The First Hong Kong Total Diet Study Report No. 4

The First Hong Kong Total Diet Study: Pesticide Residues

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KEY FINDINGS

The First Hong Kong Total Diet Study: Pesticide Residues

Key findings of the study

- The current report presents the dietary exposure assessment of the local population to the residues of 85 commonly encountered pesticides or their metabolites under four pesticide groups, namely organophosphorus pesticides (OPPs), carbamates, pyrethrins and pyrethroids, and dithiocarbamate metabolites.
- As expected, the residues of all four groups of pesticides analysed were primarily found at low levels in food samples of plant origin such as vegetables and fruits.
- Estimated dietary exposures of the local population to all pesticide residues analysed were all well below the relevant safety reference values.
- The study concluded that dietary exposures to the pesticide residues analysed would be unlikely to pose unacceptable health risks to the local population.

EXECUTIVE SUMMARY

The First Hong Kong Total Diet Study:

Pesticide Residues

The Centre for Food Safety (CFS) is conducting the First Hong Kong Total Diet Study (the 1st HKTDS) to estimate dietary exposures of the Hong Kong general population and various population subgroups to a range of substances, including contaminants and nutrients, and to assess any associated potential health risks. The 1st HKTDS comprises food sampling and preparation, laboratory analysis and dietary exposure estimation. A total of 1,800 samples, comprising 150 different TDS food items with three purchases on each of the four occasions from March 2010 to February 2011, were collected and prepared, and then combined into 600 composite samples for testing of various selected substances.

2. This report presents the dietary exposure assessment to the residues of four groups of pesticides or their metabolites, namely organophosphorus pesticides (OPPs), carbamates, pyrethrins and pyrethroids, and dithiocarbamate metabolites.

3. The use of pesticides and other chemicals has become a common practice in modern agriculture, to enhance and stabilise crop yield, protect the nutritional integrity of food, facilitate food storage to assure year-round supplies and provide attractive and appealing food products. The proper use of pesticides protects crops from contamination by harmful microorganisms,

including toxin producing fungi and is beneficial to public health. With the adoption of strict Good Agricultural Practice (GAP), only acceptable amounts of pesticide residues should remain in the crops or, in connection, foods of animal origin. OPPs, carbamates, pyrethrins and pyrethroids and dithiocarbamates are four common groups of pesticides generally used as insecticides, herbicides or fungicides on agricultural crops.

4. The adverse health effects of pesticides depend on the toxic nature of the pesticides, as well as the amount and duration of exposure to the pesticide residues. OPPs and carbamates act by inhibiting the enzyme acetylcholinesterase (AChE) and may lead to signs of neurotoxicity but they generally do not accumulate in the human body. The acute toxic effects of pyrethrins and pyrethroids are also related to their adverse effects on the nervous system. Two dithiocarbamate metabolites, ethylene thiourea (ETU) and propylene thiourea (PTU), are of greater concern than their respective parent compounds due to their known thyroid toxicity.

Results

5. A total of 85 pesticides or their metabolites under four pesticide groups, including 48 OPPs, 20 carbamates, 15 pyrethrins and pyrethroids, and two dithiocarbamate metabolites, were analysed in 600 composite samples involving 150 TDS food items. Overall, 41 pesticides (48% of pesticides analysed) were detected at low levels in 198 composite samples (33% of composite samples)*. OPPs was the most commonly detected pesticide group (in 17% of composite

* This % just reflected the detection of pesticide residues in composite samples but it could not reflect the situation in individual samples. The % of the detection in individual samples was probably lower than that of composite samples.

samples, the highest mean level: 240 μg/kg), followed by pyrethrins and pyrethroids (15%, the highest mean level: 130 μg/kg), dithiocarbamate metabolites (13%, the highest mean level: 120 μg/kg) and carbamates (10%, the highest mean level: 350 μg/kg). As regards individual pesticides, ETU was the most widely detected (in 13% of composite samples), followed by cypermethrin (11%), propamocarb (5%) and chlorpyrifos (5%).

6. Among the seven major TDS food groups (contributing to > 5% of total samples analysed), the food group "vegetables and their products" was found to contain the highest number of detectable pesticide residues and the highest % of composite samples with detectable levels within respective food groups (31 pesticides, in 69% of composite samples within the food group), followed by "mixed dishes" (14 pesticides, in 42% of composite samples within the food group) and "fruits" (17 pesticides, in 40% of composite samples within the food group). In contrast, four food groups, namely "meat, poultry and game and their products", "egg and their products", "dairy products" and "sugars and confectionery", were found to contain no detected level of any of the pesticide residues in all of the composite samples analysed.

7. The estimated dietary exposures of the Hong Kong population to all 85 individual pesticides were found to be well below their respective Acceptable Daily Intakes (ADIs). The percentage contributions of the estimated dietary exposures of the average and high consumers to individual pesticides, respectively, were < 1% for the carbamates and pyrethrins and pyrethroids, < 6% and < 24% for the OPPs, and < 1% and < 4% for the dithiocarbamate metabolites. The pesticide residues with the highest contribution to the ADI

were found to be dimethoate and omethoate† (5.2% and 23.8% of the ADI for the average and high consumers, respectively).

Conclusions and Recommendations

8. All four groups of pesticides analysed in this Study, namely OPPs, carbamates, pyrethrins and pyrethroids, and dithiocarbamate metabolites, were primarily found at low levels in food samples of plant origin such as vegetables and fruits, as expected.

9. The estimated dietary exposures of the Hong Kong population to all 85 individual pesticide residues analysed were all well below their respective ADIs. The findings indicate that dietary exposures to all the pesticide residues analysed in this Study would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population. Nevertheless, the following general advices are recommended.

10. The farmers are advised to observe Good Agricultural Practice (GAP), such as using only pesticides registered with the competent authority, and applying the minimum quantities necessary to achieve adequate pest control. They should also use the pesticides in strict accordance with the label requirements, e.g., do not harvest the crops within the specified withholding period after the last pesticide application.

11. The findings re-affirmed the safety of basic dietary advice on healthy eating, i.e. have a balanced and varied diet which includes a wide variety of

† Omethoate can be both a pesticide and a metabolite of dimethoate. The dietary exposure of dimethoate and omethoate was estimated by the sum of dimethoate and omethoate, expressed as dimethoate.

foods, including fruits and vegetables. To minimise the potential exposure to water soluble pesticide residues, the public can wash vegetables and fruits thoroughly in clean running water, and soak the vegetables in water for one hour and then rinse, or alternatively blanch the vegetables in boiling water for one minute and discard the water. To further reduce their pesticide exposure, the public can also remove the outer leaves of the vegetables or peel the vegetables and fruits as appropriate.

Chapter 1

Background

1.1 Total Diet Study (TDS) has been recognised internationally as the most cost effective way to estimate dietary exposures to food chemicals or nutrients for various population groups and to assess their associated health risks. It provides a scientific basis for assessing food safety and regulating food supply. Since 1960s, various countries including the United Kingdom (UK), the United States of America (USA), Canada, Australia, New Zealand and Mainland China, have been conducting their own TDS.

Introduction of the First Hong Kong Total Diet Study (1st HKTDS)

1.2 This was the first time a TDS was carried out in Hong Kong by the Centre for Food Safety (CFS). It aimed to estimate dietary exposures of the Hong Kong general population and various population subgroups to a range of substances including contaminants and nutrients, and to assess any associated potential health risks.

1.3 The 1st HKTDS was a large and complex project that comprised food sampling and preparation, laboratory analysis and dietary exposure estimation. It covered the majority of foods normally consumed by the Hong Kong population, with laboratory analysis of over 130 substances including contaminants and nutrients.

Pesticide Residues

1.4 The use of pesticides and other chemicals has become a common practice in modern agriculture, to enhance and stabilise crop yield, protect the nutritional integrity of food, facilitate food storage to assure year-round supplies and provide attractive and appealing food products. The proper use of pesticides protects crops from contamination by harmful microorganisms, including toxin producing fungi, and is beneficial to public health. With the adoption of strict Good Agricultural Practice (GAP), only acceptable amounts of pesticide residues should remain in the crops or, in connection, foods of animal origin. OPPs, carbamates, pyrethrins and pyrethroids and dithiocarbamates are four common groups of pesticides used as insecticides, herbicides or fungicides on agricultural crops. The adverse health effects of pesticides depend on the toxic nature of the pesticides, as well as the amount and duration of individual exposure to the pesticide residues.

1.5 This report focuses on estimating the dietary exposure of the local population to the residues of four groups of pesticides or their metabolites, including 48 organophosphorus pesticides (OPPs), 20 carbamates, 15 pyrethrins and pyrethroids, and two dithiocarbamate metabolites, as well as assessing the their associated potential health risks.

Chapter 2

Methodology and Laboratory Analysis

Methodology of the 1st HKTDS

2.1 The 1st HKTDS involved purchasing samples of food commonly consumed throughout Hong Kong, preparing them in a form of food normally consumed, combining the prepared foods into well-defined food composites, homogenising and analysing the food composites for a range of substances. The analytical results were combined with the food consumption information of the general population and various population subgroups captured from the Hong Kong Population-based Food Consumption Survey (FCS) [1] to estimate the dietary exposures of the local population to pesticide residues in foods.

2.2 Based on the FCS, 150 TDS food items (involving 15 food groups) were selected for the Study (see Figure 2.1). Three samples of each TDS food item were collected and prepared in a form of food normally consumed on each of the four occasions from March 2010 to February 2011. A total of 1,800 samples were collected and combined into 600 composite samples for laboratory chemical analysis.

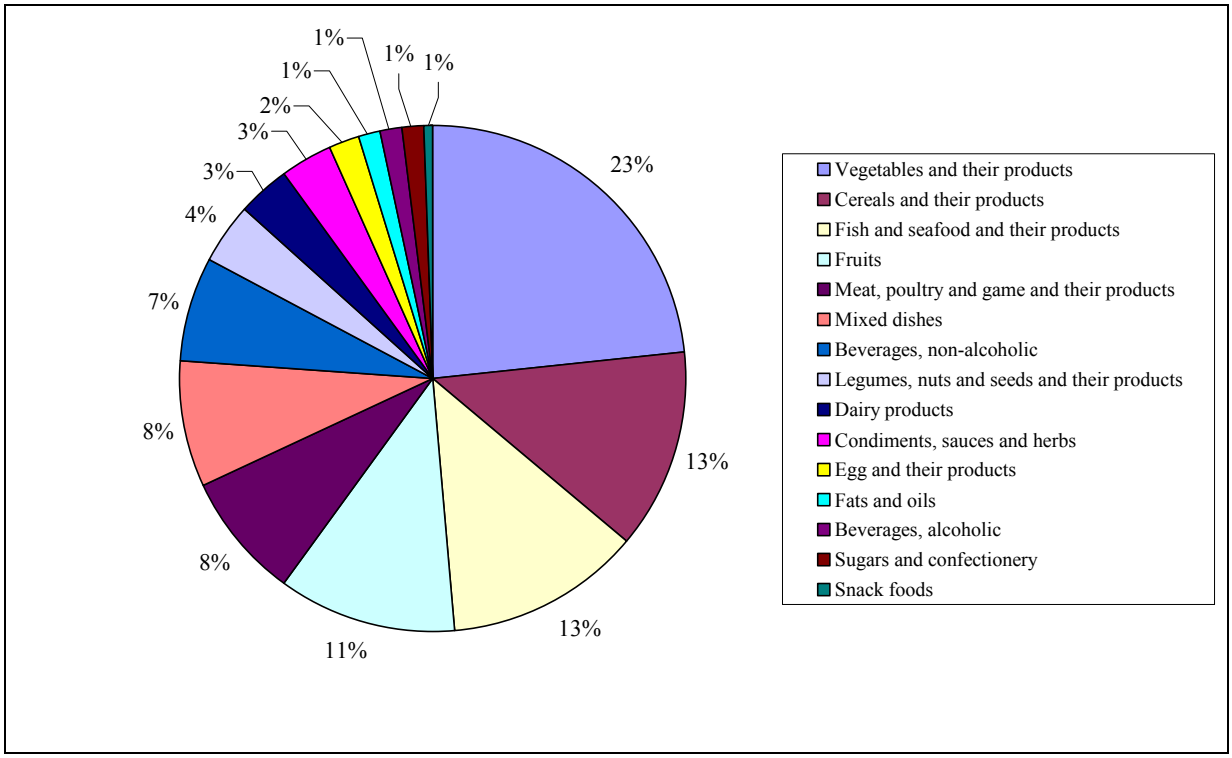

Figure 2.1: Proportion of Individual TDS Food Groups in the 150 Food Items Analysed

2.3 As the pesticides are intentionally applied to food crops, it is considered reasonable to assume that the pesticides concerned have not been used on the food samples under investigation when the residues are below their limits of detection (LOD). Accordingly, all non-detects in the present Study were assigned concentration levels of zero (lower bound) for calculating the residue levels in food and dietary exposures. For those pesticides with no detectable residues in all 600 composite samples analysed, no dietary exposures were estimated and presented. Similar approach in the treatment of study results on non-detected pesticide residues has been adopted in overseas TDS [2,3].

2.4 Dietary exposure estimates were performed with the aid of an in-house web-based computer system, the EASY (Exposure Assessment System), which involved food mapping and weighting of data. The mean and

95th percentile exposure levels were used to represent the dietary exposures of the average and high consumers of the local population, respectively. The estimated dietary exposures to individual pesticide residues of the average and high consumers were compared with the respective safety reference values of pesticides to assess the associated potential health risks.

2.5 Details of the methodology are given in the same series of reports on Methodology [4].

Laboratory Analysis

2.6 Laboratory analysis of the four groups of pesticide residues was conducted by the Food Research Laboratory (FRL) of the CFS. All 600 composite samples prepared from 1,800 individual samples of the 150 TDS food items taken from the four occasions were tested. Fifteen grams of each composite sample portion was extracted with acidified acetonitrile in the presence of magnesium sulphate, sodium acetate and sodium chloride. Part of the extract was then cleaned up with appropriate dispersive solid phase materials. Pesticide residues were determined by the liquid chromatography with tandem mass spectrometry (LC-MS/MS). The limit of detection (LOD) and the limit of quantification (LOQ) for organophosphorus pesticides (OPPs), carbamates and pyrethrins and pyrethroids in food were 2 and 10 μg/kg, respectively, and in water were 1 and 5 μg/kg, respectively. The LOD and LOQ for dithiocarbamate metabolites in both food and water were 1 and 5 μg/kg, respectively.

Chapter 3

Organophosphorus pesticides (OPPs)

3.1 Organophosphorus pesticides (OPPs) are synthetic chemical compounds, many of which are esters, amides or thiol derivatives of phosphoric, phosphonic, phosphorothioic or phosphonothioic acids. OPPs can be categorised into three main groups, namely phosphates, phosphorothioates and phosphorodithioate [5]. The 48 OPPs covered in this Study are listed in Table A.1 of Appendix A.

Sources of OPPs

3.2 OPPs are predominantly used in agriculture for crop production as insecticides in controlling insects, mites etc. Only a small percentage is used for disease vector control. OPPs are mainly applied on plants during growing stage. The pesticides can be taken up through skin, respiratory tract or the gastrointestinal tract in insects, animals and plants. The efficiency of skin absorption may be high, and field worker protection is therefore necessary. Metabolism in human and animals are primarily through oxidation, hydrolysis with esterases and by transferring portion of the molecule to glutathione. The residues are then eliminated via urine or faeces [5].

Toxicity

3.3 OPPs act by inhibiting the neurotransmitter, acetylcholinesterase (AChE), in the nervous system. As the organophosphorylated enzyme is stable in many cases, the affected organism may be slow in recovering from

intoxication, and often a lower dose compared with similar carbamate pesticides will be required to achieve a particular toxic effect. In human, overt symptoms of OPP intoxication develop quickly, except for some lipophilic OPPs where there may be a few hours delay following exposure. For mild cases, the symptoms of acute intoxication retreat quickly with little long term residual effects. For severe cases, respiratory failure often results [5].

3.4 Regarding the safety reference values of the 48 OPPs tested in this Study, the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues (JMPR) has established Acceptable Daily Intakes (ADIs) for 36 and the United States Environmental Protection Agency (EPA) has established reference doses (RfD) for eight. Two OPPs have ADIs as stated in the National Standard of Peoples' Republic of China (PRC) GB 2763-2005. One OPP has ADI as evaluated by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), while the other OPP has ADI established by the Office of Chemical Safety in Australia. The safety reference values, ranged from 0.00007 to 0.3 mg / kg body weight (bw) / day, are listed in Table A.1 of Appendix A.

Sources of Dietary Exposure

3.5 Diet is the main route of exposure for the general population. Crops that have been improperly treated with pesticides or harvested too soon after pesticide treatment contribute as the main potential sources of dietary exposure to pesticide residues. Crops that are grown under Good Agricultural Practice (GAP) should not leave pesticide residues in food at levels likely to be harmful to human health [5].

Results and Discussions

Concentrations of OPPs in TDS Foods

3.6 A total of 600 composite samples (comprising 150 TDS food items and 15 food groups, collected and prepared on four occasions) were tested for OPPs. One hundred composite samples (17%), involving 53 TDS food items and eight food groups, were found to contain detectable levels of OPPs, either singly or in combination.

3.7 Among the 48 OPPs tested, only 21 were detected in one or more of the 600 composite samples analysed. The 27 non-detected OPPs are listed in Table A.1 of Appendix A.

3.8 The numbers of composite samples with detectable levels of one or more of the 21 OPPs in the eight (of the 15) TDS food groups are summarised in Table 3.1. The lists of individual TDS food items with and without detectable levels of OPPs are presented in Table B.1 of Appendix B. The levels of individual OPPs in individual food items are shown in Table C.1 of Appendix C.

Table 3.1: Numbers of Composite Samples in TDS Food Groups of the 1st HKTDS with Detectable Levels of the 21 Organophosphorus Pesticides (OPPs)

	Food group	No. composite samples analysed (% of total composite samples)	No. composite samples with detectable levels (% within group)*	No. composite samples with detectable level of OPPs																					
				Acephate	Chlorpyrifos	Chlorpyrifos-methyl	Diazinon	Dimethoate	Ethion	Fenthion	Fosthiazate	Isocarbophos	Isofenphos-methyl	Malathion	Methamidophos	Omethoate	Phorate	Phoxim	Pirimiphos-methyl	Profenofos	Terbufos	Tolclofos-methyl	Triazophos	Trichlorfon
1	Cereals and their products	76 (13)	16 (21)	1	1	2	2	0	0	0	0	0	0	3	1	0	0	7	1	0	0	0	0	0
2	Vegetables and their products	140 (23)	40 (29)	12	11	0	0	4	0	0	0	3	1	1	10	16	3	2	0	0	1	0	5	1
3	Legumes, nuts and seeds and their products	24 (4)	9	0	4	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	3	0	0	0
4	Fruits	68 (11)	15 (22)	0	9	0	0	2	0	2	1	1	0	0	1	4	0	0	0	0	0	0	0	0
5	Meat, poultry and game and their products	48 (8)	0 (0)	Not detected in all samples																				
6	Egg and their products	12 (2)	0	Not detected in all samples																				
7	Fish, seafood and their products	76 (13)	8 (11)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
8	Dairy products	20 (3)	0	Not detected in all samples																				
9	Fats and oils	8 (1)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
10	Beverages, alcoholic	8 (1)	0	Not detected in all samples																				
11	Beverages, non-alcoholic	40 (7)	0 (0)	Not detected in all samples																				
12	Mixed dishes	48 (8)	9 (19)	1	3	0	1	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0
13	Snack foods	4 (1)	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
14	Sugars and confectionery	8 (1)	0	Not detected in all samples																				
15	Condiments, sauces and herbs	20 (3)	0	Not detected in all samples																				
	Total:	600 (100)	100 (17)	14	29	2	3	6	1	2	1	5	1	4	12	21	8	18	1	1	4	1	5	1

* The % of composite samples within the food group is quoted for those TDS food groups contributing to > 5% of the total samples analysed. This % just reflected the detection of pesticide residues in composite samples but it could not reflect the situation in individual samples. The % of the detection in individual samples was probably lower than that of composite samples.

3.9 Majority of the OPPs detected (71%, 15 OPPs) were found in a few composite samples only (≤ 1% of the total composite samples). The most commonly detected OPP residue was chlorpyrifos (detected in 29 composite samples from 20 TDS food items), followed by omethoate (detected in 21 composite samples from 13 TDS food items) and phoxim (detected in 18 composite samples from 12 TDS food items) (Table 3.1 and Table C.1 in Appendix C).

3.10 The foods most commonly found to have detectable levels of OPPs were foods of plant origin. Among the seven major TDS food groups (contributing to > 5% of the total composite samples analysed), the food group "vegetables and their products" was found to contain the highest number of detectable OPPs and the highest % of composite samples with detectable levels within respective food groups (13 OPPs, in 29% of composite samples within the food group), followed by "fruits" (7 OPPs, in 22% of composite samples within the food group) and "cereals and their products" (8 OPPs, in 21% of composite samples within the food group) (Table 3.1). Among all the 150 TDS food items, spring onion was detected with the highest number of OPPs (nine different OPPs) (Table B.1 in Appendix B) and the highest residue level of acephate among all the composite samples (mean: 240 μg/kg, ranged from non-detected to 950 μg/kg) (Table C.1 in Appendix C).

Dietary Exposures to OPPs

3.11 Table 3.2 shows the dietary exposure estimates of the local population to OPP residues. Among the 21 OPPs detected in the TDS foods, dietary exposures ranged from < 0.0005 μg/kg bw/day (chlorpyrifos-methyl,

diazinon, ethion, fenthion, isofenphos-methyl, malathion, pirimiphos-methyl, terbufos, tolclofos-methyl and trichlorfon) to 0.105 μg/kg bw/day (dimethoate and omethoate) for the average local population, and from < 0.0005 μg/kg bw/day (ethion, fenthion, fosthiazate, isofenphos-methyl, tolclofos-methyl and trichlorfon) to 0.476 μg/kg bw/day (dimethoate and omethoate) for the high consumers. The estimated dietary exposures of the average and high consumers of the local population to the 21 OPPs were all below 6% and 24% of their respective ADIs, respectively (Figure 3.1).

3.12 Further analysis of dietary exposures of the individual age-gender population subgroups was performed and the results are shown in Appendix D. The estimated dietary exposures of the individual age-gender population subgroups ranged from < 0.0005 to 0.163 μg/kg bw/day for the average consumers and from < 0.0005 to 0.669 μg/kg bw/day for the high consumers. The highest estimated dietary exposure was found in dimethoate and omethoate (0.669 μg/kg bw/day, 33.5% of the ADI for the high consumer of females aged 30 – 39). The estimated dietary exposures of the average and high consumers of the individual age-gender population subgroups were all below 9% and 34% of their respective ADIs, respectively.

3.13 The study findings reveal that all estimated dietary exposures were well below their respective ADIs, and therefore dietary exposure to OPP residues would be unlikely to pose unacceptable health risks to the average and high consumer of the local population.

Table 3.2: Dietary Exposure Estimates (μg/kg bw/day) to Organophosphorus Pesticides (OPPs) for the Average and High Consumer of the Local Population and their Contribution to Acceptable Daily Intakes (ADIs)

	ADIs (μg/kg bw/day)	Dietary exposure estimate (μg/kg bw/day) (Contribution to ADIs) * #	
		Average	High consumer
Acephate	30	0.017 (0.1%)	0.059 (0.1%)
Chlorpyrifos	10	0.010 (0.1%)	0.041 (0.4%)
Chlorpyrifos-methyl	10	0 (0%)	0.002 (0%)
Diazinon	5	0 (0%)	0.001 (0%)
Dimethoate and omethoate †	2	0.105 (5.2%)	0.476 (23.8%)
Ethion	2	0 (0%)	0 (0%)
Fenthion	7	0 (0%)	0 (0%)
Fosthiazate	0.96	0.001 (0.1%)	0 (0%)
Isocarbophos	3	0.006 (0.2%)	0.021 (0.7%)
Isofenphos-methyl	3	0 (0%)	0 (0%)
Malathion	300	0 (0%)	0.001 (0%)
Methamidophos	4	0.002 (0.1%)	0.008 (0.2%)
Phorate	0.7	0.004 (0.6%)	0.022 (3.2%)
Phoxim	4	0.024 (0.6%)	0.113 (2.8%)
Pirimiphos-methyl	30	0 (0%)	0.002 (0%)
Profenofos	30	0.001 (0%)	0.004 (0%)
Terbufos	0.6	0 (0%)	0.001 (0.1%)
Tolclofos-methyl	70	0 (0%)	0 (0%)
Triazophos	1	0.001 (0.1%)	0.003 (0.3%)
Trichlorfon	2	0 (0%)	0 (0.1%)

* Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively.

\# Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

† The dietary exposure of dimethoate and omethoate was estimated by the sum of dimethoate and omethoate, expressed as dimethoate, as omethoate can be both a pesticide and a metabolite of dimethoate.

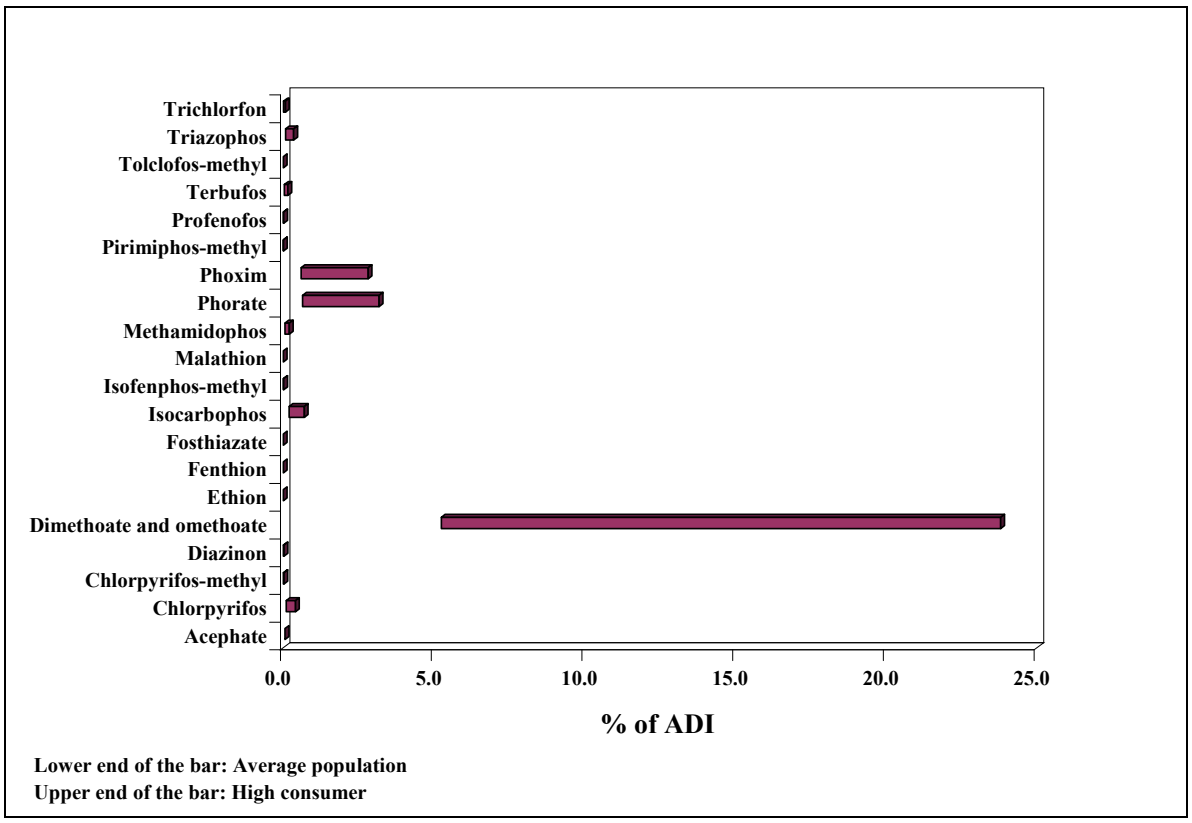

Figure 3.1: Dietary Exposure Estimates to Organophosphorus Pesticides (OPPs) for the Average and High Consumers of the Population as a Percentage of the Acceptable Daily Intake (ADI)

International Comparison

3.14 Table 3.3 presents the data on the local and reported overseas dietary exposures to OPPs. Overall, all estimated dietary exposures of the general population to OPPs for Hong Kong, Australia, New Zealand and the USA were very low, contributing to only a small % (< 0.00 – 5.2%) of their respective ADIs.

3.15 However, caution should be exercised in making any direct comparison of the data due to the difference in time the reported studies were carried out, the methods of collection of consumption data, the methods of contaminant analysis and the methods of treating results below detection limits.

Table 3.3: A Comparison of Local and Overseas Dietary Exposures to Organophosphorus Pesticides (OPPs)

	Dietary exposure (μg/kg bw/day) (Contribution to ADIs)						
	Hong Kong*	Australia[6]		New Zealand [3]		USA[7]	
		Male 25-34	Female 25-34	Male 25+	Female 25+	Male 25-30	Female 25-30
Acephate	0.017 (0.1%)	0.0028 (0.01%)	0.0027 (0.01%)	0.0004 (0.00%)	0.0006 (0.00%)	0.0078 (0.03%)	0.0082 (0.03%)
Azinphos-methyl	#	0.0004 (0.00%)	0.0006 (0.00%)	#	#	0.0044 (0.01%)	0.0061 (0.02)
Bensulide	#	NA	NA	NA	NA	NA	NA
Cadusafos	#	NA	NA	#	#	NA	NA
Chlorpyrifos	0.010 (0.1%)	0.0052 (0.05%)	0.0060 (0.06%)	0.0023 (0.02%)	0.0022 (0.02%)	0.0038 (0.04%)	0.0038 (0.04%)
Chlorpyrifos-methyl	0 (0%)	0.0723 (0.72%)	0.0633 (0.63%)	0.0064 (0.06%)	0.0062 (0.06%)	0.0116 (0.12%)	0.0101 (0.10%)
Coumaphos	#	NA	NA	#	#	NA	NA
Diazinon	0 (0%)	NA	NA	0.0005 (0.01%)	0.0005 (0.01%)	0.0037 (0.07%)	0.0033 (0.07%)
Dichlorvos (DDVP)	#	NA	NA	0.00009 (0.00%)	0.00012 (0.00%)	<0.0001 (<0.00%)	<0.0001 (<0.00%)
Dicrotophos	#	NA	NA	#	#	NA	NA
Dimethoate and omethoate	0.105 (5.2%)	0.0006 (0.03%)	0.0010 (0.05%)	0.020 (1.00%)	0.024 (1.20%)	0.0054 (0.27%)	0.0072 (0.36%)
Disulfoton	#	NA	NA	#	#	0.0003 (0.10%)	0.0004 (0.13%)
Edifenphos	#	NA	NA	#	#	NA	NA
Ethion	0 (0%)	NA	NA	0.00018 (0.01%)	0.00018 (0.01%)	0.0039 (0.20%)	0.0045 (0.23%)
Ethoprophos	#	NA	NA	#	#	NA	NA
Fenamiphos	#	NA	NA	#	#	NA	NA
Fenitrothion	#	0.0108 (0.18%)	0.0097 (0.16%)	0.0132 (0.19%)	0.0122 (0.17%)	0.0008 (0.01%)	0.0005 (0.01%)
Fenthion	0 (0%)	0.0022 (0.03%)	0.0022 (0.03%)	#	#	NA	NA
Fosthiazate	0.001 (0.1%)	NA	NA	NA	NA	NA	NA
Isocarbophos	0.006 (0.2%)	NA	NA	NA	NA	NA	NA
Isofenphos-methyl	0 (0%)	NA	NA	NA	NA	NA	NA
Malathion	0 (0%)	0.0010 (0.00%)	0.0015 (0.00%)	0.0025 (0.00%)	0.0025 (0.00%)	0.0704 (0.02%)	0.0598 (0.02%)
Methamidophos	0.002 (0.1%)	0.0786 (1.97%)	0.0737 (1.84%)	0.0053 (0.13%)	0.0062 (0.16%)	0.0141 (0.35%)	0.0167 (0.42%)
Methidathion	#	0.0003 (0.03%)	0.0005 (0.05%)	0.00004 (0.00%)	0.00004 (0.00%)	0.0002 (0.02%)	0.0002 (0.02%)
Mevinphos	#	NA	NA	#	#	0.0019 (0.24%)	0.0030 (0.38%)
Monocrotophos	#	NA	NA	#	#	0.0001 (0.02%)	0.0001 (0.02%)
Naled	#	NA	NA	#	#	NA	NA
Oxydemeton-methyl	#	NA	NA	NA	NA	NA	NA
Parathion	#	NA	NA	NA	NA	0.0009 (0.02%)	0.0011 (0.03%)
Parathion-methyl	#	0.0026 (0.09%)	0.0034 (0.11%)	#	#	<0.0001 (<0.00%)	<0.0001 (<0.00%)

	Dietary exposure (μg/kg bw/day) (Contribution to ADIs)						
	Hong Kong*	Australia[6]		New Zealand [3]		USA[7]	
		Male 25-34	Female 25-34	Male 25+	Female 25+	Male 25-30	Female 25-30
Phenthoate	#	NA	NA	0.00003 (0.00%)	0.00003 (0.00%)	NA	NA
Phorate	0.004 (0.6%)	NA	NA	#	#	0.0001 (0.01%)	0.0001 (0.01%)
Phosalone	#	NA	NA	#	#	0.0005 (0.00%)	0.0007 (0.00%)
Phosmet	#	NA	NA	#	#	0.0016 (0.02%)	0.0020 (0.02%)
Phosphamidon	#	NA	NA	#	#	0.0005 (0.10%)	0.0007 (0.10%)
Phoxim	0.024 (0.6%)	NA	NA	NA	NA	NA	NA
Pirimiphos-methyl	0 (0%)	0.0116 (0.04%)	0.00101 (0.00%)	0.106 (0.35%)	0.094 (0.31%)	0.0014 (0.00 %)	0.0016 (0.01%)
Profenofos	0.001 (0%)	NA	NA	#	#	<0.0001 (<0.00%)	<0.0001 (<0.00%)
Prothiophos	#	NA	NA	0.00006 (0.06%)	0.00008 (0.08%)	NA	NA
Quinalphos	#	NA	NA	#	#	NA	NA
Terbufos	0 (0%)	NA	NA	#	#	NA	NA
Tetrachlorvinphos	#	NA	NA	#	#	NA	NA
Tolclofos-methyl	0 (0%)	NA	NA	#	#	NA	NA
Triazophos	0.001 (0.1%)	NA	NA	#	#	NA	NA
Tribufos	#	NA	NA	NA	NA	NA	NA
Trichlorfon	0 (0%)	NA	NA	NA	NA	NA	NA
Vamidothion	#	NA	NA	NA	NA	NA	NA

* Data are extracted from the current Study. Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively. Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

\# Not detected in all samples

NA Data are not available.

Summary

3.16 Among the 48 OPPs tested, 27 were not detected in any of the 600 TDS composite food samples analysed. The most commonly detected OPP residue was chlorpyrifos (in 5% of the 600 composite samples), followed by omethoate (3.5%) and phoxim (3%), and the OPP residue with the highest level

was acephate (mean level: 240 μg/kg in spring onion). The OPPs were primarily found in food samples of plant origin such as vegetables and fruits.

3.17 The estimated dietary exposures to the 21 OPPs detected ranged from < 0.0005 μg/kg bw/day to 0.105 μg/kg bw/day for the average population, and from < 0.0005 μg/kg bw/day to 0.476 μg/kg bw/day for the high consumers. All estimated dietary exposures were well below their respective ADIs (< 24% in high consumers). The study findings indicate that dietary exposures to OPP residues would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population.

Chapter 4

Carbamates

4.1 Carbamates are synthetic chemical compounds. Two groups of carbamates, namely the alkyl or aryl carbamates and thiocarbamates, are covered in the current Study. The alkyl or aryl carbamates are *N* -substituted esters of carbamic acid while thiocarbamates are the semi-sulfur analogues of carbamates [8,9]. A total of 20 carbamates are covered in the current Study and listed in Table A.2 of Appendix A.

Sources of Carbamates

4.2 Carbamates are mainly used in agriculture, but may also be used in household products. Common agricultural uses include insecticides, fungicides and herbicides, while alkyl or aryl carbamates are also used as nematocides or sprout inhibitors [8,9]. Alkyl or aryl carbamates can be rapidly decomposed due to their light absorption characteristics and metabolised by microorganisms, plants and animals or broken down in water and soil, and may bioaccumulate in food chains to a slight extent [8]. Most thiocarbamates are rapidly degraded in the environment, especially by soil microorganisms and bioaccumulation is unlikely due to their rapid metabolism [9].

Toxicity

4.3 Alkyl or aryl carbamates are effective pesticides and act by inhibiting the neurotransmitter, acetylcholinesterase (AChE), in the nervous system [8]. In animal studies, the acute toxicity of these carbamates ranges from highly toxic to practically non-toxic. The symptoms of poisoning can appear a few minutes after exposure and last for a few hours. These carbamates are broken down quickly in rat with a half life of 3 – 8 hours. Limited data available on human suggest that excretion of these carbamates via urine is also rapid in men [8]. Therefore, the potential of alkyl or aryl carbamates to accumulate in the animal body is likely to be low.

4.4 Similarly, most of the thiocarbamates are likely to be rapidly degraded and eliminated quite rapidly from the body, mainly via expired air and urine. Thiocarbamates also exhibit AChE inhibition activity in rabbit, but it has low toxicity for birds and honey bees [9].

4.5 Regarding the safety reference values of the 20 carbamates tested in this Study, the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues (JMPR) has established Acceptable Daily Intakes (ADIs) for nine, and the United States Environmental Protection Agency (EPA) has established reference doses (RfD) for eight. The remaining three carbamates have ADIs as stated in the National Standard of Peoples' Republic of China (PRC) GB 2763-2005. The safety reference values, ranged from 0.00065 to 0.4 mg / kg body weight (bw)/day, are listed in Table A.2 of Appendix A.

Sources of Dietary Exposure

4.6 The primary route of exposure to carbamates of the general population is mainly through ingestion of food. Since some carbamates can reach groundwater via the soil, consumption of groundwater can be a minor route of dietary exposure. Occupational exposure via the inhalation and dermal routes are also possible for agricultural workers [8].

Results and Discussions

Concentrations of Carbamates in TDS Foods

4.7 A total of 600 composite samples, comprising 150 TDS food items and 15 food groups, collected and prepared on four occasions, were tested for carbamates. Sixty-one composite samples (10%), involving 33 TDS food items and five food groups, were found to contain detectable levels of carbamates, either singly or in combinations.

4.8 Among the 20 carbamates tested, only eight were detected in one or more of the 600 composite samples analysed. The 12 non-detected carbamates are listed in Table A.2 of Appendix A.

4.9 The numbers of composite samples with detectable levels of one or more of the eight carbamates in the five (of the 15) TDS food groups are summarised in Table 4.1. The lists of individual TDS food items with and without detectable levels of carbamates are presented in Table B.2 of Appendix

B. The levels of individual carbamates in individual food items are shown in Table C.2 of Appendix C.

Table 4.1: Numbers of Composite Samples in TDS Food Groups of the 1st HKTDS with Detectable Levels of the Eight Carbamates

	Food group	No. composite samples analysed (% of total composite samples)	No. composite samples with detectable levels (% within groups)*	No. composite samples with detectable level of carbamates							
				Aldicarb	Carbofuran	Carbosulfan	Fenobucarb	Isoprocarb	Methomyl	Oxamyl	Propamocarb
1	Cereals and their products	76 (13)	0 (0)	Not detected in all samples							
2	Vegetables and their products	140 (23)	46 (33)	3	7	3	0	3	8	2	29
3	Legumes, nuts and seeds and their products	24 (4)	3	0	2	0	1	0	0	0	1
4	Fruits	68 (11)	9 (13)	1	1	0	0	0	6	1	0
5	Meat, poultry and game and their products	48 (8)	0 (0)	Not detected in all samples							
6	Egg and their products	12 (2)	0	Not detected in all samples							
7	Fish and seafood and their products	76 (13)	0 (0)	Not detected in all samples							
8	Dairy products	20 (3)	0	Not detected in all samples							
9	Fats and oils	8 (1)	0	Not detected in all samples							
10	Beverages, alcoholic	8 (1)	0	Not detected in all samples							
11	Beverages, non-alcoholic	40 (7)	1 (3)	0	0	0	0	0	1	0	0
12	Mixed dishes	48 (8)	2 (4)	0	0	0	0	1	0	0	1
13	Snack foods	4 (1)	0	Not detected in all samples							
14	Sugars and confectionery	8 (1)	0	Not detected in all samples							
15	Condiments, sauces and herbs	20 (3)	0	Not detected in all samples							
	Total	600 (100)	61 (10)	4	10	3	1	4	15	3	31

* The % of composite samples within the food group is quoted for those TDS food groups contributing to > 5% of the total samples analysed. This % just reflected the detection of pesticide residues in composite samples but it could not reflect the situation in individual samples. The % of the detection in individual samples was probably lower than that of composite samples.

4.10 The most commonly detected carbamate residue was propamocarb (detected in 31 composite samples from 21 TDS food items), followed by

methomyl (detected in 15 composite samples from 11 TDS food items) and carbofuran (detected in 10 composite samples from seven TDS food items) (Table 4.1 and Table C.2 of Appendix C). The remaining five carbamates were detected in less than 1% of the total composite samples (Table 4.1).

4.11 The foods most commonly found to have detectable levels of carbamates were foods of plant origin. Among the seven major TDS food groups (contributing to > 5% of the total composite samples analysed), the food group "vegetables and their products" was found to contain the highest number of detectable carbamates and the highest % of composite samples with detectable levels within respective food groups (seven carbamates, in 33% of composite samples within the food group), followed by "fruits" (four carbamates, in 13% of composite samples within the food group). Carbamates were not detected in any composite samples of "cereals and their products" (Table 4.1). Among all the 150 TDS food items, sweet pepper was detected with the highest number of carbamates (four different carbamates) (Table B.2 in Appendix B) and Chinese flowering cabbage was detected with the highest residue level of propamocarb among all the composite samples (mean: 350 μg/kg, range from non-detected to 1200 μg/kg) (Table C.2 in Appendix C).

Dietary Exposures to Carbamates

4.12 Table 4.2 shows the dietary exposure estimates of the local population to carbamate residues in food. Among the eight carbamates detected in the TDS foods, dietary exposures ranged from < 0.0005 μg/kg bw/day (carbosulfan, fenobucarb (BPMC) and oxamyl) to 0.291 μg/kg bw/day (propamocarb) for the average local population, and from 0.001 μg/kg bw/day

(carbosulfan) to 1.145 μg/kg bw/day (propamocarb) for the high consumers (Table 4.2). The estimated dietary exposures of both the average and high consumers of the local population to the eight carbamates were all at or below 1% of their respective ADIs (Figure 4.1). In view of the low exposure of the local population to this group of pesticides, further analysis of dietary exposures of the individual age-gender population subgroups was not performed.

Table 4.2: Dietary Exposure Estimates (μg/kg bw/day) to Carbamates for the Average and High Consumer of the Local Population and their Contribution to Acceptable Daily Intakes (ADIs)

	ADIs (μg/kg bw/day)	Dietary exposure estimate (μg/kg bw/day) (Contribution to ADIs) * #	
		Average	High consumer
Aldicarb	3	0.001 (0%)	0.008 (0.3%)
Carbofuran	1	0.002 (0.2%)	0.010 (1.0%)
Carbosulfan	10	0 (0%)	0.001 (0%)
Fenobucarb (BPMC)	60	0 (0%)	0.002 (0%)
Isoprocarb	2	0.001 (0%)	0.005 (0.2%)
Methomyl	20	0.006 (0%)	0.019 (0.1%)
Oxamyl	9	0 (0%)	0.003 (0%)
Propamocarb	400	0.291 (0.1%)	1.145 (0.3%)

* Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively.

\# Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

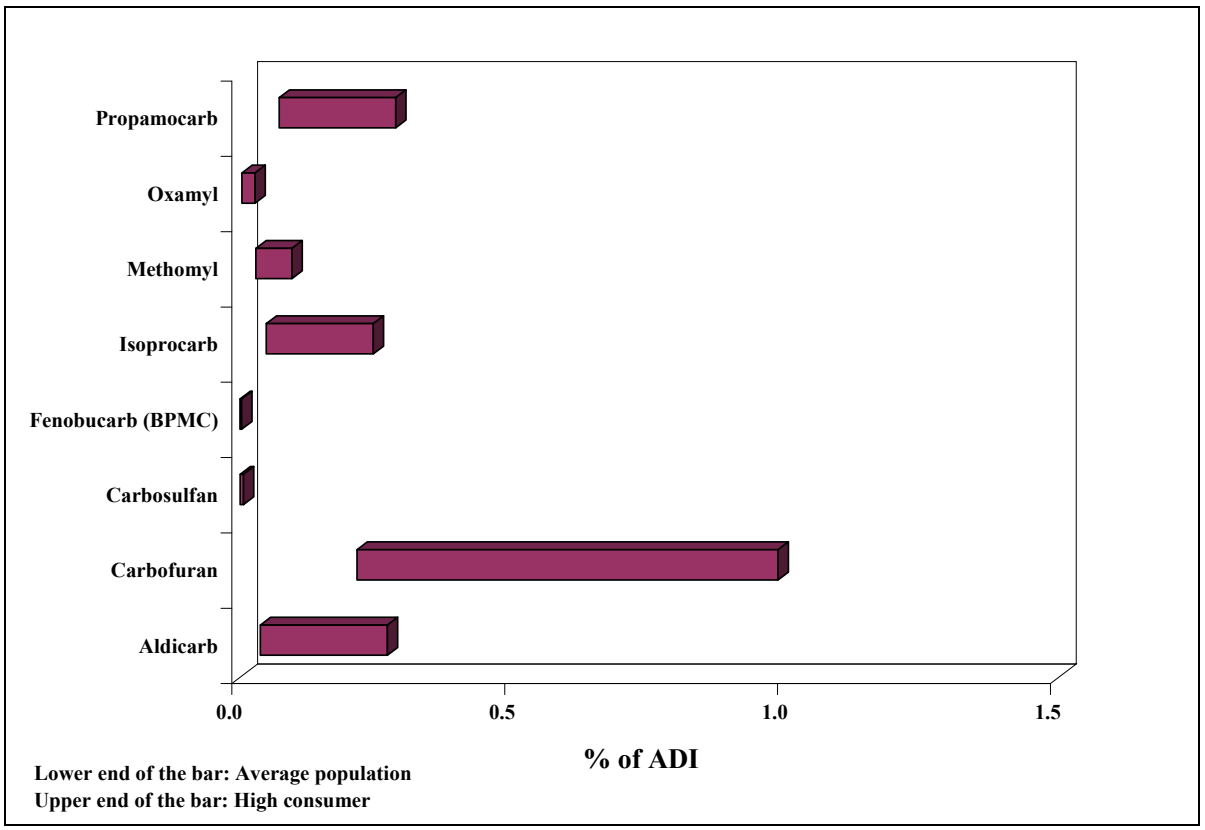

Figure 4.1: Dietary Exposure Estimates to Carbamates for the Average and High Consumers of the Population as a Percentage of the Acceptable Daily Intake (ADI)

4.13 The study findings reveal that all estimated dietary exposures were far below their respective ADIs, and therefore dietary exposure to carbamate residues would be unlikely to pose unacceptable health risks to the average and high consumer of the local population.

International Comparison

4.14 Table 4.3 presents the data on the local and reported overseas dietary exposures to carbamates. Overall, all estimated dietary exposures of the general population to carbamates for Hong Kong, Australia, New Zealand and the USA were very low, contributing to < 1% (< 0.00 – 0.6%) of their respective ADIs.

Table 4.3: A Comparison of Local and Overseas Dietary Exposures to Carbamates

	Dietary Exposure (μg/kg bw/day) (Contribution to ADIs)						
	Hong Kong*	Australia [6]		New Zealand [3]		USA [7]	
		Male 25-34	Female 25-34	Male 25+	Female 25+	Male 25-30	Female 25-30
Aldicarb	0.001 (0%)	#	#	NA	NA	<0.0001 (<0.00%)	0.0001 (0.00%)
Benfuracarb	#	NA	NA	NA	NA	NA	NA
Butylate	#	NA	NA	NA	NA	NA	NA
Carbaryl	#	0.0341 (0.43%)	0.0480 (0.60%)	0.013 (0.16%)	0.016 (0.20%)	0.0277 (0.35%)	0.0338 (0.42%)
Carbofuran	0.002 (0.2%)	NA	NA	#	#	<0.0001 (<0.01%)	0.0001 (0.01%)
Carbosulfan	0 (0%)	NA	NA	NA	NA	NA	NA
Cycloate	#	NA	NA	NA	NA	NA	NA
S-ethyl dipropylthiocarbamate (EPTC)	#	NA	NA	#	#	NA	NA
Fenobucarb (BPMC)	0 (0%)	NA	NA	#	#	NA	NA
Formetanate hydrochloride	#	NA	NA	NA	NA	NA	NA
Isoprocarb	0.001 (0%)	NA	NA	0.000 (0.00%)	0.000 (0.00%)	NA	NA
Methiocarb	#	NA	NA	0.00008 (0.00%)	0.00012 (0.00%)	0.0010 (0.00%)	0.0014 (0.01%)
Methomyl	0.006 (0%)	NA	NA	NA	NA	0.0023 (0.01%)	0.0037 (0.02%)
Molinate	#	NA	NA	NA	NA	NA	NA
Oxamyl	0 (0%)	NA	NA	NA	NA	NA	NA
Phenmedipham	#	NA	NA	NA	NA	NA	NA
Pirimicarb	#	0.0003 (0.00%)	0.0003 (0.00%)	0.0022 (0.01%)	0.0024 (0.01%)	NA	NA
Propamocarb	0.291 (0.1%)	NA	NA	NA	NA	NA	NA
Thiobencarb	#	NA	NA	#	#	NA	NA
Triallate	#	NA	NA	#	#	<0.0001 (<0.00%)	0.0001 (0.00%)

* Data are extracted from the current Study. Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively. Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

\# Not detected in all samples

NA Data are not available

4.15 However, caution should be exercised in making any direct comparison of the data due to the difference in time the reported studies were carried out, the methods of collection of consumption data, the methods of contaminant analysis and the methods of treating results below detection limits.

Summary

4.16 Among the 20 carbamates tested, 12 were not detected in any of the 600 TDS composite food samples analysed. The most commonly detected carbamate residue was propamocarb (in 5% of the 600 composite samples), followed by methomyl (3%) and carbofuran (2%), and the carbamate residue with the highest level was propamocarb (mean level: 350 μg/kg in Chinese flowering cabbage). The carbamates were primarily found in food samples of plant origin such as vegetables and fruits.

4.17 The estimated dietary exposures to the eight carbamates detected ranged from < 0.0005 μg/kg bw/day to 0.291 μg/kg bw/day for the average population, and from 0.001 μg/kg bw/day to 1.145 μg/kg bw/day for the high consumers. All estimated dietary exposures were far below their respective ADIs (< 1% in high consumers). The study findings indicate that dietary exposures to carbamate residues would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population.

Chapter 5

Pyrethrins and Pyrethroids

5.1 Pyrethrins are naturally occurring insecticides from extracts of certain chrysanthemum flowers, containing six constituents: three esters of chrysanthemic acid (pyrethrin I, cinerin I and jasmolin I) and three esters of pyrethric acid (pyrethrin II, cinerin II and jasmolin II). Pyrethroids are a group of synthetic insecticides with similar structures to the pyrethrins, further divided into types I and II based on their structures. Type I pyrethroids contain the basic cyclopropane carboxylic ester structure, while type II pyrethroids, also known as alpha-cyano pyrethroids, have an additional cyano group at the benzylic carbon atom which helps to further enhance the pyrethroid's insecticidal activity [10,11]. A total of 15 pyrethrins and common pyrethroids (or their derivatives) are covered in the current Study and listed in Table A.3 of Appendix A.

Sources of Pyrethrins and Pyrethroids

5.2 Pyrethrins and pyrethroids are insecticides commonly used as plant protectants to control pests on agricultural crops prior to harvest. They are also used in veterinary medicine and as household insecticides. They enter the environment primarily due to their uses as agricultural insecticides. They bind strongly to the soil and are therefore not easily taken up by the roots of plants. However, crop leaves, fruits and vegetables may easily be contaminated during spraying application of the pesticides in the field. Pyrethrins and pyrethroids

present in the soil are eventually degraded by microorganisms. Many of them can also be rapidly decomposed by light [10, 11].

Toxicity

5.3 Animal studies indicate that pyrethrins and pyrethroids are almost completely eliminated from the body within 4 – 12 days following oral exposure, with the majority being eliminated in the first 12 – 48 hours, primarily in urine (43 – 45%) and faeces (about 45 – 60%). However, there is limited information available on the elimination and excretion following oral exposures of pyrethrins and pyrethroids in humans [11].

5.4 Sign and symptoms of the acute oral toxicity of experimental animals vary depending on the types of pyrethrins and pyrethroids but almost all systemic effects are related to the action on the nervous system [11]. Basically, two distinct patterns of neurotoxic syndromes may be observed. Pyrethrins and type I pyrethroids have been shown to produce tremor syndrome (T syndrome) characterised by tremor, prostration and altered startle reflexes while type II pyrethroids produce the choreoathetosis and salivation syndrome (CS syndrome) with ataxia, convulsions, hyperactivity, choreoathetosis and profuse salivation. However, some pyrethroids may produce a combination of the two syndromes[10,11]. Accidental or intentional ingestion of large amounts of pyrethroids by human has been reported to cause acute neurotoxicity such as headache, muscular fasciculations, convulsions and coma [11]. Etofenprox, the ether pyrethroid, has a low acute oral toxicity in experimental animals and World Health Organization (WHO) has classified it as unlikely to present acute hazard in normal use [12].

5.5 Available animal data do not indicate significantly systemic effects other than those on the nervous system. As pyrethrins and pyrethroids can be metabolised and eliminated rapidly in mammals, low-level chronic exposures to these pesticides usually do not cause neurological signs [11].

5.6 International Agency for Research on Cancer (IARC) has classified three pyrethroids (i.e. deltamethrin, fenvalerate and permethrin) as Group 3 agent, i.e. not classifiable as to its carcinogenicity to humans [13].

5.7 Regarding the safety reference values of the 15 pyrethrins and pyrethroids tested in this Study, the Joint Food and Agriculture Organization (FAO) / WHO Meeting on Pesticide Residues (JMPR) has established Acceptable Daily Intakes (ADIs) for 13 and the United States Environmental Protection Agency (EPA) has established reference doses (RfD) for two. The safety reference values, ranged from 0.004 to 0.05 mg / kg body weight (bw)/day, are listed in Table A.3 of Appendix A.

Sources of Dietary Exposure

5.8 The primary route of exposure to pyrethrins and pyrethroids of the general population is mainly through ingestion of foods, particularly vegetables and fruits. Since pyrethrins and pyrethroids are rarely found in drinking water, drinking water is considered only a minor route of dietary exposure. Inhalation and dermal exposures are also possible routes due to their uses in household products [11].

Results and Discussions

Concentrations of Pyrethrins and Pyrethroids in TDS Foods

5.9 A total of 600 composite samples, comprising 150 TDS food items and 15 food groups, collected and prepared on four occasions, were tested for pyrethrins and pyrethroids. Eighty-nine composite samples (15%), involving 39 TDS food items and seven food groups, were found to contain detectable levels of pyrethrins and pyrethroids, either singly or in combination.

5.10 Among the 15 pyrethrins and pyrethroids tested, only 10 were detected in one or more of the 600 composite samples analysed. The five non-detected pyrethrins and pyrethroids are listed in Table A.3 of Appendix A.

5.11 The numbers of composite samples with detectable levels of one or more of the 10 pyrethrins and pyrethroids in the seven (of the 15) TDS food groups are summarised in Table 5.1. The lists of individual TDS food items with and without detectable levels of pyrethrins and pyrethroids are presented in Table B.3 of Appendix B. The levels of individual pyrethrins and pyrethroids in individual food items are shown in Table C.3 of Appendix C.

Table 5.1: Numbers of Composite Samples in TDS Food Groups of the 1st HKTDS with Detectable Levels of the 10 Pyrethrins and Pyrethroids

	Food group	No. composite samples analysed (% of total composite samples)	No. composite samples with detectable levels (% within group)*	No. composite samples with detectable level of pyrethrins/pyrethroids									
				Bifenthrin	Cyfluthrin	Cyhalothrin	Cypermethrin	Deltamethrin	Etofenprox	Fenpropathrin	Fenvalerate	Permethrin	Pyrethrins
1	Cereals and their products	76 (13)	6 (8)	0	0	0	2	3	0	0	0	1	0
2	Vegetables and their products	140 (23)	57 (41)	8	2	15	49	1	1	5	4	9	0
3	Legumes, nuts and seeds and their products	24 (4)	4	0	0	3	3	0	0	1	0	0	1
4	Fruits	68 (11)	7 (10)	0	0	2	3	0	0	2	1	0	0
5	Meat, poultry and game and their products	48 (8)	0 (0)	Not detected in all samples									
6	Egg and their products	12 (2)	0	Not detected in all samples									
7	Fish and seafood and their products	76 (13)	6 (8)	0	0	0	2	0	0	0	6	0	0
8	Dairy products	20 (3)	0	Not detected in all samples									
9	Fats and oils	8 (1)	1	0	0	0	1	0	0	0	0	0	0
10	Beverages, alcoholic	8 (1)	0	Not detected in all samples									
11	Beverages, non-alcoholic	40 (7)	0 (0)	Not detected in all samples									
12	Mixed dishes	48 (8)	8 (17)	0	0	2	6	0	0	1	1	4	0
13	Snack foods	4 (1)	0	Not detected in all samples									
14	Sugars and confectionery	8 (1)	0	Not detected in all samples									
15	Condiments, sauces and herbs	20 (3)	0	Not detected in all samples									
	Total	600 (100)	89 (15)	8	2	22	66	4	1	9	12	14	1

* The % of composite samples within the food group is quoted for those TDS food groups contributing to > 5% of the total samples analysed. This % just reflected the detection of pesticide residues in composite samples but it could not reflect the situation in individual samples. The % of the detection in individual samples was probably lower than that of composite samples.

5.12 The most commonly detected pyrethrin and pyrethroid residue was cypermethrin (detected in 66 composite samples from 31 TDS food items), followed by cyhalothrin (detected in 22 composite samples from 16 TDS food

items) and permethrin (detected in 14 composite samples from 9 TDS food items) (Table 5.1 and Table C.3 in Appendix C). In contrast, cyfluthrin, deltamethrin, etofenprox and pyrethrins were detected in less than 1% of the total composite samples (Table 5.1).

5.13 The foods most commonly found to have detectable levels of pyrethrins and pyrethroids were foods of plant origin. Among the seven major TDS food groups (contributing to > 5% of the total composite samples analysed), the food group "vegetables and their products" was found to contain the highest number of detectable pyrethrins and pyrethroids and the highest % of composite samples with detectable levels within respective food groups (nine pyrethrins and pyrethroids, in 41% of composite samples within the food group), followed by "mixed dishes" (five pyrethrins and pyrethroids, in 17% of composite samples within the food group) and "fruits" (four pyrethrins and pyrethroids, in 10% of composite samples within the food group) (Table 5.1). Among all the 150 TDS food items, petiole Chinese cabbage and sweet pepper were detected with the highest number of pyrethrins and pyrethroids (five different pyrethrins and pyrethroids) (Table B.3 in Appendix B). Chinese kale was detected with the highest residue level of cypermethrin among all the composite samples (mean: 130 μg/kg, ranged from non-detected to 520 μg/kg) (Table C.3 in Appendix C). In addition, six other kinds of vegetables, namely Chinese flowering cabbage, petiole Chinese cabbage, spinach, watercress, sweet pepper and spring onion, were also detected with cypermethrin in all four composite samples (mean levels ranged from 12 – 61 μg/kg) (Table C.3 in Appendix C). The results suggest that cypermethrin was the pesticide commonly used in these vegetables.

Dietary Exposures to Pyrethrins and Pyrethroids

5.14 Table 5.2 shows the dietary exposure estimates of the local population to pyrethrin and pyrethroid residues. Among the 10 pyrethrins and pyrethroids detected in the TDS foods, dietary exposures ranged from < 0.0005 μg/kg bw/day (etofenprox and pyrethrins) to 0.058 μg/kg bw/day (cypermethrin) for the average local population, and from < 0.0005 μg/kg bw/day (etofenprox and pyrethrins) to 0.191 μg/kg bw/day (cypermethrin) for the high consumers. The estimated dietary exposures of both the average and high consumers of the local population to the 10 pyrethrins and pyrethroids were all below 1% of their respective ADIs (Figures 5.1). In view of the low exposure of the local population to this group of pesticides, further analysis of dietary exposures of the individual age-gender population subgroups was not performed.

Table 5.2: Dietary Exposure Estimates (μg/kg bw/day) to Pyrethrins and Pyrethroids for the Average and High Consumer of the Local Population and their Contribution to Acceptable Daily Intakes (ADIs)

	ADIs (μg/kg bw/day)	Dietary exposure estimate (μg/kg bw/day) (Contribution to ADIs) * #	
		Average	High consumer
Bifenthrin	10	0.002 (0%)	0.007 (0.1%)
Cyfluthrin	40	0.002 (0%)	0.010 (0%)
Cyhalothrin	20	0.008 (0%)	0.025 (0.1%)
Cypermethrin	20	0.058 (0.3%)	0.191 (1.0%)
Deltamethrin	10	0.001 (0%)	0.004 (0%)
Etofenprox	30	0 (0%)	0 (0%)
Fenpropathrin	30	0.003 (0%)	0.014 (0%)
Fenvalerate	20	0.002 (0%)	0.009 (0%)
Permethrin	50	0.035 (0.1%)	0.135 (0.3%)
Pyrethrins	40	0 (0%)	0 (0%)

* Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively.

\# Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

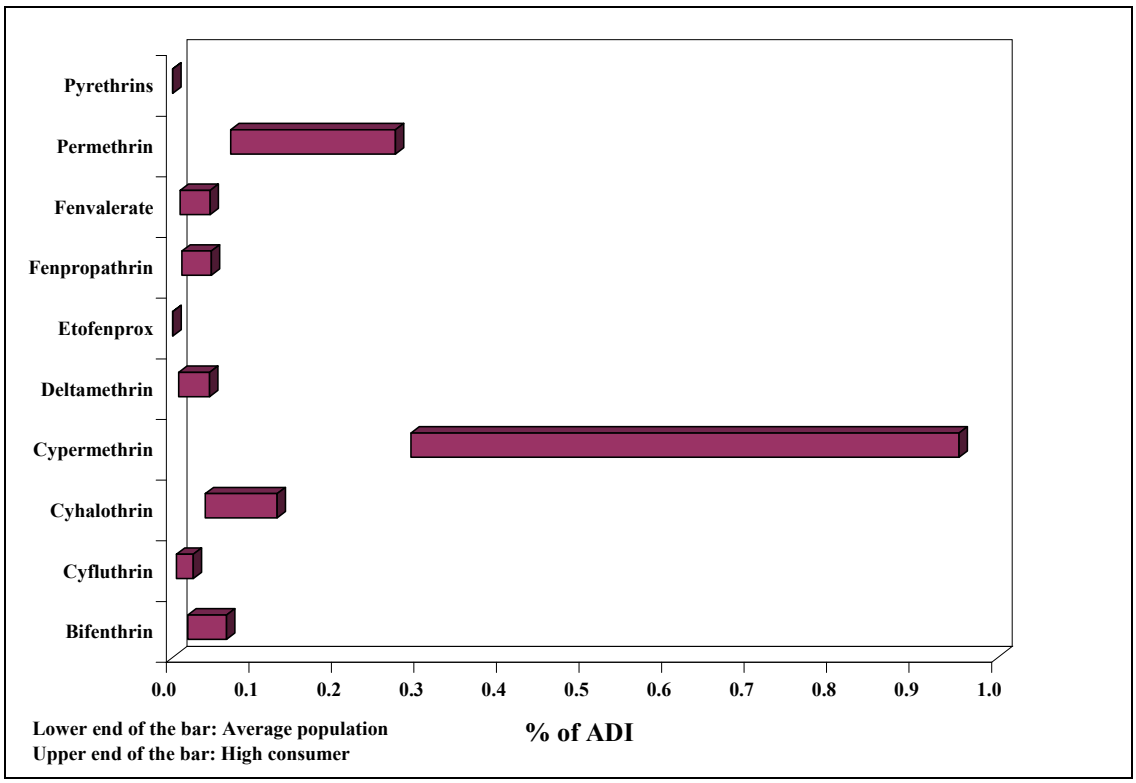

Figure 5.1: Dietary Exposure Estimates to Pyrethrins and Pyrethroids for the Average and High Consumers of the Population as a Percentage of the Acceptable Daily Intake (ADI)

5.15 The study findings reveal that all estimated dietary exposures were far below their respective ADIs, and therefore dietary exposure to pyrethrin and pyrethroid residues would be unlikely to pose unacceptable health risks to the average and high consumer of the local population.

International Comparison

5.16 Table 5.3 presents the data on the local and reported overseas dietary exposures to pyrethrins and pyrethroids. Overall, all estimated dietary exposures of the general population to pyrethrins and pyrethroids for Hong Kong, Australia, New Zealand and the USA were very low, contributing to ≤ 0.3% (< 0.01 – 0.3%) of their respective ADIs.

5.17 However, caution should be exercised in making any direct comparison of the data due to the difference in time the reported studies were carried out, the methods of collection of consumption data, the methods of contaminant analysis and the methods of treating results below detection limits.

Table 5.3: A Comparison of Local and Overseas Dietary Exposures to Pyrethrins and Pyrethroids

	Dietary exposure (μg/kg bw/day) (Contribution to ADIs)						
	Hong Kong*	Australia [6]		New Zealand [3]		USA [7]	
		Male 25-34	Female 25-34	Male 25+	Female 25+	Male 25-30	Female 25-30
Bifenthrin	0.002 (0.02%)	0.0030 (0.03%)	0.0032 (0.03%)	0.0001 (<0.01%)	0.0002 (<0.01%)	NA	NA
Cyfluthrin	0.002 (0%)	#	#	#	#	NA	NA
Cyhalothrin	0.008 (0%)	#	#	#	#	NA	NA
Cypermethrin	0.058 (0.3%)	#	#	0.00004 (<0.01%)	0.00005 (<0.01%)	NA	NA
Deltamethrin	0.001 (0%)	#	#	0.020 (0.20%)	0.016 (0.16%)	NA	NA
Etofenprox	0 (0%)	NA	NA	NA	NA	NA	NA
Fenpropathrin	0.003 (0%)	NA	NA	0.00019 (<0.01%)	0.00028 (<0.01%)	NA	NA
Fenvalerate	0.002 (0%)	#	#	#	#	0.0017 (0.01%)	0.0019 (0.01%)
Flucythrinate	#	NA	NA	#	#	NA	NA
Flumethrin	#	#	#	NA	NA	NA	NA
Fluvalinate	#	NA	NA	0.0002 (<0.01%)	0.0004 (<0.01%)	NA	NA
Permethrin	0.035 (0.1%)	0.0146 (0.03%)	0.0149 (0.03%)	0.0007 (<0.01%)	0.0007 (<0.01%)	0.046 (0.09%)	0.057 (0.11%)
Pyrethrins	0 (0%)	NA	NA	#	#	NA	NA
Resmethrin	#	NA	NA	NA	NA	NA	NA
Tefluthrin	#	NA	NA	#	#	NA	NA

* Data are extracted from the current Study. Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively. Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

\# Not detected in all samples

NA Data are not available.

Summary

5.18 Among the 15 pyrethrins and pyrethroids tested, five were not detected in any of the 600 TDS composite food samples analysed. The most commonly detected pyrethrin and pyrethroid residue was cypermethrin (in 11% of the 600 composite samples), followed by cyhalothrin (4%) and permethrin (2%), and the pyrethrin and pyrethroid residue with the highest level was cypermethrin (mean level: 130 μg/kg in Chinese kale). The pyrethrins and pyrethroids were primarily found in food samples of plant origin such as vegetables.

5.19 The estimated dietary exposures to the 10 pyrethrins and pyrethroids detected ranged from < 0.0005 μg/kg bw/day to 0.058 μg/kg bw/day for the average population, and from < 0.0005 μg/kg bw/day to 0.191 μg/kg bw/day for the high consumers. All estimated dietary exposures were far below their respective ADIs (< 1% in high consumers). The study findings indicate that dietary exposures to pyrethrin and pyrethroid residues would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population.

Chapter 6

Dithiocarbamate metabolites

6.1 Dithiocarbamates are mainly used as insecticides, herbicides and fungicides on agricultural crops. Ethylene thiourea (ETU) and propylene thiourea (PTU) are the metabolites of two classes of dithiocarbamates, namely ethylene bisthiocarbamates (EBDC) and propylene bisthiocarbamates (PBDC), respectively. ETU and PTU have been shown to be considerably more toxic than their parent compounds and are dithiocarbamate metabolites of concern due to their known thyroid toxicity [14, 15]. Hence, these two dithiocarbamate metabolites are covered in the current Study.

Sources of ETU and PTU

6.2 The dithiocarbamates, EBDC and PBDC, are commonly used on a wide range of agricultural produce and crops and they are known to degrade rapidly after application [14]. ETU is the metabolite of EBDC such as maneb, zineb and mancozeb [14], while PTU is a degradation product of the PBDC, propineb as well as a plant and animal metabolite [16].

6.3 ETU residues may be found in and on agricultural produce treated with EBDC, such as spinach, carrots, potatoes, tomatoes and grapes. The reported level of ETU is generally below 100 μg/kg. Washing the raw produce prior to processing removed 33 – 87% of EBDC and the majority of the ETU residues. ETU may also be formed from EBDC during storage, processing or cooking. Heat processing of EBDC-treated produce has been shown to convert

16 – 23% of the EBDC residues into ETU, and therefore the ETU level may be higher in processed foods than in the raw commodities [14, 15,17].

6.4 A survey conducted by the Canadian government in 1972 showed that ETU was detected in 33% of food samples, in particular, canned spinach (mean: 47 μg/kg) and orange peel (mean: 83 μg/kg) [14]. The United States Total Diet Study (from 1991 to 2003) revealed that foods with the highest ETU levels were boiled collards (mean: 10.77 μg/kg, highest: 207 μg/kg), boiled spinach (mean: 9.59 μg/kg, highest: 276 μg/kg), baked potato (mean: 5.43 μg/kg, highest: 25 μg/kg) and French fries (mean: 5.38 μg/kg, highest: 21 μg/kg) [18].

6.5 PTU may be present in agricultural produce treated with propineb. Studies have shown that PTU could be detected in apples and grapes shortly after treatment with propineb, but was subsequently rapidly transformed into other metabolites [14, 16]. The level of PTU in food has rarely been reported.

Toxicity

6.6 Animal studies indicate that following oral exposure, ETU and PTU are rapidly absorbed and eliminated, mainly in the urine. Distribution of ETU and PTU in the body is fairly uniform with the exception of the thyroid which has higher levels than other tissues [14, 19, 20].

6.7 The acute oral toxicity in experimental animals for ETU is reported to be low, but no information on the acute oral toxicity of PTU in experimental animals is available. The main adverse effects associated with long-term ingestion of ETU and PTU in experimental animals are thyroid and teratogenic effects [19, 20].

6.8 International Agency for Research on Cancer (IARC) has classified ETU as Group 3 agent, i.e. not classifiable as to its carcinogenicity to humans [21]. No classification has been made to PTU.

6.9 Regarding the safety reference values of the two dithiocarbamate metabolites, the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues (JMPR) has established Acceptable Daily Intakes (ADIs) of 4 μg/kg bw/day and 0.3 μg/kg bw/day for ETU and PTU, respectively (Table A.4 of Appendix A) [16, 19].

Sources of Dietary Exposure

6.10 The primary dietary sources of ETU and PTU are the produce treated with EBDC / PBDC and their processed food products. Exposure of the general population to ETU and PTU results from consumption of foods containing these pesticide residues in the diet [14].

Results and Discussions

Concentrations of Dithiocarbamate Metabolites in TDS Foods

6.11 A total of 600 composite samples, comprising 150 TDS food items and 15 food groups, collected and prepared on four occasions, were tested for ETU and PTU. Eighty composite samples (13%), involving 38 TDS food items and nine food groups, were found to contain detectable levels of ETU. Of them, seven composite samples, involving five TDS food items and four food groups, also contained detectable levels of PTU.

6.12 The numbers of composite samples with detectable levels of the two dithiocarbamate metabolites, ETU and / or PTU in the nine (of the 15) TDS food groups are summarised in Table 6.1. The lists of individual TDS food items with and without detectable levels of ETU and PTU are presented in Table B.4 of Appendix B. The levels of ETU and PTU in individual food items are shown in Table C.4 of Appendix C.

Table 6.1: Numbers of Composite Samples in TDS Food Groups of the 1st HKTDS with Detectable Levels of Dithiocarbamate Metabolites

	Food Group	No. composite samples analysed (% of total composite samples)	No. composite samples with detectable level (% within group)*	No. composite samples with detectable level of ETU/PTU	
				ETU	PTU
1	Cereals and their products	76 (13)	3 (4)	3	0
2	Vegetables and their products	140 (23)	46 (33)	46	3
3	Legumes, nuts and seeds and their products	24 (4)	1	1	0
4	Fruits	68 (11)	8 (12)	8	2
5	Meat, poultry and game and their products	48 (8)	0 (0)	Not detected in all samples	
6	Egg and their products	12 (2)	0	Not detected in all samples	
7	Fish and seafood and their products	76 (13)	2 (3)	2	0
8	Dairy products	20 (3)	0	Not detected in all samples	
9	Fats and oils	8 (1)	0	Not detected in all samples	
10	Beverages, alcoholic	8 (1)	5	5	0
11	Beverages, non-alcoholic	40 (7)	0 (0)	Not detected in all samples	
12	Mixed dishes	48 (8)	11 (23)	11	1
13	Snack foods	4 (1)	1	1	0
14	Sugars and confectionery	8 (1)	0	Not detected in all samples	
15	Condiments, sauces and herbs	20 (3)	3	3	1
	Total	600 (100)	80 (13)	80	7

* The % of composite samples within the food group is quoted for those TDS food groups contributing to > 5% of the total samples analysed. This % just reflected the detection of pesticide residues in composite samples but it could not reflect the situation in individual samples. The % of the detection in individual samples was probably lower than that of composite samples.

6.13 The foods most commonly found to have detectable level of ETU and PTU were foods of plant origin. Among the seven major TDS food groups (contributing to > 5% of the total composite samples analysed), the food group "vegetables and their products" was found to contain the highest % of composite

samples with detectable levels of ETU and PTU within respective food groups (in 33% of composite samples within the food group), followed by "mixed dishes" (23%) and "fruits" (12%) (Table 6.1).

6.14 Among the 38 TDS food items detected with ETU, the mean ETU levels ranged from 0 to 120 μg/kg. Five of these food items (i.e. spinach, sponge gourd, papaya, dumpling (including wonton), and tomato paste/ketchup) were found to also contain detectable levels of PTU with mean levels ranged from 0 to 32 μg/kg (Table C.4 of Appendix C).

6.15 The three food items containing the highest levels of ETU were spring onion (mean: 120 μg/kg), spinach (mean: 110 μg/kg) and Chinese spinach (mean: 35 μg/kg). Furthermore, six food items (spring onion, spinach, Chinese spinach, watercress, papaya and red wine) showed detectable levels of ETU in all four composite samples. The common occurrence of ETU in these food items suggests that the parent compound, EBDC, is likely a commonly used pesticide on the raw commodities. In contrast, PTU was detected at low levels in only five of the 150 TDS food items, with spinach containing the highest mean level of 32 μg/kg (Table C.4 of Appendix C).

Dietary Exposures to Dithiocarbamate Metabolites

6.16 Table 6.2 shows the dietary exposure estimates of the local population to ETU and PTU residues. The estimated dietary exposures to ETU for the average and high consumer of the local population were 0.040 μg/kg bw/day and 0.107 μg/kg bw/day, respectively, and their contributions to the respective ADI were all below 3%. The estimated dietary exposures to PTU of

the average and high consumer of the local population were 0.002 μg/kg bw/day and 0.011 μg/kg bw/day, respectively, and their contributions to the respective ADI were all below 4% (Figure 6.1). In view of the low exposure of the local population to this group of pesticides, further analysis of dietary exposures of the individual age-gender population subgroups was not performed .

Table 6.2: Dietary Exposure Estimates (μg/kg bw/day) to Dithiocarbamate Metabolites for the Average and High Consumer of the Local Population and their Contribution to Acceptable Daily Intakes (ADIs)

	ADIs (μg/kg bw/day)	Dietary exposure estimate (μg/kg bw/day) (Contribution to ADIs) *	
		Average	High consumer
ETU	4	0.040 (1.0%)	0.107 (2.7%)
PTU	0.3	0.002 (0.7%)	0.011 (3.8%)

* Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively.

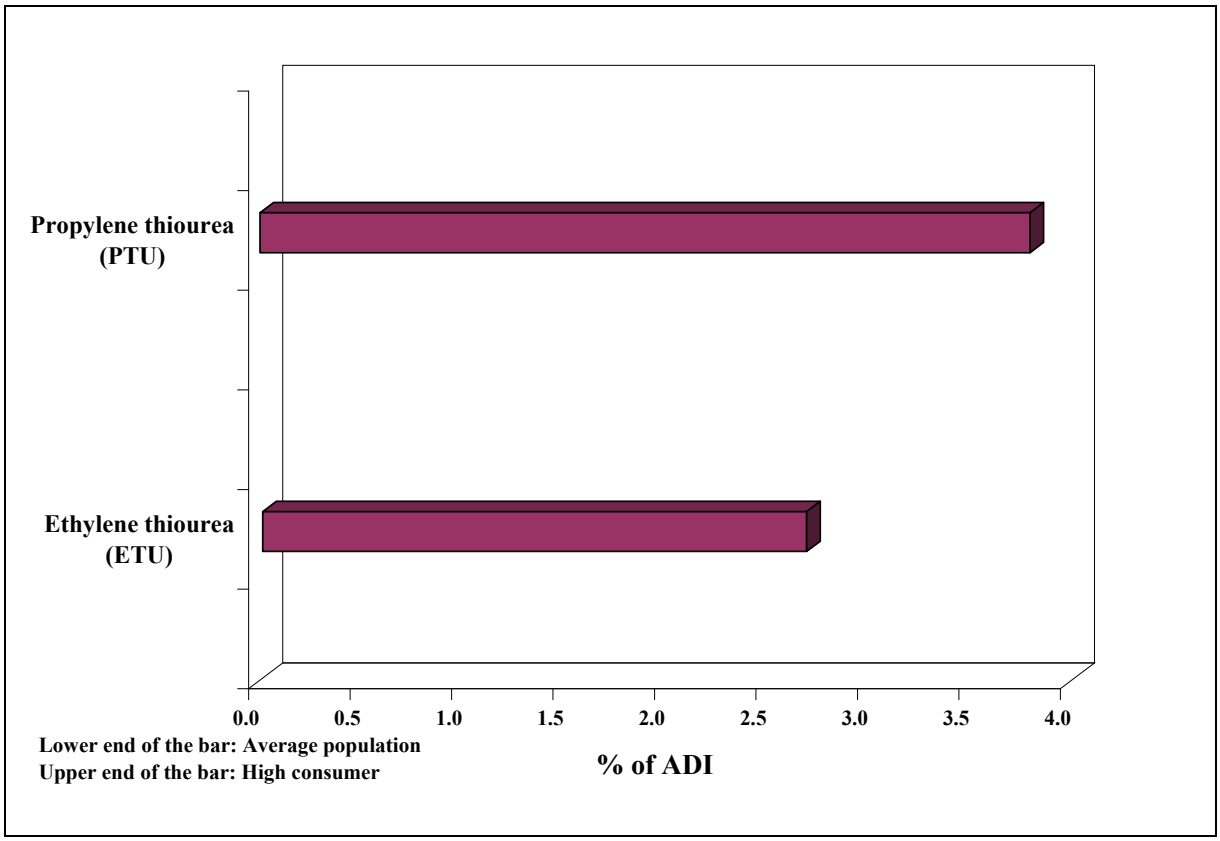

Figure 6.1: Dietary Exposure Estimates to Dithiocarbamate Metabolites for the Average and High Consumers of the Population as a Percentage of the Acceptable Daily Intake (ADI)

6.17 The study findings reveal that all estimated dietary exposures were well below their respective ADIs, and therefore dietary exposure to ETU and PTU would be unlikely to pose unacceptable health risks to the average and high consumer of the local population.

International Comparison

6.18 Table 6.3 presents the data on the local and reported overseas dietary exposures to ETU. Only limited exposure data on ETU from the USA and Canada have been reported, and no exposure data on PTU are available. Overall, dietary exposure of the general Hong Kong population to ETU was

lower than those reported in the USA and Canada (Table 6.3). Nevertheless, all reported ETU exposures were well below its ADI.

Table 6.3: A Comparison of Local and Overseas Dietary Exposure to ETU for the Average Population

Places	Mean dietary exposure (μg/kg bw/day)
Canada[14]	~ 1.0
USA[14]	0.24
Hong Kong*	0.040

* Data are extracted from the current Study.

6.19 However, caution should be exercised in making any direct comparison of the data due to the difference in time the reported studies were carried out, the methods of collection of consumption data, the methods of contaminant analysis and the methods of treating results below detection limits.

Summary

6.20 Majority of the TDS food composite samples tested were not found to contain detectable levels of the dithiocarbamate metabolites, ETU and PTU. Only 80 samples (13%), mainly foods of plant origin such as vegetables, were found to contain detectable levels of ETU (the highest mean level: 120 μg/kg in spring onion) and of which, seven samples (1%) also contained detectable levels of PTU (the highest mean level: 32 μg/kg in spinach). The foods most commonly found to contain detectable levels of ETU were spring onion, spinach, Chinese spinach, watercress, papaya and red wine.

6.21 The estimated dietary exposures to ETU and PTU were 0.040 μg/kg bw/day and 0.002 μg/kg bw/day, respectively, for the average population, and

0.107 μg/kg bw/day and 0.011 μg/kg bw/day, respectively, for the high consumers of the local population. All estimated dietary exposures were well below their respective ADIs (< 4% in high consumers). The study findings indicate that dietary exposures to ETU and PTU residues would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population.

Chapter 7

Overall Summary

Pesticide Residues Detected in TDS Foods

7.1 A total of 85 pesticides from four pesticide groups, including 48 organophosphorus pesticides (OPPs), 20 carbamates, 15 pyrethrins and pyrethroids, and two dithiocarbamate metabolites, were analysed in 600 composite samples involving 150 TDS food items. Tables 7.1 and 7.2 summarise the numbers of pesticides detected, and the numbers of TDS food items and composite samples with detectable levels among the 15 TDS food groups, respectively. Overall, 41 pesticides (48% of pesticides) were detected at low levels in 198 composite samples (33% of total composite samples)‡ (Tables 7.1 and 7.2).

7.2 Four main food groups of plant origin, namely "vegetables and their products" (31 pesticides), "fruits" (17), "legumes, nuts and seeds and their products" (14) and "mixed dishes" (14) were found to contain residues of all four pesticide groups tested. They were also detected with the highest number of pesticide residues (Table 7.1). In contrast, four food groups, namely "meat, poultry and game and their products", "egg and their products", "dairy products" and "sugars and confectionery", were found to contain no detectable level of any of the pesticide residues in all of the composite samples analysed (Table 7.1).

‡ This % just reflected the detection of pesticide residues in composite samples but it could not reflect the situation in individual samples. The % of the detection in individual samples

Table 7.1: Numbers of Pesticide Residues Detected among the Four Pesticide Groups in TDS Food Groups of the 1st HKTDS

	Food group	No. pesticide groups detected	No. pesticide residues detected				
			Overall	Organophosphorus pesticides	Carbamates	Pyrethrins and pyrethroids	Dithiocarbamate metabolites
1	Cereals and their products	3	12	8	0	3	1
2	Vegetables and their products	4	31	13	7	9	2
3	Legumes, nuts and seeds and their products	4	14	6	3	4	1
4	Fruits	4	17	7	4	4	2
5	Meat, poultry and game and their products	0	0	0	0	0	0
6	Egg and their products	0	0	0	0	0	0
7	Fish and seafood and their products	3	5	2	0	2	1
8	Dairy products	0	0	0	0	0	0
9	Fats and oils	2	2	1	0	1	0
10	Beverages, alcoholic	1	1	0	0	0	1
11	Beverages, non-alcoholic	1	1	0	1	0	0
12	Mixed dishes	4	14	5	2	5	2
13	Snack foods	2	3	2	0	0	1
14	Sugars and confectionery	0	0	0	0	0	0
15	Condiments, sauces and herbs	1	2	0	0	0	2
	Total		41	21	8	10	2

was probably lower than that of composite samples.

Table 7.2: Numbers of TDS Food Items and Composite Samples in TDS Food Groups of the 1st HKTDS with Detectable Levels of the Pesticide Residues of the Four Pesticide Groups, either Singly or in Combinations

	Food group	No. composite samples (TDS food items) analysed	No. composite samples (TDS food items) with detectable levels				
			Overall	Organophosphorus pesticides	Carbamates	Pyrethrins and pyrethroids	Dithiocarbamate metabolites
1	Cereals and their products	76 (19)	19 (11)	16 (9)	0 (0)	6 (5)	3 (2)
2	Vegetables and their products	140 (35)	96 (30)	40 (22)	46 (24)	57 (20)	46 (20)
3	Legumes, nuts and seeds and their products	24 (6)	11 (4)	9 (3)	3 (1)	4 (2)	1 (1)
4	Fruits	68 (17)	27 (10)	15 (8)	9 (6)	7 (5)	8 (3)
5	Meat, poultry and game and their products	48 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	Egg and their products	12 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	Fish and seafood and their products	76 (19)	11 (4)	8 (4)	0 (0)	6 (2)	2 (2)
8	Dairy products	20 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	Fats and oils	8 (2)	2 (2)	1 (1)	0 (0)	1 (1)	0 (0)
10	Beverages, alcoholic	8 (2)	5 (2)	0 (0)	0 (0)	0 (0)	5 (2)
11	Beverages, non-alcoholic	40 (10)	1 (1)	0 (0)	1 (1)	0 (0)	0 (0)
12	Mixed dishes	48 (12)	20 (8)	9 (5)	2 (1)	8 (4)	11 (6)
13	Snack foods	4 (1)	3 (1)	2 (1)	0 (0)	0 (0)	1 (1)
14	Sugars and confectionery	8 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	Condiments, sauces and herbs	20 (5)	3 (1)	0 (0)	0 (0)	0 (0)	3 (1)
	Total	600 (150)	198 (74)	100 (53)	61 (33)	89 (39)	80 (38)

7.3 The percentages of composite samples with detectable pesticide residues in seven major TDS food groups (contributing to > 5% of total samples analysed) are shown in Figure 7.1. Among them, the food group "vegetables and their products" was found to contain the highest % of composite samples with detectable levels within respective food groups (in 69% of composite

samples within the food group), followed by "mixed dishes" (42%) and "fruits" (40%). Although the food group "vegetables and their products" was found to be commonly detected with pesticide residues, some food items in this food group (5 out of 35 food items, Table 7.2) did not contain any detectable levels of pesticide residues analysed. They are broccoli, garlic, mung bean sprouts, onion and shiitake mushroom.

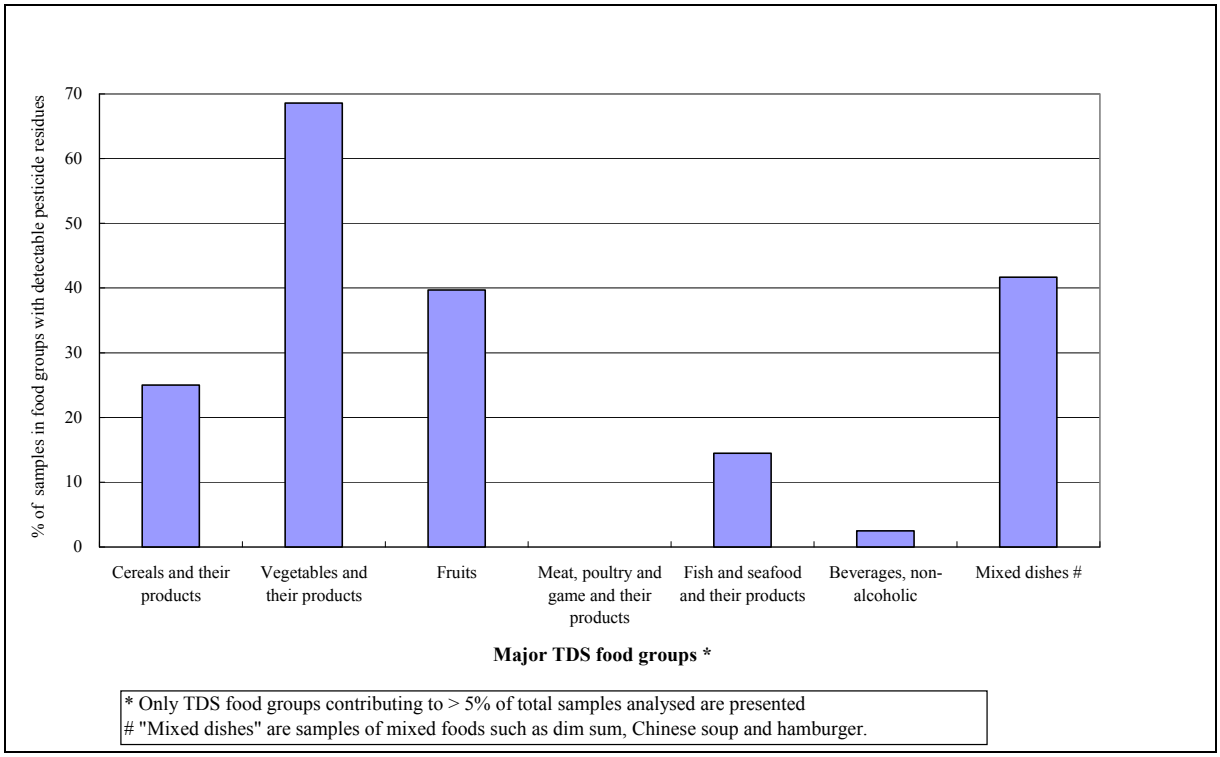

Figure 7.1: Percentages of Composite Samples in Seven Major TDS Food Groups with Detectable Pesticide Residues

7.4 Across the four pesticide groups analysed, OPPs was the most commonly detected pesticide group (in 100 composite samples, 17% of total composite samples, the highest mean level: 240 μg/kg), followed by pyrethrins and pyrethroids (in 89 composite samples, 15%, the highest mean level: 130 μg/kg), dithiocarbamate metabolites (in 80 composite samples, 13%, the highest mean level: 120 μg/kg) and carbamates (in 61 composite samples, 10%, the

highest mean level: 350 μg/kg) (Table 7.2 and Appendix C). A breakdown of the percentage of composite samples in the top four TDS food groups with detectable pesticide residues on the pesticide group basis is shown in Figure 7.2. No consistent pattern of relative contributions of detectable pesticide groups was observed among the food groups. Of the four pesticide groups, pyrethrins and pyrethroids was the most commonly detected in "vegetables and their products" while OPPs was the most commonly detected in "fruits" (Figure 7.2). In terms of individual pesticides, ETU was the most widely detected (in 13% of composite samples), followed by cypermethrin (11%), propamocarb (5%) and chlorpyrifos (5%).

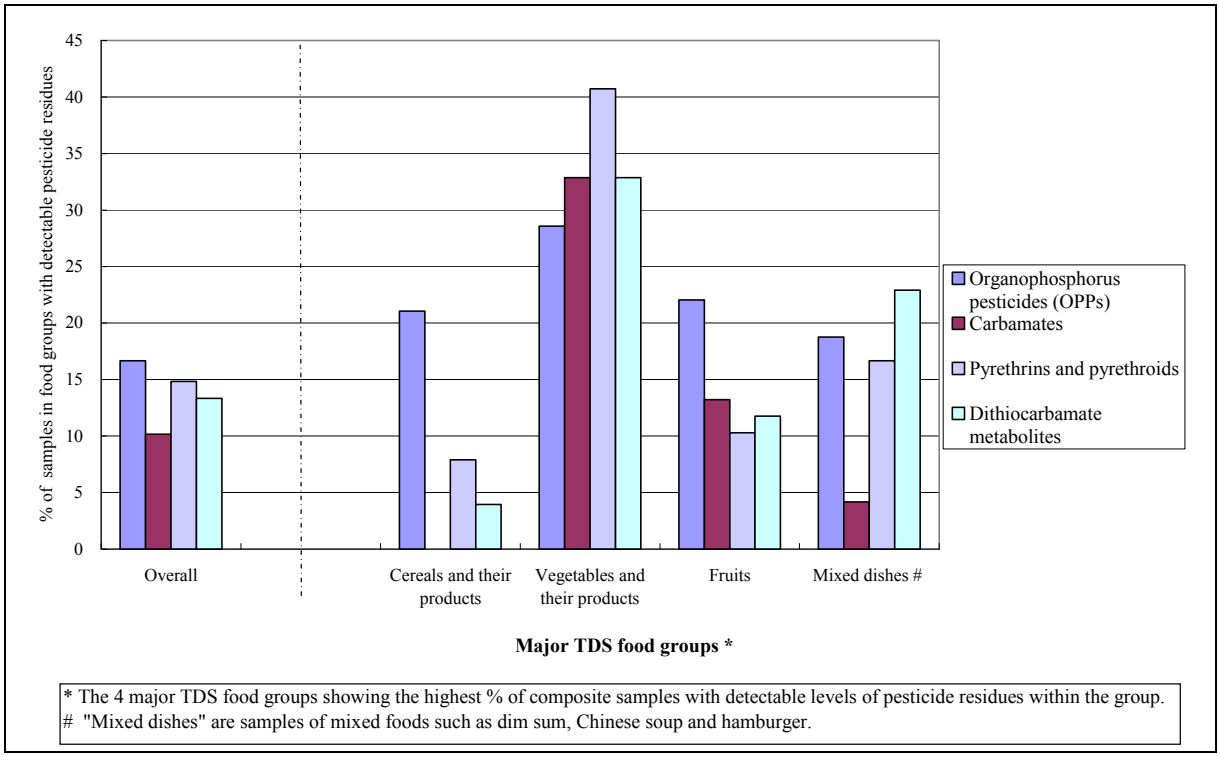

Figure 7.2: A Breakdown of the Percentage of Composite Samples in Individual Major TDS Food Groups with Detectable Pesticide Residues on Pesticide Group Basis

Dietary Exposures to the Four Pesticide Groups

7.5 Table 7.4 presents the dietary exposure estimates of the Hong Kong population to the four groups of pesticide residues analysed in this Study. The estimated dietary exposures of the Hong Kong population to all 85 individual pesticide residues were found to be well below their respective Acceptable Daily Intakes (ADIs). The percentage contributions of the estimated dietary exposures of the average and high consumers to individual pesticide residues, respectively, were < 1% for the carbamates and pyrethrins and pyrethroids, < 6% and < 24% for the OPPs, and < 1% and < 4% for the dithiocarbamate metabolites. The pesticide residues with the highest contribution to the ADI were found to be dimethoate and omethoate[§] (5.2% and 23.8% of the ADI for average and high consumers, respectively). The findings indicate that dietary exposures to the 85 pesticide residues analysed in this Study would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population.

[§] Omethoate can be both a pesticide and a metabolite of dimethoate. The dietary exposure of dimethoate and omethoate was estimated by the sum of dimethoate and omethoate, expressed as dimethoate.

Table 7.4: Ranges of Dietary Exposure Estimates (μg/kg bw/day) to the Four Groups of Pesticides for the Average and High Consumer of the Local Population and their Contribution to Acceptable Daily Intakes (ADIs)

Pesticide group (No. pesticides detected)	Dietary exposure estimate (μg/kg bw/day) (Contribution to ADIs) * #	
	Average	High consumer
Organophosphorus pesticides (OPPs) (21)	0 – 0.105 (0 – 5.2%)	0 – 0.476 (0 – 23.8%)
Carbamates (8)	0 – 0.291 (0 – 0.2%)	0.001 – 1.145 (0 – 1.0%)
Pyrethrins and pyrethroids (10)	0 – 0.058 (0 – 0.3%)	0 – 0.191 (0 – 1.0%)
Dithiocarbamate metabolites (2)	0.002 – 0.040 (0.7 – 1.0%)	0.011 – 0.107 (2.7 – 3.8%)

* Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively.

\# Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs.

Limitations of the Study

7.6 Assigning levels at "0" (i.e. lower bound) for non-detects may lead to the dietary exposures being underestimated. Nevertheless, since comparably low LODs (1 – 2 μg/kg) were adopted in the Study, the estimation of dietary exposure using lower bound values would not be significantly influenced.

7.7 Other limitations have been described in the Report on the 1st HKTDS: Methodology [4].

Chapter 8

Conclusions and Recommendations

8.1 Residues of the four groups of pesticides or their metabolites, namely organophosphorus pesticides (OPPs), carbamates, pyrethrins and pyrethroids, and dithiocarbamate metabolites, were found at low levels, primarily in food samples of plant origin such as vegetables and fruits, as expected.

8.2 The estimated dietary exposures of the Hong Kong population to all 85 individual pesticide residues analysed were all well below their respective ADIs. The findings indicate that dietary exposures to all the pesticide residues analysed in this Study would be unlikely to pose unacceptable health risks to both the average and high consumer of the local population. Nevertheless, the following general advices are recommended.

8.3 The farmers are advised to observe Good Agricultural Practice (GAP), such as using only pesticides registered with the competent authority, and applying the minimum quantities necessary to achieve adequate pest control. They should also use the pesticides in strict accordance with the label requirements, e.g., do not harvest the crops within the specified withholding period after the last pesticide application.

8.4 The findings re-affirmed the safety of basic dietary advice on healthy eating, i.e. have a balanced and varied diet which includes a wide variety of fruits and vegetables. To minimise the potential exposure to water soluble pesticide residues, the public can wash vegetables and fruits thoroughly in clean

running water, and soak the vegetables in water for one hour and then rinse, or alternatively blanch the vegetables in boiling water for one minute and discard the water. To further reduce their pesticide exposure, the public can also remove the outer leaves of the vegetables or peel the vegetables and fruits as appropriate.

REFERENCES

1 Food and Environmental Hygiene Department (FEHD). Hong Kong Population-Based Food Consumption Survey 2005-2007 Final Report. Hong Kong: FEHD; 2010

2 Food Standards Australia New Zealand (FSANZ). The 23rd Australian Total Diet Study. Australia: FSANZ; 2011. Available from URL: http://www.foodstandards.gov.au/_srcfiles/FSANZ%2023rd%20ATDS_v8_.pdf

3 New Zealand Food Safety Authority (NZFSA). 2009 New Zealand Total Diet Study. New Zealand: NZFSA; 2011. Available from URL: http://www.foodsafety.govt.nz/elibrary/industry/total-diet-study.pdf

4 FEHD. The First Hong Kong Total Diet Study: Methodology. Hong Kong: FEHD; 2011. Available from URL: http://www.cfs.gov.hk/english/programme/programme_firm/files/1st_HKTDS_Report_e.pdf

5 International Programme on Chemical Safety (IPCS). Organophosphorus Insecticides: A General Introduction. Environmental Health Criteria 63. Geneva: World Health Organization (WHO); 1986. Available from URL: http://www.inchem.org/documents/ehc/ehc/ehc63.htm

6 Food Standards Australia New Zealand (FSANZ). The 20th Australian Total Diet Survey : A total diet survey of pesticide residues and contaminants. Australia: FSANZ; 2002.

7 Gunderson EL. FDA Total Diet Study, July 1986 – April 1991, Dietary Intakes of Pesticides, Selected Elements, and Other Chemicals. Journal of AOAC International 1995; 78(6): 1353-63.

8 IPCS. Carbamate Pesticides: A General Introduction. Environmental Health Criteria 64. Geneva: WHO; 1986. Available from URL: http://www.inchem.org/documents/ehc/ehc/ehc64.htm

9 IPCS. Thiocarbamate Pesticides: A General Introduction. Environmental Health Criteria 76. Geneva: WHO; 1988. Available from URL: http://www.inchem.org/documents/ehc/ehc/ehc76.htm

10 National Poisons Information Service Centre (NPISC). UK PID Monograph: Pyrethroids. UK: NPISC; 1998. Available from URL: http://www.inchem.org/documents/ukpids/ukpids/ukpid75.htm

11 Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Pyrethrins and Pyrethroids. Public Health Service, U.S. Department of Health and Human Services; September 2003. Available from URL: http://www.atsdr.cdc.gov/toxprofiles/tp155.pdf

12 WHO. Etofenprox (Pesticide residues in food: 1993 evaluations Part II Toxicology). Geneva: WHO; 1993. Available from URL: http://www.inchem.org/documents/jmpr/jmpmono/v93pr09.htm

13 WHO IARC. Agents Classified by the IARC Monographs, Volumes 1–102. France: IARC; June 2011. Available from URL: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf

14 IPCS. Dithiocarbamate Pesticides, Ethylenethiourea and Propylenethiourea: A General Introduction. Environmental Health Criteria 78. Geneva: WHO; 1988. Available from URL: http://www.inchem.org/documents/ehc/ehc/ehc78.htm

[15] WHO. Dithiocarbamates (Pesticide residues in food: 1980 evaluations). Geneva: WHO; 1980. Available from URL: http://www.inchem.org/documents/jmpr/jmpmono/v080pr15.htm

[16] WHO. Propylene Thiourea (addendum) (Pesticide residues in food: 1999 toxicological evaluations). Geneva: WHO; 1999. Available from URL: http://www.inchem.org/documents/jmpr/jmpmono/v99pr10.htm

[17] International Union of Pure and Applied Chemistry. Ethylenethiourea: A Special Report on the Occurrence of Ethylenethiourea as a Terminal Residue Resulting from Agricultural Use of Ethylenebisdithiocarbamate Fungicides. Pure and Applied Chemical 1977; 49: 675-89.

[18] US Food and Drug Administration (FDA). Total Diet Study, Market Baskets 1991-3 through 2003-4 (Revision 3). US: FDA; 2006. [cited at 23 May 2012] Available from URL: http://www.fda.gov/downloads/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/UCM184304.pdf

[19] WHO. Ethylenethiourea (ETU) (Pesticide residues in food: 1993 evaluations Part II Toxicology). Geneva: WHO; 1993. Available from URL: http://www.inchem.org/documents/jmpr/jmpmono/v93pr08.htm

[20] WHO. Propylenethiourea (PTU) (Pesticide residues in food: 1993 evaluations Part II Toxicology). Geneva: WHO; 1993. Available from URL: http://www.inchem.org/documents/jmpr/jmpmono/v93pr17.htm

[21] WHO IARC. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 79: Ethylenethiourea France: IARC; 2001. Available from URL: http://monographs.iarc.fr/ENG/Monographs/vol79/mono79-23.pdf

Appendix A

Acceptable daily intakes (ADIs) of pesticide residues covered by the 1st HKTDS

Table A.1: Organophosphorus pesticides (OPPs)

	Acceptable Daily Intake (ADI) or similar references (mg/kg bw/day)	Source # @	Year
Acephate	0.03	JMPR	2005
Azinphos-methyl *	0.03	JMPR	2007
Bensulide *	0.005	USEPA	2006
Cadusafos *	0.0005	JMPR	2009
Chlorpyrifos	0.01	JMPR	1999
Chlorpyrifos-methyl	0.01	JMPR	2009
Coumaphos *	0.0003	USEPA	2006
Diazinon	0.005	JMPR	2006
Dichlorvos (DDVP) *	0.004	JMPR	1993
Dicrotophos *	0.00007	USEPA	2006
Dimethoate	0.002 (sum of dimethoate and omethoate expressed as dimethoate)	JMPR	1996
Disulfoton (including demeton-S, disulfoton sulphone and sulphoxide) *	0.0003	JMPR	1991
Edifenphos *	0.003	JMPR	1981
Ethion	0.002	JMPR	1990
Ethoprophos *	0.0004	JMPR	1999
Fenamiphos (including its sulphone and sulphoxide) *	0.0008	JMPR	1997
Fenitrothion *	0.006	JMPR	2007
Fenthion (including its sulphone and sulphoxide)	0.007	JMPR	1995
Fosthiazate	0.00096	USEPA	2009
Isocarbophos	0.003	GB 2763-2005	2005
Isofenphos-methyl	0.003	GB 2763-2005	2005
Malathion	0.3	JMPR	1997
Methamidophos	0.004	JMPR	2002
Methidathion *	0.001	JMPR	1992
Mevinphos *	0.0008	JMPR	1996
Monocrotophos *	0.0006	JMPR	1993
Naled *	0.002	USEPA	2006

	Acceptable Daily Intake (ADI) or similar references (mg/kg bw/day)	Source # @	Year
Omethoate	0.002 (sum of dimethoate and omethoate expressed as dimethoate)	JMPR	1996
Oxydemeton-methyl (including demeton-S-methyl, demeton-S-methylsulphon) *	0.0003	JMPR	1998
Parathion *	0.004	JMPR	1995
Parathion-methyl (including para-oxon methyl) *	0.003	JMPR	1995
Phenthoate *	0.003	JMPR	1984
Phorate (including its sulphone and sulphoxide)	0.0007	JMPR	2004
Phosalone *	0.02	JMPR	2001
Phosmet *	0.01	JMPR	1994
Phosphamidon *	0.0005	JMPR	1986
Phoxim	0.004	JMPR	1999
Pirimiphos-methyl	0.03	JMPR	1992
Profenofos	0.03	JMPR	2007
Prothiophos *	0.0001	ADHA	1993
Quinalphos *	0.0005	USEPA	1992
Terbufos (including its sulphone and sulphoxide)	0.0006	JMPR	2003
Tetrachlorvinphos *	0.0423	USEPA	2006
Tolclofos-methyl	0.07	JMPR	1994
Triazophos	0.001	JMPR	2002
Tribufos *	0.001	USEPA	2006
Trichlorfon	0.002	JECFA	2006
Vamidothion (including its sulphone and sulphoxide) *	0.008	JMPR	1988

JMPR stands for the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues; GB 2763-2005 stands for the National Standard of Peoples' Republic of China (PRC) GB2763-2005 on pesticide residues; USEPA stands for United States Environmental Protection Agency; ADHA stands for Office of Chemical Safety, Department of Health and Ageing, Australia; JECFA stands for Joint FAO/WHO Expert Committee on Food Additives.

@ ADIs established by JMPR are available from URL: http://www.fao.org/agriculture/crops/core-themes/theme/pests/lpe/en/

* Substances were not detected in all samples.

Table A.2: Carbamates

	Acceptable Daily Intake (ADI) or similar references (mg/kg bw/day)	Source # @	Year
Alkyl or Aryl Carbamate			
Aldicarb (including its sulphone and sulphoxide)	0.003	JMPR	1992
Benfuracarb *	0.01	GB 2763-2005	2005
Carbaryl *	0.008	JMPR	2001
Carbofuran (including 3-hydroxycarbofuran)	0.001	JMPR	2008
Carbosulfan	0.01	JMPR	2003
Fenobucarb (BPMC)	0.06	GB 2763-2005	2005
Formetanate hydrochloride *	0.00065	USEPA	2007
Isoprocarb	0.002	GB 2763-2005	2005
Methiocarb (including its sulphone and sulphoxide) *	0.02	JMPR	1998
Methomyl (including thiodicarb)	0.02	JMPR	2001
Oxamyl (including oxamyl oxime)	0.009	JMPR	2002
Phenmedipham*	0.24	USEPA	2005
Pirimicarb (including desmethyl-pirimicarb and desmethyl-formamido pirimicarb) *	0.02	JMPR	2004
Propamocarb	0.4	JMPR	2005
Thiocarbamate *			
Butylate *	0.05	USEPA	1993
Cycloate *	0.005	USEPA	2004
Molinate *	0.001	USEPA	2002
S-Ethyl dipropylthiocarbamate (EPTC) *	0.025	USEPA	1999
Thiobencarb *	0.01	USEPA	1997
Triallate *	0.025	USEPA	2001

JMPR stands for the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues; GB 2763-2005 stands for the National Standard of Peoples' Republic of China (PRC) GB2763-2005 on pesticide residues; USEPA stands for United States Environmental Protection Agency.

@ ADIs established by JMPR are available from URL: http://www.fao.org/agriculture/crops/core-themes/theme/pests/lpe/en/

* Substances were not detected in all samples.

Table A.3: Pyrethrins and pyrethroids

	Acceptable Daily Intake (ADI) or similar references (mg/kg bw/day)	Source # @	Year
Pyrethrins	0.04	JMPR	2003
Type I Pyrethroids			
Bifenthrin	0.01	JMPR	2009
Permethrin	0.05	JMPR	1999
Resmethrin *	0.03	JMPR	1991
Tefluthrin *	0.005	USEPA †	1997
Type II Pyrethroids			
Cyfluthrin	0.04 (Group ADI for cyfluthrin and beta-cyfluthrin)	JMPR	2006
Cyhalothrin	0.02 (Group ADI for cyhalothrin and lambda-cyhalothrin)	JMPR	2007
Cypermethrin	0.02 (Group ADI for cypermethrin, alpha-cypermethrin, and zeta-cypermethrin)	JMPR	2006
Deltamethrin	0.01	JMPR	2000
Fenpropathrin	0.03	JMPR	1993
Fenvalerate	0.02	JMPR	1986
Flucythrinate *	0.02	JMPR	1985
Flumethrin *	0.004	JMPR	1996
Fluvalinate *	0.01	USEPA ‡	1991
Ether pyrethroids			
Etofenprox	0.03	JMPR	2011

JMPR stands for the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues; USEPA stands for United States Environmental Protection Agency.

@ ADIs established by JMPR are available from URL: http://www.fao.org/agriculture/crops/core-themes/theme/pests/lpe/en/

† Chronic reference dose for tefluthrin was established by the USEPA <Available from URL: http://www.gpo.gov/fdsys/pkg/FR-1997-09-25/html/97-25499.htm >

‡ Chronic reference dose for fluvalinate was established by the USEPA <Available from URL: http://www.epa.gov/iris/subst/0281.htm >

* Substances were not detected in all samples.

Table A.4: Dithiocarbamate metabolites

	Acceptable Daily Intake (ADI) or similar references (mg/kg bw/day)	Source # @	Year
Ethylene thiourea (ETU)	0.004	JMPR	1993
Propylene thiourea (PTU)	0.0003	JMPR	1999

JMPR stands for the Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues.

@ ADIs established by JMPR are available from URL: http://www.fao.org/agriculture/crops/core-themes/theme/pests/lpe/en/

Appendix B

List of TDS food items without and with the detection of pesticide residues in the 1st HKTDS

Table B.1: Organophosphorus pesticides (OPPs)

Part A: The 97 TDS food items that were not detected with any of 48 organophosphorus pesticides are listed below:

TDS Food Item	
Cereals and their products (10 out of 19 items):	
Bread, plain	Oatmeal
Bread, raisin	Pastries, Chinese
Cakes	Rice, unpolished
Deep-fried dough	Rice, white
Noodles, rice	Sausage/ham/luncheon meat bun
Vegetables and their products (13 out of 35 items):	
Broccoli	Potato
Cabbage, Chinese	Potato, fried
Chinese kale	Pumpkin
Garlic	Sponge gourd
Mung bean sprout	Wax gourd
Mushroom, dried shiitake	Zucchini
Onion	
Legumes, nuts and seeds and their products (3 out of 6 items):	
Beancurd	Peanut butter
Mung bean vermicelli	
Fruits (9 out of 17 items):	
Banana	Persimmon
Dragon fruit	Pineapple
Kiwi fruit	Pummelo/Grapefruit
Orange	Watermelon
Papaya	
Meat, poultry and game and their products (12 out of 12 items):	
Barbecued pork	Meat sausage
Beef	Mutton
Chicken meat	Pig liver
Chicken, soy sauce	Pork
Ham	Roasted duck/goose
Luncheon meat	Roasted pork

TDS Food Item	
Egg and their products (3 out of 3 items):	
Egg, chicken	Egg, salted
Egg, lime preserved	
Fish and seafood and their products (15 out of 19 items):	
Crab	Fish, Sole
Fish ball/fish cake	Fish, Tuna
Fish, Golden thread	Fish, Yellow croaker
Fish, Grey mullet	Oyster
Fish, Grouper	Scallop
Fish, Horse head	Shrimp/ Prawn
Fish, Pomfret	Squid
Fish, Salmon	
Dairy products (5 out of 5 items):	
Cheese	Milk, whole
Ice-cream	Yoghurt
Milk, skim	
Fats and oils (1 out of 2 items):	
Oil, vegetable	
Beverages, alcoholic (2 out of 2 items):	
Beer	Red wine
Beverages, non-alcoholic (10 out of 10 items):	
Carbonated drink	Tea, Chinese
Coffee	Tea, chrysanthemum
Fruit and vegetable juice	Tea, Milk tea
Malt drink	Water, bottled, distilled
Soybean drink	Water, drinking
Mixed dishes (7 out of 12 items):	
Chinese soup	Steamed minced beef ball
Glutinous rice dumpling	Steamed rice-rolls with filling
Siu Mai	Steamed rice-rolls, plain
Steamed barbecued pork bun	
Snack foods (0 out of 1 item)	
Sugars and confectionery (2 out of 2 items):	
Chocolate	Granulated sugar
Condiments, sauces and herbs (5 out of 5 items):	
Cornstarch	Table salt
Oyster sauce	Tomato paste/ketchup
Soya sauce	

Part B: The 53 TDS food items that were detected with 21 organophosphorus pesticides (including metabolites) are listed below:

TDS Food Item	Number of pesticides detected	Pesticides detected																			
		Acephate	Chlorpyrifos	Chlorpyrifos-methyl	Diazinon	Dimethoate	Ethion	Fenthion	Fosthiazate	Isocarbophos	Isofenphos-methyl	Malathion	Methamidophos	Omethoate	Phorate	Phoxim	Pirimiphos-methyl	Profenofos	Terbufos	Tolclofos-methyl	Triazophos	Trichlorfon
Cereals and their products (9 out of 19 items)	**8**																					
Biscuits	2			✓												✓						
Breakfast cereals	2		✓									✓										
Chinese steamed bread	2											✓				✓						
Corn	2	✓											✓									
Instant noodles	1															✓						
Noodles, Chinese or Japanese style	1															✓						
Pasta, Western style	3			✓												✓	✓					
Pastries	1				✓																	
"Pineapple" bun	1				✓																	
Vegetables and their products (22 out of 35 items)	**13**																					
Bitter melon	1		✓																			
Cabbage, Chinese flowering	1		✓																			
Cabbage, European variety	2													✓								✓
Cabbage, Petiole Chinese	1		✓																			
Carrot/ Radish	1														✓							
Celery	4	✓										✓	✓	✓								
Chinese spinach	1															✓						
Cucumber	2	✓											✓									
Ear fungus	2									✓					✓							
Eggplant	3	✓											✓	✓								
Hairy gourd	1		✓																			

TDS Food Item	Number of pesticides detected	Pesticides detected																		
		Acephate	Chlorpyrifos	Chlorpyrifos-methyl	Diazinon	Dimethoate	Ethion	Fenthion	Fosthiazate	Isocarbophos	Isofenphos-methyl	Malathion	Methamidophos	Omethoate	Phorate	Phoxim	Pirimiphos-methyl	Profenofos	Terbufos	Tolclofos-methyl	Triazophos	Trichlorfon
Leaf mustard	4	✓				✓							✓	✓								
Lettuce, Chinese	2	✓											✓									
Lettuce, European	1	✓																				
Mushrooms	5		✓			✓				✓				✓							✓	
Preserved vegetables	3										✓		✓		✓							
Spinach	2	✓	✓																			
Spring onion	9	✓	✓			✓				✓			✓	✓		✓			✓		✓	
Sweet pepper	4		✓										✓	✓							✓	
Tomato	1													✓								
Water spinach	2													✓							✓	
Watercress	3	✓	✓										✓									
Legumes, nuts and seeds and their products (3 out of 6 items)	**6**																					
Fermented bean products	1																		✓			
Green string beans, with pod	4		✓							✓				✓				✓				
Peanut	2		✓												✓							
Fruits (8 out of 17 items)	**7**																					
Apple	1		✓																			
Grapes	1		✓																			
Longan/ Lychee	4		✓			✓				✓				✓								
Mango	3					✓		✓						✓								
Melons	2								✓				✓									
Peach	1		✓																			
Pear	1		✓																			
Plum	1													✓								

TDS Food Item	Number of pesticides detected	Pesticides detected																		
		Acephate	Chlorpyrifos	Chlorpyrifos-methyl	Diazinon	Dimethoate	Ethion	Fenthion	Fosthiazate	Isocarbophos	Isofenphos-methyl	Malathion	Methamidophos	Omethoate	Phorate	Phoxim	Pirimiphos-methyl	Profenofos	Terbufos	Tolclofos-methyl	Triazophos	Trichlorfon
Meat, poultry and game and their products: (0 out of 12 items)	**0**																					
Egg and their products: (0 out of 3 items)	**0**																					
Fish, seafood and their products (4 out of 19 items)	**2**																					
Fish, Big head	1															✓						
Fish, Dace, minced	1															✓						
Fish, Grass carp	2		✓													✓						
Fish, Mandarin fish	1															✓						
Dairy products (0 out of 5 items)	**0**																					
Fats and oils (1 out of 2 items)	**1**																					
Butter	1														✓							
Beverages, alcoholic (0 out of 2 items)	**0**																					
Beverages, non-alcoholic (0 out of 10 items)	**0**																					
Mixed dishes (5 out of 12 items)	**5**																					
Dumpling, including wonton	1		✓																			
Dumpling, pan-fried	1				✓																	
Dumpling, steamed	2	✓	✓																			
Hamburger	1															✓						
Turnip cake	1														✓							
Snack foods (1 out of 1 item)	**2**																					
Potato chips	2						✓													✓		
Sugars and confectionery (0 out of 2 items)	**0**																					
Condiments, sauces and herbs (0 out of 5 items)	**0**																					

Table B.2: Carbamates

Part A: The 117 TDS food items that were not detected with any of 20 carbamates are listed below:

TDS Food Item	
Cereals and their products (19 out of 19 items):	
Biscuits	Noodles, rice
Bread, plain	Oatmeal
Bread, raisin	Pasta, Western style
Breakfast cereals	Pastries
Cakes	Pastries, Chinese
Chinese steamed bread	"Pineapple" bun
Corn	Rice, unpolished
Deep-fried dough	Rice, white
Instant noodles	Sausage/ham/luncheon meat bun
Noodles, Chinese or Japanese style	
Vegetables and their products (11 out of 35 items):	
Broccoli	Mushroom, dried shiitake
Cabbage, European variety	Onion
Carrot/Radish	Potato
Ear fungus	Water spinach
Garlic	Zucchini
Mung bean sprout	
Legumes, nuts and seeds and their products (5 out of 6 items):	
Beancurd	Peanut
Fermented bean products	Peanut butter
Mung bean vermicelli	
Fruits (11 out of 17 items):	
Apple	Peach
Banana	Persimmon
Dragon fruit	Pineapple
Kiwi fruit	Plum
Mango	Pummelo/Grapefruit
Orange	
Meat, poultry and game and their products (12 out of 12 items):	
Barbecued pork	Meat sausage
Beef	Mutton
Chicken meat	Pig liver
Chicken, soy sauce	Pork
Ham	Roasted duck/goose
Luncheon meat	Roasted pork
Egg and their products (3 out of 3 items):	
Egg, chicken	Egg, salted

TDS Food Item	
Egg, lime preserved	
Fish and seafood and their products (19 out of 19 items):	
Crab	Fish, Pomfret
Fish ball/fish cake	Fish, Salmon
Fish, Big head	Fish, Sole
Fish, Dace, minced	Fish, Tuna
Fish, Golden thread	Fish, Yellow croaker
Fish, Grass carp	Oyster
Fish, Grey mullet	Scallop
Fish, Grouper	Shrimp/ Prawn
Fish, Horse head	Squid
Fish, Mandarin fish	
Dairy products (5 out of 5 items):	
Cheese	Milk, whole
Ice-cream	Yoghurt
Milk, skim	
Fats and oils (2 out of 2 items):	
Butter	Oil, vegetable
Beverages, alcoholic (2 out of 2 items):	
Beer	Red wine
Beverages, non-alcoholic (9 out of 10 items):	
Carbonated drink	Tea, chrysanthemum
Coffee	Tea, Milk tea
Fruit and vegetable juice	Water, bottled, distilled
Malt drink	Water, drinking
Soybean drink	
Mixed dishes (11 out of 12 items):	
Chinese soup	Siu Mai
Dumpling, including wonton	Steamed barbecued pork bun
Dumpling, pan-fried	Steamed rice-rolls with filling
Dumpling, steamed	Steamed rice-rolls, plain
Glutinous rice dumpling	Turnip cake
Hamburger	
Snack foods (1 out of 1 item):	
Potato chips	
Sugars and confectionery (2 out of 2 items):	
Chocolate	Granulated sugar
Condiments, sauces and herbs (5 out of 5 items):	
Cornstarch	Table salt
Oyster sauce	Tomato paste/ketchup
Soya sauce	

Part B: The 33 TDS food items that were detected with 8 carbamates (including their metabolites) are listed below:

TDS Food Item	Number of pesticides detected	Pesticides detected							
		Aldicarb	Carbofuran	Carbosulfan	Fenobucarb (BPMC)	Isoprocarb	Methomyl	Oxamyl	Propamocarb
Cereals and their products (0 out of 19 items) :	**0**								
Vegetables and their products (24 out of 35 items):	**7**								
Bitter melon	1								✓
Cabbage, Chinese	1								✓
Cabbage, Chinese flowering	1								✓
Cabbage, Petiole Chinese	1						✓		
Celery	2						✓	✓	
Chinese kale	1								✓
Chinese spinach	1								✓
Cucumber	1								✓
Eggplant	1		✓						
Hairy gourd	3		✓				✓		✓
Leaf mustard	1								✓
Lettuce, Chinese	2						✓		✓
Lettuce, European	1								✓
Mushrooms	1						✓		
Potato, fried	1	✓							
Preserved vegetables	1								✓
Pumpkin	1								✓
Spinach	2						✓		✓
Sponge gourd	3	✓	✓						✓
Spring onion	1								✓
Sweet pepper	4		✓	✓		✓			✓
Tomato	3		✓			✓			✓
Watercress	1								✓
Wax gourd	1								✓
Legumes, nuts and seeds and their products (1 out of 6 items):	**3**								
Green string beans, with pod	3		✓		✓				✓
Fruits (6 out of 17 items) :	**4**								
Grapes	1						✓		
Longan / Lychee	1						✓		

TDS Food Item	Number of pesticides detected	Pesticides detected							
		Aldicarb	Carbofuran	Carbosulfan	Fenobucarb (BPMC)	Isoprocarb	Methomyl	Oxamyl	Propamocarb
Melons	1							✓	
Papaya	2		✓				✓		
Pear	1	✓							
Watermelon	1						✓		
Meat, poultry and game and their products (0 out of 12 items)	**0**								
Egg and their products (0 out of 3 items)	**0**								
Fish and seafood and their products (0 out of 19 items)	**0**								
Dairy products (0 out of 5 items)	**0**								
Fats and oils (0 out of 2 items)	**0**								
Beverages, alcoholic (0 out of 2 items)	**0**								
Beverages, non-alcoholic (1 out of 10 items)	**1**								
Tea, Chinese	1						✓		
Mixed dishes (1 out of 12 items) :	**2**								
Steamed minced beef ball	2					✓			✓
Snack foods (0 out of 1 item)	**0**								
Sugars and confectionery (0 out of 2 items)	**0**								
Condiments, Sauces and herbs (0 out of 5 items)	**0**								

Table B.3: Pyrethrins and pyrethroids

Part A: The 111 TDS food items that were not detected with any of the 15 pyrethrins and pyrethroids are listed below:

TDS Food Item	
Cereals and their products (14 out of 19 items):	
Bread, plain	Noodles, Chinese or Japanese style
Bread, raisin	Noodles, rice
Cakes	Oatmeal
Chinese steamed bread	Pastries
Corn	Pastries, Chinese
Deep-fried dough	Rice, unpolished
Instant noodles	Rice, white
Vegetables and their products (15 out of 35 items):	
Broccoli	Mushrooms
Cabbage, European variety	Onion
Carrot/ Radish	Potato
Cucumber	Potato, fried
Garlic	Pumpkin
Hairy gourd	Wax gourd
Mung bean sprout	Zucchini
Mushroom, dried shiitake	
Legumes, nuts and seeds and their products (4 out of 6 items):	
Beancurd	Mung bean vermicelli
Fermented bean products	Peanut
Fruits (12 out of 17 items):	
Banana	Papaya
Dragon fruit	Pear
Kiwi fruit	Persimmon
Mango	Pineapple
Melons	Pummelo /Grapefruit
Orange	Watermelon
Meat, poultry and game and their products (12 out of 12 items):	
Beef	Meat sausage
Barbecued pork	Mutton
Chicken meat	Pig liver
Chicken, soy sauce	Pork
Ham	Roasted duck/goose
Luncheon meat	Roasted pork
Egg and their products (3 out of 3 items):	
Egg, chicken	Egg, salted
Egg, lime preserved	

TDS Food Item	
Fish and seafood and their products (17 out of 19 items):	
Crab	Fish, Salmon
Fish ball/fish cake	Fish, Sole
Fish, Dace, minced	Fish, Tuna
Fish, Golden thread	Fish, Yellow croaker
Fish, Grey mullet	Oyster
Fish, Grouper	Scallop
Fish, Horse head	Shrimp/ Prawn
Fish, Mandarin fish	Squid
Fish, Pomfret	
Dairy products (5 out of 5 items):	
Cheese	Milk, whole
Ice-cream	Yoghurt
Milk, skim	
Fats and oils (1 out of 2 items):	
Butter	
Beverages, alcoholic (2 out of 2 items):	
Beer	Red wine
Beverages, non-alcoholic (10 out of 10 items):	
Carbonated drink	Tea, Chinese
Coffee	Tea, chrysanthemum
Fruit and vegetable juice	Tea, Milk tea
Malt drink	Water, bottled, distilled
Soybean drink	Water, drinking
Mixed dishes (8 out of 12 items):	
Glutinous rice dumpling	Steamed minced beef ball
Hamburger	Steamed rice-rolls, plain
Siu Mai	Steamed rice-rolls with filling
Steamed barbecued pork bun	Turnip cake
Snack foods (1 out of 1 item):	
Potato chips	
Sugars and confectionery (2 out of 2 items):	
Chocolate	Granulated white sugar
Condiments, sauces and herbs (5 out of 5 items):	
Cornstarch	Table salt
Oyster sauce	Tomato paste/ ketchup
Soya sauce	

Part B: The 39 TDS food items that were detected with the 10 pyrethrins and pyrethroids are listed below:

TDS Food Item	Number of pesticides detected	Pesticides detected									
		Bifenthrin	Cyfluthrin	Cyhalothrin	Cypermethrin	Deltamethrin	Etofenprox	Fenpropathrin	Fenvalerate	Permethrin	Pyrethrins
Cereals and their products (5 out of 19 items):	**3**										
Biscuits	1				✓						
Breakfast cereals	1					✓					
Pasta, Western style	1					✓					
"Pineapple" bun	1									✓	
Sausage/ham/luncheon meat bun	1				✓						
Vegetables and their products (20 out of 35 items):	**9**										
Bitter melon	3	✓			✓				✓		
Cabbage, Chinese	1				✓						
Cabbage, Chinese flowering	4			✓	✓			✓		✓	
Cabbage, Petiole Chinese	5	✓	✓	✓	✓					✓	
Celery	2				✓					✓	
Chinese kale	3			✓	✓					✓	
Chinese spinach	3			✓	✓					✓	
Ear fungus	3			✓	✓			✓			
Eggplant	1				✓						
Leaf mustard	2			✓	✓						
Lettuce, Chinese	4	✓	✓		✓			✓			
Lettuce, European	1				✓						
Preserved vegetables	2				✓				✓		
Spinach	4	✓		✓	✓			✓			
Sponge gourd	1				✓						
Spring onion	3	✓		✓	✓						
Sweet pepper	5	✓		✓	✓	✓	✓				
Tomato	2	✓		✓							
Water spinach	2				✓				✓		
Watercress	3			✓	✓				✓		
Legumes, nuts and seeds and their products (2 out of 6 items):	**4**										
Green string beans, with pod	3			✓	✓			✓			
Peanut butter	1										✓
Fruits (5 out of 17 items):	**4**										
Apple	1			✓							

TDS Food Item	Number of pesticides detected	Pesticides detected									
		Bifenthrin	Cyfluthrin	Cyhalothrin	Cypermethrin	Deltamethrin	Etofenprox	Fenpropathrin	Fenvalerate	Permethrin	Pyrethrins
Grapes	2				✓			✓			
Longan/ Lychee	1				✓						
Peach	2			✓					✓		
Plum	1							✓			
Meat, poultry and game and their products (0 out of 12 items):	**0**										
Egg and their products (0 out of 3 items)	**0**										
Fish and seafood and their products (2 out of 19 items):	**2**										
Fish, Big head	2				✓				✓		
Fish, Grass carp	2				✓				✓		
Dairy products (0 out of 5 items)	**0**										
Fats and oils (1 out of 2 items):	**1**										
Oil, vegetable	1				✓						
Beverages, alcoholic (0 out of 2 items)	**0**										
Beverages, non-alcoholic (0 out of 10 items)	**0**										
Mixed dishes (4 out of 12 items):	**5**										
Chinese soup	1				✓						
Dumpling, including wonton	3			✓	✓					✓	
Dumpling, pan-fried	4			✓	✓			✓		✓	
Dumpling, steamed	3				✓				✓	✓	
Snack foods (0 out of 1 item)	**0**										
Sugars and confectionery (0 out of 2 items)	**0**										
Condiments, sauces and herbs (0 out of 5 items)	**0**										

Table B.4: Dithocarbamate metabolites

Part A: The 112 TDS food items that were not detected with any of two dithiocarbamate metabolites are listed below:

TDS Food Item	
Cereals and their products (17 out of 19 items):	
Biscuits	Noodles, rice
Bread, plain	Oatmeal
Bread, raisin	Pasta, Western style
Breakfast cereals	Pastries
Cakes	Pastries, Chinese
Corn	"Pineapple" bun
Deep-fried dough	Rice, white
Instant noodles	Sausage/ham/luncheon meat bun
Noodles, Chinese or Japanese style	
Vegetables and their products (15 out of 35 items):	
Broccoli	Lettuce, Chinese
Cabbage, European variety	Lettuce, European
Carrot/ Radish	Mung bean sprout
Celery	Mushroom, dried shiitake
Ear fungus	Mushrooms
Eggplant	Onion
Garlic	Pumpkin
Hairy gourd	
Legumes, nuts and seeds and their products (5 out of 6 items):	
Beancurd	Peanut
Fermented bean products	Peanut butter
Mung bean vermicelli	
Fruits (14 out of 17 items):	
Apple	Peach
Banana	Pear
Dragon fruit	Persimmon
Grapes	Pineapple
Kiwi fruit	Plum
Longan/Lychee	Pummelo /Grapefruit
Orange	Watermelon
Meat, poultry and game and their products (12 out of 12 items):	
Beef	Meat sausage
Barbecued pork	Mutton
Chicken meat	Pig liver
Chicken, soy sauce	Pork
Ham	Roasted duck/goose
Luncheon meat	Roasted pork

TDS Food Item	
Egg and their products (3 out of 3 items):	
Egg, chicken	Egg, salted
Egg, lime preserved	
Fish and seafood and their products (17 out of 19 items):	
Crab	Fish, Salmon
Fish ball/fish cake	Fish, Sole
Fish, Big head	Fish, Tuna
Fish, Golden thread	Fish, Yellow croaker
Fish, Grey mullet	Oyster
Fish, Grouper	Scallop
Fish, Horse head	Shrimp/ Prawn
Fish, Mandarin fish	Squid
Fish, Pomfret	
Dairy products (5 out of 5 items):	
Cheese	Milk, whole
Ice-cream	Yoghurt
Milk, skim	
Fats and oils (2 out of 2 items):	
Butter	Oil, Vegetable
Beverages, alcoholic (0 out of 2 items)	
Beverages, non-alcoholic (10 out of 10 items):	
Carbonated drink	Tea, Chinese
Coffee	Tea, chrysanthemum
Fruit and vegetable juice	Tea, Milk tea
Malt drink	Water, bottled, distilled
Soybean drink	Water, drinking
Mixed dishes (6 out of 12 items):	
Glutinous rice dumpling	Steamed barbecued pork bun
Hamburger	Steamed rice-rolls with filling
Siu Mai	Turnip cake
Snack foods (0 out of 1 item):	
Sugars and confectionery (2 out of 2 items):	
Chocolate	Granulated white sugar
Condiments, sauces and herbs (4 out of 5 items):	
Cornstarch	Soya sauce
Oyster sauce	Table salt

Part B: The 38 TDS food items that were detected with the two dithiocarbamate metabolites are listed below:

TDS Food Item	Number of pesticides detected	Pesticides detected	
		Ethylene thiourea (ETU)	Propylene thiourea (PTU)
Cereals and their products (2 out of 19 items):	**1**		
Chinese steamed bread	1	✓	
Rice, unpolished	1	✓	
Vegetables and their products (20 out of 35 items):	**2**		
Bitter melon	1	✓	
Cabbage, Chinese	1	✓	
Cabbage, Chinese flowering	1	✓	
Cabbage, Petiole Chinese	1	✓	
Chinese kale	1	✓	
Chinese spinach	1	✓	
Cucumber	1	✓	
Leaf mustard	1	✓	
Potato	1	✓	
Potato, fried	1	✓	
Preserved vegetables	1	✓	
Spinach	2	✓	✓
Sponge gourd	2	✓	✓
Spring onion	1	✓	
Sweet pepper	1	✓	
Tomato	1	✓	
Water spinach	1	✓	
Watercress	1	✓	
Wax gourd	1	✓	
Zucchini	1	✓	
Legumes, nuts and seeds and their products (1 out of 6 items):	**1**		
Green string beans, with pod	1	✓	
Fruits (3 out of 17 items):	**2**		
Mango	1	✓	
Melons	1	✓	
Papaya	2	✓	✓
Meat, poultry and game and their products (0 out of 12 items)	**0**		
Egg and their products (0 out of 3 items)	**0**		
Fish and seafood and their products (2 out of 19 items):	**1**		
Fish, Dace, minced	1	✓	
Fish, Grass carp	1	✓	

TDS Food Item	Number of pesticides detected	Pesticides detected	
		Ethylene thiourea (ETU)	Propylene thiourea (PTU)
Dairy products (0 out of 5 items)	**0**		
Fats and oils (0 out of 2 items)	**0**		
Beverages, alcoholic (2 out of 2 items):	**1**		
Beer	1	✓	
Red wine	1	✓	
Beverages, non-alcoholic (0 out of 10 items):	**0**		
Mixed dishes (6 out of 12 items):	2		
Chinese soup	1	✓	
Dumpling, including wonton	2	✓	✓
Dumpling, pan-fried	1	✓	
Dumpling, steamed	1	✓	
Steamed minced beef ball	1	✓	
Steamed rice-rolls, plain	1	✓	
Snack foods (1 out of 1 item):	**1**		
Potato chips	1	✓	
Sugars and confectionery (0 out of 2 items)	**0**		
Condiments, sauces and herbs (1 out of 5 items):	**2**		
Tomato paste/ ketchup	2	✓	✓

Appendix C

Pesticide residue contents (μg/kg) detected in TDS food items (sorted by pesticide residues)

Table C.1: Organophosphorus pesticides (OPPs)

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Acephate (11)	Celery	3	69	0 – 210
	Corn	1	1	0 – 5
	Cucumber	1	35	0 – 140
	Dumpling, steamed	1	1	0 – 3
	Eggplant	1	18	0 – 72
	Leaf mustard	1	2	0 – 7
	Lettuce, Chinese	1	6	0 – 25
	Lettuce, European	2	2	0 – 4
	Spinach	1	2	0 – 6
	Spring onion	1	240	0 – 950
	Watercress	1	21	0 – 82
Chlorpyrifos (20)	Apple	1	1	0 – 3
	Bitter melon	1	1	0 – 4
	Breakfast cereals	1	1	0 – 5
	Cabbage, Chinese flowering	1	2	0 – 7
	Cabbage, Petiole Chinese	1	5	0 – 20
	Dumpling, including wonton	2	2	0 – 3
	Dumpling, steamed	1	1	0 – 3
	Fish, Grass carp	1	1	0 – 3
	Grapes	1	4	0 – 16
	Green string beans, with pod	1	2	0 – 6
	Hairy gourd	1	2	0 – 6
	Longan/ Lychee	2	4	0 – 9
	Mushrooms	1	1	0 – 4
	Peach	1	1	0 – 4
	Peanut	3	8	0 – 15
	Pear	4	21	8 – 40
	Spinach	2	21	0 – 77
	Spring onion	1	1	0 – 4
	Sweet pepper	2	3	0 – 6
	Watercress	1	1	0 – 3
Chlorpyrifos-methyl (2)	Biscuits	1	1	0 – 2
	Pasta, Western style	1	1	0 – 3

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Diazinon (3)	Dumpling, pan-fried	1	1	0 – 4
	Pastries	1	1	0 – 4
	"Pineapple" bun	1	2	0 – 8
Dimethoate (5)	Leaf mustard	1	4	0 – 17
	Longan/ Lychee	1	7	0 – 26
	Mango	1	3	0 – 11
	Mushrooms	2	37	0 – 82
	Spring onion	1	3	0 – 12
Ethion (1)	Potato chips	1	1	0 – 2
Fenthion (1)	Mango	2	2	0 – 5
Fosthiazate (1)	Melons	1	11	0 – 44
Isocarbophos (5)	Ear fungus	1	10	0 – 39
	Green string beans, with pod	1	12	0 – 46
	Longan/ Lychee	1	2	0 – 9
	Mushrooms	1	1	0 – 4
	Spring onion	1	100	0 – 410
Isofenphos-methyl (1)	Preserved vegetables	1	2	0 – 9
Malathion (3)	Breakfast cereals	1	3	0 – 10
	Celery	1	1	0 – 2
	Chinese steamed bread	2	2	0 – 5
Methamidophos (11)	Celery	2	6	0 – 18
	Corn	1	1	0 – 3
	Cucumber	1	3	0 – 13
	Eggplant	1	5	0 – 19
	Leaf mustard	1	3	0 – 13
	Lettuce, Chinese	1	2	0 – 7
	Melons	1	1	0 – 4
	Preserved vegetables	1	2	0 – 7
	Spring onion	1	17	0 – 68
	Sweet pepper	1	6	0 – 25
	Watercress	1	13	0 – 50
Omethoate (13)	Cabbage, European variety	2	3	0 – 9
	Celery	1	1	0 – 5
	Eggplant	1	3	0 – 10
	Green string beans, with pod	1	28	0 – 110
	Leaf mustard	1	6	0 – 24
	Longan / Lychee	2	5	0 – 15
	Mango	1	11	0 – 43
	Mushrooms	3	110	0 – 270
	Plum	1	1	0 – 5

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
(con't) Omethoate	Spring onion	1	6	0 – 23
	Sweet pepper	3	2	0 – 4
	Tomato	1	1	0 – 3
	Water spinach	3	12	0 – 39
Phorate (6)	Butter	1	1	0 – 4
	Ear fungus	1	0	0 – 2
	Carrot/ Radish	1	42	0 – 170
	Peanut	1	1	0 – 4
	Preserved vegetables	1	1	0 – 5
	Turnip cake	3	7	0 – 22
Phoxim (12)	Biscuits	3	50	7 – 170
	Chinese spinach	1	3	0 – 10
	Chinese steamed bread	1	1	0 – 3
	Fish, Big head	2	110	0 – 430
	Fish, Dace, minced	1	1	0 – 4
	Fish, Grass carp	4	96	16 – 230
	Fish, Mandarin fish	1	1	0 – 5
	Hamburger	1	1	0 – 4
	Instant noodles	1	4	0 – 14
	Noodles, Chinese or Japanese style	1	1	0 – 4
	Pasta, Western style	1	2	0 – 7
	Spring onion	1	2	0 – 7
Pirimiphos-methyl (1)	Pasta, Western style	1	1	0 – 3
Profenofos (1)	Green string beans, with pod	1	8	0 – 32
Terbufos (2)	Fermented bean products	3	6	0 – 13
	Spring onion	1	4	0 – 14
Tolclofos-methyl (1)	Potato chips	1	1	0 – 3
Triazophos (4)	Mushrooms	1	5	0 – 21
	Spring onion	1	6	0 – 25
	Sweet pepper	1	1	0 – 4
	Water spinach	2	2	0 – 6
Trichlorfon (1)	Cabbage, European variety	1	4	0 – 15

* Four composite samples were tested for each TDS food item.

\# Non-detects were assumed to be 0 μg/kg. Mean levels below 10 μg/kg have been rounded to one significant figure and levels equal to or above 10 μg/kg have been rounded to two significant figures.

Table C.2: Carbamates

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Aldicarb (3)	Pear	1	5	0 – 20
	Potato, fried	2	2	0 – 5
	Sponge gourd	1	3	0 – 13
Carbofuran (7)	Eggplant	1	1	0 – 3
	Green string beans, with pod	2	6	0 – 22
	Hairy gourd	3	6	0 – 17
	Papaya	1	1	0 – 4
	Sponge gourd	1	1	0 – 4
	Sweet pepper	1	20	0 – 80
	Tomato	1	1	0 – 4
Carbosulfan (1)	Sweet pepper	3	4	0 – 8
Fenobucarb (BPMC) (1)	Green string beans, with pod	1	5	0 – 19
Isoprocarb (3)	Steamed minced beef ball	1	2	0 – 6
	Sweet pepper	2	14	0 – 40
	Tomato	1	4	0 – 16
Methomyl (11)	Cabbage, Petiole Chinese	1	2	0 – 6
	Celery	1	2	0 – 7
	Grapes	2	2	0 – 5
	Hairy gourd	2	3	0 – 7
	Lettuce, Chinese	2	2	0 – 5
	Longan / Lychee	2	6	0 – 18
	Mushrooms	1	3	0 – 12
	Papaya	1	1	0 – 2
	Spinach	1	1	0 – 5
	Tea, Chinese	1	1	0 – 3
	Watermelon	1	3	0 – 10
Oxamyl (2)	Celery	2	9	0 – 29
	Melons	1	2	0 – 7
Propamocarb (21)	Bitter melon	2	8	0 – 27
	Cabbage, Chinese	1	1	0 – 2
	Cabbage, Chinese flowering	2	350	0 – 1200
	Chinese kale	2	5	0 – 12
	Chinese spinach	1	1	0 – 2
	Cucumber	3	120	0 – 380
	Green string beans, with pod	1	1	0 – 4
	Hairy gourd	1	1	0 – 2
	Leaf mustard	1	35	0 – 140
	Lettuce, Chinese	1	35	0 – 140

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
(con't) Propamocarb	Lettuce, European	1	3	0 – 13
	Preserved vegetables	2	1	0 – 3
	Pumpkin	1	4	0 – 14
	Spinach	2	62	0 – 240
	Sponge gourd	2	12	0 – 37
	Spring onion	1	1	0 – 5
	Steamed minced beef ball	1	1	0 – 4
	Sweet pepper	1	3	0 – 12
	Tomato	2	11	0 – 37
	Watercress	1	3	0 – 12
	Wax gourd	2	3	0 – 7

* Four composite samples were tested for each TDS food item.

\# Non-detects were assumed to be 0 μg/kg. Mean levels below 10 μg/kg have been rounded to one significant figure and levels equal to or above 10 μg/kg have been rounded to two significant figures.

Table C.3: Pyrethrins and pyrethroids

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Bifenthrin (7)	Bitter melon	1	1	0 – 2
	Cabbage, Petiole Chinese	1	2	0 – 8
	Lettuce, Chinese	1	2	0 – 8
	Spinach	1	1	0 – 5
	Spring onion	2	20	0 – 54
	Sweet pepper	1	1	0 – 5
	Tomato	1	1	0 – 2
Cyfluthrin (2)	Cabbage, Petiole Chinese	1	6	0 – 23
	Lettuce, Chinese	1	3	0 – 12
Cyhalothrin (16)	Apple	1	1	0 – 3
	Cabbage, Chinese flowering	1	6	0 – 24
	Cabbage, Petiole Chinese	1	5	0 – 18
	Chinese kale	1	1	0 – 3
	Chinese spinach	1	1	0 – 3
	Dumpling, including wonton	1	2	0 – 9
	Dumpling, pan-fried	1	3	0 – 10
	Ear fungus	1	1	0 – 2
	Green string beans, with pod	3	7	0 – 15
	Leaf mustard	1	1	0 – 4
	Peach	1	1	0 – 2
	Spinach	2	3	0 – 6
	Spring onion	3	8	0 – 20
	Sweet pepper	2	4	0 – 7
	Tomato	1	1	0 – 2
	Watercress	1	1	0 – 5
Cypermethrin (31)	Biscuits	1	1	0 – 3
	Bitter melon	2	2	0 – 4
	Cabbage, Chinese	1	1	0 – 3
	Cabbage, Chinese flowering	4	12	2 – 31
	Cabbage, Petiole Chinese	4	48	4 – 100
	Celery	2	3	0 – 6
	Chinese kale	2	130	0 – 520
	Chinese soup	1	1	0 – 3
	Chinese spinach	1	1	0 – 3
	Dumpling, including wonton	3	8	0 – 27
	Dumpling, pan-fried	1	2	0 – 6
	Dumpling, steamed	1	2	0 – 7
	Ear fungus	2	1	0 – 3

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
(con't) Cypermethrin	Eggplant	1	1	0 – 2
	Fish, Big head	1	1	0 – 2
	Fish, Grass carp	1	1	0 – 3
	Grapes	1	1	0 – 3
	Green string beans, with pod	3	8	0 – 17
	Leaf mustard	3	25	0 – 86
	Lettuce, Chinese	3	50	0 – 180
	Lettuce, European	1	14	0 – 55
	Longan/ Lychee	2	1	0 – 3
	Oil, vegetable	1	1	0 – 2
	Preserved vegetables	3	9	0 – 26
	Sausage/ham/luncheon meat bun	1	1	0 – 3
	Spinach	4	36	2 – 130
	Sponge gourd	1	1	0 – 5
	Spring onion	4	61	2 – 210
	Sweet pepper	4	13	3 – 34
	Water spinach	3	37	0 – 77
	Watercress	4	55	10 – 98
Deltamethrin (3)	Pasta, Western style	2	2	0 – 4
	Breakfast cereals	1	1	0 – 3
	Sweet pepper	1	1	0 – 2
Etofenprox (1)	Sweet pepper	1	1	0 – 3
Fenpropathrin (8)	Cabbage, Chinese flowering	1	1	0 – 3
	Dumpling, pan-fried	1	3	0 – 12
	Ear fungus	1	2	0 – 8
	Grapes	1	4	0 – 16
	Green string beans, with pod	1	9	0 – 35
	Lettuce, Chinese	1	5	0 – 18
	Plum	1	4	0 – 16
	Spinach	2	13	0 – 47
Fenvalerate (8)	Bitter melon	1	3	0 – 13
	Dumpling, steamed	1	2	0 – 7
	Fish, Big head	4	8	3 – 24
	Fish, Grass carp	2	2	0 – 5
	Peach	1	1	0 – 3
	Preserved vegetables	1	1	0 – 2
	Water spinach	1	9	0 – 37
	Watercress	1	8	0 – 30
Permethrin (9)	Cabbage, Chinese flowering	2	33	0 – 110
	Cabbage, Petiole Chinese	1	1	0 – 2

Substance (No. food items with detectable levels)	TDS Food Item	No. composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Con't Permethrin	Celery	3	6	0 – 12
	Chinese kale	1	80	0 – 320
	Chinese spinach	2	14	0 – 46
	Dumpling, including wonton	2	5	0 – 18
	Dumpling, pan-fried	1	11	0 – 44
	Dumpling, steamed	1	12	0 – 48
	"Pineapple" bun	1	3	0 – 11
Pyrethrins (1)	Peanut butter	1	1	0 – 5

* Four composite samples were tested for each TDS food item.

\# Non-detects were assumed to be 0 μg/kg. Mean levels below 10 μg/kg have been rounded to one significant figure and levels equal to or above 10 μg/kg have been rounded to two significant figures.

Table C.4: Dithiocarbamate metabolites

TDS Food Item	No. of composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Ethylene thiourea (ETU) (38 food items)			
Cereals and their products:			
Rice, unpolished	1	4	0 – 16
Chinese steamed bread	2	2	0 – 5
Vegetables and their products:			
Potato	2	1	0 – 3
Potato, fried	3	3	0 – 8
Cabbage, Chinese	2	1	0 – 3
Cabbage, Chinese flowering	2	4	0 – 11
Cabbage, Petiole Chinese	2	10	0 – 33
Chinese kale	1	2	0 – 8
Chinese spinach	4	35	3 – 120
Leaf mustard	2	4	0 – 14
Spinach †	4	110	1 – 170
Water spinach	2	1	0 – 2
Watercress	4	11	4 – 18
Bitter melon	2	5	0 – 11
Cucumber	1	1	0 – 5
Sponge gourd †	2	4	0 – 12
Wax gourd	3	2	0 – 3
Zucchini	1	1	0 – 2
Sweet pepper	1	1	0 – 3
Tomato	3	4	0 – 9
Spring onion	4	120	14 – 390
Preserved vegetables	1	0	0 – 1
Legumes, nuts and seeds and their products:			
Green string beans, with pod	1	2	0 – 6
Fruits:			
Mango	3	3	0 – 7
Melons	1	1	0 – 2
Papaya †	4	11	2 – 22
Fish and seafood and their products:			
Fish, Grass carp	1	4	0 – 14
Fish, Dace, minced	1	1	0 – 3
Beverages, alcoholic:			
Beer	1	1	0 – 3
Red wine	4	8	1 – 13
Mixed dishes:			
Dumpling, steamed	3	11	0 – 28
Dumpling, pan-fried	1	2	0 – 7

TDS Food Item	No. of composite samples with detectable levels*	Mean # (μg/kg)	Range # (μg/kg)
Dumpling, including wonton †	2	12	0 – 29
Steamed minced beef ball	3	2	0 – 5
Steamed rice-rolls, plain	1	30	0 – 120
Chinese soup	1	5	0 – 19
Snack foods:			
Potato chips	1	2	0 – 6
Condiments, sauces and herbs:			
Tomato paste/ ketchup †	3	3	0 – 7
Total	80		

Propylene thiourea (PTU) (5 food items)

Vegetables and their products:			
Spinach	2	32	0 – 120
Sponge gourd	1	1	0 – 5
Fruits:			
Papaya	2	7	0 – 15
Mixed dishes:			
Dumpling, including wonton	1	1	0 – 3
Condiments, sauces and herbs:			
Tomato paste/ ketchup	1	0	0 – 1
Total	7		

* Four composite samples were tested for each TDS food item.

Non-detects were assumed to be 0 μg/kg. Mean levels below 10 μg/kg have been rounded to one significant figure and levels equal to or above 10 μg/kg have been rounded to two significant figures.

† Apart from ethylene thiourea (ETU), food items were also detected with propylene thiourea (PTU).

Appendix D

Dietary exposures to organophosphorus pesticides (OPPs) and a percentage contribution to the acceptable daily intakes (ADIs) by age-gender groups (the average and high consumer of the population)

		Dietary Exposure Estimate (μg/kg bw/day) (% contribution to ADI)																							
	Age	20 - 29				30 - 39				40 - 49				50 - 59				60 - 69				70 - 84			
	Gender	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
			%		%		%		%		%		%		%		%		%		%		%		%
Acephate	Average	0.012	0	0.015	0	0.015	0	0.018	0.1	0.017	0.1	0.018	0.1	0.019	0.1	0.021	0.1	0.017	0.1	0.019	0.1	0.015	0.1	0.015	0.1
	High Consumers	0.049	0.2	0.051	0.2	0.048	0.2	0.061	0.2	0.059	0.2	0.064	0.2	0.068	0.2	0.072	0.2	0.065	0.2	0.063	0.2	0.056	0.2	0.051	0.2
Chlorpyrifos	Average	0.005	0.1	0.008	0.1	0.006	0.1	0.011	0.1	0.010	0.1	0.013	0.1	0.010	0.1	0.012	0.1	0.011	0.1	0.012	0.1	0.009	0.1	0.010	0.1
	High Consumers	0.030	0.3	0.035	0.4	0.028	0.3	0.045	0.4	0.039	0.4	0.052	0.5	0.035	0.3	0.043	0.4	0.041	0.4	0.048	0.5	0.038	0.4	0.048	0.5
Chlorpyrifos-methyl	Average	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0.003	0	0.003	0	0.002	0	0.002	0	0.002	0	0.002	0	0.002	0	0.002	0	0.001	0	0.001	0	0.001	0	0.001	0
Diazinon	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.002	0	0.001	0	0.001	0	0.001	0
Dimethoate and omethoate	Average	0.086	4.3	0.113	5.6	0.074	3.7	0.159	7.9	0.074	3.7	**0.163**	**8.2**	0.083	4.2	0.133	6.7	0.055	2.8	0.089	4.5	0.060	3.0	0.060	3.0
	High Consumers	0.406	20.3	0.514	25.7	0.341	17.0	**0.669**	**33.5**	0.363	18.2	0.657	32.8	0.342	17.1	0.546	27.3	0.268	13.4	0.512	25.6	0.306	15.3	0.278	13.9
Ethion	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fenthion	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0
Fosthiazate	Average	0	0	0	0.1	0	0	0.001	0.1	0.001	0.1	0.001	0.1	0	0	0.001	0.1	0	0	0	0	0	0	0	0.1
	High Consumers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.2	0	0	0	0	0	0	0	0
Isocarbophos	Average	0.005	0.2	0.005	0.2	0.006	0.2	0.007	0.2	0.006	0.2	0.006	0.2	0.007	0.2	0.007	0.2	0.005	0.2	0.006	0.2	0.005	0.2	0.005	0.2
	High Consumers	0.017	0.6	0.019	0.6	0.020	0.7	0.022	0.7	0.019	0.6	0.026	0.9	0.021	0.7	0.026	0.9	0.020	0.7	0.019	0.6	0.016	0.5	0.016	0.5
Isofenphos-methyl	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0.001	0	0	0	0	0	0	0
Malathion	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0	0	0	0	0	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0

		Dietary Exposure Estimate (μg/kg bw/day) (% contribution to ADI)																							
	Age	20 - 29				30 - 39				40 - 49				50 - 59				60 - 69				70 - 84			
	Gender	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
			%		%		%		%		%		%		%		%		%		%		%		%
Methamidophos	Average	0.002	0	0.002	0	0.002	0	0.002	0.1	0.002	0.1	0.002	0.1	0.003	0.1	0.003	0.1	0.002	0.1	0.002	0.1	0.002	0.1	0.002	0.1
	High Consumers	0.006	0.1	0.006	0.2	0.006	0.2	0.009	0.2	0.007	0.2	0.009	0.2	0.008	0.2	0.011	0.3	0.010	0.2	0.010	0.3	0.008	0.2	0.008	0.2
Phorate	Average	0.004	0.6	0.004	0.6	0.004	0.6	0.004	0.5	0.004	0.6	0.005	0.8	0.004	0.6	0.007	0.9	0.005	0.8	0.005	0.6	0.003	0.5	0.004	0.6
	High Consumers	0.024	3.4	0.019	2.7	0.021	3.1	0.018	2.6	0.022	3.1	0.029	4.2	0.019	2.7	0.029	4.1	0.027	3.8	0.027	3.9	0.020	2.9	0.024	3.4
Phoxim	Average	0.014	0.3	0.020	0.5	0.016	0.4	0.019	0.5	0.019	0.5	0.020	0.5	0.023	0.6	0.026	0.6	0.042	1.0	0.033	0.8	0.042	1.1	0.047	1.2
	High Consumers	0.065	1.6	0.076	1.9	0.082	2.0	0.082	2.0	0.079	2.0	0.096	2.4	0.125	3.1	0.115	2.9	0.175	4.4	0.177	4.4	0.238	5.9	0.251	6.3
Pirimiphos-methyl	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0.002	0	0.002	0	0.002	0	0.002	0	0.002	0	0.002	0	0.002	0	0.001	0	0	0	0.001	0	0.001	0	0.001	0
Profenofos	Average	0	0	0	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0
	High Consumers	0.003	0	0.003	0	0.004	0	0.005	0	0.003	0	0.005	0	0.004	0	0.007	0	0.003	0	0.004	0	0.003	0	0.004	0
Terbufos	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0.001	0.1	0.001	0.1	0.001	0.2	0.001	0.2	0.001	0.1	0.001	0.2	0.001	0.2	0.001	0.2	0.001	0.2	0.001	0.1	0.001	0.1	0.001	0.1
Tolclofos-methyl	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triazophos	Average	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0.001	0.1	0	0	0	0
	High Consumers	0.003	0.3	0.003	0.3	0.002	0.2	0.005	0.5	0.003	0.3	0.005	0.5	0.004	0.4	0.003	0.3	0.003	0.3	0.003	0.3	0.002	0.2	0.002	0.2
Trichlorfon	Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	High Consumers	0.001	0	0.001	0.1	0.001	0	0.002	0.1	0.001	0	0.002	0.1	0.001	0	0.001	0.1	0.002	0.1	0.002	0.1	0.001	0.1	0.002	0.1

- Exposures of high consumers refer to the exposures at 95th percentile.
- Figures for dietary exposure estimates and contributions to ADIs were rounded to three and one decimal places, respectively.
- Values of "0" denote < 0.0005 μg/kg bw/day for dietary exposure estimates and < 0.05% for contributions to ADIs