DETERMINATION OF OCCUPATIONAL RISK AND EXPOSURE TO PESTICIDE RESIDUES ON VEGETABLES AMONG GREENGROCERS IN FRESH MARKET BANGKOK THAILAND

Miss Parichat Ong-artborirak

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Public Health
College of Public Health Sciences
Chulalongkorn University
Academic Year 2016

การวัดความเสี่ยงจากการประกอบอาชีพและการสัมผัสสารกำจัดศัตรูพืชที่ตกค้างบนผักของกลุ่มพ่อค้าแม่ค้าผักในตลาดสด กรุงเทพมหานคร ประเทศไทย

นางสาวปาริฉัตร องอาจบริรักษ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
สาขาวิชาสาธารณสุขศาสตร์
วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2559

Thesis Title	DETERMINATION OF OCCUPATIONAL RISK AND EXPOSURE TO PESTICIDE RESIDUES ON VEGETABLES AMONG GREENGROCERS IN FRESH MARKET BANGKOK THAILAND
By	Miss Parichat Ong-artborirak
Field of Study	Public Health
Thesis Advisor	Associate Professor Wattasit Siriwong, Ph.D.
Thesis Co-Advisor	Professor Mark G. Robson, Ph.D.

Accepted by the College of Public Health Sciences, Chulalongkorn University in Partial Fulfillment of the Requirements for the Doctoral Degree

....................................Dean of the College of Public Health Sciences

(Professor Sathirakorn Pongpanich, Ph.D.)

THESIS COMMITTEE

....Chairman

(Professor Surasak Taneepanichskul, M.D., M.Med)

....Thesis Advisor

(Associate Professor Wattasit Siriwong, Ph.D.)

....Thesis Co-Advisor

(Professor Mark G. Robson, Ph.D.)

....Examiner

(Associate Professor Ratana Somrongthong, M.A., Ph.D.)

....Examiner

(Nutta Taneepanichskul, Ph.D.)

....External Examiner

(Saowanee Norkaew, Ph.D.)

ปาริฉัตร องอาจบริรักษ์ : การวัดความเสี่ยงจากการประกอบอาชีพและการสัมผัสสารกำจัดศัตรูพืชที่ตกค้างบนผักของกลุ่มพ่อค้าแม่ค้าผักในตลาดสด กรุงเทพมหานคร ประเทศไทย (DETERMINATION OF OCCUPATIONAL RISK AND EXPOSURE TO PESTICIDE RESIDUES ON VEGETABLES AMONG GREENGROCERS IN FRESH MARKET BANGKOK THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร. วัฒน์สิทธิ์ ศิริวงศ์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ศ. ดร. Mark G. Robson, 160 หน้า.

การวิจัยแบบผสมนี้มีวัตถุประสงค์เพื่อประเมินความเสี่ยงต่อสุขภาพจากการประกอบอาชีพและการสัมผัสสารกำจัดศัตรูพืชที่ตกค้างบนผัก โดยทำการศึกษาจากพ่อค้าแม่ค้าผักที่ตลาดผดุงกรุงเกษมในกรุงเทพมหานคร จำนวน 91 คน การเก็บรวบรวมข้อมูลประกอบด้วยการสัมภาษณ์ การเก็บตัวอย่างสารกำจัดศัตรูพืชตกค้างบนผิวหนังโดยการเช็ดมือ และการตรวจระดับเอนไซม์โคลีนเอสเตอเรสในเลือดในฤดูแล้ง (เดือนเมษายน-พฤษภาคม) และฤดูฝน (เดือนสิงหาคม-ตุลาคม) รวมทั้งการสัมภาษณ์เชิงลึก ผลการศึกษา พบว่า ผิวหนังบริเวณมือของพ่อค้าแม่ค้าผักมีการตกค้างของสารกำจัดศัตรูพืช 3 กลุ่ม ได้แก่ ออร์แกโนฟอสเฟต, คาร์บาเมท, และไพรีทรอยด์ โดยพบคลอไพริฟอสและไซเปอร์เมทรินในทุกตัวอย่าง เมื่อเปรียบเทียบระหว่างสองฤดู พบว่า ปริมาณคลอไพริฟอสและจำนวนชนิดของสารกำจัดศัตรูพืชที่พบบนมือในฤดูแล้งมากกว่าฤดูฝนอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) แต่ไม่พบความแตกต่างที่มีนัยสำคัญของปริมาณไซเปอร์เมทรินบนมือ นอกจากนี้ พบความแตกต่างกันอย่างมีนัยสำคัญของระดับเอนไซม์โคลีนเอสเทอเรสในเลือด ($p<0.001$) การรายงานอาการทางสุขภาพจากการสัมผัสสารกำจัดศัตรูพืชตกค้างในผักที่พบมากที่สุด คือ เหนื่อยล้า อ่อนเพลีย, ระคายเคืองผิวหนัง (ผื่น/คัน), ระคายเคืองตาหรือมองเห็นไม่ชัด และปวดหัว การประเมินความเสี่ยงจากการสัมผัสสารกำจัดศัตรูพืชตกค้างทางผิวหนังที่ค่าเปอร์เซ็นไทล์ที่ 99 พบว่า ค่าการรับสัมผัสสารต่อวัน (ADD) เท่ากับ $2.42x10^{-5}$ มิลลิกรัม/กิโลกรัม/วัน และค่าดัชนีบ่งชี้อันตรายอยู่ในระดับที่ยอมรับได้ (HI=0.287) นอกจากนี้ ยังพบความสัมพันธ์ท่ามกลางการปฏิบัติตนเกี่ยวกับการป้องกันการสัมผัสสารกำจัดศัตรูพืชตกค้างในผัก, สารกำจัดศัตรูพืชตกค้างที่พบบนมือ, ระดับเอนไซม์โคลีนเอสเตอเรสในเลือด, และอาการทางสุขภาพอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) การสัมผัสสารกำจัดศัตรูพืชที่ตกค้างบนผักอาจจะทำให้เกิดผลกระทบต่อสุขภาพได้ ดังนั้น กลุ่มพ่อค้าแม่ค้าผักควรได้รับการสื่อสารความเสี่ยงเพื่อให้ความรู้และแนวทางด้านการปฏิบัติตนจากการสัมผัสสารกำจัดศัตรูพืชตกค้างในผักที่เหมาะสม (Guideline) โดยเฉพาะอย่างยิ่ง การปฏิบัติตนทางสุขอนามัยที่ดี เพื่อลดความเสี่ยงและป้องกันผลกระทบที่เกิดขึ้น

สาขาวิชา สาธารณสุขศาสตร์	ลายมือชื่อนิสิต ....
ปีการศึกษา 2559	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
	ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

5579166553 : MAJOR PUBLIC HEALTH

KEYWORDS: RISK ASSESSMENT / DERMAL EXPOSURE / PESTICIDE RESIDUE / VEGETABLE / BLOOD CHOLINESTERASE / GREENGROCER

PARICHAT ONG-ARTBORIRAK: DETERMINATION OF OCCUPATIONAL RISK AND EXPOSURE TO PESTICIDE RESIDUES ON VEGETABLES AMONG GREENGROCERS IN FRESH MARKET BANGKOK THAILAND. ADVISOR: ASSOC. PROF. WATTASIT SIRIWONG, Ph.D., CO-ADVISOR: PROF. MARK G. ROBSON, Ph.D., 160 pp.

This mixed methods study aimed at assessing the magnitude of health risk from occupational exposure to pesticide residues (PRs) on vegetables. The study was conducted among 91 greengrocers in Padung Krung Kasem market, Bangkok. Data was collected in dry (April-May) and wet (August-October) seasons, including face-to-face interview, hand wipe sampling, and blood cholinesterase (ChE) level test, and then in-depth interview was conducted. The study revealed that all hand wipe samples contained many kinds of insecticides, including organophosphates, carbamates, and pyrethroids. PRs on hands detected in all samples were chlorpyrifos and cypermethrin. Wilcoxon signed rank test revealed that amount of chlorpyrifos and types of PRs on hands in the wet season significantly decreased when compared to the dry season ($p<0.05$), while amount of cypermethrin did not significantly differ. In addition, there were statistically significant differences in blood ChE level in both seasons ($p<0.001$). The most reported symptoms from exposure to PRs were fatigue/tiredness, skin rash/itching, headache, and eye irritation/blurred vision. At 99^{th} percentile values of PR exposure, average daily dose (ADD) was 2.42×10^{-5} mg/kg/day and hazard index did not exceed acceptable level (HI=0.287). Besides, the significant relationship among practice regarding PR exposure, PRs on hands, ChE level, and health symptoms were found ($p<0.05$). Occupational exposure to PRs with poor practice may pose health effects. These findings suggest that risk communication among greengrocers should be done with guideline related to pesticide contamination in vegetables, especially proper personal hygiene practice, to prevent them from PR exposure and potential health risks.

Field of Study: Public Health	Student's Signature ....
Academic Year: 2016	Advisor's Signature ....
	Co-Advisor's Signature ....

ACKNOWLEDGEMENTS

This thesis can be accomplished due to the extensive support and assistance from my major advisor, Assoc. Prof. Wattasit Siriwong, and my co-advisor, Prof. Mark G Robson. I would like to express my sincere thanks and appreciation to them for their valuable guidances and encouragement in this research.

I sincerely thank my thesis examination members, Prof. Surasak Taneepanichskul, Assoc. Prof. Ratana Somrongthong, and Dr. Nutta Taneepanichskul for their comments and suggestions. I greatly thank Dr. Saowanee Norkaew, my external examiner for her valuable advice. Also, I would like to acknowledge Dr. Somsiri Jaipieam, and Dr. Kriangkrai Lerdthusnee for their kindness and good encouragement.

I gratefully thank all lecturers and officers, College of Public Health Sciences, Chulalongkorn University, for their help and support. The grant for aging society cluster, Ratchadaphiseksomphot Endowment Fund (CU-57-078-AS), Chulalongkorn University, is also acknowledged.

I do thank my subjects in Padung Krung Kasem market, Bangkok, for participation in this research.

Finally, I deeply thank my parents and sister for their encouragement, understanding, and love which supported and inspired me to do completely this thesis. My thanks are extended to my friends for their good assistance and friendships.

CONTENTS

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

Figure 3.1 Map of Padung Krung Kasem market 35

Figure 3.2 Diagram of data collection 42

Figure 3.3 Sample preparation for GC analysis 46

Figure 4.1 Detected frequencies of pesticide residues in vegetable samples between dry and wet seasons 75

Figure 4.2 Detected frequencies of pesticide residues in hand wipe samples between dry and wet seasons 79

Figure 4.3 Reported health symptoms in last month among greengrocers between dry and wet seasons 87

LIST OF ACRONYMS

ABS	Dermal absorption fraction
AChE	Acetylcholinesterase
ADD	Average daily dose
CA	Carbamate
ChE	Cholinesterase
GC	Gas chromatography
HQ	Hazard quotient
HI	Hazard index
HRA	Health risk assessment
LC	Liquid chromatography
LOD	Limit of detection
LOQ	Limit of quantitation
OC	Organochlorine
OP	Organophosphate
PChE	Plasma cholinesterase
PR	Pesticide residue
PY	Pyrethroid
RfD	Reference dose
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER I

INTRODUCTION

1.1 Background and Rationale

At the present time, pesticides are still being broadly used for agriculture in Thailand. Rising pesticide use may be from increase in cash crops, higher application rate to raise yield, reduction in pesticide price, lack of knowledge about correct use among farmers, and government policies (Tirado at al., 2008). About 64% of Thai vegetable farmers regularly use pesticides mainly organophosphates and pyrethroids (Chaigarun & Nathapindhu, 2006). In addition, mixtures of several kinds of pesticides are applied to the same crop (Harnpicharnchai, Chaiear, & Charerntanyarak, 2013). The amount of the chemical residues attached on sprayed plants. The pesticide residues in vegetables can be degraded from exposure to sunlight and during transportation; however, they have been detected and reported especially from fresh market (Ministry of Public Health, 2012).

In Thailand, fresh vegetables that are highest in pesticide residues were kale, chili, Chinese flowering cabbage, morning glory, cabbage, and cucumber, respectively (Ministry of Public Health, 2012). In Bangkok, vegetables from fresh market, including kale, cauliflower, and spring onion, revealed highest pesticide residues (Food and Drug Administration, 2012). Many studies have been regularly reported on contamination in market vegetables (Pakvilai et al., 2015; Sapbamrer and Hongsibsong, 2014; Wanwimolrak et al., 2015). The analysis of pesticide residues in agricultural produce in the upper Northeast of Thailand found that several kinds of vegetables, such as Chinese kale, celery, spring onion, chilli, cucumber, Thai eggplant, yard long bean, cabbage, and Chinese cabbage, etc., were greater than Maximum Residue Limits (MRLs), and the residues of chlorpyrifos (organophosphates) and cypermethrin (pyrethroids) were mainly found (Prasopsuk, Saisuphan, & Srisawangwong, 2014). Available data revealed that chlorpyrifos remained on vegetable surfaces for about 10–14 days (Kamrin, 2000). Besides, levels of pesticide residues in vegetable samples from different sources were different (Sapbamrer & Hongsibsong, 2014). Moreover, imported fresh vegetables from many countries, especially China, contaminated with pesticide residues (Nantavitayaporn, 2012). In other countries, the vegetables also contained pesticide residues (Bakirci et al., 2014; Latif, Sherazi & Bhanger, 2011; National Food Institute, 2013; Syed et al., 2014; US EPA, 2011b).

The pesticides can enter the human body through the oral route, inhalation, and skin contact, and also pose health problems. People who work around pesticides can be exposed due to the nature of their jobs (US EPA, 2014a). Occupational exposure to pesticides in agriculture affects product distributors, mixers and loaders, applicators, bystanders, and workers re-entering the fields after treatment (Maroni, Fanetti, & Metruccio, 2006). Farmers are directly exposed through the application of pesticides. Among harvesters, pesticide exposure occurs primarily due to hand contact with sprayed leaf surfaces (Krieger et al., 1990). Dermal exposure is determined by the transfer of pesticide residue from the surface of the foliage to the skin of workers. Even women tending cucumbers in vegetable-growing greenhouse experienced measurable dermal exposure (Jurewicz et al., 2009). Substantial amounts of pesticide can be absorbed through the skin (Fenske and Lu, 1994). Dermal absorption depends on exposure factors (duration, area of skin exposed, concentration of the chemical, use of protective equipment, hygiene, etc.), chemical factors (solubility in water, presence of other chemicals, etc.), and skin factors (temperature and humidity, skin thickness, etc.) (Semple, 2004). Consequently, a greengrocer may be exposed to pesticides via hand contact by transferring residues on the surface of treated vegetables to the skin during work.

Health risk assessment from pesticide exposure have been performed among farmers (Curwin et al., 2005; Jaipieam et al., 2009; Lappharat et al., 2014;

Taneepanichskul, 2012), harvesters (Jurewicz et al., 2009; R. I. Krieger & Dinoff, 2000; Li et al., 2011), and consumers or risky local population (National Food Institute, 2013; Norkaew, 2012; Shen, Xia, & Dai, 2013; Siriwong et al., 2008; Syed et al., 2014). Among greengrocers, the health risk assessment from occupational exposure to pesticide residues on vegetables is still particularly concerning. Besides, using blood cholinesterase test as a biomarker for assessing exposure to organophosphate and carbamate pesticides have been performed due to their effects on cholinesterase activity in the human body. Many studies showed that cholinesterase level in vegetable farmers were significantly lower than those in control group (Dhananjayan et al., 2012; Neupane, Jors, & Brandt, 2014; Ntow et al., 2009; Soogarun, Wiwanitkit, & Suwansaksri, 2003). Abnormal cholinesterase activity was revealed among vegetable farmers (Lu, 2009b; Thetkathuek et al., 2014). In addition, pesticide-related health symptoms, including neuromuscular system, eye symptoms, and skin problems were mostly reported among vegetable farmers (Lu, 2009b; Neupane et al., 2014; Ngowi et al., 2007; Ntow et al., 2006). However, determination of blood cholinesterase level and report of health symptoms among greengrocers has not been documented.

Exposure to pesticides can be prevented by good hygiene practice. Previous study revealed that wearing rubber latex gloves reduced harvester captan exposure compared to bare-handed harvesters (R. I. Krieger & Dinoff, 2000). In USA, harvesters use light latex gloves to reduce pesticide exposure and protect their skin because hands are the most important route of their exposure (Li et al., 2011). In addition, portion of pesticide residue is removed by washing or wiping skin such as hands (Brouwer, Boeniger, & van Hemmen, 2000; Fenske & Lu, 1994; Zendzian, 2003). Neupane et al. (2014) noted that inadequate use of personal protective equipment and poor hygienic practices might explain the reason for symptoms of pesticide intoxication and a lower red blood cell cholinesterase level among vegetable farmers. Besides, knowledge (K), attitude (A), and practice (P) about pesticide use and prevention are related with increased risk from pesticide exposure (Pidgunpai, Keithmaleesatti, & Siriwong, 2014).

A preliminary survey on personal hygiene habits among greengrocers at a large fresh market revealed that majority of greengrocers (66%) washed their hands less than 5 times a day. Only 18% of them washed their hands with soap during work, while 22% did not wash their hands before eating food. Most (82%) did not wear gloves during working. Also, 32% always reported eating vegetables without washing them during working. This is significantly associated with perception on health effect from pesticide residues on vegetables and oral route of exposure ($p<0.05$) (Ong-artborirak, Siriwong, & Robson, 2014). Moreover, most of greengrocers are informal employers, none of any employment security and protection (National Statistical Office, 2012). Because of their work routine, they may be at risk from repeated exposure to pesticide residues on various vegetables by mainly hand contact and consumption with poor hygiene habits. Therefore, determination of occupational risk and exposure to pesticide residues on vegetables among greengrocers in fresh market, Bangkok, Thailand, is the interest for this study.

1.2 Objectives

1.2.1 General objective

To assess the magnitude of health risk from occupational exposure to pesticide residues on vegetables among greengrocers in fresh market, Bangkok, Thailand

1.2.2 Specific objectives

1) To assess knowledge (K), attitude (A), and practice (P) regarding exposure to pesticide residues and protection

2) To explore health symptoms from exposure to pesticide residues on vegetables among greengrocers

3) To determine factors associated with pesticide residues on hands, blood cholinesterase level, and health symptoms

4) To compare pesticide residues on hands, blood cholinesterase level, and health symptoms between dry and wet seasons

5) To evaluate health risk regarding exposure to pesticide residues on vegetables among greengrocers

6) To develop guideline for prevention and health risk reduction related to pesticides contaminated in vegetables among greengrocers

1.3 Research Questions

1) What are KAP regarding exposure to pesticide residues and protection among greengrocers?

2) What are health symptoms from exposure to pesticide residues on vegetables among greengrocers?

3) What are factors associated with pesticide residues on hands, blood cholinesterase level, and health symptoms?

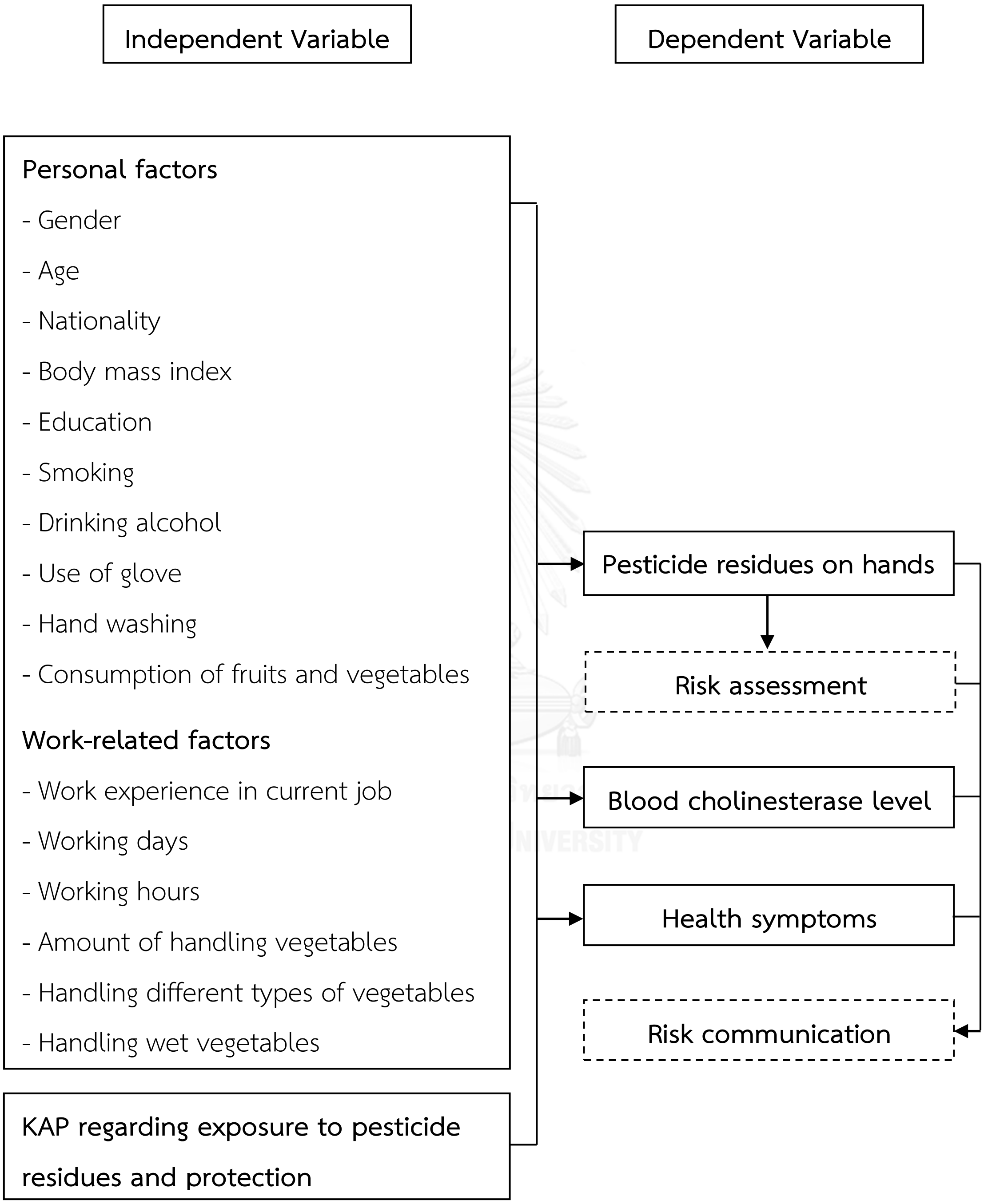
4) Are there differences in pesticide residues on hands, blood cholinesterase level, and health symptoms between dry and wet seasons?

5) Are greengrocers at risk from occupational exposure to pesticide residues on vegetables?

1.4 Research Hypotheses

Greengrocers are at risk from occupational exposure to pesticide residues on vegetables.

1.5 Conceptual Framework



1.6 Terms of Definitions

1) Health risk: Probability of health effects from occupational exposure to pesticide residues on vegetables among greengrocers based on health risk assessment and blood cholinesterase level test.

2) Occupational exposure: Exposure to pesticide residues on vegetables among greengrocers during their works through the dermal route by hands

3) Greengrocer: A person who owns or works in a shop that sells fresh vegetables.

4) Pesticide residues on hands: The amount and types of pesticide residues on greengrocer's hands, including organophosphates, carbamates and pyrethroids, which were assessed by hand wipe sampling. It was expressed in unit of micrograms per both hands (μg/both hands).

5) Blood cholinesterase level: The levels of acetylcholinesterase (AChE) and plasma cholinesterase (PChE), which were tested at the site of (sample) collection by the equipment called Test-mate ChE Kit. They were expressed in unit per millilitre (U/mL).

6) Health symptoms: Effect or health symptoms from exposure to pesticide residues on vegetables, which were interviewed by quantitative and qualitative research methods.

7) Health risk assessment: A process involved hazard identification, dose-response assessment (toxicity assessment), exposure assessment, and risk characterization to evaluate the magnitude of health risk. The pesticide residues on hands were used for exposure assessment.

8) Guideline: A guideline for prevention and health risk reduction related to pesticide contamination in vegetables, which was developed from results of this study, and implemented among greengrocers for risk communication.

9) Risk communication: A process given information via education material (developed guideline) with demonstrating pesticide contamination on vegetables,

and also results and interpretation of individual health risk assessment and blood cholinesterase level test among greengrocers.

10) Consumption of fruits and vegetables: Amount of fruits and vegetables which was weighed from picking fruit and vegetable samples consumed in a day by greengrocers. The intake of fruits and vegetables was divided into 3 levels, including small amount, moderate amount, and large amount.

11) Amount of handling vegetables: Amount of handling and touching vegetables with and without protective materials. Amount of handling vegetables with protective materials was calculated from average weight of all vegetables in shop per week divided by number of greengrocer in shop, and it was expressed in unit of kilograms per week (kg/week). Amount of handling vegetables without protective materials was answered by greengrocers, and it was expressed in unit of kilograms per day (kg/day).

12) Handling wet vegetables: The proportion of wet vegetable in shop, which was calculated from types of wet vegetable in shop divided by types of all vegetables in shop, and multiplied by 100. Handling wet vegetables was expressed in unit of percentage (%).

1.7 Expected Benefit and Application

1) The findings of the study provided the useful baseline information and can be used for making decision to risk management and risk communication regarding occupational exposure to pesticide residues on vegetables among greengrocers in fresh market.

2) The developed guideline was implemented for preventing and reducing exposure to pesticide residues on vegetables among greengrocers.

CHAPTER II

LITERATURE REVIEW

2.1 Type of Pesticides

Pesticides, materials that are used to kill, repel, or change the behavior of an unwanted organism, are a mainstay or pest control (Robson, Hamilton, & Siriwong, 2010). Over 1,055 active ingredients were registered as pesticides, and these are formulated into 100,000 of pesticide products that are available in the marketplace (US EPA, 2014a). It is common for an active ingredient to have several different formulations, such as spray, wettable powder, and liquid concentrate, etc., and also each of which can be formulated at several different concentrations. Pesticide use is highest in developing countries, those in tropical regions (Robson et al., 2010).

Pesticides are often classified according to the type of pest they control, for examples, insecticides control insects, herbicides control vegetation, and fungicides control fungi, etc. They may also be classified according to chemical structure. Although many categories of chemical have some action against insects or other pests, four categories account for most pesticides in use: organochlorines, organophosphates, carbamates, and pyrethoids (Robson et al., 2010). Examples of pesticides among four categories are shown in Table 2.1.

2.1.1 Organochlorines (OCs)

Organochlorine pesticides were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence, such as DDT, aldrin, chlordane, and dieldrin, etc. (US EPA, 2014b)

2.1.2 Organophosphates (OPs)

Organophosphate pesticides affect the nervous system. Also, some are very poisonous. However, they usually are not persistent in the environment. Most of them are insecticides. (US EPA, 2014b)

2.1.3 Carbamates (CAs)

Carbamate pesticides also affect the nervous system. They usually are not persistent in the environment. There are several subgroups within the carbamates. (US EPA, 2014b)

2.1.4 Pyrethroids (PYs)

Pyrethroid pesticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some of them are also toxic to the nervous system. (US EPA, 2014b)

Table 2.1 Examples of pesticides among four categories

Pesticides			
Organochlorine	**Organophosphate**	**Carbamate**	**Pyrethroid**
- DDT - Benzene hexachloride - Aldrin - Dieldrin - Endrin - Chlordane - Chlordecone - Chlorobenzilate - Heptachlor - Hexachloro-benzene - Mirex - Toxaphene - Endosulfan - Dicofol - Dienochlor - Lindane - Methoxychlor - etc.	- Dichlovos - Diazinon - Dicrotophos - Monocrotophos - Dimethoat - Pirimiphos-methyl - Pirimiphos-ethyl - Fenitrothion - Chlopyrifos - Prothiofos - Malathion - Parathion-methyl - Parathion-ethyl - Profenofos - Ethion - Triazophos - EPN - Fenitrothion - Methidathion - Azinphos-ethyl - Methamidophos - Mevinphos - Omethoate - Phosalone - Acephate - etc.	- Aldicarb - Oxamyl - Methomyl - Carbofuran - Carbofuran-3OH - Carbaryl - Dioxacarb - Isoprocarb - Fenobucarb - Methiocarb - Propoxur - Thiofanox - Ethidimuron - Butocarboxim - Metolcarb - Cloethacarb - Bendiocarb - Carbetamide - Ethiofencarb - Banol - Bufencarb - Promecarb - Zectran - Aminocarb - Carbosulfan - etc.	- Bifenthrin - Lambda-Cyhalothrin - Permethrin - Cypermethrin - Fenvalerate - Deltamethrin - Cyfluthrin - Fenpropathrin - Resmethrin - Sumithrin - Bioallethrin - Tetramethrin - Bioresmethrin - Allethrin - Flumethrin - Imiprothrin - Metofluthrin - Tefluthrin - Tralomethrin - etc.

2.2 Pesticide Residues in Vegetables

Pesticide residues, the pesticides that remain on or in food after being used, have become a problem of Thailand and other countries due to their effects on human body. They were always detected in fresh vegetables. In Thailand, 6 vegetables that are highest in pesticide residues were Chinese kale, chilli, Chinese flowering cabbage, morning glory, cabbage, and cucumber, respectively, and majority of pesticide residues were found from fresh market at 63% (Ministry of Public Health, 2012). In Bangkok, fresh vegetables from fresh market that are highest in pesticide residues were kale, cauliflower, and spring onion, respectively (Food and Drug Administration, 2012). In other countries, the vegetables also contained pesticide residues (Bakirci et al., 2014; Latif, Sherazi & Bhanger, 2011; National Food Institute, 2013; Syed et al., 2014; US EPA, 2011b). Many studies on pesticide residues in vegetables in Thailand have been reported. Summaries of pesticide residues in vegetables are shown in Table 2.2.

Chaikliang, Janmanee, and Hnookaw (2012) detected insecticide residues in vegetables in 5 market places of Muang District, Suratthani Province. The vegetable samples, including kale, chili, cabbage, coriander, long beans, and spring onion were collected. All 198 samples (33 samples for each vegetable) were tested with MJPK Test Kit. The results showed that the detection of pesticide residues was in safe grade of 177 samples (89.4% of all vegetable samples). Unsafe grade was found in spring onion (19 samples or 39.4% of all spring onion samples), and kale (2 samples or 6.06% of all kale samples). All samples of cabbage, coriander, long bean, and chili were in safe grade.

Nantavitayaporn (2012) reviewed the situation on pesticide residues on imported fresh fruits and vegetables during the financial year 2008 to the financial year 2012. The result showed that there were 35 items of imported fresh vegetables from India, Japan, Australia, New Zealand, England, and USA, especially China, contaminated with pesticide residues. Imported vegetable that are highest in pesticide residues were kale from China in Year 2008-2009, broccoli from China in Year 2011, and spinach from China in Year 2012.

Prasopsuk et al. (2014) detected pesticide residues in agricultural produces from 11 provinces in the upper northeast of Thailand between 2008 and 2011. It was found that the pesticide residues in the types of vegetables, including cucumber, eggplant, long bean, Chinese cabbage, cabbage, Chinese kale, broccoli, chili, bell pepper, cauliflower, Chinese flowering cabbage, and tomato, were above Maximum Residue Limits (MRLs). The residues of cypermethrin (pyrethroids) and chlorpyrifos (organophosphates) were mainly found. The results revealed that the pesticide residues were chlorpyrifos (43%), followed by cypermethrin (27.8%), profenofos (9.7%), methomyl (5.4%), and carbaryl (3.7%), respectively. Ethion and chlorpyrifos in chili, chlorpyrifos in cauliflower, carbaryl in cucumber, and cypermethrin in spring onion were above MRLs established by Codex and National Bureau of Agricultural Commodity and Food Standards (ACFH).

Sapbamrer and Hongsibsong (2014) determined OP residues in vegetables from 27 farms, and 106 markets around Kwan Phayao Lake, Northern Thailand, between August and September 2013. The findings showed that the most common organophosphates detected from all sources were chlorpyrifos. The highest chlorpyrifos level in farm samples were found in kitchen mint (2.423 mg/kg) followed by coriander (0.835 mg/kg), and long bean (0.027 mg/kg). The highest level in markets samples were found in garlic (7.785 mg/kg) followed by Chinese cabbage (2.864 mg/kg) and coriander (1.308 mg/kg). Approximately, 59% of all samples from farms and 13% from markets contained OP residues at or above the maximum residue limits (MRLs) established by the European Union (EU). Besides, levels of OP residues in vegetable samples from different sources were different. The vegetables from markets are precleaned by washing with water and disposing of unwanted parts of vegetables, resulting in decreased OP residues.

Table 2.2 Summaries of pesticide residues in vegetables

Type of vegetables	Pesticides	Remarks
Nantavitayaporn (2012)		
Cauliflower (from China)	- Organophosphates - Carbamates - Organochlorines	Organochlorines were banned in Thailand.
Celery (from China)	- Organophosphates - Pyrethroids	
Carrot (from China)	- Organophosphates - Organochlorines	
Kale (from China)	- Organophosphates - Pyrethroids	
Chinese cabbage (from China)	- Organophosphates - Carbamates - Organochlorines	Organochlorines were banned in Thailand.
Sugar pea (from China)	- Organophosphates - Pyrethroids	
Broccoli (from China)	- Organophosphates - Carbamates - Organochlorines - Pyrethroids	Organochlorines were banned in Thailand.
Spinach (from China)	- Organophosphates - Pyrethroids	

Type of vegetable	Pesticide	Remark
Prasopsuk et al., 2014		
Chili	- Cypermethrin[3] - Chlorpyrifos[1] - Pirimiphos-methyl[1] - Profenofos[1] - Ethion[1] - Oxamyl[2] - Carbofuran[2] - Carbosulfan[2] - Methomyl[2]	35% of all samples
Tomato	- Cypermethrin[3] - Chlorpyrifos[1] - EPN[1] - Lambda-cyhalothrin[3] - Carbofuran-3OH[2]	27% of all samples
Cauliflower	- Methomyl[2] - Carbaryl[2] - Chlorpyrifos[1]	100% of all samples
Cabbage	- Methomyl[2] - Cypermethrin[3] - Chlorpyrifos[1]	39% of all samples
Kale	- Profenophos[1] - Cypermethrin[3] - Chlorpyrifos[1]	20% of all samples
Chinese flowering cabbage	- Dimethoat[1] - Cypermethrin[3]	71% of all samples
Sweet basil	- Cypermethrin[3] - Chlopyrifos[1]	67% of all samples
Long cucumber	- Triazophos[1]	3% of all samples

Type of vegetable	Pesticide	Remark
Cucumber	- Carbaryl[2]	8% of all samples
Garlic	- Carbosulfan[2]	50% of all samples
Spring onion	- Cypermethrin[3]	25% of all samples
Celery	- Chlopyrifos[1]	22% of all samples
Eggplant	- Chlopyrifos[1]	14% of all samples
Long bean	- Chlopyrifos[1]	9% of all samples
Ginger	- Chlopyrifos[1]	9% of all samples
Corn	- Cypermethrin[3]	2% of all samples
Sapbamrer and Hongsibsong, 2014		
Kitchen mint (from farms)	- Chlopyrifos[1] - Malathion[1] - Monocrotophos[1]	- 100% of all samples - 75% of all samples - 25% of all samples
Coriander (from farms)	- Chlopyrifos[1] - Malathion[1] - Monocrotophos[1]	- 100% of all samples - 25% of all samples - 25% of all samples
Long bean (from farms)	- Chlopyrifos[1] - Monocrotophos[1]	- 50% of all samples - 25% of all samples
Lettuce (from farms)	- Chlopyrifos[1]	- 100% of all samples
Cucumber (from farms)	- Monocrotophos[1]	- 75% of all samples
Morning glory (from farms)	- Monocrotophos[1]	- 50% of all samples
Spring onion (from farms)	- Diazinon[1] - Dicrotophos[1] - Malathion[1] - Omethoate[1]	- 100% of all samples - 66.7% of all samples - 100% of all samples - 100% of all samples
Garlic (from markets)	- Chlopyrifos[1] - Fenitrothion[1] - Parathion- methyl[1]	- 100% of all samples - 33.3% of all samples - 33.3% of all samples
Chinese cabbage (from markets)	- Chlopyrifos[1]	- 12.5% of all samples

Type of vegetable	Pesticide	Remark
Coriander (from markets)	- Chlopyrifos[1]	- 57.1% of all samples
Spring onion (from markets)	- Chlopyrifos[1] - Diazinon[1] - Parathion- methyl[1] - Pirimiphos-ethyl[1]	- 33.3% of all samples - 77.8% of all samples - 11.1% of all samples - 22.2% of all samples
Ginger (from markets)	- Chlopyrifos[1]	- 28.6% of all samples
Onion (from markets)	- Chlopyrifos[1] - Diazinon[1]	- 66.7% of all samples - 100% of all samples
Luffa gourd (from markets)	- Diazinon[1] - Profenofos[1]	- 40% of all samples - 20% of all samples
Kitchen mint (from markets)	- Chlopyrifos[1]	- 28.6% of all samples
Broccoli (from markets)	- Chlopyrifos[1]	- 50% of all samples
Kale (from markets)	- Diazinon[1] - Profenofos[1]	- 12.5% of all samples - 12.5% of all samples

[1] Organophosphates

[2] Carbamates

[3] Pyrethroids

The vegetables may become contaminated with toxic chemicals by several different pathways. Ambient pollutants from the air may be deposited on or absorbed by the plants or dissolved in rainfall or irrigation waters that contact the plants. Pollutants may also be absorbed through plant roots from contaminated soil and ground water. The addition of pesticides, soil additives, and fertilizers may also result in contamination of vegetables (US EPA, 2011a) . Harnpicharnchai et al. (2013) assessed pesticide residues and measured the seasonal fluctuations in pesticide concentrations in a specially village leading vegetable growing area in Khon Kaen Province. Samples from selected sites were collected in two phases: Phase I was in summer (during March to May) and Phase II was in winter (during October to December). A total of 150 samples were analyzed using gas chromatography (GC-

FPD). The results showed that dicrotophos, chlorpyrifos, profenofos and ethion were found at the highest concentrations in soil and at the lowest concentrations in ambient air ($p<0.001$). The highest mean concentration of a pesticide in ambient air samples was 0.26 ± 0.27 mg/m^3 for chlorpyrifos in summer and 0.10 ± 0.04 mg/m^3 for chlorpyrifos in winter. In surface water samples, the highest mean concentration of a pesticide was 1.38 ± 0.50 mg/l for dicrotophos in summer and 0.36 ± 0.43 mg/l for ethion in winter. The highest mean concentration of a pesticide in soil samples was 42.29 ± 39.07 mg/kg ethion in summer and 90.00 ± 24.16 mg/kg of ethion in winter.

2.3 Effect of Pesticides

Pesticide toxicity is a desired property, responsible for the ability of pesticides to kill unwanted species. However, they may also affect humans, making this a public health issue. (Robson et al., 2010)

2.3.1 Acute toxicity

Acute toxicity is most associated with the organophosphates and the carbamates. These compounds block the action of acetylcholinesterase at peripheral nerves and in the central nervous system. However, carbamates have lower affinity for acetylcholinesterase than do organophosphates, which reduces their toxicity to humans. The early symptoms of poisoning include headache, hypersecretion, muscle twitching, nausea, and diarrhea. Others may irritate the skin or eyes. More severe poisoning can feature respiratory depression, loss of consciousness, and death. (Robson et al., 2010)

2.3.2 Chronic toxicity

Chronic toxicity is also a growing concern as epidemiological and toxicological evidence accumulates. Pesticide exposure may be associated with increase in the risk of several cancers, including non-Hodgkin's lymphoma, leukemia, multiple myeloma, soft-tissue sarcoma, prostate cancer, pancreatic cancer, lung cancer, ovarian cancer, breast cancer, and Hodgkin' disease. Neurological effects may result from pesticide exposure. Others may affect the endocrine and reproductive systems. (Robson et al., 2010)

Use of pesticide affects the human health, including farmers, vegetable pickers or harvester, and consumers, etc. Among vegetable farmers, there are many studies on health effects from pesticide exposure.

Lu (2009b) investigated symptoms from pesticide exposure among 211 vegetable farmers. The study revealed that the top 3 pesticides used were pyrethroids (46.4%), organophosphates (24.2%), and carbamates (21.3%). The most common symptoms were headache (64.1%), muscle pain (61.1%), cough (45.5%), weakness (42.4%), eye pain (39.9%), chest pain (37.4%), and eye redness (33.8%). These health symptoms were non-specific for pesticide exposures.

Neupane et al. (2014) compared self-reported symptoms of possible acute intoxication among 90 vegetable farmers and 90 controls in Nepal. The study revealed that organophosphate and carbamates were the most commonly used pesticides accounting for 66% of total pesticide use. Pyrethroids and organochlorines were also used. Farmers reported more symptoms of possible pesticide intoxication in the past month than did controls, mean 5.47 versus 2.02 ($p < 0.05$). On the average, farmers reported 4.78 possible symptoms of acute intoxication in the previous month compared to the controls, who reported 1.58 ($p < 0.05$). Farmers reported about 7.28 symptoms immediately after handling pesticides throughout their lifetime. The most often reported symptoms among farmers in the previous month were blurred vision (50%), extreme tiredness (47%), excessive sweating (43%), headache (40%), muscle cramps (40%), dry mouth (35%), dizziness (34%), nausea (25%), and skin allergy (25%), etc. Those who experienced symptoms immediately after spraying when farming were more likely to have experienced symptoms in the past month ($p < 0.01$). Logistic regression analysis adjusted for age, body mass index and literacy showed odds ratio consistently higher among farmers as compared to controls.

Ngowi et al. (2007) investigated health effects among 61 small-scale vegetable farmers in Northern Tanzania. The study revealed that types of pesticides used by the farmers in the study areas were mainly insecticides (59%). About a third of the farmers applied pesticides in mixtures. Sixty-eight percent of farmers reported having felt sick after routine application of pesticides. Pesticide-related health symptoms that were reported by farmers included skin problems (34%), dizziness (31%), headache (31%), excessive sweating (31%), sneezing (28%), poor vision (23%), cough (21%), nausea (18%), and stomachache (15%).

Ntow et al. (2006) investigated pesticide poisoning symptoms among 137 vegetable farmers in Ghana. The study revealed that the reported possible pesticide poisoning symptoms were body weakness (36.7%), headache/dizziness (31.0%), itching/irritation (7.8%), stomach pain (4.9%), vomiting (1.6%), and unconsciousness (0.4%). Overall, possible poisoning cases were reported more among the young farmers (<45 years) than among the aged farmers (>45 years). Various inappropriate practices in the handling and use of pesticides caused possible poisoning symptoms among those farmers who generally did not wear protective clothing.

Thetkathuek et al. (2014) identified factors influencing poisoning symptoms among 153 mixed insecticide-exposed vegetable farmers in one Cambodian village. The study found that the most commonly reported symptoms of possible poisoning by the vegetable farmers were dizziness (73.2%), headache (74.5%), nausea (43.8%), vomiting (33.5%), fever (38.6%), weakness (84.3%), fatigue and tiredness (88.9%), and eye irritation (69.3%). In the analytical model, the symptoms of possible poisoning were classified by physical system: the central nervous system (CNS)—headache, dizziness, weakness, and fatigue; the respiratory system—cough, chest pain, and breathlessness; the digestive system/gastrointestinal tract—nausea, vomiting, diarrhea, abdominal pain, and increased salivation; the skin system—skin irritation and excessive sweating; and the visual system. Among these systems, CNS symptoms were most common (132 persons; 86.3%), followed by visual (106 persons; 69.3%) and skin (105 persons; 68.6%) symptoms. Mixing an average of four to six types of insecticides, and abnormal cholinesterase level was associated with CNS symptoms. Age group >45 years and type of vegetable were associated with gastrointestinal symptoms. Farmers who reported using organophosphates (OPs) and carbamates (CMs) were significantly more likely to report respiratory symptoms than farmers who reported using only OPs or only CMs. Knowledge scores of insecticide use and personal hygiene scores and use of personal protection showed no association with symptom reporting.

2.4 Blood Cholinesterase Test

Cholinesterase is an enzyme essential to the central nervous system of human body. Organophosphate and carbamate pesticides are anticholinesterase compounds which act directly or indirectly as cholinesterase inhibitors. When overexposure to these pesticides inhibits the cholinesterase, acetylcholine, the substance responsible for transmission of nerve impulses (neurotransmitter), accumulates in the nervous system. This produces an overstimulation and subsequent blockage of nerve stimuli.

Cholinesterase blood test measures the amount of enzyme levels called plasma cholinesterase (PChE) (also called pseudocholinesterase, butyrylcholinesterase, and serum cholinesterase) and acetylcholinesterase (AChE) (also called true cholinesterase, red blood cell cholinesterase, and erythrocyte cholinesterase). These two tests have different meanings. PChE that is found primarily in the liver is used to account for acute effects, while AChE that is found in nerve tissue and red blood cells can account for chronic effects due to longer half-life. Cholinesterase levels vary within an individual, between individuals, between test laboratories, and between test methods. Results obtained by one test might be not appropriate to compare with results obtained by another. People who exposed to cholinesterase-affected pesticides can develop lowered cholinesterase levels. In addition, seasonal variation may be related with cholinesterase level. Ratner, Bar Sella, Schneeyour, Kardontchik, and Eshel (1989) found a decrease in blood cholinesterase activity among residents during the summer, and this seasonal variation was explained by the ingestion of pesticide residues left in fruit and vegetables. Therefore, cholinesterase level monitoring are useful to prevent or reduce exposure to pesticides.

There are many studies on using blood cholinesterase test as a biomarker for pesticide exposure assessment among vegetable farmers, and many studies on determining exposure to pesticides in agricultural workers by equipment called Test-mate ChE kit that is a portable field kit (EQM Research, Inc., 2003).

2.4.1 Blood cholinesterase level test among vegetable farmers

Dhananjayan et al. (2012) assessed cholinesterase levels among 2 worker groups in South India consisting of 28 agriculture workers who engaged in floriculture, cultivation of cabbage, potato, and grape, and 13 non-exposed workers who never had any exposure to OP pesticides. Blood samples were transported to analyze in laboratory. The findings showed that PChE and AChE activities among exposed workers ranged from 1.65 to 3.54, and 0.16 to 5.2 μmoles/min/ml, respectively, whereas PChE and AChE activities among non-exposed workers ranged from 2.22 to 3.51, and 2.19 to 5.06 μmoles/min/ml, respectively. With age matching, there was statistically significant reduction in enzyme activities (PChE 56%; AChE 14%) among exposed workers.

Lu (2009a) measured blood cholinesterase activity from organophosphate and carbamate exposures among 232 vegetable farmers from 6 communities in Philippines. Blood samples were transported and analyzed in laboratory. The result showed that 40% of all samples had abnormal red blood cell cholinesterase activity.

Lu (2014) examined blood cholinesterase activity from organophosphate exposures among 534 farmers in the largest eggplant producing province in the northern Philippines. Blood samples were analyzed in laboratory. The result showed that 50.8% of the samples showed depression in erythrocyte cholinesterase activity.

Ntow et al. (2009) determined blood cholinesterase activity for assessing exposure to pesticides among 63 farmers at Akumadan and 58 controls at Tono, both prominent vegetable-farming communities in Ghana. Blood samples were delivered to laboratory for analysis. The findings showed that blood cholinesterase in farmers were significantly lower in controls. The percentage of farmers with a reduction of 30% in blood cholinesterase activity was approximately 73%.

Soogarun et al. (2003) studied the plasma cholinesterase level among vegetable growers in Thailand. Seventy male participants consisting of 35 vegetable growers in a rural area in Chiang Mai province and 35 controls who resided in downtown Bangkok with low risk of exposure during their work were conducted. All serum samples were collected between midday and sent to the laboratory for analysis. The result showed that the average plasma cholinesterase level among vegetable growers (17.7±7.0 U/ml) and control group (24.7±12.4 U/ml) significantly differed (p=0.01).

Thetkathuek et al. (2014) tested blood cholinesterase (ChE) level among 153 mixed insecticide-exposed vegetable farmers in one Cambodian village, with 153 factory workers selected as a non-exposed group. The study found that ChE levels of farmer group showed 17% unsafe, 60.8% risky, 16.3% safe, and 5.9% normal. In non-exposed group, ChE levels showed 0.7% risky, 13.1% safe, and 86.2% normal. The chi-square test showed the ChE levels of the two groups to be significantly different (P < 0.001).

2.4.2 Blood cholinesterase level test by using Test-mate ChE (Model 400)

Neupane et al. (2014) compared acetyl cholinesterase levels (AChE) among 90 vegetable farmers and 90 controls in Nepal. Blood samples were collected. The study revealed that mean age was 41.83 years old in farmers and 38.36 years old in controls. AChE were significantly lower among farmers (mean = 3.35 U/ml) as compared to the controls (mean = 3.64 U/ml).

Pidgunpai et al. (2014) investigated cholinesterase levels in blood among 98 farmers consisting 51 directly exposed farmers and 47 indirectly exposed farmers at Nang Ler sub-district in Chainart province, Thailand. The study revealed that participants were composed of 44 male and 54 female with average age at 46 years old. About 75.5% of total farmers had normal AChE level (60.8% of directly exposed farmers and 91.5% of the indirectly exposed farmers). The average AChE level for total farmers was 2.9 ± 0.6 U/mL. The average AChE level between directly exposed farmers (2.7 ± 0.6 U/mL) and indirectly exposed farmers (3.1 ± 0.6 U/mL) was significantly different (p-value = 0.001). Regarding to PChE level, 87.8% of total farmers had normal AChE level (86.3% of directly exposed farmers and 89.4% of the indirectly exposed farmers). The average PChE level for total farmers was 1.6 ± 0.3 U/mL. The average PChE level between directly exposed farmers (1.5 ± 0.3 U/mL) and indirectly exposed farmers (1.7 ± 0.3 U/mL) was significantly different (p-value = 0. 0.145). The AChE level was not significantly associated with knowledge, attitude, and practice on pesticide uses in both groups. For indirectly exposed farmers, PChE level was significant positive correlation with knowledge (Spearman’s rho 0.538, p-value < 0.001). In directly exposed farmers, the significant associations were found between PChE level and both of attitude (p-value = 0.012) and knowledge (p-value = 0.015).

Wilaiwan and Siriwong (2014) assessed blood cholinesterase levels caused by organophosphate pesticides exposure among 35 rice farmers and 35 non-farmers in Sisa Krabue sub-district, Ongkharak district, Nakhon Nayok province. Blood samples were collected after 24 hours of the last of pesticide application (for farmers) and during free days (for non-farmers). The results showed that participants were 25 male and 45 female; average age was 42.63 years old. Prevalence of abnormal AChE was 31.4% in rice farmers and 14.3% in non-farmers. About 74.3% of farmers had abnormal PChE, whereas none of the non-farmers had abnormal PChE. AChE levels of farmers (mean = 2.63 U/ml) was likely lower than non-farmers (mean = 2.80 U/ml), and PChE levels in the farmer group was significantly lower than those in non-farmer group ($p<0.001$). The association between AChE levels and PChE levels were likely low negative correlation. Years of using pesticides were significantly associated with PChE levels ($p<0.05$).

2.5 Health Risk Assessment

Human health risk assessment is a method used to estimate peoples increased risk of health problems as a result of exposure to a toxic pollutant. Risk assessment methods can also be used to estimate increased risk of adverse ecological effects due to toxic pollutants in the environment. There are 4 steps to risk assessment: hazard identification, exposure assessment, dose-response assessment, and risk characterization. Diagram of health risk assessment (HRA) is shown in Figure 2.1.

2.5.1 Step 1 - Hazard Identification

The first step of risk assessment is hazard identification. This is the attempt to determine what health problems are caused by specific toxic pollutants.

Scientists perform hazard identification by evaluating all available information about the effects of a toxic pollutant. The better the evidence, the more certain scientists can be that a toxic pollutant causes specific health problems. Evidence for humans is often gathered by doing statistical studies on the number of cases of a particular illness or disease occuring in certain groups of people. Human information is very limited for most toxic pollutants. Therefore, scientists often rely on studies done with laboratory animals, such as rats. Results of these studies are used to estimate the effects of a toxic pollutant on humans. (Boguski, 2007)

2.5.2 Step 2 - Dose-Response Assessment

The second step of risk assessment is the dose-response assessment. This is the evaluation of the relationship between the amount of exposure to a toxic substance and the extent of injury or disease caused. In dose-response assessment, the dose is the amount of exposure to the toxic pollutant and the response is the reaction to the toxic pollutant. Dose-response estimates for humans are frequently estimated based on animal studies. When information about dose-response is missing or has substantial gaps, the EPA uses assumptions called default options. These assumptions are conservative in order to protect human health.

The dose-response relationship for noncancer effects are calculated differently than for cancer effects. For noncancer effects, a very low dose may not cause harm to human health. Threshold values are developed for noncancer causing chemicals. Doses below the threshold value are considered “safe” and doses above the threshold value are considered harmful. (Boguski, 2007)

2.5.3 Step 3 - Exposure Assessment

Exposure assessment is the third step of risk assessment and is used to determine how much of a toxic pollutant people are exposed to and/or how many people are exposed.

Exposure to toxic pollutants occurs through three primary exposure pathways: ingestion, inhalation, and absorption through the skin.

Exposure is investigated by taking air, water and soil samples and analyzing them in the field or at laboratories. The results indicate the concentrations of toxic pollutants present at a specific location. Exposure pathways are also evaluated. (Boguski, 2007)

2.5.4 Step 4 - Risk Characterization

Information from the hazard identification, dose-response relationship, and exposure assessment are synthesized to estimate the extra risk to human health or the environment that is caused by toxic pollutants. (Boguski, 2007)

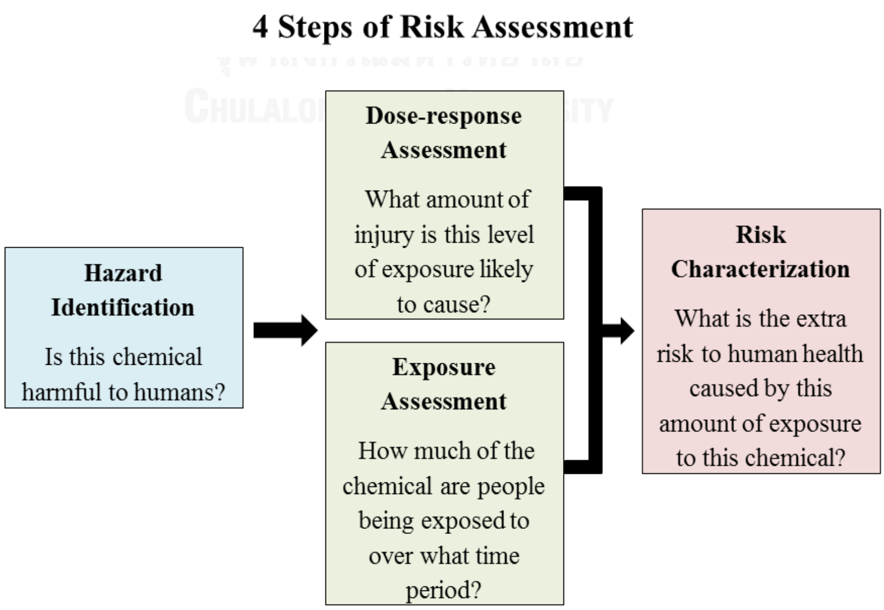


Figure 2.1 Diagram of health risk assessment (HRA)

Source: Boguski (2007)

2.6 Risk Communication

Risk communication is a special category of health communication. It consists of the two-way exchange of information about environmental, health, and safety threats. The goals of risk communication are to enhance knowledge and understanding, encourage dialogue, build trust and credibility, and influence attitudes, decisions, and behaviors. These goals apply to all four major types of risk communication. Categorized by objective, these types are 1) information and education; 2) behavioral change and other public health protection; 3) warnings of disasters and emergency notification; and 4) joint problem solving and conflict resolution. Effective risk communication provides people with timely, clear, accurate, objective, consistent, and complete risk information. Risk communication may be applied in emergency situations or in the setting of long-term environmental exposure. It may be practiced by governmental agencies, non-governmental organization, and the private sector. (Covello, 2010)

2.7 Dermal Exposure and Risk Assessment Studies

2.7.1 Farmers/Growers

Curwin et al. (2005) investigated pesticide exposure among 24 male farmers and 23 male non-farmer controls in Iowa. Urine and hand wipe samples were collected. The samples were analyzed for the parent compound or metabolites of six commonly used agricultural pesticides including alachlor, atrazine, acetochlor, metolachlor, 2,4-dichlorophenoxyacetic acid (2,4-D) and chlorpyrifos. For atrazine, acetochlor, metolachlor and 2,4-D, farmers who reported applying the pesticide had significantly higher urinary metabolite levels than non-farmers, farmers who did not apply the pesticide, and farmers who had the pesticide commercially applied ($P<0.05$). Generally, there were no differences in urinary pesticide metabolite levels between non-farmers, farmers who did not apply the pesticide, and farmers who had the pesticide commercially applied. The majority of the hand wipe samples were non-detectable. However, detection of atrazine in the hand wipes was significantly associated with urinary levels of atrazine above the median ($P<0.01$).

Jaipieam et al. (2009) determined level of inhalation exposure to organophosphate pesticides and assessed health risks among 33 vegetable growers and 17 controls (non-exposed to pesticide) living in the Bang-Rieng Subdistrict, Songkhla Province, Thailand. Personal pumps with sorbent tubes were used for air sampling during wet and dry seasons. All samples were analyzed by using gas chromatography (GC-FPD) to detect the pesticide residues, including chlorpyrifos, dicrotofos, and profenofos. The results revealed that median concentrations of three pesticides in farm areas ranged from 0.022 to 0.056 mg/m^3. In non-farm area, the samples were below the limit of detection (LOD). The concentrations of each pesticide in farm areas were significantly greater than in non-farm areas during both seasons. However, the concentrations of each pesticide between wet and dry seasons did not significantly differ. Besides, the results of risk assessment found that vegetable growers may be at risk for acute effects from exposure to chlorpyrifos and dicrotofos via inhalation route during pesticide application consisting of mixing, loading, and spraying.

Lappharat et al. (2014) evaluated dermal exposure to chlorpyrifos in 35 rice farmers along with providing a health risk assessment. Patch technique was used to evaluate dermal exposure. The chlorpyrifos residue was analyzed from the gauze patches by gas chromatography (GC-FPD). The results revealed that chlorpyrifos concentrations were greater in males (526.34 ± 478.84 mg/kg) than females (500.75 ± 595.15 mg/kg). The hazard quotient (HQ) at the mean and 95th percentile level was found to be greater than acceptable (HQ>1).

Nutta Taneepanichskul (2012) assessed the health risk from exposure to chlorpyrifos and profenofos pesticides through multiple routes among 40 chilli farmers in Ubonratchathani Province, Thailand. Samples were analyzed by gas chromatography. The resulted showed that farmers were exposed to chlorpyrifos and profenofos pesticide residues through inhalation, and dermal consisting of body, face and hand. Hand wipe samples were detected chlorpyrifos at 10.53% and profenofos at 26.32%. The concentration of pesticide residues on hands ranged from <0.02 mg/kg to 0.240 mg/kg for chlorpyrifos and from <0.02 mg/kg to 0.450 mg/kg for profenofos. The concentrations of both pesticide residues on body were higher than that on face and hands. The average daily dose (ADD) via skin contact was highest. The hazard index (HI) among chilli farmers were at acceptable level (HI<1).

2.7.2 Harvesters/Pickers

Jurewicz et al. (2009) determined skin contamination level of azoxystrobin among 19 women tending cucumbers in a vegetable-growing greenhouse in Poland after expiring restricted entry intervals. Cotton patches samples on the outside of clothing (chest, left and right shoulders), and cotton glove samples underneath regular working gloves were collected to measure dermal exposure. All samples were assessed one day after spraying azoxystrobin (day 1) and six days later (day 2) during the spring. Liquid chromatography and mass spectrometry (LC-MS/MS) were used to analyze azoxystrobin. The results showed contamination on hands, chest and shoulders. Skin contamination level of azoxystrobin on cotton glove samples (arithmetic mean equal 16.5 ng/cm^2 and 89.3 ng/cm^2 in day 1 and day 2, respectively) were higher than on cotton patches samples (arithmetic mean equal 0.14 ng/cm^2 and 0.08 ng/cm^2 in day 1 and day 2, respectively). The main route of exposure was through hands.

R. I. Krieger and Dinoff (2000) determined urine clearance rates of tetrahydrophalimide among female strawberry harvesters exposed captan fungicide in Watsonville, California. Rubber latex gloves were given to 41 harvesters for the 3 days. The harvesters were divided into two groups, including bare-handed or gloved harvesters. The 24-h urine specimens were collected each day. The result revealed that bare-handed harvesters cleared 5.3 μg captan equivalents as tetrahydrophalimide with a range of 0.4 to 13.8 μg/person/day, and gloved harvesters cleared 2.0 μg captan equivalents as tetrahydrophalimide with a range of 0.9 to 4.3 μg/person/day. It indicated that rubber latex gloves decreased absorbed dose by 38% when compared to absorbed dose by bare-handed harvesters. Small portion of foliar residue was transferred to harvesters via direct contact when they transfer residues from treated leaves to their skin or clothing.

Li et al. (2011) investigated pesticide residue accumulations on powder-free rubber latex gloves that were used to reduce pesticide exposure among strawberry harvesters in Santa Maria, California. Gloves accumulated residues of 16 active ingredients consisting of azoxystrobin, boscalid, bifenthrin, cyprodinil, captan, fludioxonil, fenpropathrin, fenhexamid, hexythiazox, malathion, methomyl, naled, pyraclostrobin, propiconazole, quinoxyfen, and quinoline at different times. The glove samples were collected for multiresidue analysis by gas chromatography (GC-μECD / GC-FPD). The findings showed that detected amounts were highly variable and declined as the time from increased pesticide application. The residues accumulated on gloved during 2-2.5 hour work periods ranged from 0.5μg/pair to as high as 20 mg/pair. The malathion levels accumulated in morning were significantly higher than that in afternoon ($p<0.05$). Dermal malathion dose was 0.2 mg/kg at pre-harvest interval. The malathion accumulation indicated trace surface residue availability. It was used to assess association between dislodgable foliar residues (DFRs) and potential hand exposure.

2.7.3 Consumer or risky local population

National Food Institute (2013) analyzed pesticide residues in foods on the Danish market and also assessed health risk. Total 17,309 samples included fruit, vegetables, cereals, meat, baby food and other processed food. The results show that more residues were found in samples of foreign origin compared to samples of Danish origin. The exposure was estimated to be 98 μg/person/day and 146 μg/person/day for children and adults, respectively. The risk assessment for a single pesticide is performed by estimating Hazard Quotient (HQ). The HQs for the individual pesticides ranged from 0.00001% to 2.35% with most of the HQs being below 1%. Risk assessment of the cumulative exposure by summing up the HQs provided Hazard Index (HI). HI varied between 4% and 49% for adults and 10% and 124% for children. With this exposure, the HI of 18% for adults and 44% for children is not considered to indicate a risk of adverse effects following a cumulative exposure to all the detected pesticides.

Norkaew (2012) assessed residential exposure to pesticide residues, including OPs from agriculture and PYs from households through multiple pathways among 54 occupational households in agricultural community, Ubonratchathani Province, Thailand. All samples were analyzed by gas chromatography. The resulted showed using household pesticides for pest control in their house (73.1%). OP residues were detected in air sample (22.2%) and surface wipes (21.3%), whereas PY residues were detected in surface wipes, hands, and foot.

Shen et al. (2013) assessed human health risk based on consumption of vegetables collected from 48 sites in Huizhou, South China. A questionnaire of 450 local residents on vegetable consumption showed that the total vegetable ingested rates of females and males were 278.80 g/person/day and 282.92 g/person/day, respectively. The weight-specific daily intakes of pollutants by females were higher than those by males because of differences in body weight. Twenty-seven pollutants were used to assess the potential risk to human health by calculating target hazard quotient (THQ) values. Results showed that the risk to females was higher than for males. Organochlorine pesticides were the major contributors to the risk for both females and males. The main risks were from consumption of eggplant, Chinese lettuce and luffa. Although the THQ values induced by individual pollutants were relatively low, the total THQ values induced by 27 pollutants were above 1 in some administrative regions of Huizhou, which might give cause for concern.

Siriwong et al. (2008) evaluated the potential health risks associated with organochlorine pesticide residues (OCPRs) contamination through freshwater organism consumption among local population in agricultural area, central Thailand. Samples of vegetables, prawn, snail, and fish were collected from canal (Khlong 7 in Pathum Thani Province). They were extracted and then analyzed by gas chromatography (GC-µECD). The findings showed low concentrations of OCPRs at levels of parts per billion (ppb). The local population could be at risk for cancer due to contaminated fish consumption with OCPRs when calculating based on a worst-case scenario.

CHAPTER III

METHODOLOGY

3.1 Study Design

This study was a mixed-method consisting of quantitative and qualitative research used to provide the magnitude of health risk from occupational exposure to pesticide residues on vegetables among greengrocers in fresh market, Bangkok, Thailand. Data was collected in dry and wet seasons, including vegetable sampling, face-to-face interview, hand wipe sampling, and blood cholinesterase level test, and then in-depth interview was conducted. After data collection and analysis were completed, a guideline for prevention and health risk reduction related to pesticide contamination in vegetables among greengrocers was developed. It was designed around obtained study results, and given to greengrocers with demonstrating pesticide contamination on vegetables.

3.2 Study Area

The recruitment of participants for this study was at Padung Krung Kasem market, a large local fresh market in the center of Bangkok. Bangkok where is the capital and the most populous city of Thailand has approximately 161 markets. Only 7 markets, including Padung Krung Kasem Market, are controlled by Bangkok Metropolitan Administration (BMA). This market opens everyday by starting at night to morning. Most of vegetables in the market have been bought from different parts of Thailand and some of them have been imported from other countries, especially China. They have not been cleaned by washing with water before the greengrocer puts them in plastic bag for sale to customers. Therefore, this study was conducted among greengrocers in this market. Map of Padung Krung Kasem market is shown in Figure 3.1

Figure 3.1 Map of Padung Krung Kasem market

Source: http://th.wikipedia.org/wiki; http://www.google.com/maps

3.3 Study Population and Sample Group

Greengrocers who have been worked in Padung Krung Kasem market both owners and employees (Thai and Lao people) were population for this study. They were chosen through the following criteria:

3.3.1 Inclusion criteria

1) Male and female with age more than 18 years old
2) Work experience in a greengrocer's shop at least 6 months
3) Working day at least 5 days per week or working hours at least 40 hours per week
4) Handle and touch fresh vegetables
5) Can communicate and read in Thai

3.3.2 Exclusion criteria

1) Being farmer
2) Cannot participate throughout the study

3.4 Sample Size and Sampling Technique

From preliminary survey on the total number of greengrocers at Padung Krung Kasem fresh market in January 2014 revealed approximately 100 vegetable vendors. All meeting the inclusion criteria were invited to participate in the study. There were 91 vegetable vendors from 30 greengrocer shops who gave informed consent prior to data collection and they were representative of this population.

Sample size for conducting in-depth interview to determine health symptoms from exposure to pesticide residues on vegetables was 10 greengrocers. The greengrocers who took part the study both dry and wet seasons were selected by purposive sampling based on different characteristics of them.

3.5 Measurement Tools

3.5.1 Questionnaire

The questionnaire was divided into 3 parts as follows:

3.5.1.1 Part 1: General information

The questionnaire was constructed about gender, age, nationality, height, weight, education, work experience in current job, second job, health problems, smoking, drinking alcohol, use of glove, hand washing during working, consumption of fruits and vegetables, number of working days per week, number of working hours per day, number of greengrocer in shop, weight of all vegetables in shop per week, amount of handling vegetables without protective materials per day, types of vegetables in shop, and types of wet vegetables in shop.

3.5.1.2 Part 2: Knowledge, attitude, and practice (KAP) regarding exposure to pesticide residues and protection

The questionnaire was developed based on literature review and preliminary survey among greengrocers at the fresh market. It was separated into 3 sections as follows:

(1) Knowledge (K) regarding exposure to pesticide residues and protection

The knowledge was contained 10 questions. Each item was scored 1 for right answer, and 0 for wrong or unsure answer. Possible scores ranged from 0 to 10 points. The scores were classified into 3 levels based on Bloom's cut-off point, consisting of low level (<60%), moderate level (60-79%), and good level (≥80%) (Bloom, 1976).

(2) Attitude (A) regarding exposure to pesticide residues and protection

The attitude was contained 10 questions. Each item was a positive or negative question, and it was assessed using 5 rating scales from strongly disagreement degree to strongly agreement degree. Possible scores ranged from 10 to 50 points. The scores were classified into 3 levels, consisting of low level (<60%), moderate level (60-79%), and good level (≥80%). For positive statements, strongly disagreement degree was scored 1 and strongly agreement degree was scored 5. For negative statements, strongly disagreement degree was scored 5 and strongly agreement degree was scored 1 as follows:

	Positive statements	Negative statements
Strongly disagree	1 score	5 scores
Disagree	2 scores	4 scores
Neutral	3 scores	3 scores
Agree	4 scores	2 scores
Strongly agree	5 scores	1 score

(3) Practice (P) regarding exposure to pesticide residues and protection

The practice was contained 10 questions. Each item was a positive or negative question, and it was assessed using 5 rating scales from hardly ever degree to almost always degree. Possible scores ranged from 10 to 50 points. The scores were classified into 3 levels, consisting of low level (<60%), moderate level (60-79%), and good level (≥80%). For positive statements, hardly ever degree was scored 1 and always degree was scored 5. For negative statements, hardly ever degree was scored 5 and always degree was scored 1 as follows:

	Positive statements	Negative statements
Hardly ever	1 score	5 scores
Occasionally	2 scores	4 scores
Sometimes	3 scores	3 scores
Frequently	4 scores	2 scores
Always	5 scores	1 score

3.5.1.3 Part 3: Health symptoms from exposure to pesticide residues on vegetables

The questionnaire was modified from Thetkathuek et al. (2014) and developed based on literature review. It was contained 15 symptoms, consisting of skin irritation (skin rash/itching), eye irritation or blurred vision, headache, dizziness, weakness, fatigue or tiredness, cough, breathlessness, nausea, vomiting, diarrhea, abdominal pain, excessive salivation, excessive sweating, and muscle twitching or cramps.

The validity of questionnaire was examined by 3 experts in the area of environmental & occupational health, and public health. Then, the questionnaire was be revised according to their comments and suggestions, and the reliability coefficient was tested by using 30 greengrocers who was similar characteristic. The content validity by using item objective congruence index (IOC) in section of knowledge (K), attitude (A), practice (P) regarding exposure to pesticide residues and protection, and part of health symptoms from exposure to pesticide residues on vegetables equaled to 0.93, 0.90, 0.87, and 1, respectively. The reliability coefficient by using Kuder-Richardson (KR-20) in section of knowledge (K), and Cronbach's alpha in section of attitude (A), and practice (P) equaled to 0.67, 0.72 and 0.70, respectively. Questionnaire is shown in Appendix A.

3.5.2 Interview guideline

A guideline for in-depth interview was constructed about opinions, feelings and perceptions around effect or health symptoms from exposure to pesticide residues on vegetables, and recommendations for developing a guideline for prevention and health risk reduction related to pesticide contamination in vegetables. Questions were open-ended. The qualitative research by conducting in-depth interview can lead to clarified answers. Interview guideline is shown in Appendix B.

3.5.3 Vegetable sampling

Vegetable sampling was used to investigate the presence of pesticide residues in vegetables. The vegetable sample was collected from a number of greengrocer shops in the market. All vegetable samples were transported to laboratory for pesticide analysis, including organophosphates, carbamates and pyrethroids.

3.5.4 Hand wipe sampling

Hand wipe sampling was used to assess exposure to pesticide residues on vegetables via the dermal route. Hand wiping was done by using gauze pads. All hand wipe samples were transported to laboratory for analysis of organophosphate, carbamate and pyrethroid pesticides by using gas chromatography (GC) and liquid chromatography (LC) techniques. A gas chromatograph is an analytical instrument consisting of injector, column to separate components of mixture, and detector to detect the presence of chemicals eluting from column. Similarly, a liquid chromatography instrument requires a high-pressure pump that can force liquid mobile phase through column.

3.5.5 Blood cholinesterase level test

Blood cholinesterase level test was used as biomarker of pesticide exposure because most organophosphate and carbamate chemical classes can affect the acetylcholinesterase (AChE), and plasma cholinesterase (PChE) enzymes. The test was performed by the equipment called Test-mate ChE Kit (Model 400) that was manufactured by EQM Research, Inc. The kit can specifically measure either AChE or PChE, depending on ChE-inhibiting reagents used with the system. Blood specimen was collected by finger-prick technique and it required only 10 microliters (μL) of blood for each measurement. The entire assay was completed in less than 4 minutes. All samples were tested at the site of (sample) collection. The kit is useful in monitoring occupational exposure to pesticides. It is a highly portable, easy-to-use tool for cholinesterase activity testing in clinic, laboratory, or field research setting (Hofmann et al., 2008).

3.6 Data Collection

Data collection was mainly divided into 2 seasons; dry (April to May) and wet (August to October) seasons. Data was similarly collected by vegetable sampling, face-to-face interview, hand wipe sampling, and blood cholinesterase level test. Each greengrocer was collected data within one week in the dry and wet seasons. After data collection in both seasons was completed, in-depth interview was conducted. The greengrocers were informed about the study by a researcher. They gave their permission by completion of written consent form prior to data collection. Diagram of data collection is shown in Figure 3.2.

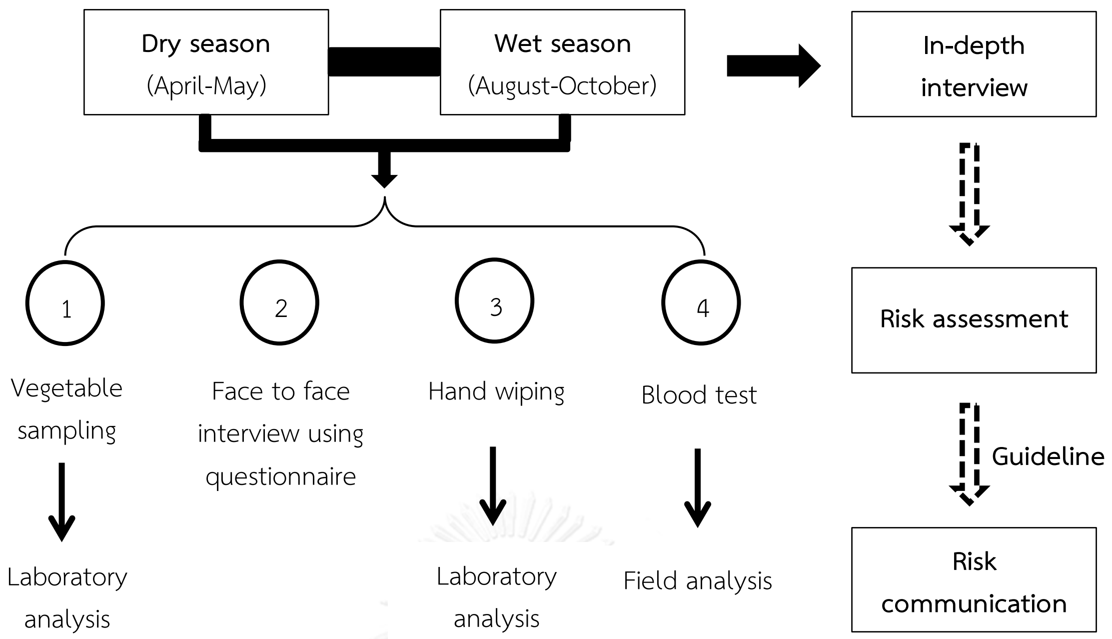


Figure 3.2 Diagram of data collection

3.6.1 Vegetable sampling

A total of 10 greengrocer shops in the fresh market were randomly sampled for analysis of pesticide residues in vegetables. The 10 vegetable commodities, which were mostly consumed and sold in the market, consisting of Chinese flowering cabbage, morning glory, cabbage, Chinese cabbage, chilli, Chinese kale, cucumber, Thai eggplant, yard long bean, and celery, were bought from each shop (if they were available). The different vegetable sample from the shop was chopped into small pieces and equally mixed together. All vegetable samples were transported to laboratory for pesticide analysis, including organophosphates, carbamates and pyrethroids. The analysis was performed at the Central Laboratory (Thailand) Co., Ltd, (Chachoengsao Province branch) certificated by the Bureau of Laboratory Quality Standards, Ministry of Public Health. The vegetable sampling was done in dry and wet seasons.

3.6.2 Face-to-face interview

All participants were interviewed using the questionnaire about general information, KAP regarding exposure to pesticide residues and protection, and health symptoms from exposure to pesticide residues on vegetables at the end of their shift by a researcher. The interview was conducted in dry and wet seasons (only Part 3 about health symptoms).

3.6.3 Hand wipe sampling

Hand wiping to detect the types and amount of pesticide residues on hands among greengrocers was done after the end of their shift on Monday through Friday by a researcher. The wipe sample was collected in dry and wet seasons.

3.6.3.1 Hand wipe sample collection

Hand wipe sampling modified from Geno et al. (1996) and Taneepanichskul et al. (2014) was used to assess exposure to pesticide residues (PRs) on vegetables via the dermal route. The participants who wore glove(s) removed their gloves before sampling. Both hands of greengrocer were immediately wiped only once after the end of their shift by using 2 moistened gauze pads (4"x4") with 6 mL of 40% 2-propanol (first pad to perform a general wipe of hands, second pad to wipe each finger and palm of hands). The 2 gauze pads which were combined for a single analysis, were foiled and kept in a Ziploc® plastic bag, and frozen in an ice box. All wipe samples were transported to the laboratory and stored in the refrigerator at -20 °C before analysis. All greengrocers were sampled with hand wipe samples for analysis of organophosphate and pyrethroid pesticides. Only 39 participants were randomly sampled for analysis of carbamate pesticides which were performed at the Central Laboratory (Thailand) Co., Ltd, (Chachoengsao Province branch) certificated by the Bureau of Laboratory Quality Standards, Ministry of Public Health.

3.6.3.2 Hand wipe sample analysis

1) Standard solution preparation

A total of 10 organophosphate and pyrethroid pesticide standards (ethoprophos, malathion, chlorpyrifos, prothiofos, profenofos, ethion, EPN, guthion (azinphos-methyl), permethrin, and cypermethrin) were chosen based on the reporting of the presence of pesticide residues in vegetable samples. Stock standard solutions at a concentration of 500 mg/L were prepared in hexane, acetone, and acetonitrile. Pesticide mixture solutions at a concentration level of 50 mg/L were produced, and then diluted at a concentration level of 0.01, 0.05, 0.10, 0.50, 1.0, and 5.00 mg/L in acetonitrile for calibration solutions.

2) Sample preparation

A multi-residue method for extraction of organophosphate and pyrethroid insecticides from hand wipe samples was modified from Anastassiades et al. (2003). The gauze pad samples were soaked with 40 mL acetonitrile (HPLC grade) in an Erlenmeyer flask. Then, the sample was shaken by a vortex machine for 10 minutes and left at room temperature for 1 hour. After gauze pads were removed, the sample solution was evaporated to almost dryness with nitrogen gas at 40±2 °C. Acetonitrile containing 0.1% acetic acid was added to adjust the volume to 1 mL. For clean-up, the sample was transferred into an Eppendorf tube packed with 150 mg MgSO4, 25 mg primary secondary amine (PSA). The tube was immediately shaken by a vortex machine for 1 minute and centrifuged at 6,000 rpm for 2 minutes. Then, 0.5 mL of supernatant was transferred into a 1.5 mL vial for analysis of organophosphate and pyrethroid residues by GC. For extraction of carbamate insecticides, methanol was used as solvent. Sample preparation for GC analysis is summarized in Figure 3.3.

3) Gas chromatography analysis

An Agilent 7890N GC equipped with 2 detectors consisting of a flame photometric detector (GC-FPD), and a micro-electron capture detector (GC-μECD), was used for analysis of the types and concentrations of pesticide residues on hands. A HP-5 capillary column (30 m length, 0.25 mm diameter, 0.25 μm film thickness) was used with helium constant flow of 2.3 mL/min to separate the pesticides. For organophosphate analysis, the injector and FPD temperature were maintained at 230 °C and 250 °C. The column temperature was raised from 80 °C at 12 °C/min to 195 °C, at 2 °C/min to 210 °C (held for 3 min), at 15 °C/min to 225 °C (held for 2 min), and at 40 °C/min to 275 °C (held for 7 min), respectively. For pyrethroid analysis, the injector and μECD temperature were set at 250 °C and 290 °C. The oven temperature was programmed from 90 °C at 20 °C/min to 200 °C, at 3 °C/min to 230 °C (held for 3 min), and at 10 °C/min to 280 °C (held for 5 min), respectively. A 1 μL sample was injected by auto sampler in splitless mode for analysis in each group of insecticides. The types and amounts of carbamate pesticides were determined by a liquid chromatography with a mass spectrometry (LC-MS). Gas chromatography (GC) and liquid chromatography (LC-MS) conditions for pesticide analysis are shown in Table 3.1 and Table 3.2, respectively.

4) Method validation and quality control

Correlation coefficients (R^2) obtained from plotting the calibration curves of investigated pesticides at 6 concentrations with analysis of 3 replicates, ranged from 0.999 to 0.9999. Average recoveries of organophosphate and pyrethroid mixtures by analyzing 7 replicates at 2 spiked levels (0.1 and 1.0 ug) were between 96 and 125%, with a relative standard deviation (RSD) ranging from 1.7 to 7.1%. The limit of detection (LOD) for all pesticide estimated from the chromatograms at signal to noise ratio (S/N) of 3 ranged from 0.01 to 0.05 ug/hands, and the limit of quantitation (LOQ) at S/N of 10 ranged from 0.02 to 0.10 ug/hands. Also, a calibration mixture solution was run for every 10 wipe samples. For carbamate pesticides, many values were reported, ranging from 0.99 to 0.999 for R^2, ranging from 61 to 124% for average recoveries, ranging from 0.2 to 5.3% for RSD, 0.01 ug/hands for LOD, and 0.02 ug/hands for LOQ. Method validation for pesticide analysis is summarized in Table 3.3. Standard calibration curves of organophosphate and pyrethroid pesticides are shown in Appendix C.

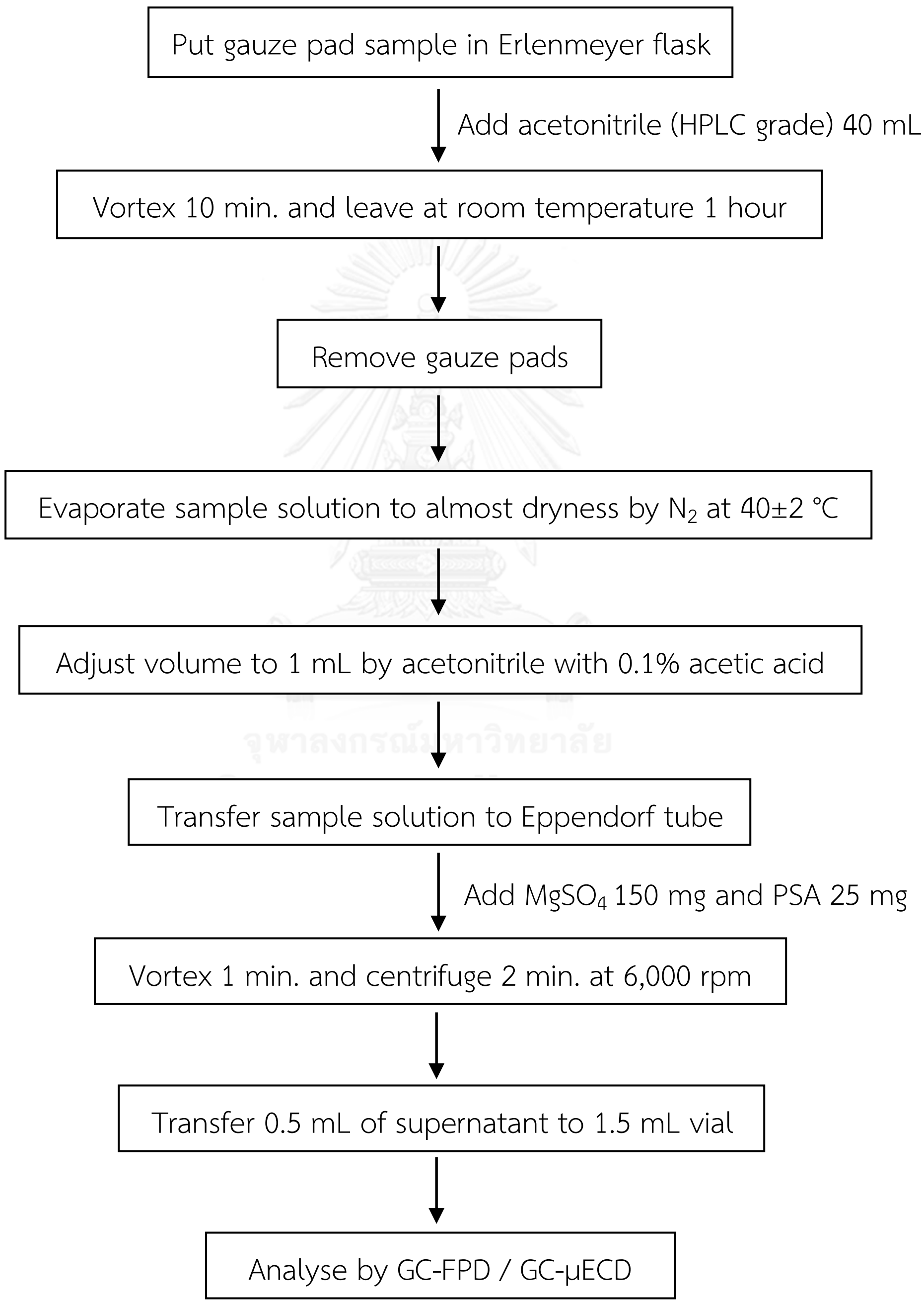


Figure 3.3 Sample preparation for GC analysis

Table 3.1 Gas chromatography (GC) condition for pesticide analysis

<table>
<tr><th colspan="3">Organophosphate pesticides</th><th colspan="3">Pyrethroid pesticides</th></tr>
<tr><td colspan="6">GC model: Agilent 7890N</td></tr>
<tr><td colspan="6">Inlets</td></tr>
<tr><td colspan="3">Inject: 1 μL
Temperature: 230 °C
Mode: Spitless</td><td colspan="3">Inject: 1 μL
Temperature: 250 °C
Mode: Spitless</td></tr>
<tr><td colspan="6">Column</td></tr>
<tr><td colspan="6">Model number: HP-5 capillary column (30 m length, 0.25 mm diameter, 0.25 μm film thickness)
Flow rate: 2.3 mL/min
Carrier gas: Helium</td></tr>
<tr><td colspan="6">Oven</td></tr>
<tr><td colspan="3">Initial temperature: 80 °C</td><td colspan="3">Initial temperature: 90 °C</td></tr>
<tr><td>Rate
(°C/min.)</td><td>Value
(°C)</td><td>Hold time
(min)</td><td>Rate
(°C/min.)</td><td>Value
(°C)</td><td>Hold time
(min)</td></tr>
<tr><td>12
2
15
40</td><td>195
210
225
275</td><td>0
3
2
7</td><td>20
3
10</td><td>200
230
280</td><td>0
3
5</td></tr>
<tr><td colspan="6">Detector</td></tr>
<tr><td colspan="3">Type: FPD
Temperature: 250 °C</td><td colspan="3">Type: μECD
Temperature: 290 °C</td></tr>
</table>

Table 3.2 Liquid chromatography (LC) condition for pesticide analysis

Carbamate pesticides		
LC model:	Agilent 11000 series	
Column:	C-18 column (3.9 mm x 150 mm, 5 μm)	
Flow rate:	0.20 mL/min	
Column temperature:	40 °C	
Injection volume:	5 μL	
Mobile phase:	A : 0.01% formic acid in deionized water	
	B : 0.01% formic acid in methanol	
MS model:	Agilent SL G1956B	
Mode:	ES+	
Drying gas:	7 L/min	
Nebulizer pressure:	40 psi	
Drying gas temperature:	315 °C	
Capillary voltage:	4000 V	
Detected m/z ion:		
No	Compound	Target ion
1	Aldicarb sulfoxide	207.10
2	Aldicarb sulfone	223.10
3	Oxamyl	237.10
4	Aldicarb	116.10
5	Methomyl	163.10
6	Carbofuran-3-OH	238.10
7	Isoprocarb	194.10
8	Carbaryl	202.10
9	Carbofuran	222.10
10	Fenobucarb	208.20
11	Methiocarb	226.10

Table 3.3 Method validation for pesticide analysis

Pesticides	Calibration curve (R^2)	LOD (µg/hands)	LOQ (µg/hands)	% Recovery	%RSD
Organophosphates					
1. Ethoprophos	0.99996	0.01	0.02	97	6.8
2. Malathion	0.99996	0.01	0.02	122	6.0
3. Chlorpyrifos	0.99998	0.01	0.02	113	4.9
4. Prothiofos	0.99994	0.01	0.02	110	4.8
5. Profenofos	0.99947	0.01	0.02	125	3.7
6. Ethion	0.99998	0.01	0.02	119	4.4
7. EPN	0.99993	0.02	0.05	115	1.7
8. Guthion	0.99954	0.05	0.10	117	6.2
Pyrethroids					
9. Permethrin[1]					
- Permethrin-I	0.99957	0.01	0.02	101	6.9
- Permethrin-II	0.99987	0.01	0.02	99	7.1
10. Cypermethrin[2]					
- Cypermethrin-I	0.99966	0.01	0.02	96	6.7
- Cypermethrin-II	0.99911	0.01	0.02	100	5.5
- Cypermethrin-III	0.99961	0.01	0.02	86	5.7
- Cypermethrin-IV	0.99952	0.01	0.02	97	5.6
Carbamates					
11. Aldicarb[3]					
- Aldicarb sulfoxide	0.99910	0.01	0.02	136	3.1
- Aldicarb sulfone	0.99512	0.01	0.02	104	0.3
- Aldicarb	0.99961	0.01	0.02	94	0.3
12. Oxamyl	0.99795	0.01	0.02	124	0.2
13. Methomyl	0.99827	0.01	0.02	67	1.6

Pesticides	Calibration curve (R^2)	LOD (µg/hands)	LOQ (µg/hands)	% Recovery	%RSD
14. Carbofuran[4]					
- Carbofuran-3-OH	0.99503	0.01	0.02	61	0.6
- Carbofuran	0.99870	0.01	0.02	90	4.1
15. Isoprocarb	0.99951	0.01	0.02	62	5.3
16. Carbaryl	0.99789	0.01	0.02	61	2.4
17. Fenobucarb	0.99964	0.01	0.02	61	2.52
18. Methiocarb	0.99978	0.01	0.02	64	1.35

[1] Permethrin = Sum of permethrin-I and permethrin-II

[2] Cypermethrin = Sum of cypermethrin-I, cypermethrin-II, cypermethrin-III, and cypermethrin-IV

[3] Aldicarb = Sum of aldicarb sulfoxide, aldicarb sulfone, and aldicarb

[4] Carbofuran = Sum of carbofuran-3-OH and carbofuran

3.6.4 Blood cholinesterase level test

The blood cholinesterase level test among greengrocers was performed at a room within the market by using the equipment called Test-mate ChE Kit. Both AChE and PChE were simultaneously examined after the end of their shift by a researcher. The test was done in dry and wet seasons. The test procedure (EQM Research Inc, 2003) was consisted of:

1) Turn on Test-mate ChE analyzer, and press Test key.

2) Insert new assay tube into the analyzer, and press Test key.

3) When prompted by the analyzer, remove the assay tube, and press Test key.

4) Clean puncture site before finger stick (by a nurse), fill 10 uL capillary with blood (20 uL for 2 capillaries to measure AChE and PChE at the same time), and

place it into the assay tube. Shake the assay tube for 15 seconds. Align the capillary and then insert the assay tube into the analyzer. And press Test key.

5) When prompted by the analyzer, remove the assay tube, and press Test key.

6) Dissolve reagent with 3 drops of reagent solvent. Add the dissolved reagent to the assay tube using transfer pipette, and press Test key.

7) Shake the assay tube by inversion for 5 seconds. Align the capillary and then insert the assay tube into the analyzer. And press Test key.

8) When prompted by the analyzer, remove and discard the assay tube, and press Test key.

9) Record the analyzer readings, using Test key to advance the display, and press Done key.

10) Record the temperature ($^{\circ}C$).

3.6.5 In-depth interview

In-depth interview was conducted after data collection both seasons was completed. It was done in a number of greengrocers after the end of their shift by a researcher through using interview guideline to reveal opinions, feelings and perceptions around effect or health symptoms from exposure to pesticide residues on vegetables. General purpose of the interview was explained and permission to record conversation was obtained. All interviews were lasted between 15 and 20 minutes.

3.7 Data Analysis

3.7.1 Statistical analysis

Data was analyzed by using SPSS statistical program as follows:

1) Descriptive statistics

Frequency, arithmetic mean, standard deviation (SD), minimum (Min), and maximum (Max), and percentile for describing general information, KAP regarding exposure to pesticide residues and protection, detected pesticide residues in vegetables, detected pesticide residues on hands, blood cholinesterase level, and health symptoms from exposure to pesticide residues on vegetables

2) Analytic statistics

(1) Wilcoxon signed rank test

- To compare the differences in pesticide residues on hands between dry and wet seasons

- To compare the differences in blood cholinesterase level between dry and wet seasons

(2) McNemar's chi-square test to compare the differences in proportion of health symptoms from exposure to pesticide residues on vegetables between dry and wet seasons

(3) Multiple linear regression to test the relationship between blood cholinesterase level and multiple independent variables, including personal factors, work-related factors, practice regarding exposure to pesticide residues and protection, and pesticide residues on hands

(4) Binary logistic regression

- To test the relationship between pesticide residues on hands and multiple independent variables, including personal factors and work-related factors

- To test the relationship between health symptoms from exposure to pesticide residues on vegetables and multiple independent variables, including personal factors, work-related factors, practice regarding exposure to pesticide residues and protection, and blood cholinesterase level

3.7.2 Health risk assessment

Health risk from occupational exposure to pesticide residues on vegetables among greengrocers was evaluated by 4 steps as follows:

1) Hazard identification

There were 3 groups of pesticides that may cause the effect on the human body.

(1) Organophosphate pesticides (OP group)

OP group included ethoprophos, malathion, chlorpyrifos, prothiofos, profenofos, ethion, EPN, and guthion.

(2) Pyrethriod pesticides (PY group)

PY group included permethrin, and cypermethrin.

(3) Carbamate pesticides (CA group)

CA group included aldicarb, oxamyl, methomyl, isoprocarb, carbaryl, carbofuran, fenobucarb, and methiocarb

2) Dose-response assessment

Reference dose (RfD) was used as toxicity index. The reference dose is an estimate of a daily exposure to the population that is likely to be without an appreciable risk of adverse health effects during a lifetime. It is expressed in units of milligrams per kilogram of bodyweight per day (mg/kg-day). Reference dose values and toxicity data of pesticides are shown in Table 3.4.

Table 3.4 Reference dose values and toxicity data of pesticides

PRs	Classification by Hazard[a]	Cholinesterase Inhibitor	RfD (mg/kg-day)
OP group			
Ethoprophos	Ia	Yes	0.0001 (US EPA, 2006a)
Malathion	III	Yes	0.07 (US EPA, 2009a)
Chlorpyrifos	II	Yes	0.0003 (US EPA, 2002b)
Prothiofos	II	Yes	NR[b]
Profenofos	II	Yes	0.00005 (US EPA, 1999b)
Ethion	II	Yes	0.0005 (US EPA, 1996)
EPN	Ia	Yes	0.00001 (US EPA, 1987)
Guthion	Ib	Yes	0.00149 (US EPA, 2001)
PY group			
Permethrin	II	No	0.25 (US EPA, 2009b)
Cypermethrin	II	No	0.06 (US EPA, 2008)
CA group			
Aldicarb	Ia	Yes	0.001 (US EPA, 1998a)
Oxamyl	Ib	Yes	0.001 (US EPA, 2000)
Methomyl	Ib	Yes	0.008 (US EPA, 1998b)
Isoprocarb	II	Yes	NR[b]
Carbaryl	II	Yes	0.01 (US EPA, 2007a)
Carbofuran	Ib	Yes	0.00006 (US EPA, 2006b)
Fenobucarb	II	Yes	NR[b]
Methiocarb	Ib	Yes	0.005 (US EPA, 1994)

[a] Classification of active pesticide ingredients by hazard (WHO, 2010): Ia = Extremely hazardous, Ib = Highly hazardous, II = Moderately hazardous, and III = Slightly hazardous

[b] No report by US EPA

3) Dermal exposure assessment

The average daily dose (ADD) from exposure to each PR through the dermal route was calculated by a formula modified from US EPA (2007b) as follows:

$$\text{ADD (mg/kg-day)} = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$$

Where;

DA_{event}	=	Absorbed dose per event (mg/cm^2-event) [PR amount (mg-event)/SA x dermal absorption fraction (ABS)]
EV	=	Event frequency (events/day)
ED	=	Exposure duration (years)
EF	=	Exposure frequency (days/year)
SA	=	Skin surface area available for contact (cm^2)
BW	=	Body weight (kg)
AT	=	Averaging time (ED x 365 days) (days)

4) Risk characterization

The results from dose-response and dermal exposure assessment steps were used to calculate the magnitude of health risk as follows:

For each individual pesticide;

$$\text{Hazard Quotient (HQ)} = \text{ADD / RfD}$$

Where; RfD = Dermal reference dose (mg/kg/day) which assumed at 100% of oral reference dose (US EPA, 2004)

For multiple pesticides in a sample, hazard index (HI) was calculated by summing the HQ.

$$\text{HI (Hazard index)} = \sum \text{HQ}$$

If $HI \geq 1$, Concern for potential non-carcinogenic effect
$HI < 1$, No concern for potential non-carcinogenic effect (acceptable level)

3.7.3 Content analysis

Data obtained from in-depth interview was organized, interpreted, and concluded to explore health symptoms from exposure to pesticide residues on vegetables among greengrocers. Synthesis of their ideas was reported and illustrated by quotes.

3.8 Guideline Development

A guideline for prevention and health risk reduction related to pesticide contamination in vegetables was developed from the results of this study. The guideline, education material, was implemented among greengrocers for risk communication. It was given them with demonstrating pesticide contamination on vegetables. The risk communication included giving information about the results and interpretation of individual health risk assessment and blood cholinesterase level test. Guideline for prevention and health risk reduction related to pesticide contamination in vegetables is shown in Appendix D.

3.9 Ethical Consideration

Ethics approval was obtained from the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University (COA No. 046/2558). Participants gave their permission by completion of written consent form before collecting data. They had the right to refuse for participation at all time.

CHAPTER IV

RESULTS

In dry season, total 91 greengrocers were initially selected, and 89 of them were chosen for data analysis regarding blood testing because of an error from the Test-mate cholinesterase kit in 2 subjects. In wet season, 6 subjects withdrew from the study and 1 subject refused to collect blood sample. Finally, there were 82 greengrocers who completed face-to-face interview, hand wipe sampling, and blood cholinesterase level test in both seasons. The results of this study were divided into 8 parts as follows:

Part 1: General information of participants

Part 2: Knowledge, attitude, and practice regarding exposure to pesticide residues and protection

Part 3: Pesticide residues in vegetables

Part 4: Pesticide residues on hands

Part 5: Blood cholinesterase level

Part 6: Health symptoms from exposure to pesticide residues

Part 7: Factors associated with pesticide residues on hands, blood cholinesterase level, and health symptoms

Part 8: Health risk assessment

4.1 General Information of Participants

4.1.1 Personal information

Personal information among greengrocers in fresh market is shown in Table 4.1. Both men (39.5%) and women (61.5%) participated in the study. Participants were Thai (70.3%) and Lao (29.7%). The average age was 41 ± 13.2 years with a range of 18 - 67 years. Mean body weight for both genders was 64.6 ± 17.1 kg with a range of 40.3 - 150.0 kg. The average BMI was 26.0 ± 6.8 kg/m^2 with a range of 17.5 - 62.4 kg/m^2. The majority of subjects (54.9%) had an education level of primary school. Only 26.4% had at least 1 health problem diagnosed by physician. Most of them (81.3%) were non-smoker, and did not drink alcohol. Nearly half of them (48.4%) consumed moderate amounts of fruits and vegetables. Most of them (68.1%) reported no glove wearing during working; 7.7% wore always disposable latex gloves on hands at all of the time during working. Only 9.9% of them did not wash their hands during working; 18.7% washed their hands with soap or other detergents.

Table 4.1 Personal information among greengrocers in fresh market

Personal information (N=91)	N (%)
Gender	
Male	35 (38.5%)
Female	56 (61.5%)
Nationality	
Thai	64 (70.3%)
Lao	27 (29.7%)
Age (years)	
≤30	24 (26.4%)
31-40	18 (19.8%)
41-50	22 (24.2%)
>50	27 (29.7%)
Mean ± SD	41.0 ± 13.2
Min - Max	18 – 67
Weight (kg.)	
Mean ± SD	64.6 ± 17.1
Min - Max	40.3 – 150.0
Height (cm.)	
Mean ± SD	157.8 ± 7.3

Personal information (N=91)	N (%)
Min - Max	144 – 175
BMI (kg/m^2)	
≤25	48 (52.7%)
>25	43 (47.3%)
Mean ± SD	26.0 ± 6.8
Min - Max	17.5 – 62.4
Education	
No official education	4 (4.4%)
Elementary school	50 (54.9%)
High school/vocational certificate	32 (35.2%)
Bachelor	5 (5.5%)
Health problems	
No	67 (73.6%)
Yes[a]	24 (26.4%)
- Hypertension	7 (7.7%)
- Diabetes	6 (6.6%)
- Dyslipidemia	8 (8.8%)
- Asthma	8 (8.8%)
- Gastritis	4 (4.4%)
- Hepatitis B	1 (1.1%)
Smoking	
No	74 (81.3%)
Yes	17 (18.7%)
- ≤10 cigarettes/day	13 (14.3%)
- >10 cigarettes/day	4 (4.4%)
Drinking alcohol	
No	74 (81.3%)
Sometimes	4 (4.4%)
Always	13 (14.3%)
- Whisky <150 cc./Beer 1-2 bottles	9 (9.9%)

Personal information (N=91)	N (%)
- Whisky >150 cc./Beer 3 bottles	4 (4.4%)
Consumption of fruits and vegetables	
Small amounts (≤350 g/day)	20 (22.0%)
Moderate amounts (351–500 g/day)	44 (48.4%)
Large amounts (>500 g/day)	27 (29.7%)
Use of latex gloves during working	
No wearing	62 (68.1%)
Sometimes and/or short time	6 (6.6%)
Always by half of time and/or 1 hand	16 (17.6%)
Always by all time and 2 hands	7 (7.7%)
Frequency of washing hands during working	
No washing	9 (9.9%)
1-3 times/day	55 (60.4%)
>3 times/day	27 (29.7%)
Way of washing hands during working	
No washing	9 (9.9%)
Only water	65 (71.4%)
With soap	10 (11.0%)
With other detergents	7 (7.7%)

[a] Having at least 1 health problem

4.1.2 Work-related information

Work-related information among greengrocers in fresh market is shown in Table 4.2. The average number of years worked in their current job was 14.1±11.0 years, with a range of 1 - 44 years. All of them had not another job. They worked an average of 6.3 days/week for 10.3 hours/day. Mean handling vegetables with protective materials was about 1,850 kg/week. The greengrocers handled approximately 260 kg/day of produce, consisting of up to 35 types of vegetables, 20% of the commodities being wet.

The various types of vegetables in greengrocer shops included root and tuber vegetables (carrot, white radish, finger root, ginger, potato, etc.), bulb and stem vegetables (onion, shallot, garlic, spring onion, lemongrass, lotus stem, asparagus, etc.), leafy vegetable (Chinese kale, Chinese flowering cabbage, lettuce, cabbage, Chinese cabbage, morning glory, spinach, coriander, celery, ivy gourd leaves, climbing wattle, holy basil, sweet basil, peppermint, kaffir lime leaves, etc.), flower vegetables (cauliflower, broccoli, etc.), and fruit vegetables (tomato, Thai eggplant, cucumber, chilli, sweet pepper, baby corn, yard long bean, sugar pea, pumpkin, angled luffa, bitter melon, white gourd, etc.). The wet vegetables in their shops consisted of vegetables soaked with water (julienned ginger, julienned finger root, chopped Thai eggplant, etc.), and vegetables washed with water or preserved with ice (lettuce, broccoli, yard long bean, morning glory, lotus stem, holy basil, sweet basil, coriander, celery, etc.).

Table 4.2 Work-related information among greengrocers in fresh market

Work-related information (N=91)	N (%)
Duration of work in current job (years)	
≤10	43 (47.3%)
>10	48 (52.7%)
Mean ± SD	14.1 ± 11.0
Min - Max	1 – 44
Working hour per day (hours)	
≤10	52 (57.1%)
>10	39 (42.9%)
Mean ± SD	10.3 ± 2.31
Min - Max	6 - 17

Work-related information (N=91)	N (%)
Workday per week (days)	
Mean ± SD	6.3 ± 1.03
Min - Max	4 – 7
Handling vegetables with protective materials (kg/week)	
≤1000	28 (30.8%)
1001 - 2000	33 (36.3%)
>2000	30 (33.0%)
Mean ± SD	1,851 ± 1,788
Min - Max	70 – 15,000
Handling vegetables without protective materials (kg/day)	
≤100	22 (24.2%)
101 - 400	56 (61.5%)
>400	13 (14.3%)
Mean ± SD	260 ± 192
Min - Max	10 – 1,000
Types of vegetables in shop (types)	
≤20	29 (31.9%)
21 - 50	41 (45.0%)
>50	21 (23.1%)
Mean ± SD	35.5 ± 23.92
Min - Max	10 – 100
Wet vegetables in shop (%)	
≤20	64 (70.3%)
>20	27 (29.7%)
Mean ± SD	20.1 ± 12.90
Min - Max	0 – 50

4.2 Knowledge, Attitude, and Practice Regarding Exposure to Pesticide Residues and Protection

4.2.1 Knowledge regarding exposure to pesticide residues and protection

Percentage of knowledge regarding exposure to pesticide residues and protection among greengrocers is presented in Table 4.3. The highest item of correct answer (98.9%) was the question no. 10 “Correct cleaning or washing vegetables and hands before consumption can reduce pesticide residues entered the body”. Most of workers (90.11%) knew that using gloves can prevent pesticide residues through the skin. Whereas, the lowest item of correct answer (48.35%) was the question no. 9 “Pesticide residues on vegetables cannot enter the body by inhalation route”. The majority of them (56.04%) only knew that pesticide residues on vegetables can pass through the body by the oral route.

Table 4.3 Percentage of knowledge regarding exposure to pesticide residues and protection among greengrocers

Knowledge item	Correct answer (%)
1. Most vegetables are contaminated with pesticide residues.	89.01%
2. Pesticide residues on vegetables have not any effect on human body.	87.91%
3. Pesticide residues on vegetables can pass through the body only ingestion route.	56.04%
4. Each vegetable may be contaminated with several pesticides.	80.22%
5. There are no pesticide residues in vegetables imported from other countries.	86.81%

Knowledge item	Correct answer (%)
6. Some pesticide contaminated in vegetables can degrade when they are exposed to heat.	76.92%
7. Using gloves can prevent pesticide residues through the skin.	90.11%
8. Pesticide residues not only are on surface of vegetable but also are in texture of vegetable.	86.81%
9. Pesticide residues on vegetables cannot enter the body by inhalation route.	48.35%
10. Correct cleaning or washing vegetables and hands before consumption can reduce pesticide residues entered the body.	98.90%

4.2.2 Attitude regarding exposure to pesticide residues and protection

Percentage of attitude regarding exposure to pesticide residues and protection among greengrocers is presented in Table 4.4. The highest item of score (mean = 4.59) was the question no. 4 “I think that clean washing vegetables before eating can diminish effect of pesticide residues on vegetables” with strongly agreement of 61.5%. Whereas, the lowest item of score (mean = 2.23) was the question no. 7 “I think that wearing gloves during working are not comfortable although it may reduce exposure to pesticide residues on vegetables” with agreement of 67.0%.

Table 4.4 Percentage of attitude regarding exposure to pesticide residues and protection among greengrocers

Attitude item	Degree					Mean
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1. I think that pesticide residues on vegetables may not acutely affect health but it can be accumulated in body.	0.0%	2.2%	1.1%	41.8%	54.9%	4.49
2. I think that I can eat vegetables without washing if I have good health.[a]	0.0%	51.6%	36.3%	3.3%	8.8%	4.31
3. I think that eating vegetables in season can get lower pesticide residues.	1.1%	22.0%	25.3%	36.3%	15.4%	3.43
4. I think that clean washing vegetables before eating can diminish effect of pesticide residues on vegetables.	0.0%	0.0%	2.2%	36.3%	61.5%	4.59
5. I think that eating with unwashed hands during working can directly get pesticide residues.	0.0%	2.2%	2.2%	50.5%	45.1%	4.38
6. I think that pesticide residues on vegetables get into body not only through ingestion route but also through dermal contact with handling vegetables contaminated pesticides.	0.0%	2.2%	4.4%	50.5%	42.9%	4.34

Attitude item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
	Degree					
7. I think that wearing gloves during working are not comfortable although it may reduce exposure to pesticide residues on vegetables.[a]	3.3%	12.1%	3.3%	67.0%	14.3%	2.23
8. I think that frequently hand washing during working can diminish amount of pesticide residues on vegetables pass through the body	0.0%	4.4%	2.2%	56.0%	37.4%	4.26
9. I think that hand washing with soap is better than hand washing with only water, for removing pesticide residues on hands.	0.0%	0.0%	1.1%	45.1%	53.8%	4.53
10. I think that hand washing and bath after finishing work can reduce pesticide residues pass through body due to their contamination on clothes and body.	0.0%	0.0%	0.0%	52.7%	47.3%	4.47

[a] Negative statement

4.2.3 Practice regarding exposure to pesticide residues and protection

Percentage of practice regarding exposure to pesticide residues and protection among greengrocers is presented in Table 4.5. The highest item of score (mean = 4.95) was the question no. 8 “You eat vegetables without washing them during stay at home" with hardly ever degree of 95.6%. Whereas, the lowest item of score (mean = 1.62) was the question no. 7 "When you wash your hand during working hours, you wash with soap or other detergents" with hardly ever degree of 71.4%.

Table 4.5 Percentage of practice regarding exposure to pesticide residues and protection among greengrocers

Practice item	Degree					Mean
	Hardly ever	Occasionally	Sometimes	Frequently	Always	
1. You eat food without hand washing during working hours.[a]	47.3%	17.6%	11.0%	4.4%	19.8%	3.68
2. You wear gloves during working.	70.3%	1.1%	1.1%	2.2%	25.3%	2.11
3. You eat vegetables in your shop without washing them during working.[a]	70.3%	14.3%	6.6%	2.2%	6.6%	4.40
4. You wash your hands with clean water during working hours.	9.9%	2.2%	1.1%	1.1%	85.7%	4.51
5. You wash your hand after finishing your work.	2.2%	0.0%	3.3%	2.2%	92.3%	4.82
6. You take a bath/shower after finishing your work or when you return your home.	4.4%	4.4%	6.6%	2.2%	82.4%	4.54
7. When you wash your hand during working hours, you wash with soap or other detergents.	71.4%	13.2%	5.5%	2.2%	7.7%	1.62

Practice item	Degree					Mean
	Hardly ever	Occasionally	Sometimes	Frequently	Always	
8. You eat vegetables without washing them during stay at home.[a]	95.6%	3.3%	1.1%	0.0%	0.0%	4.95
9. You choose well-shaped vegetables, without pore or biting of insect worm for your own cooking.[a]	14.3%	1.1%	18.7%	6.6%	59.3%	2.04
10. You wash vegetables with running water, salt, potassium permanganate, vinegar, limewater, water from washing rice, sodium bicarbonate, or washing agents.	23.1%	8.8%	5.5%	5.5%	57.1%	3.65

[a] Negative statement

4.2.4 Levels of knowledge, attitude, and practice regarding exposure to pesticide residues and protection

Levels of knowledge, attitude, and practice regarding exposure to pesticide residues and protection among greengrocers are shown in Table 4.6. For knowledge, each correct answer was given 1 score with a total of 10 scores. The average knowledge score was 8.0 ± 1.5 scores with a range of 4 - 10 scores. The majority of greengrocers (67.0%) had good level of knowledge. For attitude, the average score was 41.0 ± 3.0 scores with a range of 32 - 48 scores. The most of them (75.8%) had good level of attitude. For practice, the average score was 36.3 ± 5.7 scores with a range of 20 – 50 scores. The majority of them (62.6%) had moderate level of practice. In addition, mean score of dermal practice (17.6 ± 3.3 scores) was lower than mean score of oral practice (18.7 ± 3.9 scores).

Table 4.6 Levels of knowledge, attitude, and practice regarding exposure to pesticide residues and protection among greengrocers

KAP	N (%)	Mean ± SD	Min - Max
Knowledge			
Low (1-5 scores)	6 (6.6%)		
Moderate (6-7 scores)	24 (26.4%)	8.0 ± 1.5	4 - 10
Good (8-10 scores)	61 (67.0%)		
Attitude			
Low (10-29 scores)	0 (0.0%)		
Moderate (30-39 scores)	22 (24.2%)	41.0 ± 3.0	32 - 48
Good (40-50 scores)	69 (75.8%)		
Practice			
Low (10-29 scores)	10 (11.0%)		
Moderate (30-39 scores)	57 (62.6%)	36.3 ± 5.7	20 - 50
Good (40-50 scores)	24 (26.4%)		
Practice – oral[a]			
Low (<20 scores)	42 (46.2%)	18.7 ± 3.9	9 - 25
High (≥20 scores)[1]	49 (53.8%)		
Practice – dermal[b]			
Low (<17 scores)	26 (28.6%)	17.6 ± 3.3	7 - 25
High (≥17 scores)[2]	65 (71.4%)		

[a] Summing scores of practice in item 1, 3, 8, 9, 10

[b] Summing scores of practice in item 2, 4, 5, 6, 7

[1] Scores of oral practice above median

[2] Scores of dermal practice above median

4.2.5 Correlations among scores of knowledge, attitude, and practice regarding exposure to pesticide residues and protection

Correlations among scores of knowledge, attitude, and practice regarding exposure to pesticide residues and protection are presented in Table 4.7. There were positively and statistically significant association between knowledge and attitude (Spearman's rank correlation coefficient = 0.254, p-value<0.05), and attitude and practice (Spearman's rank correlation coefficient = 0.319, p-value<0.05).

Table 4.7 Correlations among scores of knowledge, attitude, and practice regarding exposure to pesticide residues and protection

KAP		Spearman's rho	P-value
Knowledge	- Attitude	0.254	0.015*
	- Practice	0.101	0.340
Attitude	- Knowledge	0.254	0.015*
	- Practice	0.319	0.002*
Practice	- Knowledge	0.101	0.340
	- Attitude	0.319	0.002*

* Significance at the 0.05 level (2-tailed)

4.3 Pesticide Residues in Vegetables

In dry season, the vegetable samples from all 10 shops contained pesticide residues, including organophosphates (OPs), carbamates (CAs), and pyrethroids (PYs). The frequently detected residues in organophosphate group were chlorpyrifos (<0.02 - 0.36 mg/kg), followed by profenofos (<0.02 - 0.39 mg/kg), and prothiofos (0.07 - 0.84 mg/kg), respectively. In pyrethroid group, the frequently detected residue was cypermethrin (0.01 - 0.57 mg/kg). The detected residues in carbamate group were fenobucarb (0.38 mg/kg) and carbaryl (0.16 mg/kg). Types and amounts of pesticide residues in market vegetable samples in dry season are shown in Table 4.8.

In wet season, the vegetable samples from all 10 shops contained residues of organophosphate and pyrethroid pesticides. In organophosphate group, only chlorpyrifos (0.03 - 0.56 mg/kg) was detected. Whereas, cypermethrin (<0.01 - 0.05 mg/kg), lamda-Cyhalothrin (<0.01 mg/kg), and deltamethrin (<0.01 mg/kg) in pyrethroid group were detected with low concentration. Types and amounts of pesticide residues in market vegetable samples in wet season are shown in Table 4.9.

Comparison of pesticide residues in market vegetable samples between dry and wet seasons is shown in Table 4.10. It was found that the detected types and frequency of residues in vegetable samples in wet season were likely to lower than those in dry season. The types of organophosphate residues showed decreasing in wet season. The contamination of carbamate pesticide in vegetable samples was not detected in wet season, while many types of pyrethroid pesticides were detected with low concentration. However, the residues of chlorpyrifos and cypermethrin were mainly found in both seasons. Detected frequencies of pesticide residues in vegetable samples between dry and wet seasons are shown in Figure 4.1.

Table 4.8 Types and amounts of pesticide residues in market vegetable samples in dry season

Shop	Type of Vegetable	Amount of pesticide residues (mg/kg)		
		Organophosphates[a]	Carbamates[a]	Pyrethroids[b]
1	10	Chlorpyrifos ethyl (0.36) Profenofos (0.15) Prothiofos (0.16)	-	Cypermethrin (0.57)
2	9	Prothiofos (0.84)	Fenobucarb (0.38)	Cypermethrin (0.02)
3	10	Chlorpyrifos ethyl (<0.02) Profenofos (<0.02)	-	Cypermethrin (0.04)
4	10	Chlorpyrifos ethyl (0.02) Profenofos (0.28)	-	Cypermethrin (0.06)
5	10	Chlorpyrifos ethyl (0.15) Prothiofos (0.07)	-	Cypermethrin (0.16)
6	8	Chlorpyrifos ethyl (0.12) Profenofos (0.03)	-	Cypermethrin (0.06)
7	8	Profenofos (0.03) Prothiofos (0.82)	-	Cypermethrin (0.01)
8	9	Chlorpyrifos ethyl (<0.02) Profenofos (0.39)	Carbaryl (0.16)	Cypermethrin (0.03)
9	6	-	-	Cypermethrin (0.06)
10	4	Chlorpyrifos ethyl (0.29)	-	-

[a] LOD = 0.01 mg/kg

[b] LOD = 0.003 mg/kg

Table 4.9 Types and amounts of pesticide residues in market vegetable samples in wet season

Shop	Type of Vegetable	Amount of pesticide residues (mg/kg)		
		Organophosphates[a]	Carbamates[a]	Pyrethroids[b]
1	10	Chlorpyrifos ethyl (0.56)	-	Cypermethrin (0.02)
2	9	-	-	-
3	10	Chlorpyrifos ethyl (0.05)	-	Lamda-Cyhalothrin (<0.01) Cypermethrin (0.02) Deltamethrin (<0.01)
4	10	-	-	Cypermethrin (0.05)
5	10	Chlorpyrifos ethyl (0.03)	-	Cypermethrin (<0.01)
6	8	Chlorpyrifos ethyl (0.2)	-	Cypermethrin (<0.01)
7	8	-	-	-
8	9	Chlorpyrifos ethyl (0.05)	-	Cypermethrin (0.05)
9	6	-	-	Cypermethrin (<0.01)
10	4	Chlorpyrifos ethyl (0.24)	-	Cypermethrin (<0.01)

[a] LOD = 0.01 mg/kg

[b] LOD = 0.003 mg/kg

Table 4.10 Comparison of pesticide residues in market vegetable samples between dry and wet seasons

Pesticide residues	Dry season		Wet season	
	Detected frequency	Amount (mg/kg)	Detected frequency	Amount (mg/kg)
OPs				
- Chlorpyrifos	70%	<0.02-0.36	60%	0.03-0.56
- Profenofos	50%	<0.02-0.39	-	-
- Prothiofos	40%	0.07-0.84	-	-
CAs				
- Fenobucarb	10%	0.38	-	-
- Carbaryl	10%	0.16	-	-
PYs				
- Cypermethrin	90%	0.01-0.57	80%	<0.01-0.05
- Cyhalothrin	-	-	10%	<0.01
- Deltamethrin	-	-	10%	<0.01

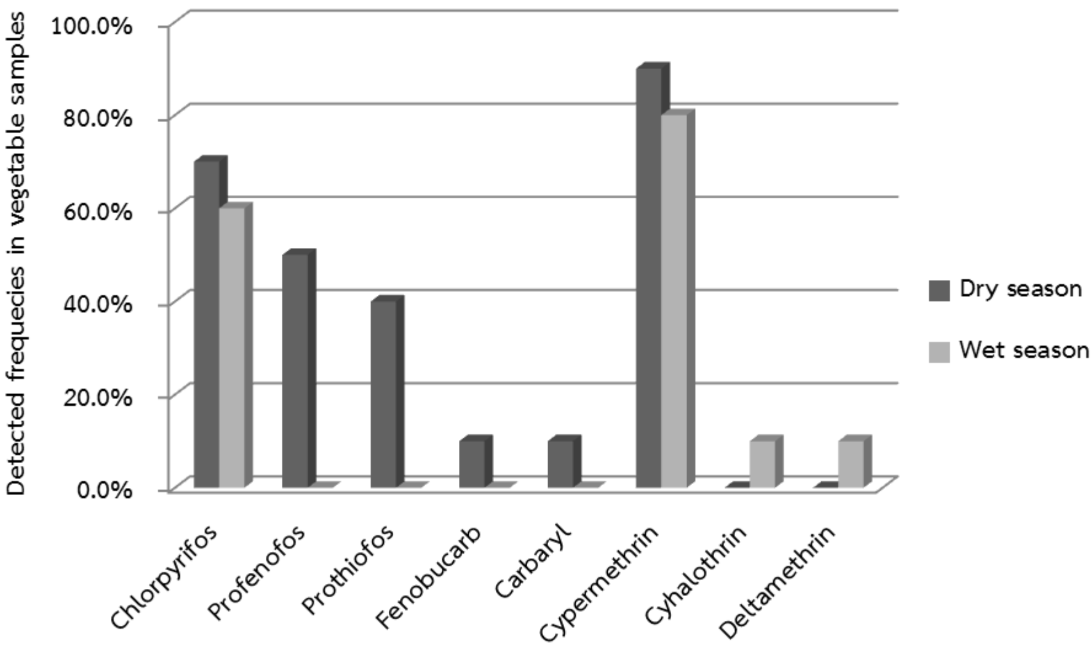


Figure 4.1 Detected frequencies of pesticide residues in vegetable samples between dry and wet seasons

4.4 Pesticide Residues on Hands

4.4.1 Pesticide residues on hands in dry and wet seasons

In dry season, hand wipe sampling among 91 greengrocers revealed 18.7% of them who wore gloves on the day collected their samples (one or two hands/half of time or all time). All hand wipe samples contained many kinds of insecticides, including organophosphates, carbamates, and pyrethriods. From ten organophosphate and pyrethriod pesticide standards, the types of pesticide residues on their hands were detected at an average of 4.6 ± 1.6 types with a range of 2 - 8 types. In addition, the types of carbamates on hands were found at an average of 2.9 ± 1.4 types with a range of 1 - 6 types (from eight pesticide standards). Pesticide residues on hands detected in all samples were chlorpyrifos and cypermethrin, at an average of 0.027 μg and 2.031 μg, respectively. The most frequently detected pesticide residues were aldicarb (87.2%) followed by carbofuran (69.2%), permethrin (63.7%), profenofos (60.0%), and ethion (59.3%), respectively. The highest concentration for hand contamination was found to be fenobucarb for carbamates, profenofos for organophosphates, and cypermethrin for pyrethriods. Detected frequencies and amounts of pesticide residues in hand wipe samples in dry season are shown in Table 4.11.

In wet season, hand wipe sampling among 85 greengrocers revealed 22.4% of them who wore gloves on the day collected their samples (one or two hands/half of time or all time). All hand wipe samples contained many kinds of insecticides, including organophosphates, carbamates, and pyrethriods. From ten organophosphate and pyrethriod pesticide standards, the types of pesticide residues on their hands were detected at an average of 3.7 ± 1.2 types with a range of 2 - 7 types. In addition, the types of carbamates on hands were found at an average of 2.3 ± 1.1 types with a range of 1 - 5 types (from eight pesticide standards). Pesticide residues on hands detected in all samples were chlorpyrifos and cypermethrin, at an average of 0.025 μg and 2.311 μg, respectively. The most frequently detected pesticide residues were profenofos (37.6%), and ethion (36.5%), permethrin (23.5%), respectively. The highest concentration for hand contamination was found to be aldicarb for carbamates, chlorpyrifos for organophosphates, and cypermethrin for pyrethriods. Most of greengrocers' hands were no detectable residues of carbamates in the wet season. Detected frequencies and amounts of pesticide residues in hand wipe samples in wet season are shown in Table 4.12. Detected frequencies of pesticide residues in hand wipe samples between dry and wet seasons are shown in Figure 4.2; types of pesticide residues in hand wipe samples between dry and wet seasons are shown in Table 4.13.

Table 4.11 Detected frequencies and amounts of pesticide residues in hand wipe samples in dry season

PRs	Detected frequency (%)[a]	Amount of PRs on both hands (µg)						
		Mean±SD[b]	Min	Percentile				Max[c]
				25th	50th	75th	95th	
OP group (n=91)								
Ethoprophos[1]	7.7%	0.005±0.002	<LOD	<LOD	<LOD	<LOD	0.010	0.016
Malathion[1]	25.3%	0.011±0.011	<LOD	<LOD	<LOD	0.018	0.034	0.069
Chlorpyrifos[1]	100.0%	0.027±0.020	0.012	0.015	0.020	0.030	0.071	0.136
Prothiofos[1]	6.6%	0.005±0.002	<LOD	<LOD	<LOD	<LOD	0.010	0.014
Profenofos[1]	60.0%	0.042±0.162	<LOD	<LOD	0.011	0.023	0.099	1.428
Ethion[1]	59.3%	0.021±0.036	<LOD	<LOD	0.012	0.020	0.066	0.296
EPN[2]	17.6%	0.015±0.012	<LOD	<LOD	<LOD	<LOD	0.035	0.095
Guthion[3]	14.3%	0.030±0.014	<LOD	<LOD	<LOD	<LOD	0.050	0.130
All		0.156±0.190	0.072	0.088	0.118	0.157	0.284	1.776
PY group (n=91)								
Permethrin[1]	63.7%	0.227±0.927	<LOD	<LOD	0.022	0.130	0.898	8.670
Cypermethrin[1]	100.0%	2.031±2.038	0.420	0.679	1.310	2.441	6.244	11.640
All		2.258±2.307	0.445	0.750	1.375	2.755	7.258	11.645
CA group (n=39)								
Aldicarb[1]	87.2%	0.038±0.023	<LOD	0.020	0.037	0.055	0.082	0.101
Oxamyl[1]	17.9%	0.016±0.035	<LOD	<LOD	<LOD	<LOD	0.154	0.163
Methomyl[1]	15.4%	0.007±0.007	<LOD	<LOD	<LOD	<LOD	0.033	0.041
Isoprocarb[1]	10.3%	0.009±0.015	<LOD	<LOD	<LOD	<LOD	0.032	0.096
Carbaryl[1]	33.3%	0.008±0.005	<LOD	<LOD	<LOD	0.010	0.021	0.031
Carbofuran[1]	69.2%	0.036±0.056	<LOD	<LOD	0.021	0.032	0.246	0.261
Fenobocarb[1]	23.1%	0.019±0.050	<LOD	<LOD	<LOD	<LOD	0.118	0.289
Methiocarb[1]	28.2%	0.007±0.004	<LOD	<LOD	<LOD	0.010	0.014	0.024
All		**0.139±0.083**	**0.048**	**0.082**	**0.110**	**0.179**	**0.364**	**0.377**

[a] Concentration above limit of detection (LOD)

[b] Amounts of pesticides below LOD were assigned a value equal to LOD/2 (US EPA, 1992).

[c] Maximum or 99th percentile amounts of pesticide residues

[1] LOD = 0.01 ug/hands

[2] LOD = 0.02 ug/hands

[3] LOD = 0.05 ug/hands

Table 4.12 Detected frequencies and amounts of pesticide residues in hand wipe samples in wet season

PRs	Detected frequency (%)[a]	Amount of PRs on both hands (µg)						
		Mean±SD[b]	Min	Percentile				Max[c]
				25th	50th	75th	95th	
OP group (n=85)								
Ethoprophos[1]	16.5%	0.006±0.002	<LOD	<LOD	<LOD	<LOD	0.011	0.013
Malathion[1]	14.1%	0.007±0.005	<LOD	<LOD	<LOD	<LOD	0.021	0.026
Chlorpyrifos[1]	100.0%	0.025±0.032	0.011	0.013	0.016	0.025	0.070	0.271
Prothiofos[1]	4.7%	0.005±0.001	<LOD	<LOD	<LOD	<LOD	<LOD	0.010
Profenofos[1]	42.4%	0.013±0.021	<LOD	<LOD	<LOD	0.014	0.059	0.157
Ethion[1]	49.4%	0.015±0.028	<LOD	<LOD	<LOD	0.015	0.049	0.230
EPN[2]	7.1%	0.011±0.004	<LOD	<LOD	<LOD	<LOD	0.026	0.028
Guthion[3]	0.0%	0.025±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
All		0.108±0.056	0.071	0.079	0.090	0.114	0.197	0.399
PY group (n=85)								
Permethrin[1]	30.6%	0.055±0.152	<LOD	<LOD	<LOD	0.013	0.349	0.931
Cypermethrin[1]	100.0%	2.311±3.080	0.332	0.581	1.140	2.733	9.165	19.711
All		2.367±3.082	0.337	0.616	1.185	2.738	9.170	19.716
CA group (n=39)								
Aldicarb[1]	5.1%	0.032±0.166	<LOD	<LOD	<LOD	<LOD	0.010	1.040
Oxamyl[1]	0%	0.005±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Methomyl[1]	0%	0.005±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Isoprocarb[1]	0%	0.005±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Carbaryl[1]	0%	0.005±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

PRs	Detected frequency (%)[a]	Amount of PRs on both hands (µg)						
		Mean±SD[b]	Min	Percentile				Max[c]
				25th	50th	75th	95th	
Carbofuran[1]	0%	0.005±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Fenobocarb[1]	2.6%	0.006±0.004	<LOD	<LOD	<LOD	<LOD	<LOD	0.030
Methiocarb[1]	0%	0.005±0.000	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
All		**0.067±0.166**	**0.040**	**0.040**	**0.040**	**0.040**	**0.070**	**1.075**

[a] Concentration above limit of detection (LOD)

[b] Amounts of pesticides below LOD were assigned a value equal to LOD/2 (US EPA, 1992).

[c] Maximum or 99th percentile amounts of pesticide residues

[1] LOD = 0.01 ug/hands

[2] LOD = 0.02 ug/hands

[3] LOD = 0.05 ug/hands

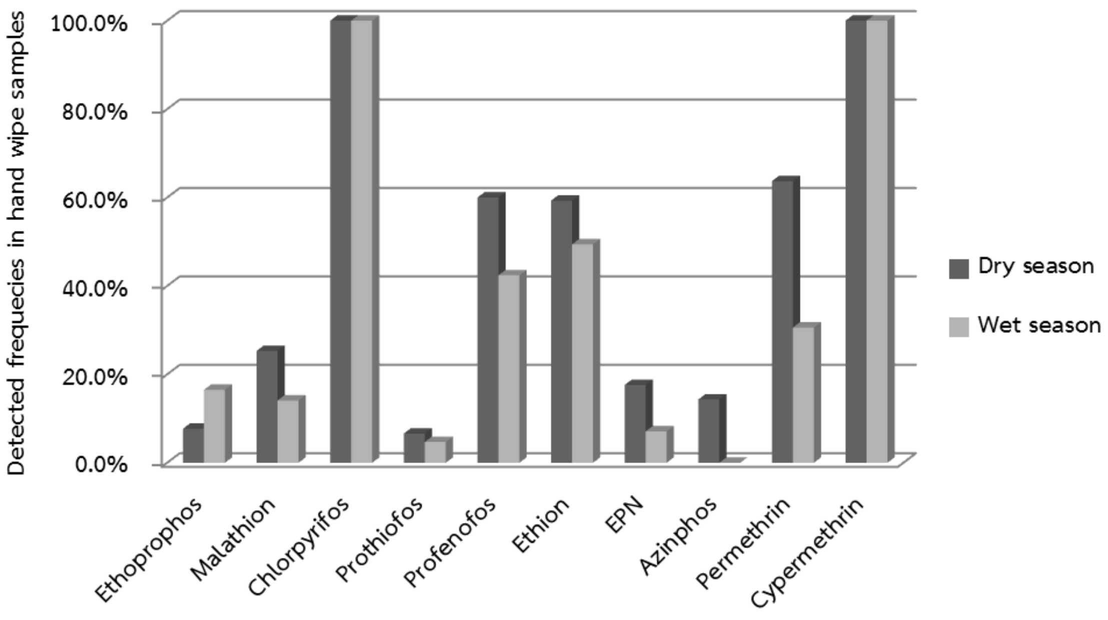


Figure 4.2 Detected frequencies of pesticide residues in hand wipe samples between dry and wet seasons

Table 4.13 Types of pesticide residues in hand wipe samples between dry and wet seasons

Type of PRs on hands	Dry season	Wet season
	N (%)	N (%)
OP group		
N	91	85
Low exposure	38 (41.8%)	22 (25.9%)
High exposure[1]	53 (58.2%)	63 (74.1%)
Mean ± SD	2.9 ± 1.4 types	2.3 ± 1.1 types
Min - Max	1 – 6 types	1 – 5 types
PY group		
N	91	85
Low exposure	33 (36.3%)	59 (69.4%)
High exposure[1]	58 (63.7%)	26 (30.6%)
Mean ± SD	1.6 ± 0.5 types	1.3 ± 0.5 types
Min - Max	1 – 2 types	1 – 2 types
CA group		
N	39	39
Low exposure	19 (48.7%)	39 (100.0%)
High exposure[1]	20 (51.3%)	0 (0.0%)
Mean ± SD	2.9 ± 1.5 types	0.1 ± 0.3 type
Min - Max	1 – 6 types	0 - 1 type
OP and PY groups		
N	91	85
Low exposure	47 (51.6%)	65 (76.5%)
High exposure[1]	44 (48.4%)	20 (23.5%)
Mean ± SD	4.6 ± 1.6 types	3.7 ± 1.2 types
Min - Max	2 – 8 types	2 – 7 types

[1] Type of pesticide residues on hands above mean of group

4.4.2 Comparison of pesticide residues on hands between dry and wet seasons

Comparison of pesticide residues in hand wipe samples between dry and wet seasons by Wilcoxon signed ranks test is shown in Table 4.14. Because pesticide residues of chlorpyrifos and cypermethrin were detected in all hand samples, they were used to compare amounts of pesticide residues on hands between two seasons. The analysis revealed that there were statistically significant differences in amounts of chlorpyrifos on hands and types of pesticide residues on hands between dry and wet season (p-value<0.05). Whereas, no significant difference in amount of cypermethrin on hands between dry and wet season was found.

Table 4.14 Comparison of pesticide residues on hands between dry and wet seasons by Wilcoxon signed ranks test

PRs on hands (N=85)	Dry season	Wet season	Mean differences	P-value
	Mean ± SD	Mean ± SD		
Amount of PRs on hands				
Chlorpyrifos	0.027 ± 0.020	0.025 ± 0.032	0.002 ± 0.031	0.012*
Cypermethrin	2.081 ± 2.077	2.311 ± 3.080	-0.231 ± 2.973	0.897
Type of PRs on hands				
OPs and PYs	4.6 ± 1.5	3.7 ± 1.2	1.0 ± 1.7	<0.001*

* Significance at the 0.05 level (2-tailed)

4.5 Blood Cholinesterase Level

4.5.1 Blood cholinesterase level in dry and wet seasons

In dry season, blood cholinesterase levels were tested among greengrocers during ambient temperature ranges from 25.0 to 33.0°C with mean of 29.5±2.0 °C. The results revealed that the average acetylcholinesterase (AChE) level among greengrocers was 3.35 ± 0.67 U/ml with a range of 1.33 - 5.19 U/ml. For haemoglobin adjusted AChE (HAChE), it was found the mean at 28.7 ± 4.2 U/g Hgb ranging from 13.8 to 44.5 U/g Hgb. Also, the average plasma cholinesterase (PChE) level of them was 2.06±0.48 U/ml with a range of 1.02 - 3.44 U/ml.

In wet season, blood cholinesterase levels were tested among greengrocers during ambient temperature ranges from 27.9 to 31.7°C with mean of 29.6 ± 0.7 °C. The results revealed that the average AChE level among greengrocers was 3.00 ± 0.57 U/ml with a range of 1.88 - 4.75 U/ml. The HAChE level was found the mean at 26.3 ± 3.33 U/g Hgb ranging from 19.8 to 36.6 U/g Hgb. Also, the average PChE level of them was 1.98 ± 0.49 U/ml with a range of 0.94 - 3.23 U/ml. Blood cholinesterase level among greengrocers in dry and wet seasons are shown in Table 4.15

Table 4.15 Blood cholinesterase level among greengrocers in dry and wet seasons

Cholinesterase (ChE)	Dry season	Wet season
	N (%)	N (%)
Acetylcholinesterase: AChE		
N	89	82
Normal	42 (47.2%)	23 (28.0%)
Abnormal[1]	47 (52.8%)	59 (72.0%)
Mean ± SD	3.35 ± 0.67 U/ml	3.00 ± 0.57 U/ml
Min - Max	1.33 - 5.19 U/ml	1.88 – 4.75 U/ml

Cholinesterase (ChE)	Dry season	Wet season
	N (%)	N (%)
Haemoglobin adjusted acetylcholinesterase: HAChE		
N	89	82
Normal	47 (52.8%)	18 (22.0%)
Abnormal[2]	42 (47.2%)	64 (78.0%)
Mean ± SD	28.7 ± 4.2 U/g Hgb	26.3 ± 3.3 U/g Hgb
Min - Max	13.8 - 44.5 U/g Hgb	19.8 – 36.6 U/g Hgb
Plasma cholinesterase: PChE		
N	89	82
Normal	42 (47.2%)	26 (31.7%)
Abnormal[3]	47 (52.8%)	56 (68.3%)
Mean ± SD	2.06 ± 0.48 U/ml	1.98 ± 0.49 U/ml
Min - Max	1.02- 3.44 U/ml	0.94 - 3.23 U/ml

[1] Value of AChE below mean (<3.35 U/ml)

[2] Value of HAChE below mean (<28.7 U/g Hgb)

[3] Value of PChE below mean (<2.06 U/ml)

4.5.2 Comparison of blood cholinesterase level between dry and wet seasons

The blood cholinesterase level of greengrocers between dry and wet seasons were compared by Wilcoxon Signed Ranks Test due to non-normally distributed data. The analysis revealed the statistically significant difference in blood cholinesterase level between two seasons. Among AChE, HAChE, and PChE levels in dry season were significantly higher than those in wet seasons (p-value<0.01). Comparison of blood cholinesterase level between dry and wet seasons by Wilcoxon signed ranks test are shown in Table 4.16.

Table 4.16 Comparison of blood cholinesterase level between dry and wet seasons by Wilcoxon signed ranks test

ChE (N=82)	Dry season	Wet season	Mean	P-value
	Mean ± SD	Mean ± SD	differences	
AChE (U/mL)	3.34 ± 0.68	3.00 ± 0.57	0.34 ± 0.41	<0.001*
HAChE (U/g Hgb)	28.4 ± 3.8	26.3 ± 3.3	2.1 ± 2.2	<0.001*
PChE (U/mL)	2.07 ± 0.49	1.98 ± 0.49	0.10 ± 0.27	0.001*

* Significance at 0.05 level (2-tailed)

4.6 Health Symptoms from Exposure to Pesticide Residues

4.6.1 Health symptoms in dry season and wet seasons

Reports of health symptoms from exposure to pesticide residues among greengrocers in dry season are shown in Table 4.17. Of 91 greengrocers completed data collection in dry seasons. It was reported that the most frequent symptoms in last month were skin rash/itching (54.9%), followed by fatigue/tiredness (47.3%), headache (30.8%), and eye irritation/blurred vision (29.7%), respectively. Similarly, the most frequent symptoms reported in last week were fatigue/tiredness (22.0%), followed by skin rash/itching (20.9%), eye irritation/blurred vision, headache and excessive sweating (9.9%), respectively. There were no reports of weakness in last week.

Reports of health symptoms from exposure to pesticide residues among greengrocers in wet season are shown in Table 4.18. Of 85 greengrocers completed data collection in wet seasons. It was reported that the most frequent symptoms in last month were fatigue/tiredness (31.8%), followed by eye irritation/blurred vision (27.1%), headache (22.4%), and muscle twitching or cramps (16.5%), respectively. Likely, the most frequent symptoms reported in last week were fatigue/tiredness and eye irritation/blurred vision (12.9%), followed by headache (7.1%). There were no reports of weakness and abdominal pain in last week. Reported health symptoms in last month and last week among greengrocers between dry and wet seasons are shown in Figure 4.3 and Figure 4.4, respectively.

Table 4.17 Reports of health symptoms from exposure to pesticide residues among greengrocers in dry season

Health symptoms (N=91)	Ever in the past month	Ever in the past week
	N (%)	N (%)
1. Skin irritation (skin rash/itching)	**50 (54.9%)**	**19 (20.9%)**
2. Eye irritation or blurred vision	**27 (29.7%)**	**9 (9.9%)**
3. Neuromuscular system	**59 (64.8%)**	**30 (33.0%)**
- Headache	28 (30.8%)	9 (9.9%)
- Dizziness	24 (26.4%)	4 (4.4%)
- Weakness	1 (1.1%)	0 (0.0%)
- Fatigue or tiredness	43 (47.3%)	20 (22.0%)
- Excessive salivation	3 (3.3%)	3 (3.3%)
- Excessive sweating	17 (18.7%)	9 (9.9%)
- Muscle twitching or cramps	18 (19.8%)	4 (4.4%)
4. Respiratory system	**14 (15.4%)**	**5 (5.5%)**
- Cough	10 (11.0%)	3 (3.3%)
- Breathlessness	10 (11.0%)	5 (5.5%)

Health symptoms (N=91)	Ever in the past month	Ever in the past week
	N (%)	N (%)
5. Digestive system	**19 (20.9%)**	**4 (4.4%)**
- Nausea	1 (1.1%)	1 (1.1%)
- Vomiting	1 (1.1%)	1 (1.1%)
- Diarrhea	15 (16.5%)	2 (2.2%)
- Abdominal pain	7 (7.7%)	1 (1.1%)
6. At least 1 symptom	**77 (84.6%)**	**45 (49.5%)**

Table 4.18 Reports of health symptoms from exposure to pesticide residues among greengrocers in wet season

Health symptoms (N=85)	Ever in the past month	Ever in the past week
	N (%)	N (%)
1. Skin irritation (skin rash/itching)	**13 (15.3%)**	**2 (2.4%)**
2. Eye irritation or blurred vision	**23 (27.1%)**	**11 (12.9%)**
3. Neuromuscular system	**43 (50.6%)**	**21 (24.7%)**
- Headache	19 (22.4%)	6 (7.1%)
- Dizziness	10 (11.8%)	1 (1.2%)
- Weakness	2 (2.4%)	0 (0.0%)
- Fatigue or tiredness	27 (31.8%)	11 (12.9%)
- Excessive salivation	2 (2.4%)	2 (2.4%)
- Excessive sweating	6 (7.1%)	4 (4.7%)
- Muscle twitching or cramps	14 (16.5%)	4 (4.7%)

Health symptoms (N=85)	Ever in the past month	Ever in the past week
	N (%)	N (%)
4. Respiratory system	**13 (15.3%)**	**7 (8.2%)**
- Cough	10 (11.8%)	4 (4.7%)
- Breathlessness	7 (8.2%)	5 (5.9%)
5. Digestive system	**15 (17.6%)**	**4 (4.7%)**
- Nausea	1 (1.2%)	1 (1.2%)
- Vomiting	1 (1.2%)	1 (1.2%)
- Diarrhea	7 (8.2%)	2 (2.4%)
- Abdominal pain	8 (9.4%)	0 (0.0%)
6. At least 1 symptom	**61 (71.8%)**	**32 (37.6%)**

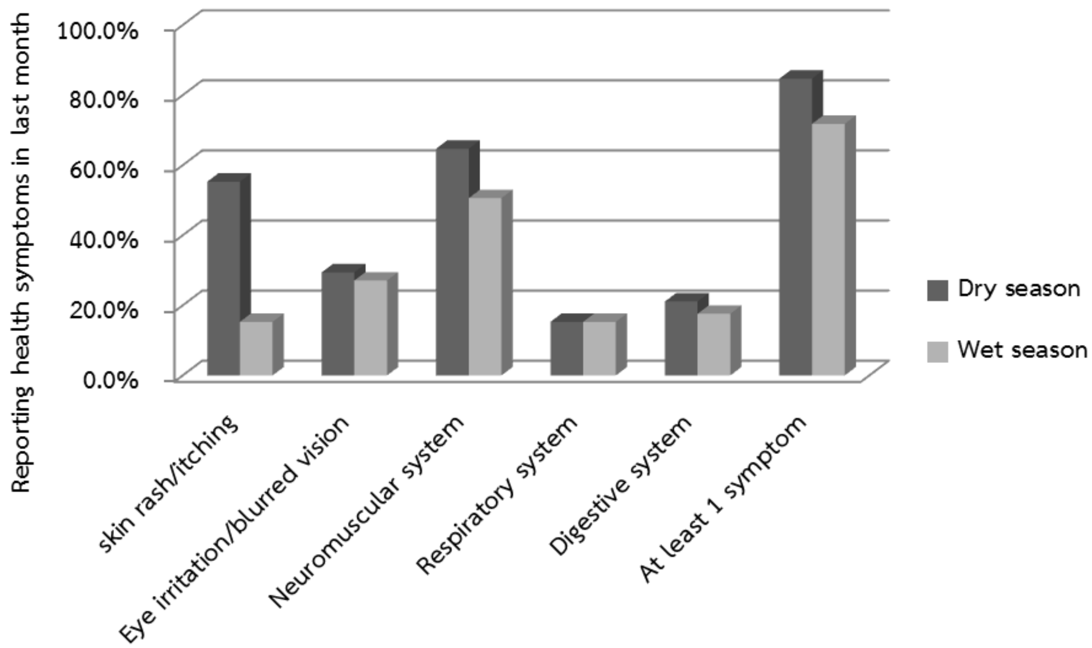


Figure 4.3 Reported health symptoms in last month among greengrocers between dry and wet seasons

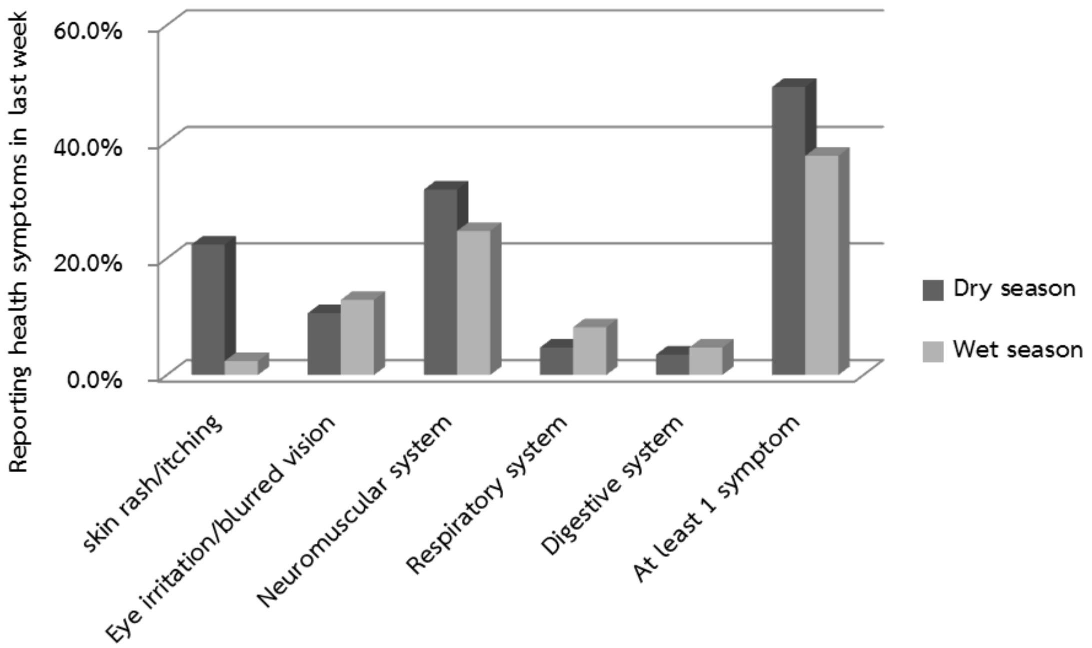


Figure 4.4 Reported health symptoms in last week among greengrocers between dry and wet seasons

4.6.2 Comparison of health symptoms between dry and wet seasons

Comparison of reported health symptoms in last month among greengrocers between dry and wet seasons by McNemar's chi-square test are shown in Table 4.19. Reporting health symptoms in last month, it was found that there were significant difference in proportion of skin irritation, dizziness, fatigue/tiredness, and excessive sweating between two seasons (p-value<0.05). The symptoms of neuromuscular system among greengrocers between dry and wet seasons significantly differed (p-value<0.05). Reporting health symptoms in last week, it was found that there was statistically significant difference in proportion of skin irritation between dry and wet season (p-value<0.001). Whereas, no significant differences in proportion of eye irritation or blurred vision, symptom of respiratory system, and symptom of digestive system in last month and last week between dry and wet seasons were found.

Table 4.19 Comparison of reported health symptoms among greengrocers between dry and wet seasons by McNemar's chi-square test

Health symptoms (N=85)	Dry season (%)	Wet season (%)	P-value
1. Skin irritation (skin rash/itching)			
1.1 In the last month	55.3%	15.3%	<0.001*
1.2 In the last week	22.4%	2.4%	<0.001*
2. Eye irritation or blurred vision			
2.1 In the last month	29.4%	27.1%	0.727
2.2 In the last week	10.6%	12.9%	0.625
3. Neuromuscular system			
3.1 In the last month	64.7%	50.6%	0.012*
- Headache	31.8%	22.4%	0.096
- Dizziness	25.9%	11.8%	0.004*
- Weakness	1.2%	2.4%	1.000
- Fatigue or tiredness	47.1%	31.8%	0.002*
- Excessive salivation	2.4%	2.4%	1.000
- Excessive sweating	17.6%	7.1%	0.012*
- Muscle twitching or cramps	18.8%	16.5%	0.500
3.2 In the last week	31.8%	24.7%	0.109
- Headache	9.4%	7.1%	0.500
- Dizziness	3.5%	1.2%	0.500
- Weakness	0%	0%	-[a]
- Fatigue or tiredness	20.0%	12.9%	0.070
- Excessive salivation	2.4%	2.4%	1.000

Health symptoms (N=85)	Dry season (%)	Wet season (%)	P-value
- Excessive sweating	8.2%	4.7%	0.375
- Muscle twitching or cramps	4.7%	4.7%	1.000
4. Respiratory system			
4.1 In the last month	15.3%	15.3%	1.000
- Cough	10.6%	11.8%	1.000
- Breathlessness	10.6%	8.2%	0.687
4.2 In the last week	4.7%	8.2%	0.375
- Cough	2.4%	4.7%	0.500
- Breathlessness	4.7%	5.9%	1.000
5. Digestive system			
5.1 In the last month	21.2%	17.6%	0.508
- Nausea	1.2%	1.2%	1.000
- Vomiting	1.2%	1.2%	1.000
- Diarrhea	16.5%	8.2%	0.065
- Abdominal pain	7.1%	9.4%	0.687
5.2 In the last week	3.5%	4.7%	1.000
- Nausea	1.2%	1.2%	1.000
- Vomiting	1.2%	1.2%	1.000
- Diarrhea	1.2%	2.4%	1.000
- Abdominal pain	0%	0%	-[a]
6. At least 1 symptom			
6.1 In the last month	84.7%	71.8%	0.003*
6.2 In the last week	49.4%	37.6%	0.013*

* Significance at the 0.05 level (2-tailed)

[a] No compute

4.6.3 Health symptoms from in-depth interview

The qualitative study by in-depth interview was conducted among 10 random greengrocers including 5 males and 5 females. The results from content analysis can be concluded as follows:

4.6.3.1 Effect or health symptoms from exposure to pesticide residues on vegetables

1) No health symptom

A few of participants never had any health symptoms from exposure to pesticide residues on vegetables in their opinions.

"I thought that I never had any health symptoms from exposure to pesticide residues, but I had headache due to hot working condition." A female participant stated.

2) Having health symptom after hours

A half of participants ever had symptoms from exposure to pesticide residues on vegetables after hours in their feelings, including neuromuscular system (fatigue/tireness, headache, dizziness, weakness, and tongue numbness), respiratory system (cough, running nose, and sore throat), and digestive system (nauseas, vomiting, diarrhea, and abdominal pain).

"I had symptoms comprised of headache, cough, running nose, and sore throat every 2-3 month, with reason unknown." A male participant said.

"I ever had many symptoms consisted of fatigue/tiredness, weakness, nauseas, vomiting, diarrhea after I ate fresh Chinese kale at restaurants. Also, I ever had tongue numbness immediately after I ate yard long beans without washing" A female participant who has highest experience in job said.

"I always had symptoms included fatigue/tiredness, dizziness, nauseas, vomiting, diarrhea, abdominal pain after I ate some fruits and vegetables." A male participant who has highest experience in job stated.

"I ever had tongue numbness immediately after I ate washed yard long beans." Male and female participants stated.

3) Having health symptom during working hours or at the end of shift

Most of participants ever had symptoms from exposure to pesticide residues on vegetables during their working or at the end of their shift, including dermatitis or skin irritation (skin rash/itching on hands, arms, and legs), and neuromuscular system (fatigue/tireness, and dizziness).

"I always had dizziness during my work hours when I smelled something from some vegetables." A female participant who has highest experience in job said.

"I ever had skin rash with itching, and peeling skin, especially my hands touched fresh vegetables." A female participant stated.

"I frequently had skin rash with itching on my hands, arms and legs. Also, I had fatigue but it may be from my heavy workload." A male participant said.

"I had skin rash on my arms once a week in hot season, and occasionally in rainy season with more itching." A Lao male participant who wore gloves said.

"I had skin rash with itching, unlike heat rash or sweat rash, especially on skin touched fresh vegetables." A female participant who wore gloves stated.

4.6.3.2 Way to prevent and treat the symptoms

1) Prevention

The way to prevent exposure to pesticide residues on vegetables among greengrocers included prevention via oral route (washing vegetables before eating and before cooking), and dermal route (improving behaviors such as hand washing and glove wearing).

"I always washed fruits and vegetables before eating and before cooking." Male and female participants who had nauseas, vomiting, and diarrhea stated.

"I wore gloves about 2-3 days per week." A female participant who had skin rash and peeling skin said.

"I changed new one of gloves during working, and washed my hands when I went to restroom." A female participant who had skin rash with itching stated.

2) Treatment

The way to treat health symptoms from exposure to pesticide residues on vegetables among greengrocers included self-treatment (using ORS oral rehydration/electrolyte powder, applying balm, calamine lotion, and body powder), taking/applying medicine purchased from the drug stores (oral antihistamines and drug for external use to cure itchy rash, cough medicine, and paracetamol), and taking/applying medicine from the dermatology clinic (oral antihistamines and drug for external use to cure skin rash).

"I applied balm and calamine lotion to relieve skin symptom." A male participant who had skin rash with itching said.

"I applied calamine lotion to cure itchy rash, and I went to the drug stores to purchase cough medicine and paracetamol to treat headache, cough, running nose, and sore throat." A male participant said.

"I went to the drug stores to purchase drug for external use." A female participant who had skin rash with itching, and peeling skin said.

"I went to see doctor at the dermatology clinic to treat skin irritation, and I got both oral antihistamines and drug for external use." A female participant who had itchy rash on skin touched fresh vegetables stated.

"I applied body powder and took oral antihistamines." A Lao male participant who had itchy rash stated.

4.6.3.3 Factors associated with health symptoms from exposure to pesticide residues on vegetables

1) Personal factors

Personal factors influenced health symptoms from exposure to pesticide residues on vegetables among greengrocers in their perception included individual susceptibility, personal hygiene practices (glove wearing, hand washing, arm washing, choosing vegetable for their cooking, and vegetable washing before eating), and eating out behaviour.

"I thought that Lao people were stronger than Thai people." A female participant stated.

"I thought that eating out behaviour may be associated with exposure to pesticide residues via oral route because of unclean vegetable washing before serving." A male participant stated.

"I thought that clean vegetable washing before cooking may reduce pesticide residues in contaminated vegetables." A few of participants said.

"I thought that hand washing and glove wearing may prevent symptoms from exposure to pesticide residues." Most of participants stated.

"I had skin rash if I did not wear gloves." A few of female participants said.

"I had no itchy rash on hands due to wearing gloves, but I had this symptom on my arms. So, arm washing may be a good practice." A Lao male participant said.

"I thought that choosing vegetable without pore or biting of insect worm for cooking may be highly exposed to pesticide residues." A female participant stated.

2) Work-related factors

Work-related factors influenced health symptoms from exposure to pesticide residues on vegetables among greengrocers in their perception included seasonal variation, workload or working condition, amount of all vegetables in shop, and types of different vegetables.

"I felt that the pesticide residues in vegetables were highest in hot season and pre-harvesting may be a contributing factor." A female participant said.

"I may be highly exposed to pesticide residues because of large amount of all vegetables in my shop." A male participant said.

"I thought that amount of all vegetables in my shop and seasonal variation may be related to skin irritation. Because I often had this symptom when I exposed to large amount of vegetables, and worked in hot season which highest pesticide residues" A male participant said.

"I felt that I had skin irritation in rainy season more than in hot season which not included sweat rash. It depended on amounts and types of different pesticide residues in vegetables. And I thought rainy season was highest residues." A female participant said.

"I had irritation both dry and wet seasons, and I thought that pesticides were frequently used in wet season due to raining and their dilution with water." A female participant said.

"I thought that characteristics of some vegetables had influence my skin irritation. For example, when I touched the fine hairs on the sheath of bamboo shoot or the petioles of turkey berry covered with short hairs, I had itch and allergic skin reaction." A male participant stated.

4.7 Factors Associated with Pesticide Residues on Hands, Blood Cholinesterase Level, and Health Symptoms

4.7.1 Factors associated with pesticide residues on hands

Factors associated with pesticide residues on hands by binary logistic regression are shown in Table 4.20. The results of the data analysis in dry season revealed a significant association between many factors, including glove wearing, types of vegetables and percentage of wet vegetables in the market, and the level of chlorpyrifos on hands among greengrocers after adjusting for gender (p-value<0.05). In addition, glove wearing and amount of handling vegetables were significantly related to the level of cypermethrin on the greengrocer's hands (p-value<0.05). Also, the frequency of hand washing, glove wearing, and duration of working per day were significantly associated with number of organophosphate and pyrethriod pesticides in the pesticide residue mixture found per sample (p-value<0.05).

Table 4.20 Factors associated with pesticide residues on hands by binary logistic regression

Factor (N=91)	B	S.E.	Wald	P-value	OR (95% CI)
Amount of chlorpyrifos (0 = ≤0.02 µg, 1 = >0.02 µg)					
Glove wearing[1]	-2.142	0.759	7.955	0.005*	0.177 (0.027, 0.520)
Vegetables ≤20 types	Ref.		4.543	0.103	
Vegetables 21-50 types	1.164	0.594	3.834	0.050*	3.202 (0.999, 10.266)
Vegetables >50 types	1.201	0.674	3.173	0.075	3.323 (0.886, 12.457)
Wet vegetables in shop[2]	-1.803	0.580	9.682	0.002*	0.165 (0.053, 0.513)
Amount of cypermethrin (0 = ≤1 µg, 1 = >1 µg)					
Glove wearing[1]	-1.730	0.680	6.463	0.011*	0.177 (0.047, 0.673)
Handling ≤100 kg.	Ref.		5.173	0.075	

Factor (N=91)	B	S.E.	Wald	P-value	OR (95% CI)
Handling 101-400 kg.	0.698	0.543	1.651	0.199	2.009 (0.693, 5.822)
Handling >400 kg.	2.471	1.132	4.762	0.029*	11.832 (1.286, 108.854)
Type of OPs and PYs on hands (0 = <5 types, 1 = ≥5 types)					
No hand washing	Ref.		9.463	0.009*	
Hand washing 1-3 times	-0.574	0.883	0.423	0.515	0.563 (0.100, 3.177)
Hand washing >3 times	-2.503	1.028	5.933	0.015*	0.082 (0.011, 0.613)
Glove wearing[1]	-2.746	0.904	9.223	0.002*	0.064 (0.011, 0.378)
Working hours per day[3]	1.697	0.619	7.519	0.006*	5.458 (1.623, 18.357)

Note: Adjusted for gender

* Significance at the 0.05 level (2-tailed)

[1] 0 = No or wore shortly, 1 = wore all time (1 or 2 hands)

[2] 0 = ≤20% wet vegetables, 1 = >20% wet vegetables

[3] 0 = ≤10 hours, 1 = >10 hours

4.7.2 Factors associated with blood cholinesterase level

Factors associated with blood cholinesterase level by multiple linear regression are shown in Table 4.21. The results of the data analysis in wet season adjusting for gender, nationality, age (years), and BMI (kg/m^2) revealed that scores of practice regarding exposure to pesticide residues was positively and significantly associated with acetylcholinesterase level among greengrocers (p-value<0.05). In addition, washing hands during working was positively related to haemoglobin adjusted acetylcholinesterase level (p-value<0.05). Besides, there was a negatively significant relationship between types of organophosphate pesticides on hands and plasma cholinesterase level (p-value<0.05).

Table 4.21 Factors associated with blood cholinesterase level by multiple linear regression

Factor (N=82)	B	S.E.	Beta	P-value	95% CI
AChE (U/ml)					
Practice (scores)	0.026	0.012	0.257	0.042*	0.001 - 0.050
HAChE (U/g Hgb)					
Washing hands during working[1]	2.550	1.255	0.229	0.046*	0.049 – 5.050
PChE (U/ml)					
OP pesticides on hands (types)	-0.095	0.047	-0.217	0.048*	-0.189 - 0.000

Note: Adjusted for gender, nationality, age (years), and BMI (kg/m^2)

* Significance at the 0.05 level (2-tailed)

[1] 0 = No, 1 = Yes

4.7.3 Factors associated with health symptoms

Factors associated with skin symptom by binary logistic regression are shown in Table 4.22. The results of the data analysis in dry season showed that percentage of wet vegetables in shop was marginally associated with skin symptom in last month. In addition, the score level of dermal practice was significantly related to eye symptom in the last week (p-value<0.05), whereas percentage of wet vegetables in shop was marginally associated.

Factors associated with eye symptom by binary logistic regression are shown in Table 4.23. The results of the data analysis in dry season adjusting for age group more than 50 years showed that types of vegetables in shop was significantly associated with eye symptom in last month (p-value<0.05). In addition, types of vegetables in shop and acetylcholinesterase level were significantly related to eye symptom in the last week (p-value<0.05).

Factors associated with neuromuscular symptom by binary logistic regression are shown in Table 4.24. The results of the data analysis in dry season showed that types of vegetables in shop and plasma cholinesterase level were significantly associated with neuromuscular symptom in last month (p-value<0.05). Also, types of vegetables in shop and acetylcholinesterase level were significantly related to neuromuscular symptoms in the last week (p-value<0.05).

Factors associated with respiratory symptom by binary logistic regression are shown in Table 4.25. The result of the data analysis in dry season adjusting for BMI (kg/m^2) showed that scores of practice regarding exposure to pesticide residues was significantly associated with respiratory symptom in last month (p-value<0.05).

Factors associated with digestive symptom by binary logistic regression are shown in Table 4.26. The result of the data analysis in dry season showed that plasma cholinesterase level was significantly associated with digestive symptom in last month (p-value<0.05).

Table 4.22 Factors associated with skin symptom by binary logistic regression

Factor (N=91)	B	S.E.	Wald	P-value	OR (95% CI)
Skin symptom in the last month (0=No, 1=Yes)					
Wet vegetables in shop[1]	0.928	0.490	3.582	0.058	2.528 (0.967, 6.607)
Skin symptom in the last week (0=No, 1=Yes)					
Wet vegetables in shop[1]	1.188	0.624	3.632	0.057	3.282 (0.967, 11.141)
Score of dermal practice[2]	-1.245	0.625	3.965	0.046*	0.288 (0.085, 0.981)

* Significance at the 0.05 level (2-tailed)

[1] 0 = ≤20% wet vegetables, 1 = >20% wet vegetables

[2] 0 = low score of dermal practice, 1 = high score of dermal practice

Table 4.23 Factors associated with eye symptom by binary logistic regression

Factor (N=89)	B	S.E.	Wald	P-value	OR (95% CI)
Eye symptom in the last month (0=No, 1=Yes)					
Vegetables ≤20 types			7.124	0.028*	
Vegetables 21-50 types	0.352	0.613	0.330	0.566	1.422 (0.427, 4.732)
Vegetables >50 types	1.669	0.677	6.076	0.014*	5.308 (1.408, 20.015)
Eye symptom in the last week (0=No, 1=Yes)					
Vegetables ≤20 types			7.421	0.024*	
Vegetables 21-50 types	-1.283	1.246	1.060	0.303	0.277 (0.024, 3.188)
Vegetables >50 types	2.003	1.034	3.753	0.053	7.412 (0.977, 56.236)
AChE (U/ml)	-2.024	0.839	5.820	0.016*	0.132 (0.026, 0.684)

Note: Adjusted for age group > 50 years

* Significance at the 0.05 level (2-tailed)

Table 4.24 Factors associated with neuromuscular symptom by binary logistic regression

Factor (N=89)	B	S.E.	Wald	P-value	OR (95% CI)
Neuromuscular symptom in the last month (0=No, 1=Yes)					
Vegetables ≤20 types			6.682	0.035*	
Vegetables 21-50 types	0.628	0.524	1.439	0.230	1.875 (0.671, 5.236)
Vegetables >50 types	1.948	0.755	6.662	0.010*	7.012 (1.598, 30.771)
PChE (U/ml)	-1.024	0.521	3.861	0.049*	0.359 (0.129, 0.997)
Neuromuscular symptom in the last week (0=No, 1=Yes)					
Vegetables ≤20 types			11.640	0.003*	
Vegetables 21-50 types	-0.358	0.594	0.363	0.547	0.699 (0.218, 2.240)
Vegetables >50 types	1.726	0.655	6.950	0.008*	5.617 (1.557, 20.264)
AChE (U/ml)	-0.898	0.424	4.479	0.034*	0.407 (0.177, 0.936)

* Significance at the 0.05 level (2-tailed)

Table 4.25 Factors associated with respiratory symptom by binary logistic regression

Factor (N=91)	B	S.E.	Wald	P-value	OR (95% CI)
Respiratory symptom in the last month (0=No, 1=Yes)					
Practice (scores)	-0.116	0.058	3.960	0.047*	0.890 (0.794, 0.998)

Note: Adjusted for BMI (kg/m^2)

* Significance at the 0.05 level (2-tailed)

Table 4.26 Factors associated with digestive symptom by binary logistic regression

Factor (N=89)	B	S.E.	Wald	P-value	OR (95% CI)
Digestive symptom in the last month (0=No, 1=Yes)					
PChE (U/ml)	-1.276	0.634	4.048	0.044*	0.279 (0.080, 0.968)

* Significance at the 0.05 level (2-tailed)

4.8 Health Risk Assessment

Values of variables for calculating average daily dose (ADD) are shown in Table 4.27. Because of the initial exposure information collected among greengrocers in this study, the 99th percentile values are extremely conservative which is likely to contribute significantly to the uncertainty in estimates selected to make a screening-level assessment. This is close to a worst-case or maximum exposed person assessment. If the overestimated value is low, it is not necessary to do a refined assessment (anticipated level) (US EPA, 1992; 2002a). The estimate revealed that exposure to profenofos residue was responsible for the highest potential dose (ADD = 9.93×10^{-6}) and the highest potential risk (HQ = 1.99×10^{-1}) of any individual pesticide. The conservative approach assumed additive toxicity for all pesticides in the sample without considering mode of action (common mechanism of toxicity) – performing a worst-case screening-level assessment (US EPA, 2002a). Exposure assessment showed the 99th percentile average daily dose for all pesticide residues of each greengrocer at 2.42×10^{-5} mg/kg-day. The health risk from exposure to 15 pesticide residues on vegetables through hand contact among greengrocers was acceptable (99th percentile HI = 0.287). Meanwhile, the reference dose values of 3 pesticides were not established by US EPA. Exposure to organophosphates and carbamates resulting in cholinesterase inhibition were grouped together to do a cumulative risk assessment. The 99th percentile average daily dose and hazard index for organophosphate and carbamate pesticides were 1.94 x 10^{-5} mg/kg-day and 0.287, respectively. This is not different from the worst-case estimate. Health risk assessment from exposure to pesticide residues on vegetables among greengrocers is presented in Table 4.28.

Table 4.27 Values of variables for calculating average daily dose (ADD)

Variable	Value
PR concentration	At 99th percentile level[a] (mg-event)
ABS	From US EPA
EV	1 event/day
ED	14.1 years (questionnaire)
EF	6.3 days/week x 52 weeks/year (days/year) (questionnaire)
SA	840 cm^2 (US EPA, 1997)
BW	64.6 kg (questionnaire)
AT	14.1 years x 365 days/year (days)

[a] At the 99th percentile of pesticide residue concentration were used due to variability of pesticide residue among participants in this study (US EPA, 1992)

Table 4.28 Health risk assessment from exposure to pesticide residues on vegetables among greengrocers

Pesticide residues	Dermal absorption (ABS)	ADD[a] (mg/kg-day)	HQ
OP group			
Ethoprophos	1.00 (US EPA, 2006b)	2.23×10^{-7}	2.23×10^{-3}
Malathion	0.10 (US EPA, 1999a)	9.60×10^{-8}	1.37×10^{-6}
Chlorpyrifos	0.03 (US EPA, 2002b)	5.68×10^{-8}	1.89×10^{-4}
Prothiofos	1.00[1]	1.39×10^{-7}	-[2]
Profenofos	0.50 (US EPA, 1999b)	9.93×10^{-6}	1.99×10^{-1}
Ethion	0.066 (US EPA, 1996)	2.72×10^{-7}	5.44×10^{-4}
EPN	1.00[1]	1.32×10^{-6}	1.32×10^{-1}
Guthion	0.42 (US EPA, 2001)	7.60×10^{-7}	5.10×10^{-4}
	$ADD_{OP}^{b} = 1.36 \times 10^{-5}$, $HI_{OP}^{b} = 2.86 \times 10^{-1}$		
PY group			
Permethrin	0.057 (EPA, 2009b)	6.87×10^{-6}	2.75×10^{-5}
Cypermethrin	0.025 (EPA, 2008)	4.05×10^{-6}	6.75×10^{-5}
	$ADD_{PY}^{b} = 5.65 \times 10^{-6}$, $HI_{PY}^{b} = 8.10 \times 10^{-5}$		
CA group			
Aldicarb	1.00 (US EPA, 1998a)	1.40×10^{-6}	1.41×10^{-3}
Oxamyl	1.00[1]	2.27×10^{-6}	2.27×10^{-3}
Methomyl	1.00[1]	5.70×10^{-7}	7.13×10^{-5}
Isoprocarb	1.00[1]	1.34×10^{-6}	-[2]
Carbaryl	0.127 (US EPA, 2007b)	5.48×10^{-8}	5.48×10^{-6}
Carbofuran	0.06 (US EPA, 2006a)	2.18×10^{-7}	3.63×10^{-3}
Fenobucarb	1.00[1]	4.02×10^{-6}	-[2]

Pesticide residues	Dermal absorption (ABS)	ADD[a] (mg/kg-day)	HQ
Methiocarb	1.00[1]	3.34×10^{-7}	6.68×10^{-5}
ADD_{CA}[b] = 5.71×10^{-6}, HI_{CA}[b] = 6.47×10^{-3}			
With considering mode of action; $ADD_{OP\&CA}$[b] = 1.94×10^{-5}, $HI_{OP\&CA}$[b] = 2.87×10^{-1}			
Without considering mode of action; ADD_{all}[b] = 2.42×10^{-5}, HI_{all}[b] = 2.87×10^{-1}			

[1] Default value of dermal absorption at 100% was assumed due to molecular weight <500 and/or log Pow between -1 and 4 (DG SANCO, 2004).

[2] No calculation due to no report of RfD by US EPA

[a] At 99th percentile values for each individual pesticide values

[b] At 99th percentile values by computing the values for each participant and taking the 99th percentile

CHAPTER V

DISCUSSION

5.1 General Information of Participants

Personal information among greengrocers revealed 29.7% of them with age more than 50 years. A half of them (54.9%) had an education of elementary school. Most of them (68.1%) reported no glove wearing during working. Only 29.3% of them washed their hands more than 3 times a working day; 18.7% washed their hands with soap or other detergents. These indicated that greengrocers had inadequate hygiene habits. For work-related information, most of greengrocers worked nearly every day with long period a day (more than 10 hours). They handled approximately 260 kg/day of produce, consisting of up to 35 types of vegetables, 20% of the commodities being wet. These indicated that working condition among greengrocers may be the potential factor influenced their health, and they may be at risk from occupational exposure to pesticide residues on vegetables.

5.2 Knowledge, Attitude, and Practice (KAP) Regarding Exposure to Pesticide Residues and Protection

Knowledge, attitude, and practice (KAP) regarding exposure to pesticide residues and protection, the majority of greengrocers had good knowledge and attitude levels, and moderate practice level. Most of them did not assure about routes of pesticide residue exposure like dermal contact. Risk behaviours such as eating fresh vegetables without washing and eating food without hand washing, may pose health effects due to directly exposure via oral route. Moreover, they had poor hygiene practices related to the dermal route, especially no wearing gloves. The significantly positive association between knowledge (K) and attitude (A), and between attitude (A) and practice (P) were observed. The greengrocers may be at risk from exposure pesticide residues on various vegetables via the dermal and oral routes with poor hygiene practices. The findings suggested that educated program regarding routes of occupational exposure to pesticide residues and prevention may be needed.

5.3 Pesticide Residues in Vegetables

The study showed that the vegetables from all shop contained pesticide residues including organophosphates (OP), carbamate (CA), and pyrethroids (PY), especially cypermethrin (PY), chlorpyrifos and prefenofos (OP). The findings are similar to many studies reported on contamination in market vegetables in Thailand. Pakvilai et al. (2015) revealed contamination at least one pyrethriod in all vegetable samples. Also, Sapbamrer and Hongsibsong (2014) revealed that chlorpyrifos was the dominant insecticide and found in combination with other insecticides. Besides, Wanwimolrak and colleagues (2015) found profenofos and cypermethrin at high concentration in Chinese kale samples from markets in central Thailand. Moreover, analysis of insecticide residues in vegetables in upper Northeastern Thailand revealed mainly chlorpyrifos and cypermethrin (Prasopsuk et al, 2014).

The detected frequencies of pesticide residues in vegetables in dry season were slightly higher than those in wet season. This is agreed with previous study investigated pesticide concentrations in vegetables of different season in India. It showed that the winter vegetables are most contaminated followed by summer and rainy vegetables (Bhanti & Taneja, 2007). Furthermore, the levels of pesticide depend on vegetables sources, and types (Sapbamrer and Hongsibsong, 2014). Some vegetable was produced seasonally. The findings indicated that seasonal variation had influence on the types and amount of pesticide residues in vegetables.

5.4 Pesticide Residues on Hands

Among greengrocers, like harvester, pesticide exposure occurs primarily due to hand contact with sprayed leaf surfaces (Krieger et al., 1990). Dermal exposure is determined by the transfer of pesticide residue from the surface of the foliage to the skin of them. Based on this study, greengrocers were exposed to a total of 18 pesticide residues at low levels through hand contact. All of them had at least 2 residues, chlorpyrifos (organophosphate insecticide) and cypermethrin (pyrethroid insecticide), whereas the detected residue with highest concentration for organophosphates in dry season was profenofos. This finding corresponds to the report of the highest quantity of insecticides imported into Thailand in 2014 and 2015, which showed the 1^{st} ranking of chlorpyrifos, and the 2^{nd} ranking of cypermethrin, and the 5^{th} ranking (in 2015) of profenofos (OAR, 2015, 2016). In addition, this is consistent with detected types of pesticide residues in vegetable samples in this market. Also, it is consistent with previous studies which monitored pesticide contamination in vegetables.

Sapbamrer and Hongsibsong (2014) who studied organophosphate insecticides in the eighteen types of market vegetables in Northern Thailand, revealed that chlorpyrifos was the dominant insecticide and found in combination with other insecticides. According to another study in Northern Thailand, Pakvilai and colleagues (2015) investigated pyrethroid insecticides in ten vegetable commodities from markets, and found contamination at least one pyrethroid in all samples. Moreover, analysis of insecticide residues in vegetables in the upper Northeast of Thailand revealed mainly chlorpyrifos and cypermethrin (Prasopsuk et al, 2014). Also, Wanwimolrak and colleagues (2015) analyzed the residues in Chinese kale samples from markets in central Thailand, and found profenofos and cypermethrin at high concentration.

The frequently detected residues on hands (more than 50% of all samples in dry season), aldicarb, carbofuran, permethrin, profenofos, and ethion, implies that these pesticides have been broadly used for vegetable growing. Moreover, many pesticide residues with high toxicity (category I) such as aldicarb, carbofuran, EPN, guthion (azinphos-methyl), and ethoprophos have been detected; these compounds are so toxic as to have been banned somewhere. These pesticides can penetrate the skin (Brouwer et al., 1992; Fenske and Lu, 1994) and this is of concern because it can pose health effects via dermal and oral routes.

The amounts of pesticide residues on hands were highly variable among greengrocers. This may be due to a variability of pesticide residues in vegetables. Each source of vegetables may use pesticides of different types and in different amounts (Sapbamrer and Hongsibsong, 2014). The amount removed by wiping only represents the amount which is accessible by the sampling method at the time of sampling (Brouwer et al., 2000). Due to hand wiping for only one time in each participant in this study, consecutive wipe sampling according to the fluctuation of a working day and day-to-day variation should be performed to measure changes over time in pesticide residues on the greengrocers' hands.

Comparison of pesticide residues in hand wipe samples found that percentage of detected frequencies in pesticides in wet season were likely to lower than those in dry season. This is consistent with detected frequencies of pesticide residues in market vegetable samples between two seasons. The analysis by Wilcoxon signed ranks test revealed that amounts of chlorpyrifos on hands and types of pesticide residues on hands in wet season significantly decreased when compared to those in dry season. Whereas, no significant difference in amount of cypermethrin on hands between dry and wet season was found. Besides, the highest concentration of profenofos on hands in wet season was likely to lower than in dry season, whereas highest concentration of cypermenthrin on hands in wet season was likely to higher than in dry season. These are possible that the water solubility of profenofos (28 mg/L) is higher than that of cypermethrin (0.004 mg/L) (Wanwimolrak et al., 2015). Seasonal variation may be a main factor influenced on pesticide residues in vegetables and on hands.

5.5 Blood Cholinesterase Level

The blood cholinesterase levels among greengrocers were found to be lowest in wet season. It revealed that the average acetylcholinesterase (AChE) level, haemoglobin adjusted AChE (HAChE), and plasma cholinesterase (PChE) of them were 3.00 ± 0.57 U/ml, 26.3 ± 3.33 U/g Hgb, and 1.98 ± 0.49 U/ml, respectively. The levels of the current study were lower than the levels of the previous study. Neupane et al. (2014) found that the mean of AChE and HAChE among 90 vegetable farmers in Nepal performed by the Test-mate cholinesterase kit were 3.35 U/ml and 28.92 U/g Hgb, respectively. While, the cholinesterase levels of the greengrocers were higher than those of rice farmers in Thailand. Pidgunpai et al. (2014) found that the average AChE level and PChE level of farmers was 2.9 ± 0.6 U/mL and 1.6 ± 0.3 U/mL, respectively. According to another study, they revealed acetylcholinesterase level caused by organophosphate pesticides at an average of 2.63 U/ml (Wilaiwan and Siriwong, 2014). However, the findings indicated that the greengrocers were exposed to pesticide residues on vegetables.

The analysis by Wilcoxon signed rank test revealed that levels of AChE, HAChE, and PChE among greengrocers in dry season were significantly higher than those in wet season (p-value<0.01). The findings are contrast to lower types of pesticide residues on their hands in wet season. The available data to support these findings is limited. There are 2 reasons which might be explained. First, raining with high humidity in wet season, it is possible that skin moisture increases absorption of pesticides (Meuling et al., 1997; Williams et al., 2005), and wetted vegetable may change forming pesticide residues. This is supported by previous data, demonstrating the transfer of chemical residue onto and subsequently through the skin depended on the physical attributes of the residue formed (Belsey et al., 2011). In addition, dermal exposure assesssment among strawberry harvester noted that morning dew may influence glove accumulation of pesticide residues since moisture enhanced the transferability of surface residues (Li et al., 2016). Another reason, the concentrations of detected pesticides fluctuated due to seasonal variation with a variability of pesticide residues in vegetables. This is supported by highest detected concentrations of chlorpyrifos, cypermethrin and aldicarb on hands in wet season. However, absorption of substances through the skin also depends on many factors, such as area of skin exposed, solubility in water, temperature and humidity, skin thickness, etc. (Semple, 2004), while some factors did not include in this study.

5.6 Health Symptoms from Exposure to Pesticide Residues

Reporting health symptoms from exposure to pesticide residues was found to be highest in dry season. It was reported that the most frequent symptoms in last month were skin rash/itching (54.9%), followed by fatigue/tiredness (47.3%), headache (30.8%), and eye irritation/blurred vision (29.7%), dizziness (26.4%), muscle twitching or cramps (19.8%), excessive sweating (18.7%), and diarrhea (16.5%). These are agreed with many studies. Lu (2009b) revealed that the most common symptoms from pesticide exposure among 211 vegetable farmers were headache (64.1%), muscle pain (61.1%), and cough (45.5%), respectively. The study of Neupane et al. (2014) found that the most often reported symptoms among vegetable farmers in the previous month were blurred vision (50%), extreme tiredness (47%), excessive sweating (43%), headache (40%), and muscle cramps (40%), respectively. Similarly, Ngowi et al. (2007) reported pesticide-related health symptoms among 61 small-scale vegetable farmers, consisting of skin problems (34%), dizziness (31%), headache (31%), and excessive sweating (31%), respectively. Likewise, Ntow et al. (2006) revealed that reported possible pesticide poisoning symptoms among 137 vegetable farmers were body weakness (36.7%), headache/dizziness (31.0%), and itching/irritation (7.8%), respectively. When the symptoms were classified by system, it was reported that the neuromuscular system (64.8%), skin system (54.9%), and eye system (29.7%) were most common symptoms. This is similar to the study of Thekathuek et al. (2014). They revealed that most common symptoms were central nervous system, visual system, and skin system. The findings indicated that occupational exposure to pesticide residues may pose health effects among greengrocers.

The skin irritation symptom reported among greengrocers between dry and wet seasons was significantly differed both in last month and last week. In neuromuscular system, the dizziness, fatigue/tiredness, and excessive sweating symptoms in last month between two seasons were significantly altered. The findings are contrast to lower blood cholinesterase level of greengrocers in wet season. This may be due to subjective symptoms. Besides, these health symptoms were non-specific for pesticide exposures (Lu, 2009b). Also, the working condition may have an impact on the findings, which is supported by qualitative study conducting in-depth interview. It was revealed having fatigue/tiredness and dizziness after eating food, having fatigue associated with heavy workload, and skin irritation symptom from heat rash or sweat rash in hot working condition. However, eye, respiratory and digestive symptoms between two seasons both in last month and last week, none were significantly differed.

5.7 Factors Associated with Pesticide Residues on Hands, Blood Cholinesterase Level, and Health Symptoms

Greengrocers' hands contained many kinds of insecticides; even if they wore latex gloves. This can be explained by penetration into the skin due to the fast breakthrough time of disposable gloves (Phalen et al., 2014). However, using gloves was a protective factor for exposure to pesticide residues in this study. It is consistent with previous data, in which gloves have been shown to reduce absorption of pesticides (Li et al., 2011; MacFarlane et al., 2013). The association between frequency of hand washing and number of pesticide residues on hands was observed because a portion of pesticide residues were removed by hand washing (Brouwer et al., 2000; Fenske and Lu, 1994). This indicated that greengrocers who wore a glove or gloves and/or washed their hands have a lower risk from pesticide residue exposure than those who did not. Findings also suggest that good personal hygiene practices reduced their exposure risk.

The regression analysis has shown the association between pesticide residues on hands and all work-related factors. Exposure with wet vegetables can reduce the amount of pesticide residues on hands. However, it may be a potential factor to a higher risk because wet vegetables may cause a potential hydration layer between skin and PRs (Belsey et al., 2011). Skin moisture is known to increase absorption of pesticides (Meuling et al., 1997; Williams et al., 2005). Accordingly, the influence of seasonal variations should be considered. Not surprisingly, the types of vegetables, amount of handling and touching of vegetables, and duration of working were positively related to the amounts of pesticide residues on hands. This is due to the fact that they increase more chances of exposure, especially vegetables containing pesticide mixtures (Harnpicharnchai et al., 2013; Pakvilai et al., 2015).

The low correlation with the standardized regression coefficient (Beta) range of -0.217 to 0.257 between blood cholinesterase level and personal hygiene practice, and organophosphate pesticides on hands by multiple linear regression analysis adjusting for gender, nationality, age (years), and BMI (kg/m^2) were presented. The results revealed that the each score of practice regarding exposure to pesticide residues could increase the acetylcholinesterase level of greengrocers about 0.026 U/ml (p-value<0.05). In addition, washing hands during their work in every working day, which associated with pesticide residues on hands, could increase the haemoglobin adjusted acetylcholinesterase level of greengrocers about 2.55 U/g Hgb (p-value<0.05). Besides, it was found that number of organophosphate pesticides on hands could decrease the plasma cholinesterase level of greengrocers about 0.095 U/ml (p-value<0.05). This is supported by study of Fenske and Lu, 1994, reported that the substantial amounts of insecticide can be absorbed through to the skin. This study indicated that pesticide exposure via hand contact may be a main route among greengrocers. The findings can imply that dermal exposure to pesticide residues on vegetables can affect blood cholinesterase level among greengrocers, whereas good personal hygiene practice can prevent them.

The association between health symptoms from exposure to pesticide residues on vegetables and many factors, including work-related factor, scores of practice regarding exposure to pesticide residues, and blood cholinesterase level by binary logistic regression analysis was found. The results revealed that the modeled odds of having skin irritation in last week were 0.288 times lower in the group of high dermal practice score than the group of low dermal practice score, and 3.282 times higher in the high wet vegetable exposure group than in the low wet vegetable exposure group. In addition, the modeled odds of having eye irritation/blurred vision in last week adjusting for age group more than 50 years, per unit increase in acetylcholinesterase level, were 0.132. Similarly, the modeled odds of having neuromuscular symptom in last month per unit increase in plasma cholinesterase level, were 0.359, and the modeled odds of having neuromuscular symptom in last week per unit increase in acetylcholinesterase level, were 0.407. This is similar to previous study, which found the significant association between central nervous system symptom and abnormal cholinesterase level among vegetable farmers (Thetkathuek et al., 2014). Besides, the modeled odds of having respiratory symptom in last month adjusting for BMI (kg/m^2), per unit increase in score of practice regarding exposure to pesticide residues, were 0.890. Also, the modeled odds of having digestive symptom in last month, per unit increase in plasma cholinesterase level, were 0.279. It is consistent with previous data, which found relationship between serum cholinesterase level and digestive, and neuromuscular symptoms among rice farmers (Markmee, Taneepanichskul, & Chapman, 2012). The findings indicated that greengrocer with poor hygiene practice more likely to have skin irritation and respiratory symptoms, and they with low blood cholinesterase level more likely to have neuromuscular and digestive symptoms.

The findings are consistent with data conducted by in-depth interview. In their perception, personal factors influenced health symptoms from exposure to pesticide residues on vegetables were individual susceptibility, personal hygiene practices (glove wearing, hand washing, arm washing, choosing vegetable for their cooking, and vegetable washing before eating), and eating out behaviour. Also, they explored work-related factors, including seasonal variation, workload or working condition, amount of all vegetables in shop, and types of different vegetables.

5.8 Health Risk Assessment

The 99^{th} percentile values of pesticide exposure, which are reflective of non-glove persons were chosen to do a screening-level assessment. Exposure to profenofos residue has been shown. The highest average daily dose (ADD = 9.93×10^{-6}), was the major contributor to health risks among greengrocers (HQ = 1.99×10^{-1}). Dermal exposures to low-levels may be a potential source of exposure, especially when doses from multiple pesticide residues were combined. Based on this study, the hazard index did not exceed the acceptable level (HI = 0.287). There is no concern for potential non-carcinogenic effects from hand exposure to multiple pesticides in greengrocers, therefore adverse health impacts are not expected. However, the greengrocers were dermally exposed to 28.7% of the reference dose according to US EPA. This value may be underestimated because reference doses of prothiofos, isoprocarb, and fenobucarb pesticides have not been established by US EPA, resulting in no evaluation of hazard quotient. Moreover, the current study investigated only 18 residues. This may not cover all pesticides used in growing domestic and imported vegetables. According to many reports of pesticide contamination in vegetables, organophosphate pesticides which are highly toxic (monocrotofos, dicrotophos, parathion-methyl, etc.) were found (Prasopsuk et al., 2014; Sapbamrer and Hongsibsong, 2014), and organochlorine pesticides banned in Thailand were reported to be found in vegetables imported from China; carrot, cauliflower, Chinese cabbage, and broccoli (Nantavitayaporn, 2012). Potential doses and risks from these pesticides should be determined in another study because they are also likely to be found on hands. Besides, this study only evaluated health risks related to hand exposure. Dermal exposure assessment from pesticide residues deposited on clothes and/or other body parts (especially body areas not covered by clothing such as arms, face, and feet) which can become in contact with contaminated vegetables should be investigated because it may be potential source of exposure. From these limitations of the study, it is strongly possible that the greengrocers might have a higher risk than this study evaluated. They probably are exposed to these same doses on a daily basis.

CHAPTER VI

CONCLUSIONS

6.1 Conclusion

This study aimed to assess the magnitude of health risk from occupational exposure to pesticide residues on vegetables among greengrocers in fresh market, Bangkok, Thailand. Data collection included face-to-face interview, hand wipe sampling, and blood cholinesterase level test in dry and wet seasons, and then in-depth interview. Of 91 vegetable vendors from 30 greengrocer's shops initially enrolled in the study. The findings could be concluded as follow:

1. The majority of greengrocers have good level of knowledge and attitude regarding exposure to pesticide residues and protection, and moderate level of practice regarding exposure to pesticide residues and protection. Overall, they were uncertain about other routes of pesticide exposure like dermal contact. Practices related to prevention from dermal exposure to pesticide residues were inadequate. Also, there were statistically and positively significant correlations between knowledge and attitude, attitude and practice. The increase of knowledge about pesticide residue exposure may improve attitude and behaviors of greengrocers.

2. The face-to-face interview with in-depth interview explored health symptoms from exposure to pesticide residues, including skin irritation, eye system, neuromuscular system, respiratory system, and digestive system. Reported most common symptoms were skin rash/itching, fatigue/tiredness, headache, and eye irritation/blurred vision, dizziness, muscle twitching or cramps, excessive sweating, diarrhea, etc. These symptoms may also be from working condition or workload, and pesticide residue exposure via oral route. Exposure to pesticide residues on vegetables may cause health effect among greengrocers.

3. The pesticide residues on hands were significantly associated with personal hygiene practices (glove wearing and hand washing), and work-related factors (exposure to wet vegetable, amount of handling vegetables, types of vegetables in shops, working hours/day) ($p<0.05$). The blood cholinesterase levels were significantly related to type of pesticide residues on hands, and scores of practice regarding exposure to pesticide residues and protection ($p<0.05$). Also, the reported health symptoms were significantly associated with personal hygiene practice, blood cholinesterase levels, and work-related factors ($p<0.05$). Occupational exposure to pesticide residues on various vegetables may pose acute and/or chronic effects via dermal and oral routes among greengrocers, while good personal hygiene practices may prevent and reduce the health effects from pesticide residue exposure.

4. The types of detected pesticide residues on greengrocers' hands between dry and wet seasons significantly differed ($p<0.001$). The average acetyl and plasma cholinesterase levels of greengrocers in dry season were significantly higher than those in wet season ($p<0.001$). The significant differences in reported health symptoms of skin system and neuromuscular system both past month and past week between dry and wet seasons were found ($p<0.05$). The season may influence exposure to pesticide residues on vegetables via skin contact by hands among greengrocers.

5. At 99^{th} percentile values of pesticide residue exposure, average daily dose (ADD) from dermal exposure was 2.42×10^{-5} mg/kg/day and hazard index did not exceed acceptable level (HI=0.287). There was no concern for potential non-carcinogenic effect. Based on this study, greengrocers may be not at risk from pesticide residues on vegetables and exposure via hands during their work.

6. A guideline for prevention and health risk reduction related to pesticide contamination in vegetables was developed from results of this study. It was an education material which can be implemented among greengrocers for risk

communication and informed regarding health effects of pesticide exposure. The ways to prevent and reduce the risk from exposure to pesticide residues via oral and dermal routes were considered. For oral route, the washing with water or soaking in solutions such as salt, sodium bicarbonate, potassium permanganate, vinegar, or other washing agents, is simplest way to reduce pesticide residues in vegetables, which also depend on types of pesticides. It includes choosing vegetables with pore or biting of insect worm for cooking, and prohibiting vegetable consumption without washing them during working. For dermal route, the wearing gloves all of the time with changing frequently new one, washing hands with soap or other detergents during working, before eating food, and after the end of shift, and taking a bath/shower after the end of shift to reduce potential dermal exposure were recommended.

This study was preliminarily assessed the health risk from occupational exposure to pesticide residues on vegetables through dermal route among greengrocers in fresh market, Bangkok, Thailand. The findings indicate that they were exposed to pesticide residues on various vegetables during their working. Hand exposure may be a main route among vegetable vendors. The pesticide residue exposure with poor hygiene practices may pose acute and chronic health effects, especially elderly people (vulnerable group) who may be more sensitive to pesticides. The health risk from the occupational exposure among greengrocers was marginally concerned. The findings suggest that risk communication should be done in this population to inform regarding potential health risks from occupational exposure, with guideline for prevention/reduction related to pesticides contaminated in vegetables which developed from results of this study, especially proper personal hygiene practice. Also, health surveillance and education programs for this population should be considered.

6.2 Limitation of the Study

1. For analysis of carbamate pesticides on hands performed by the Central Laboratory (Thailand) Co., Ltd, a number of participants were collected the wipe samples due to budget limitation. This might not be representative of this population. However, the number of them was selected by simple random sampling.

2. For interviewing the participants by the questionnaire, an error from reporting health symptoms related to exposure to pesticide residues could be occurred due to non-specific symptoms and subjective bias based on personal feelings. However, the study was strengthened by reporting the symptoms both in last month and last week, and conducting in-depth interview.

3. The study investigated seasonal factor (dry and wet season); however contributing factors such as ambient temperature and humidity in study area were not recorded.

6.3 Recommendation for Further Study

1. This study investigated only 18 pesticide residues. It may not cover all pesticides used in growing domestic and imported vegetables. The investigation of other substances is required.

2. This study evaluated health risk related hand exposure. Dermal exposure assessment from pesticide residues deposited on clothes and/or other body parts (especially body area uncovered by clothing such as arms, face, and feet) which can contact with contaminated vegetables should be investigated further because it may be potential source of exposure.

3. This study used blood cholinesterase level as biomarker which cannot specific exposure to different pesticides. Human biomonitoring such as urinary metabolites should be examined. It can clearly show the internal dose from exposure to pesticide residues.

4. This study collected hand wipe sample at the end of the shift. Consecutive wipe sampling according to the fluctuation of a working day and day-to-day variation should be performed to measure changes over time in pesticide residues on the greengrocers' hands.

REFERENCES

Anastassiades, M., Lehotay, S. J., Stajnbaher, D., & Schenck, F. J. (2003). Fast and easy multiresidue method employing acetonitrile extraction/partitioning and "dispersive solid-phase extraction" for the determination of pesticide residues in produce. *J AOAC Int, 86*(2), 412-431.

Bakirci, G. T., Yaman Acay, D. B., Bakirci, F., & Otles, S. (2014). Pesticide residues in fruits and vegetables from the Aegean region, Turkey. *Food Chem, 160*, 379-392. doi: 10.1016/j.foodchem.2014.02.051

Belsey, N. A., Cordery, S. F., Bunge, A. L., & Guy, R. H. (2011). Assessment of dermal exposure to pesticide residues during re-entry. *Environ Sci Technol, 45*(10), 4609-4615. doi: 10.1021/es200172q

Bhanti, M., & Taneja, A. (2007). Contamination of vegetables of different seasons with organophosphorous pesticides and related health risk assessment in northern India. *Chemosphere, 69*(1), 63-68. doi: 10.1016/j.chemosphere.2007.04.071

Bloom, B. S. (1976). *Human characteristics and school learning*. New York: McGraw-Hill.

Boguski, T. K. (2007). Human health risk assessment. *Environmental Science and Technology Briefs for Citizens*.

Brouwer, D. H., Boeniger, M. F., & van Hemmen, J. (2000). Hand wash and manual skin wipes. *Ann Occup Hyg, 44*(7), 501-510.

Chaigarun, S., & Nathapindhu, G. (2006). A Case Study of Pesticide Use Behavior of Farmers: Ban Bueng Khrai Nun, Bueng Nium sub-district, Muang district, Khon Kaen. *KKU Res J*, 139-148.

Covello, V. T. (2010). Risk communication. In H. Frumkin (Ed.), *Environmental Health: From Global to Local*. San Francisco: Jossey-Bass.

Curwin, B. D., Hein, M. J., Sanderson, W. T., Barr, D. B., Heederik, D., Reynolds, S. J., . . . Alavanja, M. C. (2005). Urinary and hand wipe pesticide levels among farmers and nonfarmers in Iowa. *J Expo Anal Environ Epidemiol, 15*(6), 500-508. doi: 10.1038/sj.jea.7500428

Dhananjayan, V., Ravichandran, B., Anitha, N., & Rajmohan, H. R. (2012). Assessment of acetylcholinesterase and butyrylcholinesterase activities in blood plasma of agriculture workers. *Indian J Occup Environ Med, 16*(3), 127-130. doi: 10.4103/0019-5278.111755

EQM Research Inc. (2003). Test-mate ChE Cholinesterase Test System (Model 400) Instruction Manual.

European Commission Health & Consumer Protection Directorate-General (DG SANCO). (2004). *Guidance Document on Dermal Absorption. Sanco/222/2000 rev.7*. Brussels, Belgium.

Fenske, R. A., & Lu, C. (1994). Determination of handwash removal efficiency: incomplete removal of the pesticide chlorpyrifos from skin by standard handwash techniques. *Am Ind Hyg Assoc J, 55*(5), 425-432. doi: 10.1080/15428119491018862

Food and Drug Administration. (2012, 9 August). Pesticide residues.

Harnpicharnchai, K., Chaiear, N., & Charerntanyarak, L. (2013). Residues of organophosphate pesticides used in vegetable cultivation in ambient air, surface water and soil in Bueng Niam Subdistrict, Khon Kaen, Thailand. *Southeast Asian J Trop Med Public Health, 44*(6), 1088-1097.

Hofmann, J. N., Carden, A., Fenske, R. A., Ruark, H. E., & Keifer, M. C. (2008). Evaluation of a clinic-based cholinesterase test kit for the Washington State Cholinesterase Monitoring Program. *Am J Ind Med, 51*(7), 532-538. doi: 10.1002/ajim.20588

Jaipieam, S., Visuthismajarn, P., Siriwong, W., Borjan, M., & Robson, M. G. (2009). Inhalation exposure of organophosphate pesticides by vegetable growers in the Bang-Rieng subdistrict in Thailand. *J Environ Public Health, 2009*, 452373. doi: 10.1155/2009/452373

Jurewicz, J., Hanke, W., Sobala, W., & Ligocka, D. (2009). Assessment of the dermal exposure to azoxystrobin among women tending cucumbers in selected Polish greenhouses after restricted entry intervals expired--the role of the protective gloves. *Int J Occup Med Environ Health, 22*(3), 261-267. doi: 10.2478/v10001-009-0026-3

Kamrin, M. A. (2000). *Pesticide profiles*. New York: CRC Press.

Krieger, R., Blewett, C., Edmiston, S., Fong, H., Gibbons, D., Meinders, D., . . . et al. (1990). Gauging pesticide exposure of handlers (mixer/loaders/applicators) and harvesters in California agriculture. *Med Lav, 81*(6), 474-479.

Krieger, R. I., & Dinoff, T. M. (2000). Captan fungicide exposures of strawberry harvesters using THPI as a urinary biomarker. *Arch Environ Contam Toxicol, 38*(3), 398-403.

Lappharat, S., Siriwong, W., Taneepanichskul, N., Borjan, M., Maldonado Perez, H., & Robson, M. (2014). Health risk assessment related to dermal exposure of chlorpyrifos: a case study of rice growing farmers in Nakhon Nayok Province, Central Thailand. *J Agromedicine, 19*(3), 294-302. doi: 10.1080/1059924X.2014.916643

Latif, Y., Sherazi, S. T., & Bhanger, M. I. (2011). Assessment of pesticide residues in commonly used vegetables in Hyderabad, Pakistan. *Ecotoxicol Environ Saf, 74*(8), 2299-2303. doi: 10.1016/j.ecoenv.2011.07.030

Li, Y., Chen, L., Chen, Z., Coehlo, J., Cui, L., Liu, Y., . . . Krieger, R. (2011). Glove accumulation of pesticide residues for strawberry harvester exposure assessment. *Bull Environ Contam Toxicol, 86*(6), 615-620. doi: 10.1007/s00128-011-0272-5

Lu, J. L. (2009a). Comparison of pesticide exposure and physical examination, neurological assessment, and laboratory findings between full-time and part-time vegetable farmers in the Philippines. *Environ Health Prev Med, 14*(6), 345-352. doi: 10.1007/s12199-009-0105-x

Lu, J. L. (2009b). Total pesticide exposure calculation among vegetable farmers in Benguet, Philippines. *J Environ Public Health, 2009*, 412054. doi: 10.1155/2009/412054

Lu, J. L. (2014). 0006 Effects of agricultural work practices and pesticide use on occupational health of farmers. *Occup Environ Med, 71 Suppl 1*, A56-57. doi: 10.1136/oemed-2014-102362.175

Markmee, P., Taneepanichskul, S., & Chapman, R. S. (2012). Insecticide use, protective behavior, serum cholinesterase levels, and health effects among rice farmers in Kongkrailat district, Sukhothai province, Thailand. *J Health Res, 26*, S67-S73.

Maroni, M., Fanetti, A. C., & Metruccio, F. (2006). Risk assessment and management of occupational exposure to pesticides in agriculture. *Med Lav, 97*(2), 430-437.

Ministry of Public Health. (2012, 4 December). Pesticide residues, *Thai News Agency*.

Nantavitayaporn, A. (2012). Study of the situation, regulation, and control measures of pesticide residues in the imported fresh fruits and vegetables. *FDA Journal, 19*(3), 36-45.

National Food Institute. (2013). Pesticide Residues: Results from the period 2004-2011. Denmark.

National Statistical Office. (2012). The informal employment survey 2012.

Neupane, D., Jors, E., & Brandt, L. (2014). Pesticide use, erythrocyte acetylcholinesterase level and self-reported acute intoxication symptoms among vegetable farmers in Nepal: a cross-sectional study. *Environ Health, 13*, 98. doi: 10.1186/1476-069X-13-98

Ngowi, A. V., Mbise, T. J., Ijani, A. S., London, L., & Ajayi, O. C. (2007). Pesticides use by smallholder farmers in vegetable production in Northern Tanzania. *Crop Prot, 26*(11), 1617-1624. doi: 10.1016/j.cropro.2007.01.008

Norkaew, S. (2012). *Pesticide exposure of family in chili farm community, Hua-rua Sub-district, Muang District, Ubonratchathani Province, Thailand.* (Doctoral Dissertation), Chulalongkorn University.

Ntow, W. J., Gijzen, H. J., Kelderman, P., & Drechsel, P. (2006). Farmer perceptions and pesticide use practices in vegetable production in Ghana. *Pest Manag Sci, 62*(4), 356-365. doi: 10.1002/ps.1178

Ntow, W. J., Tagoe, L. M., Drechsel, P., Kelderman, P., Nyarko, E., & Gijzen, H. J. (2009). Occupational exposure to pesticides: blood cholinesterase activity in a farming community in Ghana. *Arch Environ Contam Toxicol, 56*(3), 623-630. doi: 10.1007/s00244-007-9077-2

Office Agricultural Regulatory (OAR). (2016). Summary Report on Import of Hazardous Substances in 2015. Retrieved June 20, 2016, from http://www.doa.go.th/ard/FileUpload/hazzard/4.2/Top 10 Import of Hazardous (B.E. 2558).pdf

Office Agricultural Regulatory (OAR). (2015). Summary Report on Import of Hazardous Substances in 2014. Retrieved June 20, 2016, from http://www.doa.go.th/ard/FileUpload/StatisticsHazard Top57.pdf

Ong-artborirak, P., Siriwong, W., & Robson, M. G. (2014). *Occupational exposure and personal hygiene to prevent pesticide residues on vegetables among greengrocers in fresh market, Bangkok: a preliminary study*. Paper presented at the 14th International Conference of Public Health Sciences, Bangkok, Thailand.

Pakvilai, N., Prapamontol, T., Thavornyutikarn, P., Mangklabruks, A., Chantara, S., Hongsibsong, S., & Santasup, C. (2015). A Simple and Sensitive GC-ECD Method for Detecting Synthetic Pyrethroid Insecticide Residues in Vegetable and Fruit Samples. *Chiang Mai J. Sci., 42*(1), 196-207.

Phalen, R. N., Le, T., & Wong, W. K. (2014). Changes in chemical permeation of disposable latex, nitrile, and vinyl gloves exposed to simulated movement. *J Occup Environ Hyg, 11*(11), 716-721. doi: 10.1080/15459624.2014.908259

Pidgunpai, K., Keithmaleesatti, S., & Siriwong, W. (2014). Knowledge, attitude and practice associated with cholinesterase level in blood among rice farmers in Chainart province, Thailand. *J Health Res, 28*(2), 93-99.

Prasopsuk, J., Saisuphan, P., & Srisawangwong, W. (2014). Analysis of pesticide residues in vegetables and fruits for the certification of Good Agricultural Practice in upper Northeast Thailand. *Knon Kean Agr J, 42*, 430-439.

Ratner, D., Bar Sella, P., Schneeyour, A., Kardontchik, A., & Eshel, E. (1989). Seasonal variation in blood cholinesterase activity. *Isr J Med Sci, 25*(5), 247-250.

Robson, M. G., Hamilton, G. C., & Siriwong, W. (2010). Pest control and pesticides. In H. Frumkin (Ed.), *Environmental Health: From Global to Local*. San Francisco: Jossey-Bass.

Sapbamrer, R., & Hongsibsong, S. (2014). Organophosphorus pesticide residues in vegetables from farms, markets, and a supermarket around Kwan Phayao

Lake of Northern Thailand. *Arch Environ Contam Toxicol, 67*(1), 60-67. doi: 10.1007/s00244-014-0014-x

Semple, S. (2004). Dermal exposure to chemicals in the workplace: just how important is skin absorption? *Occup Environ Med, 61*(4), 376-382.

Shen, L., Xia, B., & Dai, X. (2013). Residues of persistent organic pollutants in frequently-consumed vegetables and assessment of human health risk based on consumption of vegetables in Huizhou, South China. *Chemosphere, 93*(10), 2254-2263. doi: 10.1016/j.chemosphere.2013.07.079

Siriwong, W., Thirakhupt, K., Sitticharoenchai, D., Rohitrattana, J., Thongkongowm, P., Borjan, M., & Robson, M. (2008). A Preliminary Human Health Risk Assessment of Organochlorine Pesticide Residues Associated with Aquatic Organisms from the Rangsit Agricultural Area, Central Thailand. *Human and Ecological Risk Assessment: An International Journal, 14*(5), 1086-1097. doi: 10.1080/10807030802387929

Soogarun, S., Wiwanitkit, V., & Suwansaksri, J. (2003). Report on blood cholinesterase among vegetable growers. *Southeast Asian J Trop Med Public Health, 34*(3), 687-689.

Syed, J. H., Alamdar, A., Mohammad, A., Ahad, K., Shabir, Z., Ahmed, H., . . . Eqani, S. A. (2014). Pesticide residues in fruits and vegetables from Pakistan: a review of the occurrence and associated human health risks. *Environ Sci Pollut Res Int, 21*(23), 13367-13393. doi: 10.1007/s11356-014-3117-z

Taneepanichskul, N. (2012). *The agricultural health surveillance of chili farmer exposure to pesticide: a case study of agricultural area, Hua-rua Sub-district, Muang District, Ubonratchathani Province, Thailand.* (Doctoral Dissertation), Chulalongkorn University.

Taneepanichskul, N., Norkaew, S., Siriwong, W., Siripattanakul-Ratpukdi, S., Maldonado Perez, H. L., & Robson, M. G. (2014). Organophosphate pesticide exposure and dialkyl phosphate urinary metabolites among chili farmers in northeastern Thailand. *Rocz Panstw Zakl Hig, 65*(4), 291-299.

Thetkathuek, A., Suybros, N., Daniell, W., Meepradit, P., & Jaidee, W. (2014). Factors influencing poisoning symptoms: a case study of vegetable farmers exposed to mixed insecticides in Prek Balatchheng Village, Cambodia. *J Agromedicine, 19*(4), 337-345. doi: 10.1080/1059924X.2014.950923

United States Environmental Protection Agency (US EPA). (1987). Integrated Risk Information System (IRIS): EPN. Retrieved September 20, 2014, from https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=236

United States Environmental Protection Agency (US EPA). (1992). *Guidelines for Exposure Assessment. EPA/600/Z-92/001*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (1994). *Reregistration Eligibility Decision (RED) Methiocarb. EPA-738-R-94-002*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (1996). *Third RfD/Peer Review Report of Ethion: Reassessment of the Reference Dose.* . Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (1998a). *Aldicarb - Report of Hazards Identification Assessment Review Committee*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (1998b). *Reregistration Eligibility Decision (RED) Methomyl. EPA 738-R-98-021*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (1999a). *Malathion: Preliminary Risk Assessment for the Reregistration Eligibility Decision (RED) Document*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (1999b). *Man Health Risk Assessment Profenofos*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2000). *Interim Reregistration Eligibility Decision (IRED) Oxamyl. EPA-738-R-00-015.* Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2001). *Interim Reregistration Eligibility Decision for Azinphos-Methyl*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2002a). *Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2002b). *Interim Reregistration Eligibility Decision for Chlorpyrifos. EPA-738-R-01-007*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2004). *"Supplemental Guidance for Dermal Risk Assessment," Part E of Risk Assessment Guidance for Superfund, Human Health Evaluation Manual (Volume I). EPA/540/R/99/005*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2006a). *Addendum to the 2001 Ethoprop Interim Reregistration Eligibility Decision (IRED). EPA-738-R-06-018*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2006b). *Interim Reregistration Eligibility Decision Carbofuran. EPA-738-R-06-031.* Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2007a). *Dermal Exposure Assessment: A Summary of EPA Approaches. EPA/600/R-07/040F*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2007b). *Reregistration Eligibility Decision for Carbaryl. EPA-738-R-07-018*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2008). *Reregistration Eligibility Decision for Cypermethrin. EPA OPP-2005-0293*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2009a). *Reregistration Eligibility Decision (RED) for Malathion. EPA-738-R-06-030*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2009b). *Reregistration Eligibility Decision (RED) for Permethrin. EPA 738-R-09-306*. Washington, DC, USA.

United States Environmental Protection Agency (US EPA). (2011a). *Exposure factors handbook*. Washington.

United States Environmental Protection Agency (US EPA). (2011b). Pesticide Residues in Food. Retrieved September 22, 2014, from http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewPDF&ch=48&lShowInd=0&subtop=312&lv=list.listByChapter&r=224028

United States Environmental Protection Agency (US EPA). (2014a). Assessing Health Risks from Pesticides. Retrieved April 12, 2014, from http://www.epa.gov/pesticides/factsheets/riskassess.htm

United States Environmental Protection Agency (US EPA). (2014b). Types of pesticides. Retrieved September 20, 2014, from http://www.epa.gov/pesticides/about/types.htm

Wanwimolruk, S., Kanchanamayoon, O., Phopin, K., & Prachayasittikul, V. (2015). Food safety in Thailand 2: Pesticide residues found in Chinese kale (Brassica oleracea), a commonly consumed vegetable in Asian countries. *Sci Total Environ, 532*, 447-455. doi: 10.1016/j.scitotenv.2015.04.114

Wilaiwan, W., & Siriwong, W. (2014). Assessment of health effects related to organophosphate pesticides exposure using blood cholinesterase activity as a biomarker in agricultural area at Nakhon Nayok province, Thailand. *J Health Res, 28*(1), 23-30.

Williams, R. L., Reifenrath, W. G., & Krieger, R. I. (2005). Artificial sweat enhances dermal transfer of chlorpyrifos from treated nylon carpet fibers. *J Environ Sci Health B, 40*(4), 535-543. doi: 10.1081/PFC-200061525

World Health Organization (WHO). (2010). *The WHO recommended classification of pesticides by hazard and guidelines to classification: 2009*. Geneva: WHO Press.

Zendzian, R. P. (2003). Pesticide residue on/in the washed skin and its potential contribution to dermal toxicity. *J Appl Toxicol, 23*(2), 121-136. doi: 10.1002/jat.900

APPENDIX

APPENDIX A

QUESTIONNAIRE

(English version)

Questionnaire

Research Title "Determination of Occupational Risk and Exposure to Pesticide Residues on Vegetables among Greengrocers in Fresh Market, Bangkok, Thailand"

Description:

1. This questionnaire is used by face-to-face interview among greengrocers.
2. The questionnaire is divided into 3 parts as follows:

Part 1: General information (20 items)

Part 2: Knowledge, attitude, and practice (KAP) regarding exposure to pesticide residues and protection (30 items)

It is separated into 3 sections consisting knowledge (K), attitude (A), and practice (P) regarding exposure to pesticide residues and protection. Each section contains 10 items.

Part 3: Health symptoms from exposure to pesticide residues on vegetables (15 items)

ID number.....................

Part 1: General information

Instruction: Please mark (✓) in ☐ or fill in the blank (...)

1) Gender

☐ Male ☐ Female

2) Age..years

3) Nationality

☐ Thai ☐ Lao

4) Height ....cm. Weight ....kg.

5) Education level..

6) Work experience in current job............................years

7) Do you have another job?

☐ No ☐ Yes (please specify)..

8) Do you have any health problems diagnosed by physician?

☐ No ☐ Yes (please specify)..

9) Do you smoke?

☐ No ☐ Yes ....cigarettes per day

10) Do you drink alcohol?

☐ No (including less than once a month)

☐ Sometimes (≤ 2 times per week)

☐ Always (≥ 3 times per week)

Type.. Amount...

11) Do you wear gloves during working?

☐ No (including less than once a month)

☐ Sometimes (≤ 2 times per week) Type of gloves ....

☐ Always (≥ 3 times per week) Type of gloves ....

- ☐ One hand by wearing all time
- ☐ Both hands by wearing all time
- ☐ One hand by wearing half of working time in a day
- ☐ Both hands by wearing half of working time in a day
- ☐ One hand by wearing short time
- ☐ Both hands by wearing short time

12) Hand washing during working

☐ No

☐ Yes ....times

- ☐ Only water - ☐ With soap
- ☐ Other (please specify)..

13) Amount of eating fruits and vegetables daily

☐ Small amounts ☐ Moderate amounts ☐ Large amounts

14) Working day............................per week

15) Working hours ....per day

16) Number of greengrocer in shop...............................persons

17) Average weight of all vegetables in shop per week.........................kg.

18) Amount of handling vegetables without protective materials....................kg. per day

19) Types of vegetables in shop..........................types

Please specify...

....

20) Types of wet vegetable in shop.............................types

Part 2: Knowledge, attitude, and practice (KAP) regarding exposure to pesticide residues and protection

Knowledge (K) regarding exposure to pesticide residues and protection

Instruction: Please mark (✓) in the blank corresponding to your knowledge.

Item	Knowledge	No	Yes	Unsure
1.	Most vegetables are contaminated with pesticide residues.			
2.	Pesticide residues on vegetables have not any effect on human body.			
3.	Pesticide residues on vegetables can pass through the body only ingestion route.			
4.	Each vegetable may be contaminated with several pesticides.			
5.	There are no pesticide residues in vegetables imported from other countries.			
6.	Some pesticide contaminated in vegetables can degrade when they are exposed to heat.			
7.	Using gloves can prevent pesticide residues through the skin.			
8.	Pesticide residues not only are on surface of vegetable but also are in texture of vegetable.			
9.	Pesticide residues on vegetables cannot enter the body by inhalation route.			
10.	Correct cleaning or washing vegetables and hands before consumption can reduce pesticide residues entered the body.			

Attitude (A) regarding exposure to pesticide residues and protection

Instruction: Please mark (✓) in the blank corresponding to your attitude. Choose only one answer for each item.

Item	Attitude	Degree				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1.	I think that pesticide residues on vegetables may not acutely affect health but it can be accumulated in body.					
2.	I think that I can eat vegetables without washing if I have good health.					
3.	I think that eating vegetables in season can get lower pesticide residues.					
4.	I think that clean washing vegetables before eating can diminish effect of pesticide residues on vegetables.					
5.	I think that eating with unwashed hands during working can directly get pesticide residues.					
6.	I think that pesticide residues on vegetables get into body not only through ingestion route but also through dermal contact with handling vegetables contaminated pesticides.					

Item	Attitude	Degree				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
7.	I think that wearing gloves during working are not comfortable although it may reduce exposure to pesticide residues on vegetables.					
8.	I think that frequently hand washing during working can diminish amount of pesticide residues on vegetables pass through the body					
9.	I think that hand washing with soap is better than hand washing with only water, for removing pesticide residues on hands.					
10.	I think that hand washing and bath after finishing work can reduce pesticide residues pass through body due to their contamination on clothes and body.					

Practice (P) regarding exposure to pesticide residues and protection

Instruction: Please mark (✓) in the blank corresponding to your practice. Choose only one answer for each item.

Each degree is classified by frequency of doing activities as follows:

Hardly ever

- For Item 1-6, less than 2 from 10 working days
- For Item 7, less than 2 from 10 times of hand washing during working
- For Item 8, less than 2 from 10 days
- For Item 9-10, less than 2 from 10 times of own cooking

Occasionally

- For Item 1-6, between 2 and 3 from 10 working days
- For Item 7, between 2 and 3 from 10 times of hand washing during working
- For Item 8, between 2 and 3 from 10 days
- For Item 9-10, between 2 and 3 from 10 times of own cooking

Sometimes

- For Item 1-6, between 4 and 6 from 10 working days
- For Item 7, between 4 and 6 from 10 times of hand washing during working
- For Item 8, between 4 and 6 from 10 days
- For Item 9-10, between 4 and 6 from 10 times of own cooking

Frequently

- For Item 1-6, between 7 and 8 from 10 working days
- For Item 7, between 7 and 8 from 10 times of hand washing during working
- For Item 8, between 7 and 8 from 10 days
- For Item 9-10, between 7 and 8 from 10 times of own cooking

Always

- For Item 1-6, more than 8 from 10 working days
- For Item 7, more than 8 from 10 times of hand washing during working
- For Item 8, more than 8 from 10 days
- For Item 9-10, more than 8 from 10 times of own cooking

Item	Practice	Degree				
		Hardly ever	Occasionally	Sometimes	Frequently	Always
1.	You eat food without hand washing during working hours.					
2.	You wear gloves during working.					
3.	You eat vegetables in your shop without washing them during working.					
4.	You wash your hands with clean water during working hours.					
5.	You wash your hand after finishing your work.					
6.	You take a bath/shower after finishing your work or when you return your home.					
7.	When you wash your hand during working hours, you wash with soap or other detergents.					
8.	You eat vegetables without washing them during stay at home.					
9.	You choose well-shaped vegetables, without pore or biting of insect worm for your own cooking.					
10.	You wash vegetables with running water, salt, potassium permanganate, vinegar, limewater, water from washing rice, sodium bicarbonate, or washing agents					

Part 3: Health symptoms from exposure to pesticide residues on vegetables

Symptoms	In the last month		In the last week	
	No	Yes	No	Yes
1. Skin irritation (skin rash/itching)				
2. Eye irritation or blurred vision				
3. Headache				
4. Dizziness				
5. Weakness				
6. Fatigue or tiredness				
7. Cough				
8. Breathlessness				
9. Nausea				
10. Vomiting				
11. Diarrhea				
12. Abdominal pain				
13. Excessive salivation				
14. Excessive sweating				
15. Muscle twitching or cramps				

APPENDIX A

QUESTIONNAIRE

(Thai version)

แบบสัมภาษณ์

งานวิจัยเรื่อง “ความเสี่ยงจากการประกอบอาชีพและการสัมผัสสารกำจัดศัตรูพืชที่ตกค้างบนผักของกลุ่มพ่อค้าแม่ค้าผักในตลาดสด กรุงเทพมหานคร ประเทศไทย”

คำชี้แจง:

1. แบบสัมภาษณ์นี้ใช้โดยการสัมภาษณ์ในกลุ่มพ่อค้าแม่ค้าผัก
2. แบบสัมภาษณ์แบ่งเป็น 3 ส่วน ดังนี้

ส่วนที่ 1: ข้อมูลทั่วไป (20 ข้อ)

ส่วนที่ 2: ความรู้ ทัศนคติ และการปฏิบัติตนเกี่ยวกับการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักและการป้องกัน (30 ข้อ)

แบบสัมภาษณ์ส่วนนี้แบ่งเป็น 3 ส่วนย่อย ประกอบด้วย ความรู้ ทัศนคติ และการปฏิบัติตนเกี่ยวกับการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักและการป้องกัน แต่ละส่วนย่อยมีคำถาม 10 ข้อ

ส่วนที่ 3: อาการทางสุขภาพจากการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผัก (15 ข้อ)

เลขรหัส....................

ส่วนที่ 1: ข้อมูลทั่วไป

คำแนะนำ: โปรดทำเครื่องหมาย (✓) ใน ☐ หรือ เติมคำในช่องว่าง (...)

1) เพศ

☐ ชาย ☐ หญิง

2) อายุ...ปี

3) สัญชาติ

☐ ไทย ☐ ลาว

4) ส่วนสูง ....ซม. น้ำหนัก ....กก.

5) ระดับการศึกษา..

6) ประสบการณ์การทำงานในงานปัจจุบัน........................ปี

7) คุณมีงานอื่นนอกเหนือจากงานประจำหรือไม่

☐ ไม่มี ☐ มี (โปรดระบุ)...

8) คุณมีปัญหาสุขภาพที่ได้รับการวินิจฉัยโดยแพทย์หรือไม่

☐ ไม่มี ☐ มี (โปรดระบุ)...

9) คุณสูบบุหรี่หรือไม่

☐ ไม่สูบ ☐ สูบ ....มวนต่อวัน

10) คุณดื่มแอลกอฮอล์หรือไม่

☐ ไม่ดื่ม (รวมถึงดื่มน้อยกว่าเดือนละครั้ง)

☐ ดื่มเป็นบางครั้ง (≤ 2 ครั้งต่อสัปดาห์)

☐ ดื่มเป็นประจำ (≥ 3 ครั้งต่อสัปดาห์)

ชนิด... ปริมาณ..

11) คุณสวมใส่ถุงมือระหว่างการทำงานหรือไม่?

☐ ไม่ใส่ (รวมถึงใส่น้อยกว่าเดือนละครั้ง)

☐ ใส่เป็นบางครั้ง (≤ 2 ครั้งต่อสัปดาห์) ชนิดของถุงมือ......................................

☐ ใส่เป็นประจำ (≥ 3 ครั้งต่อสัปดาห์) ชนิดของถุงมือ......................................

- ☐ สวมใส่มือหนึ่งข้างตลอดเวลาการทำงาน
- ☐ สวมใส่มือทั้งสองข้างตลอดเวลาการทำงาน
- ☐ สวมใส่มือหนึ่งข้างเป็นระยะเวลาครึ่งหนึ่งของการทำงาน
- ☐ สวมใส่มือทั้งสองข้างเป็นระยะเวลาครึ่งหนึ่งของการทำงาน
- ☐ สวมใส่มือหนึ่งข้างเป็นระยะเวลาสั้นๆ
- ☐ สวมใส่มือทั้งสองข้างเป็นระยะเวลาสั้นๆ

12) การล้างมือระหว่างการทำงาน

☐ ไม่ล้าง

☐ ล้าง ....ครั้ง

- ☐ ล้างด้วยน้ำเปล่า - ☐ ล้างร่วมกับสบู่
- ☐ อื่นๆ (โปรดระบุ)..

13) ปริมาณการรับประทานผักและผลไม้ในแต่ละวัน

☐ ปริมาณน้อย ☐ ปริมาณกลางๆ ☐ ปริมาณมาก

14) จำนวนวันทำงาน..........................ต่อสัปดาห์

15) จำนวนชั่วโมงทำงาน ....ต่อวัน

16) จำนวนของคนขายผักในร้าน................................คน

17) น้ำหนักของผักทั้งหมดในร้านเฉลี่ยต่อสัปดาห์....................................กก.

18) การสัมผัสผักที่ไม่มีวัสดุห่อหุ้ม....................................กก. ต่อวัน

19) ชนิดของผักทั้งหมดในร้าน............................ชนิด

โปรดระบุ..

....

20) ชนิดของผักที่ชุ่มด้วยน้ำในร้าน...........................ชนิด

ส่วนที่ 2: ความรู้ ทัศนคติ และการปฏิบัติตนเกี่ยวกับการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักและการป้องกัน

ความรู้เกี่ยวกับการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักและการป้องกัน

คำแนะนำ: โปรดทำเครื่องหมาย (✓) ในช่องที่ท่านคิดว่าถูกต้อง

ข้อ	ความรู้	ไม่ใช่	ใช่	ไม่แน่ใจ
1.	ผักหลายชนิดปนเปื้อนด้วยสารเคมีกำจัดศัตรูพืช			
2.	สารเคมีกำจัดศัตรูพืชที่ตกค้างในผักไม่มีผลกระทบต่อสุขภาพ			
3.	สารเคมีกำจัดศัตรูพืชที่ตกค้างในผักเข้าสู่ร่างกายได้จากการรับประทานผักเท่านั้น			
4.	ผักหนึ่งชนิดอาจจะปนเปื้อนด้วยสารเคมีกำจัดศัตรูพืชหลายชนิด			
5.	ผักที่นำเข้าจากต่างประเทศไม่มีสารเคมีกำจัดศัตรูพืชตกค้าง			
6.	สารเคมีกำจัดศัตรูพืชบางชนิดที่ตกค้างในผักสามารถลดปริมาณลงได้เมื่อถูกความร้อน			
7.	การใช้ถุงมือสามารถป้องกันการดูดซึมสารเคมีกำจัดศัตรูพืชที่เข้าสู่ผิวหนัง			
8.	นอกจากสารเคมีกำจัดศัตรูพืชจะตกค้างบนผิวผักแล้วยังอาจจะตกค้างในเนื้อผักด้วย			
9.	สารเคมีกำจัดศัตรูพืชที่ตกค้างในผักไม่สามารถเข้าสู่ร่างกายผ่านทางการหายใจได้			
10.	การทำความสะอาดหรือการล้างผักและมืออย่างถูกต้องก่อนการบริโภคสามารถลดสารเคมีกำจัดศัตรูพืชตกค้างในผักที่เข้าสู่ร่างกายได้			

<u>ทัศนคติเกี่ยวกับการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักและการป้องกัน</u>

คำแนะนำ: โปรดทำเครื่องหมาย (✓) ในช่องที่ตรงกับทัศนคติของท่าน โดยเลือกเพียงหนึ่งคำตอบในแต่ละข้อคำถาม

ข้อ	ทัศนคติ	ระดับ				
		ไม่เห็นด้วยอย่างยิ่ง	ไม่เห็นด้วย	ไม่แน่ใจ	เห็นด้วย	เห็นด้วยอย่างยิ่ง
1.	ฉันคิดว่าสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักอาจจะไม่มีผลกระทบต่อสุขภาพอย่างทันที แต่อาจจะสะสมในร่างกายจนก่อให้เกิดอันตรายได้					
2.	ฉันคิดว่าฉันสามารถรับประทานผักโดยไม่ล้างได้หากฉันยังมีสุขภาพดี					
3.	ฉันคิดว่าการเลือกรับประทานผักตามฤดูกาลทำให้ได้รับสารเคมีกำจัดศัตรูพืชตกค้างในผักน้อยลง					
4.	ฉันคิดว่าการล้างผักให้สะอาดก่อนรับประทานจะช่วยลดอันตรายจากสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักได้					
5.	ฉันคิดว่าการไม่ล้างมือก่อนการรับประทานอาหารในระหว่างการทำงานอาจทำให้ได้รับสารเคมีกำจัดศัตรูพืชตกค้างทางอ้อม					
6.	ฉันคิดว่านอกจากสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักจะเข้าสู่ร่างกายเมื่อรับประทานผักแล้ว ยังสามารถเข้าสู่ร่างกายเมื่อหยิบจับผักที่มีการปนเปื้อนของสารเคมีกำจัดศัตรูพืช					
7.	ฉันคิดว่าการสวมใส่ถุงมือในระหว่างการทำงานทำให้หยิบจับสิ่งของไม่สะดวก แม้ว่ามันอาจจะลดการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผัก					

ข้อ	ทัศนคติ	ระดับ				
		ไม่เห็นด้วยอย่างยิ่ง	ไม่เห็นด้วย	ไม่แน่ใจ	เห็นด้วย	เห็นด้วยอย่างยิ่ง
8.	ฉันคิดว่าการล้างมือบ่อยๆ ในระหว่างการทำงานจะช่วยลดปริมาณสารเคมีกำจัดศัตรูพืชตกค้างในผักที่เข้าสู่ร่างกายได้					
9.	ฉันคิดว่าการล้างมือด้วยสบู่มีประสิทธิภาพในการกำจัดสารเคมีกำจัดศัตรูพืชที่ตกค้างได้ดีกว่าการล้างมือด้วยน้ำเพียงอย่างเดียว					
10.	ฉันคิดว่าการล้างมือและอาบน้ำหลังเลิกงานจะช่วยลดปริมาณสารเคมีกำจัดศัตรูพืชตกค้างที่อาจเข้าสู่ร่างกายเนื่องจากการปนเปื้อนบนเสื้อผ้าและร่างกาย					

<u>การปฏิบัติตนเกี่ยวกับการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผักและการป้องกัน</u>

คำแนะนำ: โปรดทำเครื่องหมาย (✓) ในช่องที่ตรงกับการปฏิบัติของท่าน โดยเลือกเพียงหนึ่งคำตอบในแต่ละข้อคำถาม

การปฏิบัติตนในแต่ละระดับถูกจำแนกโดยความถี่ของการทำกิจกรรม ดังนี้

<u>แทบจะไม่</u>

- สำหรับข้อ 1-6, น้อยกว่า 2 วัน จาก 10 วันการทำงาน
- สำหรับข้อ 7, น้อยกว่า 2 ครั้ง จากการล้างมือในระหว่างการทำงาน 10 ครั้ง
- สำหรับข้อ 8, น้อยกว่า 2 วัน จาก 10 วัน
- สำหรับข้อ 9-10, น้อยกว่า 2 ครั้ง จากการประกอบอาหาร 10 ครั้ง

<u>นานๆ ครั้ง</u>

- สำหรับข้อ 1-6, ระหว่าง 2-3 วัน จาก 10 วันการทำงาน
- สำหรับข้อ 7, ระหว่าง 2-3 ครั้ง จากการล้างมือในระหว่างการทำงาน 10 ครั้ง
- สำหรับข้อ 8, ระหว่าง 2-3 วัน จาก 10 วัน
- สำหรับข้อ 9-10, ระหว่าง 2-3 ครั้ง จากการประกอบอาหาร 10 ครั้ง

<u>บางครั้ง</u>

- สำหรับข้อ 1-6, ระหว่าง 4-6 วัน จาก 10 วันการทำงาน
- สำหรับข้อ 7, ระหว่าง 4-6 ครั้ง จากการล้างมือในระหว่างการทำงาน 10 ครั้ง
- สำหรับข้อ 8, ระหว่าง 4-6 วัน จาก 10 วัน
- สำหรับข้อ 9-10, ระหว่าง 4-6 ครั้ง จากการประกอบอาหาร 10 ครั้ง

<u>บ่อยๆ</u>

- สำหรับข้อ 1-6, ระหว่าง 7-8 วัน จาก 10 วันการทำงาน
- สำหรับข้อ 7, ระหว่าง 7-8 ครั้ง จากการล้างมือในระหว่างการทำงาน 10 ครั้ง
- สำหรับข้อ 8, ระหว่าง 7-8 วัน จาก 10 วัน
- สำหรับข้อ 9-10, ระหว่าง 7-8 ครั้ง จากการประกอบอาหาร 10 ครั้ง

<u>อย่างสม่ำเสมอ</u>

- สำหรับข้อ 1-6, มากกว่า 8 วัน จาก 10 วันการทำงาน
- สำหรับข้อ 7, มากกว่า 8 ครั้ง จากการล้างมือในระหว่างการทำงาน 10 ครั้ง
- สำหรับข้อ 8, มากกว่า 8 วัน จาก 10 วัน
- สำหรับข้อ 9-10, มากกว่า 8 ครั้ง จากการประกอบอาหาร 10 ครั้ง

ข้อ	การปฏิบัติตน	ระดับ				
		แทบจะไม่	นานๆ ครั้ง	บางครั้ง	บ่อยๆ	อย่างสม่ำเสมอ
1.	ท่านรับประทานอาหารในระหว่างชั่วโมงการทำงานโดยไม่ล้างมือ					
2.	ท่านใส่ถุงมือในระหว่างการทำงาน					
3.	ในระหว่างการทำงาน, ท่านรับประทานผักสดที่ขายโดยไม่ล้าง					
4.	ท่านล้างมือด้วยน้ำสะอาดในระหว่างชั่วโมงการทำงาน					
5.	ท่านล้างมือหลังเลิกงาน					
6.	ท่านอาบน้ำหรือชำระล้างร่างกายหลังเลิกงานหรือเมื่อกลับถึงบ้าน					
7.	หากท่านได้ล้างมือในระหว่างชั่วโมงการทำงาน ท่านจะล้างมือกับสบู่หรือสารชะล้างอื่นๆ					
8.	ท่านรับประทานผักสดโดยไม่ล้างเมื่ออยู่บ้าน					
9.	ท่านเลือกผักที่มีความสวยงาม ไม่มีรอยกัดแทะหรือรูพรุน เพื่อนำมาประกอบอาหารที่บ้าน					
10.	ท่านล้างผักโดยให้น้ำไหลผ่านหรือแช่ด้วยน้ำเกลือ, น้ำด่างทับทิม, น้ำส้มสายชู, น้ำปูนใส, น้ำซาวข้าว, เบกกิ้งโซดา หรือน้ำยาล้างผักอื่นๆ					

ส่วนที่ 3: อาการทางสุขภาพจากการการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างในผัก

คำแนะนำ: โปรดทำเครื่องหมาย (✓) ในช่องที่ตรงกับอาการทางสุขภาพของท่าน

อาการ	ใน 1 เดือนที่ผ่านมา		ใน 1 สัปดาห์ที่ผ่านมา	
	ไม่เป็น	เป็น	ไม่เป็น	เป็น
1. การระคายเคืองผิวหนัง (ผื่น/คัน)				
2. การระคายเคืองตาหรือมองเห็นไม่ชัด				
3. ปวดหัว				
4. เวียนศีรษะ				
5. ร่างกายอ่อนแรง				
6. ความเหนื่อยล้า อ่อนเพลีย				
7. ไอ				
8. หายใจลำบาก				
9. คลื่นไส้				
10. อาเจียน				
11. ท้องเสีย				
12. ปวดท้อง				
13. น้ำลายไหลมาก				
14. เหงื่อออกมากผิดปกติ				
15. กล้ามเนื้อกระตุกหรือเป็นตะคริว				

APPENDIX B
INTERVIEW GUIDELINE
(English version)

ID number.....................

1. Do you think that you have ever gotten any effect or had health symptoms from exposure to pesticide residues on vegetables? Please explain

....

....

....

2. If yes, how to prevent, treat and protect yourself from those problems?

....

....

....

3. What are factors associated with health symptoms from exposure to pesticide residues on vegetables in your opinion?

....

....

....

4. What are recommendations for developing guideline for prevention and health risk reduction related to pesticides contaminated in vegetables among greengrocers?

....

....

....

APPENDIX B
INTERVIEW GUIDELINE
(Thai version)

เลขรหัส....................

1. ท่านคิดว่าท่านเคยได้รับผลกระทบหรือมีอาการทางสุขภาพจากการได้รับสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างบนผักหรือไม่ โปรดอธิบาย

....

....

....

2. หากท่านเคยมีอาการ ท่านมีวิธีการในการป้องกันและดูแลรักษาอาการเหล่านั้นอย่างไร

....

....

....

3. ท่านคิดว่าปัจจัยใดบ้างที่มีความเกี่ยวข้องกับอาการจากการสัมผัสสารเคมีกำจัดศัตรูพืชที่ตกค้างบนผัก โปรดอธิบาย

....

....

....

4. ท่านมีคำแนะนำสำหรับการจัดทำแนวทางการป้องกันและลดผลกระทบต่อสุขภาพจากการได้รับสัมผัสสารกำจัดศัตรูพืชปนเปื้อนในผักสำหรับกลุ่มพ่อค้าแม่ค้าผักหรือไม่ โปรดอธิบาย

....

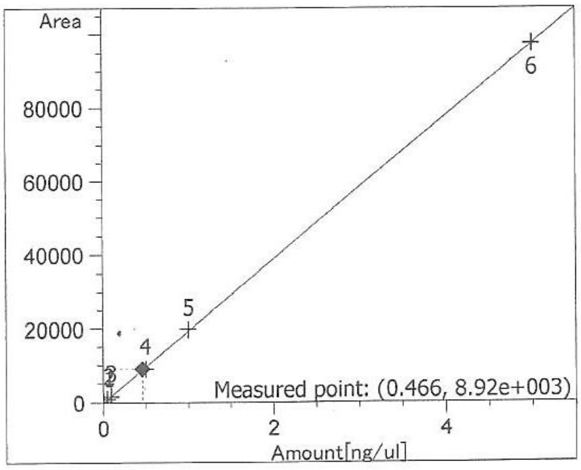
....

....

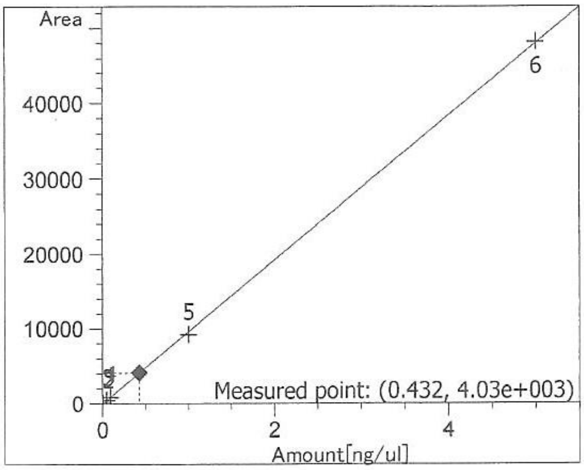
APPENDIX C

STANDARD CALIBRATION CURVES OF ORGANOPHOSPHATE AND PYRETHROID PESTICIDES

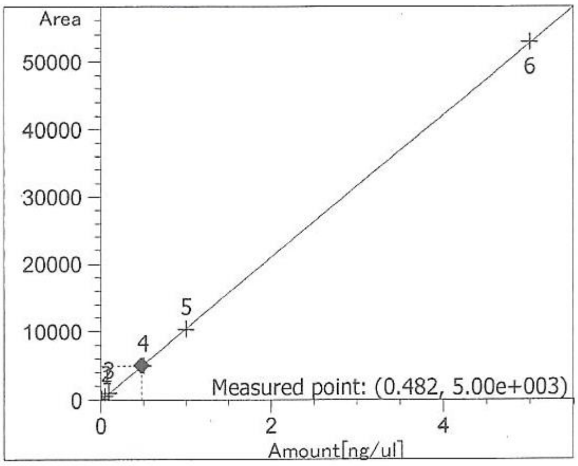
1. Organophosphate pesticides



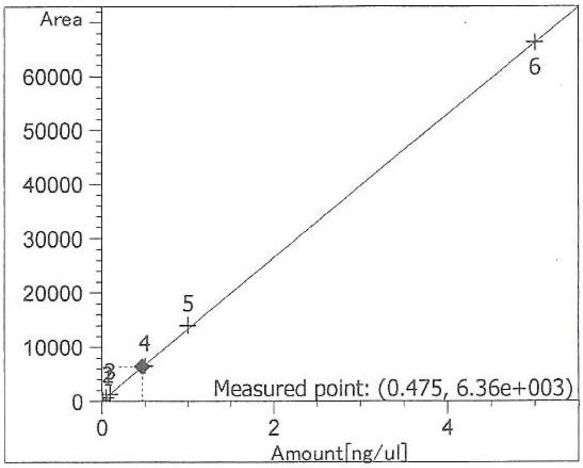
Ethoprophos at exp. RT: 8.177
DFPD1 B, Back Signal 2
Correlation: 0.99996
Residual Std. Dev.: 357.79022
Formula: y = mx + b
m: 19527.89097
b: -188.84337
x: Amount
y: Area



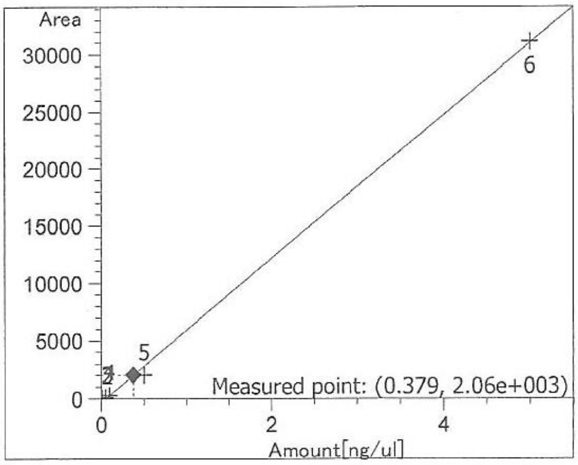
Malathion at exp. RT: 11.108
DFPD1 B, Back Signal 2
Correlation: 0.99996
Residual Std. Dev.: 195.15318
Formula: y = mx + b
m: 9659.72043
b: -148.95482
x: Amount
y: Area



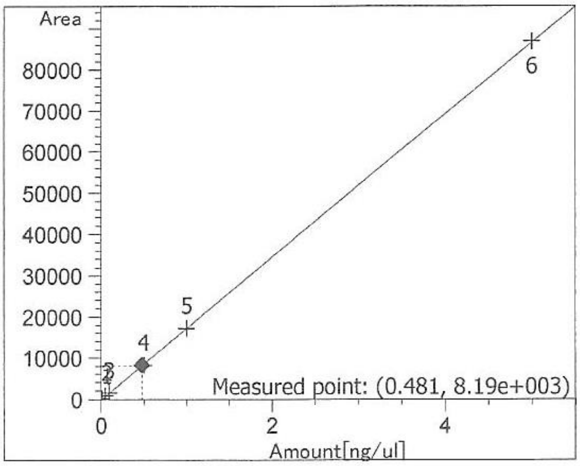

```
Chlorpyrifos at exp. RT: 11.251
DFPD1 B, Back Signal 2
Correlation:             0.99998
Residual Std. Dev.:   116.68191
Formula: y = mx + b
       m:  10581.24675
       b:   -101.75892
       x: Amount
       y: Area
```



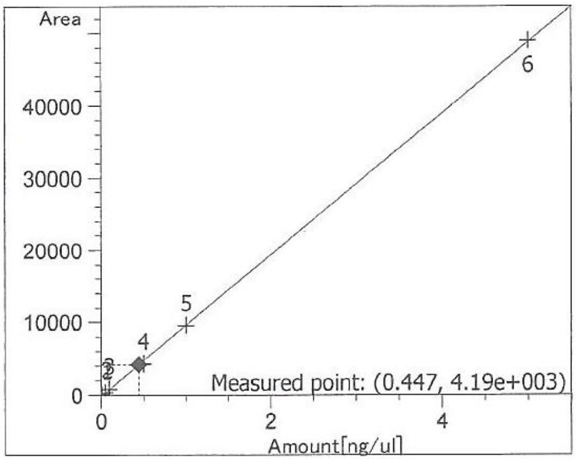

```
Prothiofos at exp. RT: 13.186
DFPD1 B, Back Signal 2
Correlation:             0.99994
Residual Std. Dev.:   299.90912
Formula: y = mx + b
       m:  13253.92134
       b:     54.73422
       x: Amount
       y: Area
```



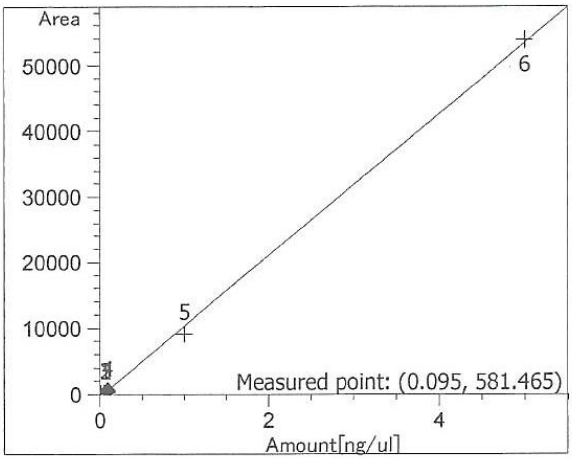

```
Profenofos at exp. RT: 13.287
DFPD1 B, Back Signal 2
Correlation:             0.99947
Residual Std. Dev.:   455.40537
Formula: y = mx + b
       m:   6282.11221
       b:   -327.07471
       x: Amount
       y: Area
```



Ethion at exp. RT: 14.916
DFPD1 B, Back Signal 2
Correlation: 0.99998
Residual Std. Dev.: 192.02972
Formula: y = mx + b
m: 17405.73658
b: -180.02161
x: Amount
y: Area

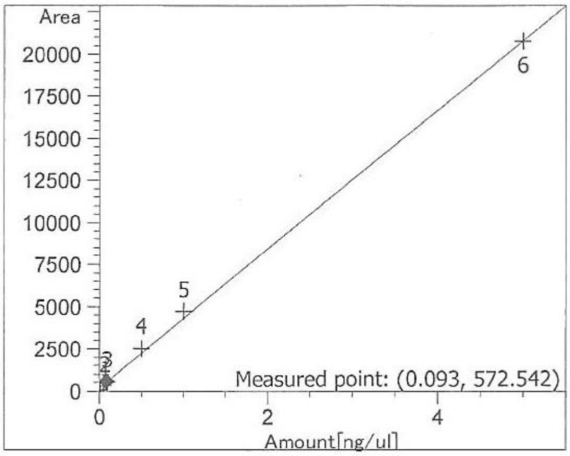


EPN at exp. RT: 18.135
DFPD1 B, Back Signal 2
Correlation: 0.99993
Residual Std. Dev.: 235.06468
Formula: y = mx + b
m: 9812.81684
b: -192.91196
x: Amount
y: Area

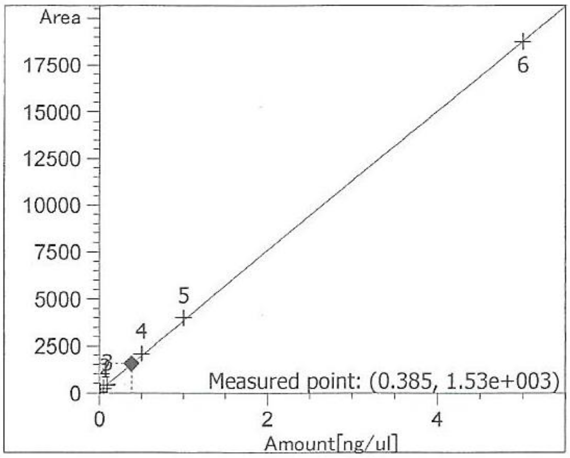


Guthion at exp. RT: 19.730
DFPD1 B, Back Signal 2
Correlation: 0.99954
Residual Std. Dev.: 661.00954
Formula: y = mx + b
m: 10792.29595
b: -438.52796
x: Amount
y: Area

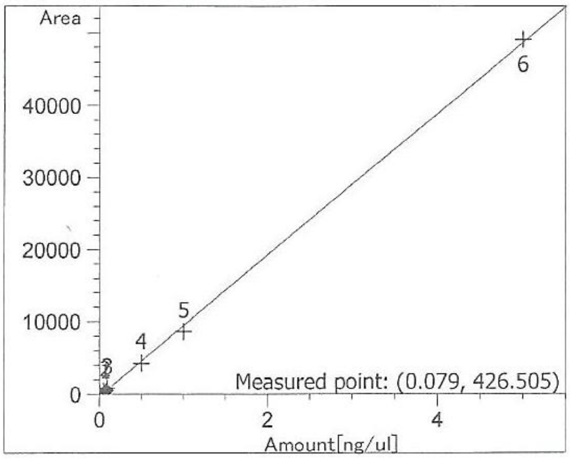
2. Pyrethroid pesticides



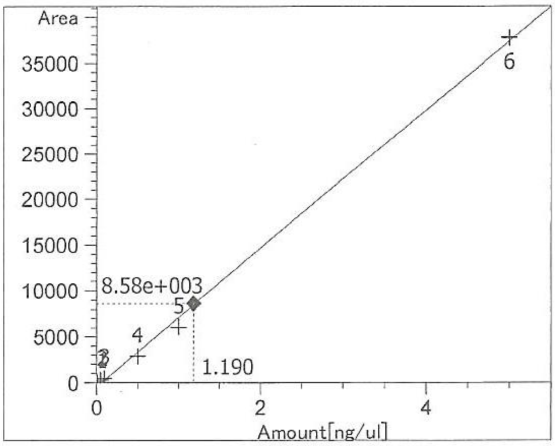
Permethrin-I at exp. RT: 15.278
ECD1 A, Front Signal
Correlation: 0.99957
Residual Std. Dev.: 242.02331
Formula: y = mx + b
m: 4133.38197
b: 187.06737
x: Amount
y: Area



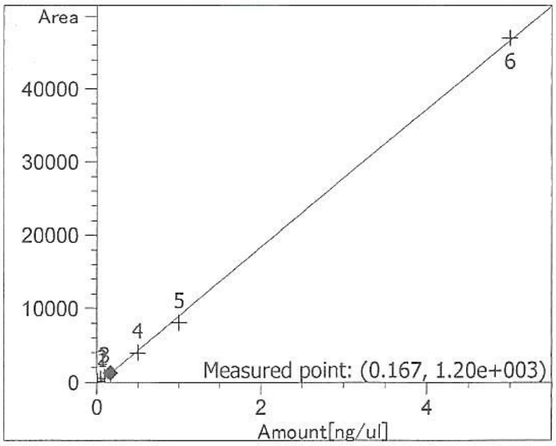
Permethrin-II at exp. RT: 15.610
ECD1 A, Front Signal
Correlation: 0.99987
Residual Std. Dev.: 120.37160
Formula: y = mx + b
m: 3745.84730
b: 87.98837
x: Amount
y: Area



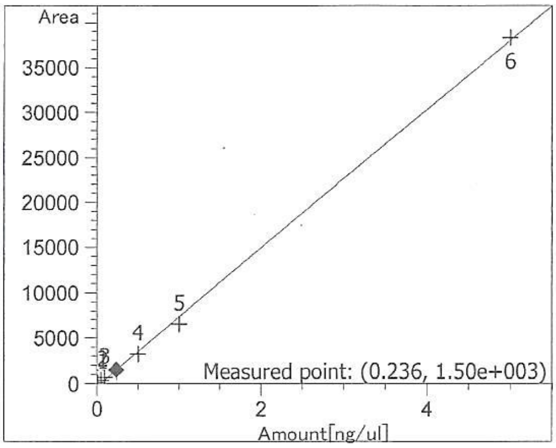
Cypermethrin-I at exp. RT: 17.836
ECD1 A, Front Signal
Correlation: 0.99966
Residual Std. Dev.: 508.19635
Formula: y = mx + b
m: 9830.81105
b: -349.28132
x: Amount
y: Area




```
Cypermethrin-II at exp. RT: 18.227
ECD1 A, Front Signal
Correlation:              0.99911
Residual Std. Dev.:   637.23992
Formula: y = mx + b
      m:    7579.31812
      b:    -439.82037
      x: Amount
      y: Area
```




```
Cypermethrin-III at exp. RT: 18.419
ECD1 A, Front Signal
Correlation:              0.99961
Residual Std. Dev.:   528.60570
Formula: y = mx + b
      m:    9421.71456
      b:    -368.22207
      x: Amount
      y: Area
```




```
Cypermethrin-IV at exp. RT: 18.602
ECD1 A, Front Signal
Correlation:              0.99952
Residual Std. Dev.:   476.19561
Formula: y = mx + b
      m:    7685.08129
      b:    -319.02618
      x: Amount
      y: Area
```

APPENDIX D

GUIDELINE FOR PREVENTION AND HEALTH RISK REDUCTION RELATED TO PESTICIDE CONTAMINATION IN VEGETABLES

VITA

Name: Miss Parichat Ong-artbotrirak

Date of Birth: 14 March 1984

Place of Birth: Bangkok, Thailand

Educational Achievement:

- Bachelor of Science (Environmental Science)
  Thammasat University
- Master of Science (Industrial Hygiene and Safety)
  Mahidol University

Research Experience:

- Acute Effects of Noise on Hearing Threshold Level, Blood Pressure and Heart Rate in Rubberwood Furniture Factory Workers
- Respiratory Effects among Rubberwood Furniture Factory Workers in Thailand