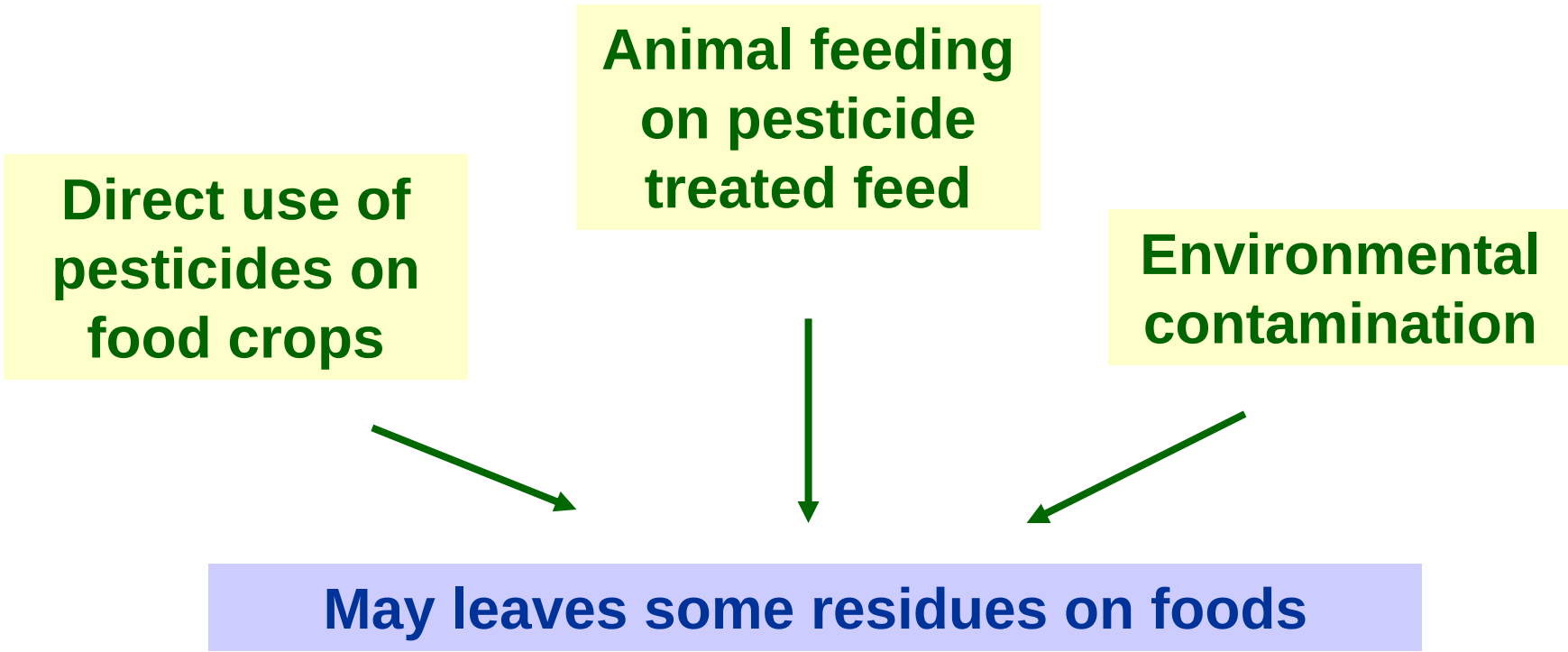
- The term includes substances intended for use as a **plant-growth regulator, defoliant, desiccant, fruit thinning agent, or sprouting inhibitor** and **substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport**.

- The term normally excludes fertilizers, plant and animal nutrients, food additives and animal drugs.

Note: "Agricultural commodities" refers to commodities such as raw cereals, sugar beet, and cottonseed which might not, in the general sense, be considered food.

Codex Alimentarius Commission. Pesticide Residue MRL. Glossary.
http://www.codexalimentarius.net/pestres/data/reference/glossary.html

Why would pesticide residues appear in food?



Pesticide Residue

- "Pesticide residue" means any specified substances in food, agricultural commodities, or animal feed resulting from the use of a pesticide.
- The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance.
- Note: The term "pesticide residue" includes residues from unknown or unavoidable sources (e.g., environmental), as well as known uses of the chemical.

The Incident

ORIGINAL PAPER

Vegetable-Borne Pesticide Poisoning

Lau Fei Lung*, MRCP
Senior Medical Officer
Accident and Emergency Department
United Christian Hospital

Background

Around 4 p.m. on 26th October, 1988, four groups of 14 patients presented to the Accident and Emergency Department of the United Christian Hospital. All had various combination of nausea,

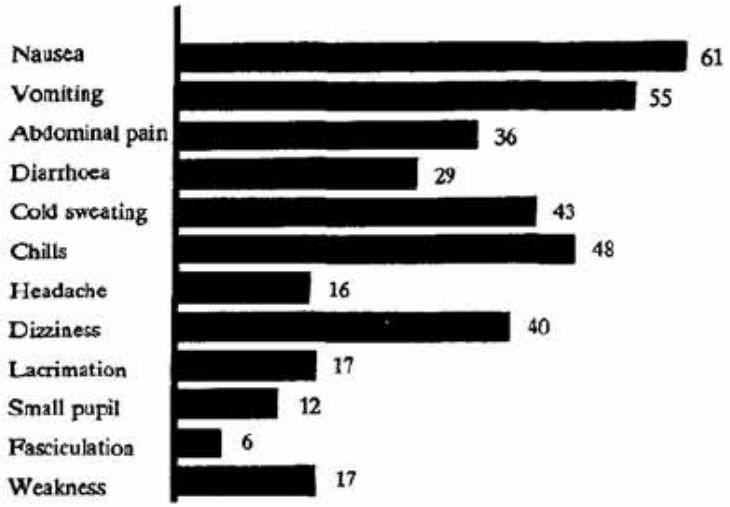


Fig. 4 Clinical Features by Number of Patients (N=64).

Lau FL. Vegetable-borne Pesticide Poisoning. Hong Kong Practitioners. 1990, 12: 1193-7.

An outbreak of pesticide poisoning in 1988 in Hong Kong

Vegetable Consumed	
Choi-Sum	58
White Cabbage	4
Both	2
Method of Cooking	
Boil	21
Fry	42

Fig. 2: The Distribution of Types of Vegetable Consumed and Methods of Cooking in 64 Patients.

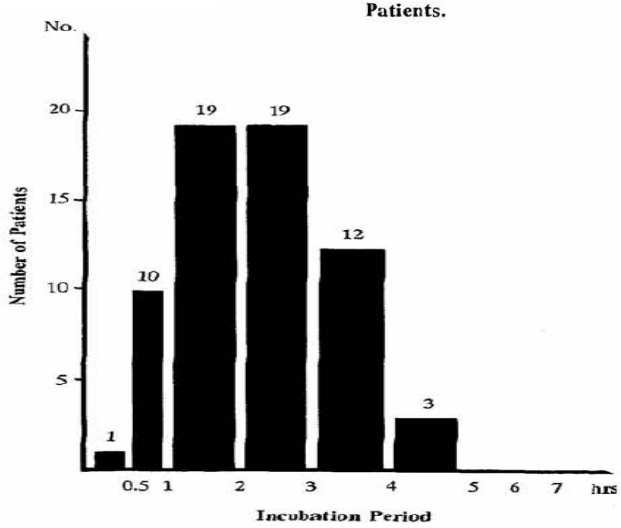


Fig. 3: Numbers of Patients by Incubation Period.

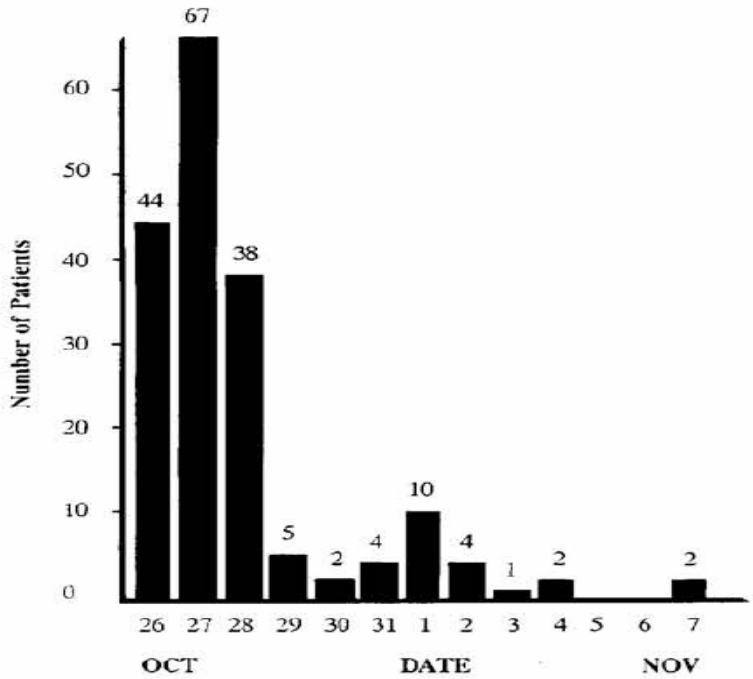


Fig. 1: Number of Daily Attendances of Vegetable Borne Pesticide Poisoned Patients to the United Christian Hospital A & E Department During the Outbreak.

Methamidophos

- An organophosphate insecticide
- Acute toxicity: central and peripheral neurological effects; may cause respiratory paralysis in severe cases
- Water soluble
- Found in vegetables

Responses…

- Implement import control measures
- Introduce testing at boundary control point
- Enhance awareness among medical professionals
- Urge the public to wash vegetables thoroughly; to boil the vegetables and discard the water

Table 3 Vegetable Sample Results of Different Vegetables Types (For the Period April to July 1996)

Vegetables Types	Total Number of Samples Tested	Number of Samples with Pesticide Detected	Positive Rate (%)
Chinese Flowering Cabbage 菜心	836	17	2.0
Chinese White Cabbage 白菜	694	26	3.7
Chinese Spinach 莧菜	518	1	0.2
Water Spinach 蕹菜	354	32	9.0
Lettuce 生菜	324	7	2.2
Bosella 潺菜	38	7	18.4
Matrimony Vine 枸杞	3	2	66.7
Others 其他	629	11	1.7
Total	3 396	103	3.0

Control of pesticide-tainted vegetables in the Man Kam To Control Office.
Lee WO, Chu CF.
Public Health and Epidemiologic Bulletin. 1996 Nov: 28-30.

Table 1 Food Poisoning Cases due to Pesticide Contaminated Vegetables

Year	Number of Cases (Number of Persons Affected)
1987	81 (205)
1988	312 (497)
1989	5 (27)
1990	0 (0)
1991	42 (71)
1992	29 (71)
1993	24 (56)
1994	57 (141)
1995	18 (48)
1996 (up to July)	2 (6)

Control of pesticide-tainted vegetables in the Man Kam To Control Office.
Lee WO, Chu CF.
Public Health and Epidemiologic Bulletin. 1996 Nov: 28-30.

To date:

- Public Health and Municipal Services Ordinance requires all food on sale be wholesome, unadulterated and fit for human consumption
- Maintain under surveillance through dentification tags, sample and test.
- The Maximum Residue Limits (MRLs) and Extraneous Maximum Residues Limits (EMRLs) for pesticides recommended by Codex Alimentarius Commission are used as Tolerance Levels.

Impact on Human Health

Effects of pesticide residues on health

- **Depend on the nature of the pesticide, as well as the amount and duration of exposure**

- **Possible adverse effects due to excessive intake of pesticide residues**：

  - **Acute effects：methamidophos may affect nervous system**

  - **Chronic effects：lindane may affect the kidney and liver of animals, dicofol may affect foetal development**

The WHO Recommended Classification of Pesticides by Hazard

- Approved by the 28th World Health Assembly in 1975, first published in 1975 (latest : 2009 edition)
- Sets out a classification system to distinguish between the more and the less hazardous forms of selected pesticides based on **acute risk to human health** (that is the risk of single or multiple exposures over a relatively short period of time)
- Takes into consideration the toxicity of the technical active substance and also describes methods for the classification of formulations

Basis of WHO classification system

- Apply toxicology principles: based on the **acute oral and dermal toxicity to the rat (LD_{50})**

WHO Class		LD_{50} for the rat (mg/kg body weight)	
		Oral	Dermal
Ia	Extremely hazardous	< 5	< 50
Ib	Highly hazardous	5–50	50–200
II	Moderately hazardous	50–2000	200–2000
III	Slightly hazardous	Over 2000	Over 2000
U	Unlikely to present acute hazard	5000 or higher	

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

GHS Classification

GHS Category	Classification criteria			
	Oral		Dermal	
	LD_{50} [a] (mg/kg bw)	Hazard Statement	LD_{50} [b] (mg/kg bw)	Hazard Statement
Category 1	< 5	Fatal if swallowed	< 50	Fatal in contact with skin
Category 2	5 - 50	Fatal if swallowed	50 - 200	Fatal in contact with skin
Category 3	50 - 300	Toxic if swallowed	200 - 1000	Toxic in contact with skin
Category 4	300 - 2000	Harmful if swallowed	1000 - 2000	Harmful in contact with skin
Category 5	2000 - 5000	May be harmful if swallowed	2000 - 5000	May be harmful in contact with skin

[a] For oral data the rat is the preferred species, though data from other species may be appropriate when scientifically justified

[b] For dermal data the rat or rabbit are the preferred species, though data from other species may be appropriate when scientifically justified

Other aspects of toxicology

- Organ damage
- Reproductive organs
- Pregnancy and foetus

PRINCIPLES GOVERNING CONSUMER SAFETY IN RELATION TO PESTICIDE RESIDUES

Report of a Meeting
of a WHO Expert Committee on Pesticide Residues
held jointly with the
FAO Panel of Experts on the Use of Pesticides
in Agriculture

WORLD HEALTH ORGANIZATION

GENEVA

1962

1. Pesticides are indispensable to the farmer in his fight against pests and diseases. Without their use, many foods could not be produced economically or perhaps at all, and the yield of all crops could be seriously reduced.

2. Pesticides vary widely in the degree of possible hazard they present to users, consumers of treated crops, farm animals, wild life and the public. The Meeting was concerned only with the possible hazards to human and animal consumers. It acknowledged the need for studies on the hazards to operators and to wild life and was pleased to note that the aspects concerning the safety of the operator have already received, and continue to receive, the attention of WHO and ILO and of nature conservationists concerned, internationally, with the problem of protecting wild life against the effects of pesticides.

JMPR - Joint FAO/WHO Meeting on Pesticide Residues

- A scientific advisory body to FAO, WHO, their respective member governments, and the Codex Alimentarius Commission.

- Develop a series of **toxicological evaluations and monographs** to be used by the Codex Alimentarius Commission and national governments for setting international food standards and safe levels for protection of the consumer.

JMPR and Codex

- JMPR provides advice to the Codex Alimentarius Commission on pesticides via the Codex Committee on Pesticide Residues (CCPR).
- CCPR provides advice, based on the evaluations of JMPR, on appropriate standards for pesticide residues in food

Acceptable Daily Intake (ADI)

- The daily intake which, during an entire **lifetime**, appears to be without appreciable risk to the health of the consumer on the basis of all the known facts at the time of the evaluation of the chemical by the Joint FAO/WHO Meeting on Pesticide Residues.

- It is expressed in milligrams of the chemical per kilogram of body weight.

- Concerns about Long Term Toxicity

Setting Standards

CCPR - Codex Committee on Pesticide Residues

Terms Of Reference

- to **establish maximum limits for pesticide residues** in specific food items or in groups of food;
- to **establish maximum limits for pesticide residues** in certain animal feeding stuffs moving in international trade where this is justified for reasons of protection of human health;
- to prepare priority lists of pesticides for evaluation by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR);
- to consider methods of sampling and analysis for the determination of pesticide residues in food and feed;
- to consider other matters in relation to the safety of food and feed containing pesticide residues; and,
- to **establish maximum limits for environmental and industrial contaminants** showing chemical or other similarity to pesticides, in specific food items or groups of food.

Maximum residue limits (MRLs)

- "MRL" is the maximum concentration of a pesticide residue (expressed as mg/kg), recommended by the Codex Alimentarius Commission to be legally permitted in or in food commodities and animal feeds.
- MRLs are based on GAP data, and
- Foods derived from commodities that comply with the respective MRLs are intended to be toxicologically acceptable.

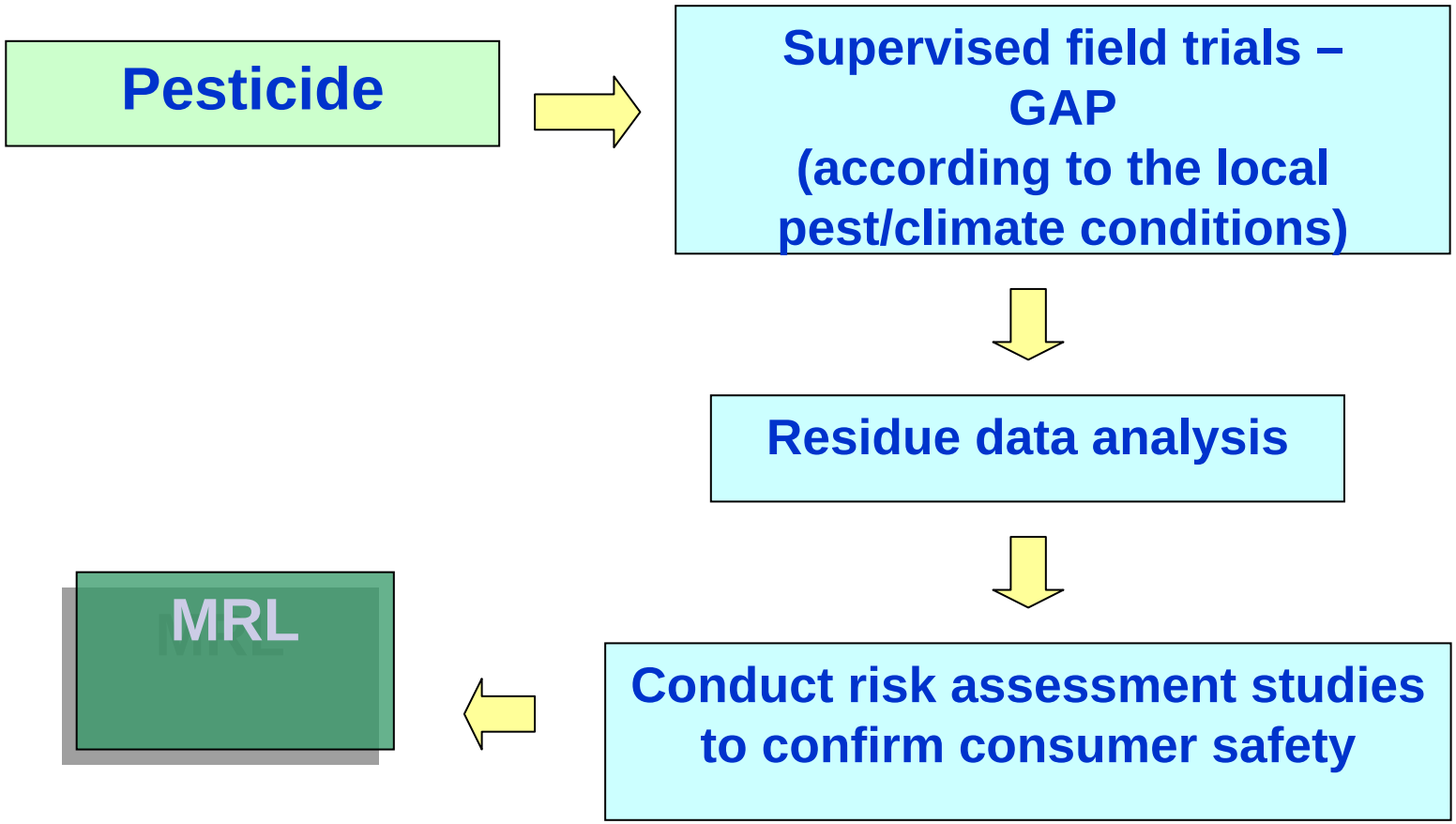
Extraneous maximum residue limits (EMRLs)

- "EMRL" refers to a pesticide residue or a contaminant arising from environmental sources (including former agricultural uses) other than the use of a pesticide or contaminant substance directly or indirectly on the commodity.
- It is the maximum concentration of a pesticide residue or contaminant that is recommended by the Codex Alimentarius Commission to be legally permitted or recognized as acceptable in or on a food, agricultural commodity, or animal feed.
- The concentration is expressed in milligrams of pesticide residue or contaminant per kilogram of the commodity.

Good Agricultural Practice in the Use of Pesticides (GAP)

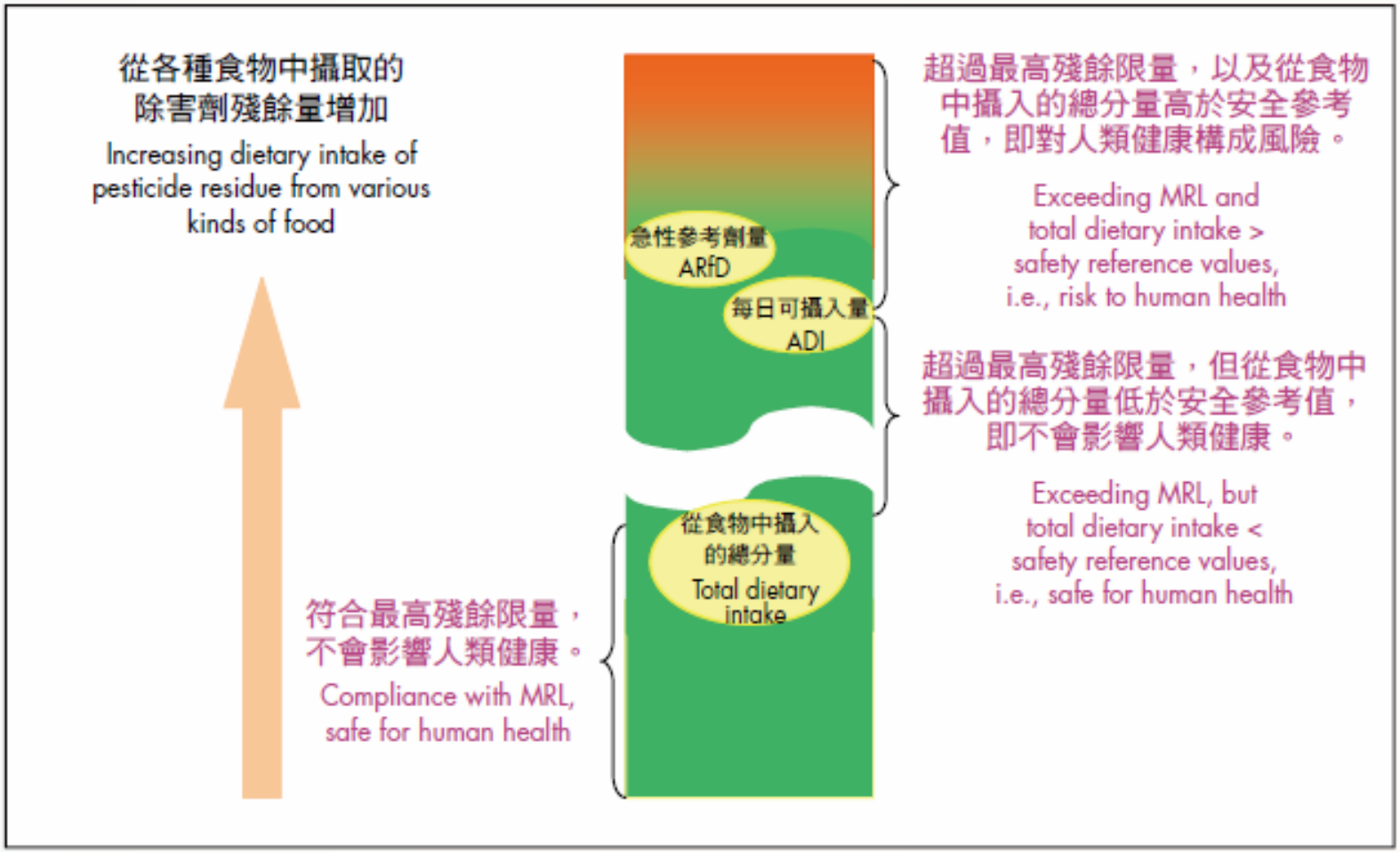
- "GAP" includes the nationally authorised safe uses of pesticides under actual conditions necessary for effective and reliable pest control.
- It encompasses a range of levels of pesticide applications up to the highest authorised use, applied in a manner which **leaves a residue which is the smallest amount practicable**.
- Authorised safe uses are determined at the national level and include nationally registered or recommended uses, which take into account public and occupational health and environmental safety considerations.
- Actual conditions include any stage in the production, storage, transport, distribution and processing of food commodities and animal feed.

Development of MRL



圖一：最高殘餘限量與安全參考值的關係

Figure 1: Relationship between Maximum Residue Limit (MRL) and Safety Reference Values



Lum J. Pesticide Residues in Food (Part III). Food Safety Focus. 2008 (Apr); 21: 3-4. http://www.cfs.gov.hk

MRLs for Methamidophos

Pesticide Residues in Food and Feed

PESTICIDE DETAILS

100 Methamidophos

Functional Class

- Insecticide

Maximum Residue Limits for Methamidophos

Commodity	MRL	Year of Adoption	Symbols	Note
Artichoke, Globe	0.2 mg/Kg	2005		
Beans, except broad bean and soya bean	1 mg/Kg	2006		
Cotton seed	0.2 mg/Kg	2005		
Edible offal (mammalian)	0.01 mg/Kg	2005	(*)	
Eggs	0.01 mg/Kg	2005	(*)	
Fodder beet	0.02 mg/Kg	2005		
Meat (from mammals other than marine mammals)	0.01 mg/Kg	2005	(*)	
Milks	0.02 mg/Kg	2005		
Potato	0.05 mg/Kg	2005		
Poultry meat	0.01 mg/Kg	2005	(*)	
Poultry, Edible offal of	0.01 mg/Kg	2005	(*)	
Soya bean (dry)	0.1 mg/Kg	2005		
Sugar beet	0.02 mg/Kg	2005		

(*) At or about the limit of determination.

EMRLs for DDT

Pesticide Residues in Food and Feed

PESTICIDE DETAILS

21 DDT

Functional Class

- Insecticide

Maximum Residue Limits for DDT

Commodity	MRL	Year of Adoption	Symbols	Note
Carrot	0.2 mg/Kg	1997	E	
Cereal grains	0.1 mg/Kg		E	
Eggs	0.1 mg/Kg	1997	E	
Meat (from mammals other than marine mammals)	5 mg/Kg	2001	(fat) E	EMRL: 1-5 mg/kg
Milks	0.02 mg/Kg	1997	F E	
Poultry meat	0.3 mg/Kg	2003	(fat) E	EMRL: 0.1-0.3 mg/kg

(fat) (for meat) The MRL/EMRL applies to the fat of meat.

F (for milks) The residue is fat soluble and MRLs for milk products are derived as explained in "Codex Maximum Residue Limits/Extraneous Maximum Residue Limits for Milk and Milk Products".

E (only for MRLs) The MRL is based on extraneous residues.

Other information
JMPR-related information

ADI/PTDI	0.01 mg/kg body weight (2000)
Residue definition	Sum of p,p'-DDT, o,p'-DDT, p,p'-DDE and p,p'-TDE (DDD) (fat-soluble).

Food Classification and MRL Setting

- Developed “Codex Classification of Foods and Animal Feeds” for the purpose of establishing group MRLs for commodities
- Foods in the same groups and/or sub-groups with similar characteristics and residue potential
- Provide uniform nomenclature

MRLs for Leafy Vegetables

Pesticide Residues in Food and Feed

COMMODITY DETAILS

VL 0053 – Leafy vegetables

- Class
  Primary Food Commodities of Plant Origin
- Type
  Vegetables
- Category
  Leafy Vegetables (Including Brassica Leafy Vegetables)

Maximum Residue Limits for Leafy vegetables

Pesticide	MRL	Year of Adoption	Symbols	Note
Aldrin and Dieldrin	0.05 mg/Kg	1997	E	
Paraquat	0.07 mg/Kg	2006		
Cypermethrins (including alpha- and zeta- cypermethrin)	0.7 mg/Kg	2009		
Deltamethrin	2 mg/Kg	2006		
Spirotetramate	7 mg/Kg	2009		
Spinozad	10 mg/Kg	2004		
Tebufenozide	10 mg/Kg	2004		
Chlorantraniliprole	20 mg/Kg	2009		
Mandipropamid	25 mg/Kg	2009		
Boscalid	30 mg/Kg	2010		The Committee noted the reservation of the EU regarding the proposed MRL for leafy vegetable in light of their higher MRL for lamb's lettuce. The EU agreed to submit their data for JMPR evaluation. (42-79)

E (only for MRLs) The MRL is based on extraneous residues.

MRLs for Citrus Fruits

Pesticide Residues in Food and Feed

COMMODITY DETAILS

FC 1 – Citrus fruits

- Class
  Primary Food Commodities of Plant Origin
- Type
  Fruits
- Category
  Citrus Fruits

Maximum Residue Limits for Citrus fruits

Pesticide	MRL	Year of Adoption	Symbols	Note
Heptachlor	0.01 mg/Kg			
Abamectin	0.01 mg/Kg	2001	(*)	
Deltamethrin	0.02 mg/Kg	2004		
Paraquat	0.02 mg/Kg	2006		
Aldrin and Dieldrin	0.05 mg/Kg	1997		
Pyrethrins	0.05 mg/Kg	2003		
Haloxyfop	0.05 mg/Kg	2001	(*)	
Glufosinate-Ammonium	0.1 mg/Kg	1997		
Aldicarb	0.2 mg/Kg	1991		
Cyhalothrin (includes lambda-cyhalothrin)	0.2 mg/Kg	2009		
Spinozad	0.3 mg/Kg	2003		
Cyfluthrin/beta-cyfluthrin	0.3 mg/Kg	2008		
Diflubenzuron	0.5 mg/Kg	2004		
Trifloxystrobin	0.5 mg/Kg	2006		

Codex Classification of Foods and Animal Feeds

- Five classes:
  - Class A Primary Food Commodities of Plant Origin
  - Class B Primary Food Commodities of Animal Origin
  - Class C Primary Animal Feed Commodities
  - Class D Processed Foods of Plant Origin
  - Class E Processed Foods of Animal Origin

- Hierarchy: Class ☞ Type ☞ Group ☞ Commodity

Class A

Type 2 **Vegetables** **Group 013** **Group Letter Code VL**

Group 013 Leafy vegetables are foods derived from the leaves of a wide variety of edible plants, usually annuals or biennials. They are characterized by high surface : weight ratio. The leaves are fully exposed to pesticides applied during the growing season.

The entire leaf may be consumed, either fresh or after processing or household cooking.

Portion of the commodity to which the MRL applies (and which is analysed): **Whole commodity as usually marketed, after removal of obviously decomposed or withered leaves.**

Group 013 Leafy vegetables (including Brassica leafy vegetables)

Code No.	Commodity
VL 0053	**Leafy vegetables**
VL 0054	**Brassica leafy vegetables** *Brassica* spp.
VL 0460	**Amaranth** among others *Amaranthus dubius* Mart. ex Thell.; *A. cruentus* L.; *A. tricolor* L., several var.
VL 4313	**Amsoi**, see Indian Mustard
VL 4315	**Arrugula**, see Rucola
VL 0421	**Balsam pear leaves** *Momordica charantia* L.

Primary Food Commodities of Plant Origin

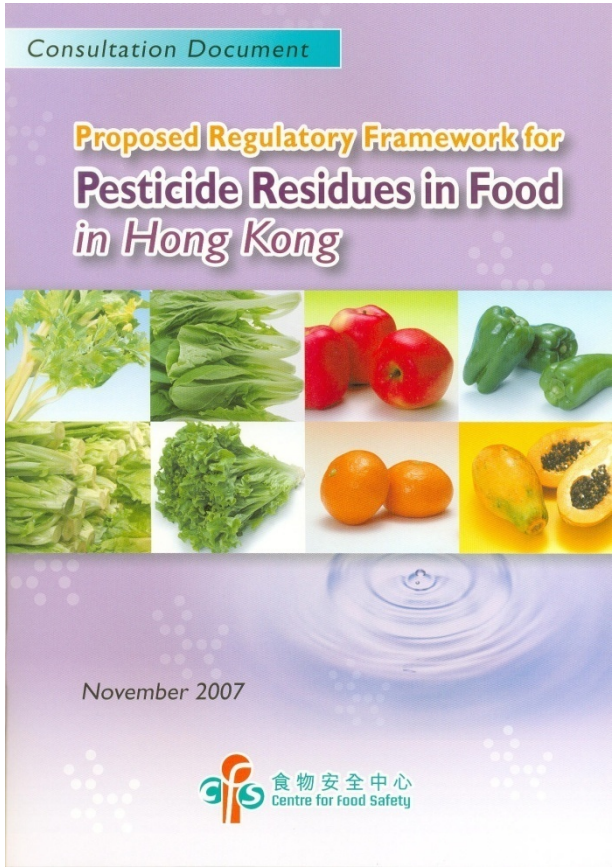
Type	Group
01 Fruits	Citrus fruits
	Pome fruits
	Stone fruits
	Berries and other small fruits
	Assorted tropical and sub-tropical fruits – edible peel
	Assorted tropical and sub-tropical fruits – inedible peel
02 Vegetables	Bulb vegetables
	Brassica (cole or cabbage) vegetables, Head cabbages, Flowerhead cabbages
	Fruiting vegetables, Cucurbits
	Fruiting vegetables, other than Cucurbits
	Leafy vegetables (including Brassica leafy vegetables)
	Legume vegetables
	Pulses
	Root and tuber vegetables
	Stalk and stem vegetables
03 Grasses	Cereal grains
	Grasses, for sugar or syrup production
04 Nuts and Seeds	Tree nuts
	Oilseed
	Seed for beverages and sweets
05 Herbs and Spices	Herbs
	Spices

Regulatory Framework for Hong Kong

Chronology

- Developed an initial framework for regulating pesticide residues in food in Hong Kong in 2007
- Conducted public consultation from Nov 2007 to Jan 2008
- Revisited and refined with development of preliminary list of MRL/EMRL
- Started technical consultation on practical details since Jan 2011

Public Consultation Exercise: Nov 2007 to Jan 2008



- Public consultation;

- Legislation

Thank you.