Alliance 2015

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What is in Your Food?

A Study of Pesticide Residues on Vegetables in Cambodia

What is in Your Food?

A project on food safety in Cambodia, implemented by the Alliance2015 partners:

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Acronyms & Definitions

AC	Acaricides
ADI	Acceptable Daily Intake
ARfD	Acute reference dose
ASEAN	Association of South East Asian Nations
C	Carbamate
CABI	Centre for Agriculture and Biosciences International
CAC	CODEX Alimentarius Commission
CEDAC	Centre d'Etude et de Développement Agricole Cambodgien / Cambodian Center for Study and Development in Agriculture
CFSI	Center for Food Safety Information
Ch	Chloronitrile
DPPSPS	Department of Plant Protection Sanitary and Phytosanitary
EBA	Everything But Arms
EFSA	European Food Safety Authority
EU	European Union
FU	Fungicide
FAO	Food and Agriculture Organization of the United Nations
GDA	General Directorate of Agriculture
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HHP	Highly Hazardous Pesticide
HRs	Highest Residues
Im	Fichlomicotmile
IN	Insecticide
IPM	Integrated Pest Management
I/NGO	International / Non-governmental Organization
JMPR	Joint Meeting on Pesticide Residues
LDC	Least Developed Country
MAFF	Ministry of Agriculture, Forestry and Fisheries
MRL	Maximum Residue Limit
NT	No Tolerance
OC	Organochlorines
OP	Organophosphates
Org	Organic Compound
P	Pyrethroids
PAN	Pesticide Action Network
PIC	Prior Informed Consent
PIN	People in Need
POP	Persistent Organic Pollutant
PPE	Personal Protective Equipment
US EPA	United States Environmental Protection Agency
WHH	Welthungerhilfe
WHO	World Health Organization

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The opinions expressed by Alliance2015 in this report do not necessarily reflect the view of the donors.

Studies and Reports connected to the Alliance2015 Project:
The documents referenced in this report contain the details of the pesticide residue study and the risk assessment:

Dr. Suwannarong (SUPA71): "A Literature Review & Field Investigation into Pesticide Residues on Vegetables in Cambodia" (October 2016).
Lars Neumeister: "Pesticide residues in vegetables on five Cambodian markets – Evaluation of the project and risk assessment" (January 2017).

Available upon request. If interested, please contact:
cambodia@peopleinneed.cz
khm.pnh.info@welthungerhilfe.de
paris@acted.org

This project supports the Sustainable Development Goals:

2_Zero Hunger, 3_Good Health, 6_Clean Water and Sanitation, 13_Climate Action, 14_Life below Water, 15_Life on Land.

Executive Summary

Alliance2015, a network of seven European non-government organizations, responded to concerns about pesticide contamination in food in Cambodia by commissioning a study to quantify pesticide residues on five commonly eaten market vegetables. The study also sought to identify possible recommendations for in-home treatment of vegetables to remove pesticide residues, based on a review of scientific literature. An expert assessment of the risk to consumers associated with the pesticide residues found was also commissioned.

Before the results are discussed, the following caveats should be noted. The results represent a snap shot in time and may not be representative of the situation at any point in time in Cambodia. There were also numerous uncertainties associated with the study, meaning that no definitive conclusions can be drawn specifically from the study's results in terms of the risks to consumers that the pesticide residues represent. Guidance on the potential risks the results might represent has been provided by the independent pesticide expert, Mr. Lars Neumeister.

The results of the study show that 25% of the samples contained detectable residues, affecting all types of vegetables except for head cabbage samples. Any residues present were below the maximum residue limits set by the CODEX MRLs, the international food standards set by the Food and Agriculture Organization and the World Health Organization. However, 10 samples (eight tomato and two carrot samples) had levels of pesticides that exceeded European Union MRLs and 20 of the samples could not be imported into the United States, based on their current legislation.

Evidence of the use of up to three pesticides banned from use in Cambodia was found, suggesting border controls need improvement, both for the importation of pesticides and of fresh produce. The highly hazardous banned pesticide methamidophos was found in four tomato samples (20% of the tomato samples) and phorate sulfoxide, a known metabolite of the extremely hazardous banned pesticide phorate, was detected in two carrot samples. It should be noted, however, that while methamidophos is a pesticide itself, it can also be a metabolite of acephate, which is legal in Cambodia. Similarly, cypermethrin was detected in two morning glory samples. It exists as two different isomers: alpha-cypermethrin or zeta-cypermethrin, only the latter of which is banned in Cambodia, but the isomers are unable to be detected separately.

Although 75% of all samples contained no detectable pesticide residues, several reasons for concern remain when looking at the other 25%, especially in the case of tomatoes. Seventy-five percent of the tomato samples contained concerning pesticide residues and Cambodians are urged to not eat them untreated and raw until further tests can confirm they are safe for consumption.

The independent risk assessment used the results from the study and made broad assumptions about Cambodian consumption habits and other sources of exposure to pesticides. The assessment suggests that all samples containing phorate and metamidophos pose an acute risk for consumers, particularly children. Phorate was found in two carrot samples and metamidophos in four tomato samples.

In terms of food preparation, the literature review revealed that in-home washing, peeling and cooking vegetables would substantially reduce pesticide residues, although the actual chemicals present must be considered. By combining soaking in salted water for 20 minutes, peeling and then blanching in boiling water for five minutes (or stir frying or baking), a considerable reduction in pesticide residue can be achieved.

Further studies are needed to fully understand the pesticide residue situation in Cambodia. A pesticide residue study in the dry season, using samples collected from farms, would identify problematic farming practices. Another study to determine the dietary exposure of Cambodians to contaminants in their food, based on the type and amount of food they consume is also recommended. A full list of recommendations is included in this report. They relate to border controls, farming practices, government testing regimes and regulations, further studies and the promotion of clean, green produce and practices to farmers and consumers.

1. Introduction

In Cambodia, pesticides that have been banned in Europe and North America, and even in Cambodia itself, are still available. This represents a danger for human health and the natural environment. Numerous illegal pesticides are still available in the local markets and they are often the cheapest options available. Many developing countries are unable to effectively monitor and restrict use of the substances, which puts users and consumers at risk alike - Cambodia is one such country.

One major problem with pesticide usage is rooted in the limited knowledge of proper application along with a lack of law enforcement. This has created a big challenge for pesticide management in Cambodia. Though the country has banned a range of pesticides itself, many illegal pesticides still find their way on to local farmlands. Moreover, some products are labelled in foreign languages, leading to overuse, application at improper times or even dangerous mixes of different pesticides and other chemicals. In addition to significant health risks for farmers, the environment and biodiversity is suffering, affecting the country as a whole. At the end of the chain is the Cambodian population, ingesting food that has potentially been exposed to dangerous mixes and/or too high portions of pesticides.

The question remains: If it is not safe to breathe, how can it be safe to eat?

1.1 What is in Your Food? – The Alliance2015 Project

Although the Cambodian government has made efforts to improve the situation, assessments of the safety of local or imported foods is still limited, sporadic and information is rarely available to the public, leaving Cambodians with products potentially not healthy for consumption. Since many poor and vulnerable groups in Cambodia have limited options regarding their choice of food, the Alliance2015[1] members, ACTED, People In Need (PIN) and Welthungerhilfe (WHH), came together to design a project on nutrition and food safety called "What is in your Food?". Its objective was to improve the health and nutrition of Cambodians by increasing awareness and availability to wholesome and safe food, with a focus on the pesticide content of fresh vegetables. In a second step, the project aimed to drive change so that related actors and responsible entities actively work on improving the current situation regarding pesticides. Simultaneously, the Cambodian public was to be made aware of the situation and encouraged to demand and support this process.

There is a lot of speculation in Cambodia about the use of pesticides from certain regions and countries, on both local and imported vegetables. A review revealed that very few studies have been conducted in this area. This provided an opportunity for Alliance2015 to provide up to date data about the situation, which might potentially impact the intake and access to safe fresh produce.

To this end, a scientific research project was conducted to determine the actual level of potentially harmful residues on fresh produce.

Although rice is the staple food in Cambodia, vegetables were selected for testing due to the need of many households to improve their nutrition. Encouraging households to eat more vegetables will help fight prevailing malnutrition, a major issue that Alliance2015 wanted to tackle with this project. Taking this approach, the aim was not just to make produce safer for consumption, but also to remove barriers that prevent families including more vegetables in their daily diet.

[1] *Alliance2015* partners conducted a study at 4 markets (2 in Phnom Penh, 1 each in Ratanakiri and Kampong Chhnang). Participants were randomly selected and invited to participate in a 5-minute survey. Total number of participants was 126 and 87% of all participants said they were concerned about the use of pesticides on their vegetables (whilst 13% said no).

Throughout Cambodia, there is a marked lack of information and education regarding the use and dangers of residual pesticides in food. There is great concern, therefore, about what potentially harmful substances may be being ingested by the general population. By testing what pesticides are present in vegetables available in Cambodian markets and at what levels, the project hoped to establish the data needed to inform the public about the situation as well as use the information to lobby government to enforce stricter regulations on their management, if appropriate.

It is noted that "the use of highly toxic pesticides is one of the most significant hazards among agricultural workers in low-income countries as a wide range of acute health effects have been reported." The Cambodian Centre for Study and Development in Agriculture (CEDAC, a local partner of the Alliance2015 member WHH), has, along with other I/NGOs, been conducting research as well as education and training for farmers on the issue of pesticides and their health. Whilst the danger to farmers is recognized, this study focuses on the chronic exposure of consumers via the food supply.

Regardless of the results of the testing, Alliance2015 hoped to draw attention to food safety. The project wanted to encourage Cambodians to demand and purchase safe food. It also wanted the people to eat more vegetables, instead of precluding them from their diet due

to a fear of unsafe chemical content. Anecdotally, this has been reported to happen mainly in dry season in rural areas, where people are greatly aware of farmers' spraying regimes due to a higher occurrence of pests during that time. However, this will clearly not solve the problem, but rather result in the risk of increased malnourishment in a country where malnutrition and, in some cases, undernourishment continue to pose a major problem, especially among the most vulnerable population groups. One-third of all children under the age of five continues to be stunted, almost a quarter are underweight. Pesticides in agriculture and on food is nothing that should be taken lightly, however, not all produce is contaminated or sufficiently contaminated to justify not eating vegetables at all and risk other acute or chronic health issues. The long-term solution is clear, reduce or stop the use of chemical pesticides as there are safer alternatives available and make sure that pesticide application is appropriate, where no alternative is possible or wanted by farmers for the time being. This will in turn also decrease the direct exposure farmers experience when working with the substances.

Further recommendations will be given in the last chapter of this study, preceded by the study's findings and discussion. The next chapter will give an overview of the topic of pesticides in general and of its use and status in the context of Cambodia.

2. General Background

Eighty-two percent of the Cambodian population relies on the agriculture sector for their livelihood[I]. Before 1980, only seven percent of farmers used pesticides, with the figure growing to 98% during the dry season by 2009.[I] In a recent census of agriculture in Cambodia, 70% of agricultural households reported use of inorganic fertilizer (synthetic) and around 50% reported use, or preferring the use, of organic fertilizers, which are made from animal wastes and plant residues.

To curb pesticide use, the Royal Government of Cambodia's Ministry of Agriculture, Forestry and Fisheries (MAFF) as well as several I/NGOs encourage eco-friendly measures of agricultural production, integrated pest management (IPM) practices and organic farming which directly or indirectly support the use of bio-pesticides and curb pesticide use. The Government also organizes training and awareness programs on the safe use[I] of pesticides. However, there are serious challenges to this education and training programs, which stem from the number of pesticides circulating legally and illegally in Cambodia.

2.1 Pesticide Use in South East Asia

Cambodia's larger neighbours, Thailand and Vietnam, have both battled to control pesticide use in their own agriculture sectors.[VI,VII] A paper published in 2013 describes the situation in Vietnam: "Vietnam is facing serious challenges with respect to the amount and toxicity of the pesticides used. With hardly any domestic pesticides production, Vietnam experienced an exponential growth of both the quantity and the value of imported pesticides in recent years. The increasing imports of newly formulated (and safer) pesticides has not replaced or reduced the highly toxic pesticides with low efficacy."[VI]

Cambodia imports fresh produce from its neighbours, so shares the consequences of pesticide use in those countries. Unfortunately, the informality of cross-border trade in Cambodia does not allow estimation of the true extent of agricultural exports or imports. Official statistics do not properly capture this information, including imports of vegetables in apparently large volumes. This makes it nearly impossible to determine the origin of vegetables available for sale to Cambodian consumers. The problem of pesticides in food is not just one of managing agricultural inputs in Cambodia. It also requires formal border controls and food importing processes.

The Royal Cambodian Government's Ministry of Agriculture, Forestry and Fisheries stated in a 2015 policy article that "Indiscriminate use of pesticides not only puts sustainable agricultural production at risk through the disruption of vital ecosystem services, pesticide residues on fresh produce that exceed the maximum (allowable) residue limits (MRLs) also raise food safety concerns and jeopardize their export potentials. MRLs are standards set by individual countries for traded agricultural commodities according to both the pesticide and the type of commodity.

Pesticide residues result from:

1) heavy pesticide use on growing crops;
2) insecticide used in post-harvest management to preserve food during storage;
3) the persistence and carry-over effect of residues in the soil"[V] or transmission by wind from spraying on neighbouring crops.

Cambodia does not manufacture pesticides of its own and therefore must rely on imports from neighbouring countries.[VIII] Chemicals are also imported and processed illegally along the uncontrolled borders of Cambodia.[VIII] In 2014, pesticides made up 5.9% of imports, a value of 51.5 million USD.[IX] Over half of the pesticides imported in 2014 came from Vietnam (60%), followed by Thailand (21%), and China (17%).[IX] In the last decade, Cambodia has imported the majority of pesticides from Thailand and Vietnam. However, this figure does not include any pesticides imported illegally.

All pesticides imported must be authorized by the Royal Cambodian Government's Ministry of Agriculture, Forestry and Fisheries (MAFF) and be labelled in the Khmer language, communicating the health and environmental factors affected by pesticides and the active ingredients. [VIII] A study undertaken in 2011 by The NGO Forum in Cambodia found that only 5% of the study's respondents in Kandal Province, Cambodia had pesticides with important consumer information labelled in Khmer. This means farmers are purchasing and applying pesticides without understanding the associated risks. This is one example that highlights the gap between regulation and enforcement. The NGO Forum in Cambodia also noted that pesticide users reported a common practice of mixing pesticides together for use.[X] This alarming practice creates hazards for the handlers, community and environment at-large.

From a food safety perspective, a study by Neufeld et al. in 2010 on the prevalence of pesticides in market vegetables in Phnom Penh found between 15% (long bean) and 95% (white-stemmed kale) of samples of these market vegetables contained detectable levels of organophosphate and organochloride (OP/C) pesticides.[XI]
Given the findings of the small amount of previous studies available in Cambodia and the region, there was a clear need for further studies to determine the pesticide residues in vegetables available for consumption in Cambodia. This study was thus designed to meet this information gap.

2.2. Pesticides and their Impact on Food Safety

Pesticides are ubiquitous globally. According to the Food and Agricultural Organization of the United Nations (FAO) Code of Conduct on the Distribution and Use of Pesticides, the definition of a pesticide is:

"Any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport."[xiii]

Pests globally consume enough food to feed an additional one billion people.[XIV] In low and middle-income countries, pesticides improve crop productivity and crop specialization, supporting the production of up to three crops per year.[XV] Albeit, globally, despite the increase in use of pesticides in developing countries, global crops losses are still considerable.[XV] Furthermore, the Human Rights Council of the United Nations have recently published a report denouncing the myth that pesticides are needed to feed he world, even calling pesticides a global human rights concern and stating that their use can have very detrimental consequences on the enjoyment of the right to food.[XVI]

When talking about food safety, one important topic to mention is pesticide toxicity to wildlife and bees in particular. "Bees are critically important in the environment, sustaining biodiversity by providing essential pollination for a wide range of crops and wild plants. They contribute to human wealth and wellbeing directly through the production of honey and other food and feed supplies such as: pollen, wax for food processing, propolis in food technology, and royal jelly as a dietary supplement and ingredient in food."[XVII] Though the discussion about insecticides threatening bee populations will not be part of this report, it is worth highlighting that many pesticides are reported to pose a significant risk to bees, which indirectly affects food safety.

Types of pesticides and their toxicity

There are many different types of pesticides, for example insecticides, fungicides and herbicides, with the chemical compounds used for each being from four main classes:

- Organochlorines (OC) are chemicals that have joined carbon and chlorine atoms. The pesticide residue quantification component of this study identified two types of OC pesticide residues: difenoconazole and propiconazole, both are used as fungicides. They are difficult to break down and stay in the environment and human bodies for a long time. They are stable and vapor forming and can easily be transmitted long distances through the air. These chemicals are harmful because they build up in lipid tissues and can affect fertility and the immune system of humans.[XVIII]

- Organophosphates (OP) are phosphate esters that form the base of most insecticides. In this study, two types of pesticide residue were identified: acephate and methamidophos. Organophosphates in the human body can destroy enzymes, called acetylcholinesterase, which are critical for controlling nerve signals.[XIX]

- Carbamate (C) compounds are widely used for insect control and applicable for a wide range of insects. The compounds decay easily and they have

limited half-lives. The group is familiarly known for mosquito spray.[XIX]

- Pyrethroids (P) compounds, such as the permethrin found in this study, are similar to the natural pyrethrin produced by the flowers of pyrethrums. Generally not acutely toxic, they can easily enter and exit human bodies. Exposure to pyrethroids may cause dizziness, headaches, diarrhea, and respiratory conditions, and can affect human's reproductive capacity. Pyrethroids are particularly toxic to aquatic species.[XX]

International Standards for Pesticide Residues in Food

In 1963, WHO and FAO established the CODEX Alimentarius Commission (CAC), to develop international food standards, guidelines and codes of practice to contribute to the safety, quality, and fairness of the international food trade. CODEX standards are based on the best available science on food issues including biotechnology, food additives, and pesticides. Although CODEX standards are voluntary, they serve as the basis for national legislation in many places. It should be noted that the CODEX maximum residual limits (MRLs) are based on good agricultural practice, something which may not be applied in developing countries. Furthermore, they do not include all consumer groups, as will be further discussed in chapter 3.2.

The CODEX maximum residue levels (MRLs) are not only used for food and agricultural commodities circulating in international trade. They also form health-based guidance for pesticides (i.e. toxicological values ADIs and ARfDs - see chapter 3.4). The MRL standards are available online.[XXI]

The CAC Procedural Manual (currently 25th edition) outlines CODEX methods of collection, sampling and analysis for pesticide residues. [XXII] These methods are designed to ensure that fair and valid sampling procedures are used when food is being tested for compliance with a particular CODEX commodity standard. For these reasons, the pesticide residue quantification component of this study followed recommended CODEX guidelines on the methods for collection, sampling, and analysis from the determination of pesticide residues for compliance with MRLs.

Country-specific Limits for Pesticide Residues in Food

In addition to the CODEX maximum residue levels (MRLs), many countries and economic regions set their own limits for the pesticide residues in foods. The European Commission determines MRLs for all food and animal feed to ensure food is safe for residents of countries in the European Union. These limits are typically lower than those set by CODEX and include more pesticide compounds. [XXIII]

As a Least Developed Country (LDC), Cambodia benefits from the EU's Everything But Arms (EBA) scheme, which gives the 49 Least Developed Countries duty free access to the EU for exports of all products, except arms and ammunition. In terms of fresh produce, these exports from Cambodia to the EU remain low, with shipments of vegetables in 2013 being only 1.687 tons, or 0.003% of the overall 453.200 tons estimated to be produced in the country.[XXIV] However, increasing these export volumes to the EU and to other countries, particularly in the ASEAN region, may be an important source of income for Cambodia in the future. Managing the pesticide residues in vegetables destined for export is critical to the growth of the industry.

2.3. Health Impacts of Pesticides

Many foods, including fruits and vegetables, contain pesticide residues even after being washed or peeled. One reason is the difference of systemic and contact pesticides. Contact pesticides have to reach their target directly, thus must be absorbed through the external body surface or the exposed plant tissue to be effective. Systemic pesticides, in contrast, are in the plant, not on it, as they are actually absorbed when applied to seeds, soil, or leaves. The chemicals then circulate through the plant's tissues, killing the insects that feed on them. The plant itself is, therefore, made poisonous to predators. Systemic pesticides cannot be washed off,[XVI] though applying heat helps. Furthermore, chemicals that are no longer used in agriculture but that are resistant to breakdown for long periods may remain in soil and water and thus find their way into food.[XXV]

Eating food with residues of pesticides can be a major contributor to overall exposure to those pesticides. A 2008 study in Washington State, USA assessed urban/rural children's (3 to 11 years of age; n=23) exposure to OP pesticides, including the contribution of dietary intake to overall OP exposure. The findings stated that dietary intake of OP pesticides is the major source of exposure for young children. By substituting organic fresh fruits and vegetables for corresponding conventional food items, the median urinary metabolite concentrations were reduced to non-detectable or close to non-detectable levels for malathion and chlorpyrifos at the end of the 5-day organic diet intervention.[XXVI] These findings were supported in a small sample of adults (n=13), as Oates et al. found the consumption of an organic diet for one week significantly reduced OP pesticide exposure in adults by nearly 90%.[XXVII]

The negative health effects of chronic exposure to hazardous pesticides have been well documented. The effects can be categorized as carcinogenic (can cause cancer), neurotoxic (can cause damage to the brain or nervous system), or teratogenic (can cause birth defects).

[xxviii] It should be noted that malnutrition (prevalent among Cambodian children) and dehydration may increase sensitivity to pesticides, making many in the population even more vulnerable to illness or health effects.[xxix] The neurological effects of certain pesticides are illustrated in Table 1 Recognized neurological effects of pesticides, and studies relating to various cancers resulting from overexposure are illustrated in Table 1.

Whilst we are unaware of the specific effects that pesticides are having in Cambodia, one study revealed that 'concentrations of DDT's (dichlorodiphenyltrichloroethane) in human milk collected from Cambodia were notably higher than those collected from developed countries.[xxx] Given the wide number of pesticides that are on the market in Cambodia, the potential health effects and ramifications of their use is varying and widespread. A very brief summary can be found in Table 1.

Long-term Health Effects

Many studies have examined the effects of pesticide exposure on the risk of cancer. Associations have been found with: leukemia, Non-Hodgkin's, lymphoma, multiple myeloma,brain, kidney, breast, prostate, colon, rectum, pancreatic, pancreas, liver, lung, bladder as well as skin, colorectal, testicular, esophageal and stomach cancers and association between exposure to pesticides and cancer incidences.[xxxi]

Table 1. Recognized neurological effects of pesticides [xxix]

Effect	Causative agent(s)
Delayed neurotoxicity	Certain organophosphorus compounds, e.g. leptophos
Behavior changes	Certain organophosphorus insecticides
Lesions of the central nervous system	Organochlorine and organophosphorus insecticides and organomercury fungicides
Peripheral neuritis	Chlorophenoxy herbicides, pyrethroids and certain organophosphorus insecticides

Table 2. Pesticides associated with elevated incidence of cancer in epidemiological studies [xxxi]

Type of cancer	Pesticide	Reference
Leukemia	chlordane/heptachlor	Purdue et al. (2007)
	chlorpyrifos	Lee et al. (2004b)
	diazinon	Beane Freeman et al. (2005)
	EPTC	Van Bemmel et al (2008)
	fonofos	Mahajan et al. (2006)
Non-Hodgkin's	lindane	Purdue et al. (2007)
Lymphoma	oxychlordane/chlordane	Spinelli et al. (2007)
Multiple myeloma	permethrin	Rusiecki et al. (2009)
Brain cancer	chlorpyrifos	Lee et al. (2004b)
Prostate cancer	fonofos	Mahajan et al. (2006)
	methylbromide	Alavanja et al. (2003)
	butylate	Lynch et al. (2009)
	clordecone	Multigner et al. (2010)
	DDT, lindane, simazine	Band et al. (2011)
Colon cancer	aldicarb	Lee et al. (2007)
	dicamba	Samanic et al. (2006)
	EPTC	Van Bemmel et al. (2008)
	imazethapyr	Koutros et al. (2009)
	trifluralin	Kang et al. (2008)
Rectum cancer	chlordane	Purdue et al. (2007)
	chlorpyrifos	Lee et al. (2004b)
		Lee et al. (2007)
Pancreatic cancer	EPTC, pendimethalin	Andreotti et al. (2009)
	DDT	Garabrant et al. (1992)
Lung cancer	chlorpyrifos	Lee et al. (2004b)
	diazinon	Beane Freeman et al. (2005)
	dicamba	Alavanja et al. (2004)
	dieklrin	Purdue et al. (2007)
	metolachlor	Alavanja et al. (2004)
	pendimethalin	Jou et al. (2006)
Bladder cancer	imazethapyr	Koutros et al. (2006)
Melanoma	carbaryl	Mahajan et al. (2007)
	toxaphene	Purdue et al. (2007)
	carbaryl, parathion maneb/mancozeb	Dennis et al. (2010)

2.4. The Commercial Impacts of Pesticide Use

The poorly managed use of pesticides can also have negative commercial impacts, with the loss of export opportunities due to high pesticide residues on products, and a degraded agro-ecosystem that reduces agricultural productivity. For example, in Vietnam, the annual cost of pesticide-related domestic human health and of lost export opportunities for vegetables and fruits is estimated at US$700 million. In 2002, the Environmental Justice Foundation estimated the direct cost of pesticide use in Cambodia at US$7-20 million per year, not including indirect costs such as inappropriate pesticide use and negative impacts on food security, public health, the export market, and on the burgeoning tourism industry.[II]

As well as their current exports to the EU and other countries, Cambodia's agricultural sector has the opportunity to benefit from free trade with the ASEAN economic community.

Cambodian agriculture enjoyed considerable growth in the period 2004-2012, helping four million people out of poverty. The poverty headcount dropped from 50% in 2007 to 18% in 2012.[XXXIII] However, growth slowed to 1 percent during the 2013-2014 period.[XXXIII]

Key policy recommendations in the World Bank's 2015 report 'Cambodian agriculture in transition' included the promotion of the safe use of agricultural chemicals as well as government investment in improving agricultural "public good" investment programs - including food safety and agricultural input quality control programs.[XXXIII]

Cambodia's National Action Plan for Zero Hunger Challenge, released in March 2016[XXXIV], describes food safety as becoming increasingly important as Cambodia aims to increase its export of agricultural products in regional and global markets. It lists establishing and promoting National Food Quality and Safety Standards as a required action, with a target completion date of 2023.

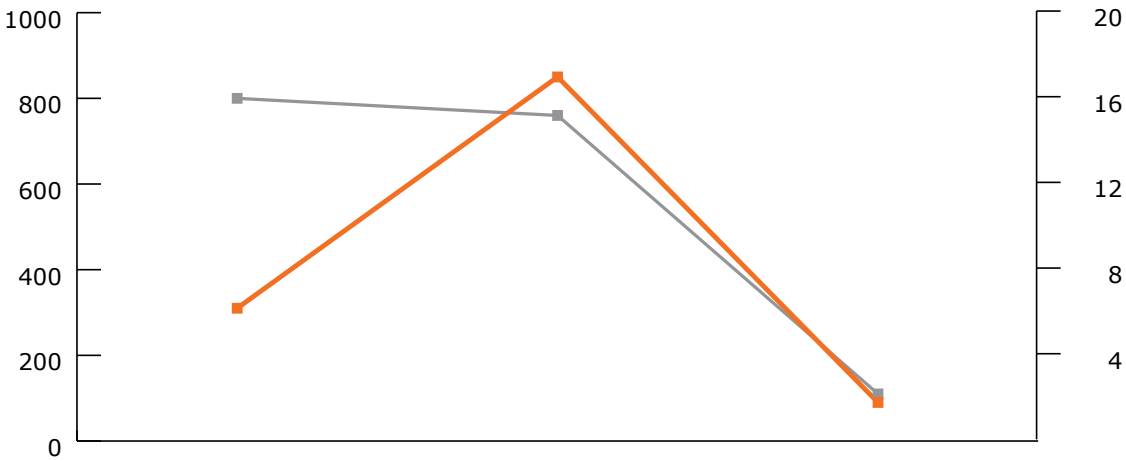
Exports to the European Union

As discussed above, Cambodia supplies fresh produce to the EU as part of the Everything But Arms (EBA) scheme. In November 2014, The European Union's Directorate General of Health and Food Safety conducted an audit to evaluate controls of pesticides in food of plant origin intended for export to the European Union. The audit report mentions that the audit "was undertaken mainly on the basis of non-compliances notified by EU Member States with regard to products originating from Cambodia. In the period 01 January 2013 to 01 November 2014, a total of 20 cases were reported via the EU Rapid Alert System for Food and Feed, where either a direct or indirect risk for consumers was identified. Sixteen of these were related to fresh vegetables, mainly aubergines,

Chinese celery and yard long beans, and four to herbs, mainly coriander." [XXIV]

Data obtained from the EU Rapid Alert System for Food and Feed indicates that the number of notifications has decreased considerably since 2014, as shown in the graph below. The corresponding volume of fresh vegetables (commodity code 07) exported to EU Member States over that period is also shown, as obtained from the EU's online Trade Export Helpdesk.[XXXV] There is a clear association between the volume of vegetables shipped over the period 2014-2015 and the number of notifications. This suggests that it is simply lower export volumes that are driving the reduced number of notifications, not necessarily better pesticide management on Cambodia's behalf.

Figure 1. The annual volume of vegetables shipped from Cambodia to EU member countries and the annual number of notifications of direct or indirect risk for consumers raised by member countries.



	2013	2014	2015
volume of vegetable	796	763	118
EU alert	7	19	2

2.5 Government Policy and Approaches to Pesticide Management in Cambodia

The Royal Government of Cambodia has shown political will by banning and restricting various hazardous chemical substances and by introducing legislation to tackle the issue of the use of hazardous pesticides.

National and International Laws

Internationally, Cambodia has signed the Stockholm Convention and agreed to ban Persistent Organic Pollutants (POPs). It has also acceded to the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, which is aimed at reducing use of dangerous pesticides imported from other countries, and assisting developing countries to develop strategies to deal with the issues surrounding hazardous pesticides. Through the procedure, Cambodia can publicize decisions on whether or not it desires imports of the PIC chemicals (those banned or severely restricted in member countries), passing the onus on the control of trade to exporting countries.[II] Cambodia has also acceded to the Basel Convention to control transboundary movements of hazardous waste and its disposal.

Furthermore, several national laws and regulations have been introduced to complement the signed or voluntarily followed international agreements. Cambodia had no legislation explicitly regulating pesticides until the 1998 sub-decree 69 On Standards and Management of Agricultural Materials. It was the first legal instrument mentioning pesticides, and covers import, sale, labelling, packaging, quality, storage, disposal and marketing of pesticides in Cambodia. The sub-decree prohibits the use and sale of pesticides classified by WHO as class 1 (1a extremely or 1b highly hazardous to human health). However, a study conducted five years later (2002) by the Environmental Justice Foundation found many of those chemicals were still in use in Cambodia.[II]

A further legislature regulating the management of chemicals in general is the National Profile on Chemicals Management in Cambodia under the Ministry of Environment from 2004. It regulates chemical production, import, export and use of chemicals, including pesticides.

Since the sub-decree 69 was not fully implemented in the pesticide management departments, the Government ratified the Law on the Management of Pesticides and Fertilizers on 21st December 2011, which to date is the most current legislature governing pesticides. However, as described in the paper submitted by MAFF to the 2015 FFTC-KU International Workshop on Risk Management on Agrochemicals through Novel Technologies for Food

Safety in Asia, the implementation and enforcement of this law still has some way to go, with illegal pesticides being readily available for sale in Cambodia and limited awareness or knowledge of the law by farmers.[v]

Approved and Banned Pesticides

The Cambodian Ministry of Agriculture, Forestry and Fisheries publishes a list of banned, restricted and permitted pesticide products. The latest version was released through Ministerial Proclamation (Prakas) No. 484 MAFF dated 26 November 2012. The Prakas listed 163 chemical compounds as banned or deregistered at that time.

Included in the list of recommendations as part of the Audit Report issued by the European Union's Directorate General of Health and Food Safety (discussed above), are recommendations that apply equally for exported produce and that domestically consumed. These recommendations are for Cambodia to "ensure that an up-to-date register of authorized plant protection products, including application rates, crops and pre-harvest intervals, is made available" and "ensure that pre-export official and/or mandatory private sampling and pesticide residue analysis is carried out." [xxiv] These two actions are yet to be implemented by MAFF and are critical to pesticide management.

Food Law

The Cambodian Government released a draft version of a new Cambodian Food Law in July 2015, which plans to establish a Food Safety Authority which shall: "advise the Minister on food control and food safety matters, all along the food chain including the production, manufacture, import, export, labelling and sale of food, in consumer protection and on emerging food control issues including street food." In addition, article 16 of the draft law states: "…only safe, wholesome, appropriately packaged and accurately labelled food may be prepared for sale or sold."[xxxvi] This would prohibit food contaminated with pesticide residues above the maximum residue limits.

Unfortunately, it seems that little progress has been made in finalizing and implementing this law, which could go some way to reducing the amount of unsafe food available in Cambodia.

Governing Ministries and Departments

There are various stages of the agro-chemical life cycle including production, importation, storage, transport, distribution, use, and disposal. The National Profile on Chemicals Management in Cambodia (2004) states there are legal instruments to manage pesticides at every stage of their lifecycle in Cambodia.

There are implementation mechanisms among seven main ministries for managing chemicals (ministries most important for pesticide management in bold) with the

role and responsibility determined by the governmental ordinance (sub-decree) including:

1) **Ministry of Agriculture, Forestry and Fisheries**
2) Ministry of Commerce (**Department of CAMCONTROL),**
3) Ministry of Economic and Finance **(Office of Customs and Excise),**
4) **Ministry of Environment,**
5) Ministry of Industry, Mines and Energy,
6) **Ministry of Health**,
7) Ministry of Interior (National Authority for Controlling Drugs).[VIII]

When looking at the most important responsibilities in relation to this study, CAMCONTROL is responsible for import control and MAFF holds several responsibilities within the department of General Directorate of Agriculture (GDA):

- The Department of Agriculture Legislation is the authority in charge of pesticide registration, licensing, and inspection.

- The Department of Plant Protection Sanitary and Phytosanitary (DPPSPS) is the technical adviser for field evaluation of pesticides and efficacy field-testing for registration. The department also plays a role as technical adviser, providing training on pest management, pest control technology, pest monitoring, pest forecasting, pest outbreak warning, invasive species control and general pesticide advisory. It also conducts researches and developments on various pests to strengthen the implementation, managing pesticides including pesticide registration (providing efficacy field testing), and development of recommendation on pesticide use.

- Additionally, the National Agricultural Laboratory of GDA has a role in the analysis of pesticides.[V]

Despite the existence of regulations, many of the legal instruments only have general provisions, the roles and responsibilities of government institutions are not clearly defined, and law enforcement is limited. The National Profile on Chemicals Management states itself that "Cambodia faces parallel problems regarding human capacities, experience, legal framework, and facilities and mechanisms for managing chemicals and information dissemination. Current problems include:

- Low level chemical awareness on the part of workers, farmers and public at large who are directly using chemicals due to limited education;

- Cambodian people's preference for the long-term use of chemicals throughout the country has created direct impacts on users, non-users, and the local environment;

- Cambodia has no accidental [sic!] data and information for accidents caused by the misuse / wrong-use of chemicals;

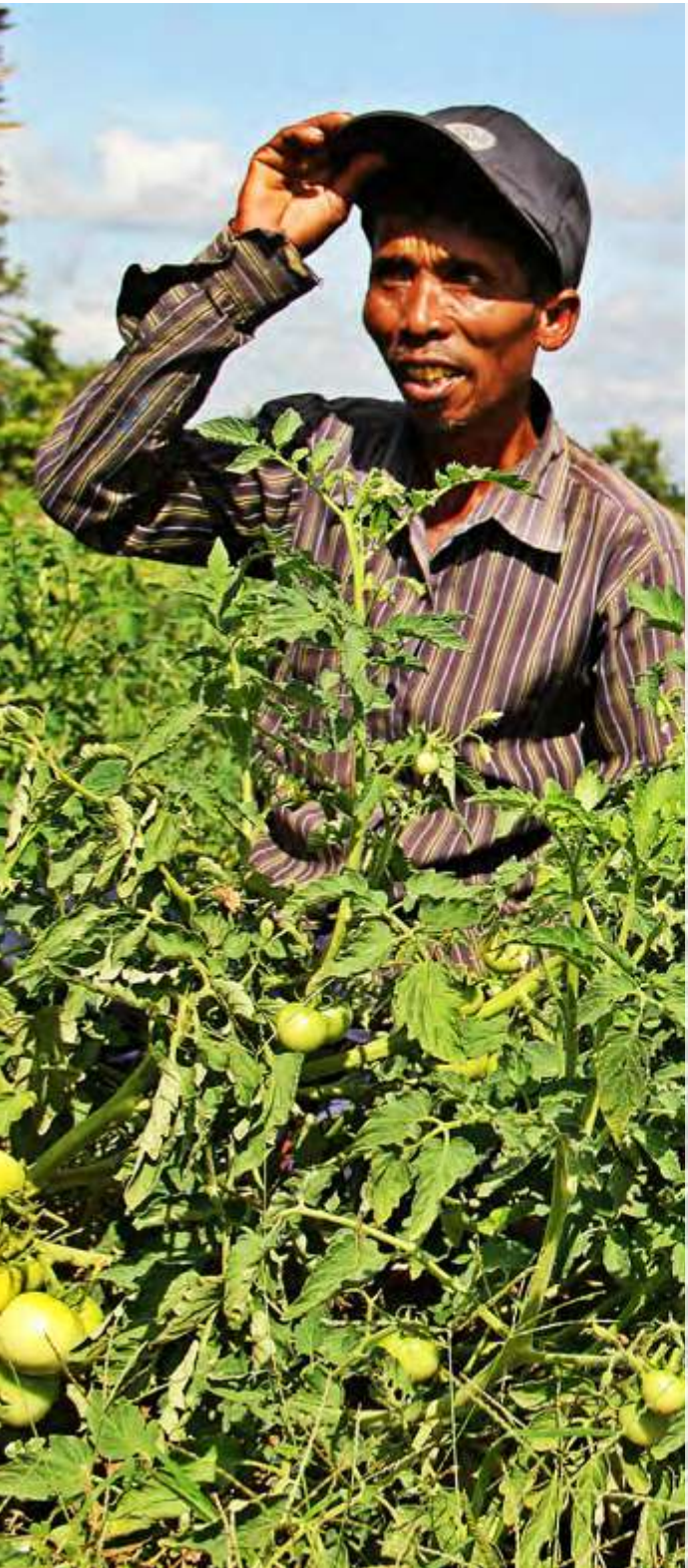
- Governmental institutions do not have sufficient ability for chemicals assessment and the identification of chemicals-related problems in the production, trade, storage, use, and disposal of such chemicals. This is because Cambodia does not have a clear chemicals management goal coupled with a limited capacity for assessing chemical hazards and identifying their impacts;

- Cambodia has a lack of good cooperation among laboratories and stakeholders responsible for managing emission sources of the chemicals and persistent toxic substances, lack of human resources in operating lab as well as technical expertise related to chemicals analysis and management capacity, and lack of reliable laboratories and equipment for chemicals monitoring and analyzing; and

- The governmental mechanism for information exchange, as well as relevant organizations for chemicals management, has not been operating smoothly in response to current requirements." [VIII]

According to Preap et al. the lack of law enforcement creates a big challenge for pesticide management in Cambodia. In addition, Preap et al. found that illegal pesticides are often available in local markets from unregistered pesticide retailers, and that traders often take advantage of farmers' lack of information and promote the use of banned or restricted pesticides.[V]

3. The Study



The study commissioned by Alliance2015 members ACTED, PIN and WHH aimed to improve access to safe and diversified produce with a focus on levels of pesticides in vegetables.

Some smaller studies had previously been conducted, finding that pesticide residues were present in Cambodian (market) food and that pesticides are poorly used by Cambodian farmers. However, no data was available that quantitated pesticide residues in a wide range of fresh produce. To fill this information gap, an independent analysis of the pesticide residues present in vegetables available to consumers in Cambodia was commissioned by Alliance2015. The Thai scientific consultancy SUPA71 conducted the study, the details of which can be found in the study analysis "A Literature Review & Field Investigation into Pesticide Residues on Vegetables in Cambodia", available upon request (refer to page 5).

The study included the collection of 100 samples, 20 of each of the following: head cabbage, carrot, morning glory, tomato, and water lily, purchased from ten stalls in five markets. The capital city and four provinces were selected for data collection, i.e. a) Phnom Penh, b) Takeo, c) Kampong Chhnang, d) Ratanakiri, and e) Siem Reap. Sites were selected due to their population density or closeness to international borders with Lao PDR, Thailand, and Vietnam. Commodities chosen were identified by several interviews about what participants

most commonly purchase which were conducted in four markets in three of the target areas (i.e. two markets in Phnom Penh, one in Kampong Chhnang and one in Ratanakiri). At each site information was recorded including the country of origin of the vegetable sample, as stated by the stall vendor. Note that the accuracy of the statements is unknown, as stall vendor may claim the country/region of production that they think the customer wants to hear and/or the full supply chain may not be known to them. The study also sought to identify possible recommendations for in-home treatment of vegetables to remove pesticide residues, based on a review of scientific literature.

Samples were collected and prepared as per the CODEX sampling methods. They were then tested for 355 pesticides active ingredients and pesticide metabolites by the laboratory AsureQuality in Wellington, New Zealand.

Note: Examination of the results by another independent expert found that the sampling methodology used for the study did not include a representative sample size for the geographical area covered nor was the margin of error and confidence level associated with the results established. Unfortunately, budget constraints limited the study design. The results obtained should be considered as a snap shot in time that give an indication of the pesticide residues present in vegetables available in Cambodian markets at that point in time. Researchers conducting future studies may wish to consult the detailed study assessment, available upon request (refer to page 2).

3.1 Study Results

Seventy-five percent of the samples contained no detectable pesticide residues. However, there were concerning findings amongst the results of the other 25% of samples. Pesticide residues were detected in samples of: carrots, tomatoes, morning glory, and water lily. A total of 53 residues were detected in the 25 samples, an average of over two substances per sample. In 11 samples, more than one residue was detected, with one sample containing as many as six different residues.

Residues of about[2] 12 unique pesticides were detected . Four are fungicides (FU) and the rest are insecticides/ acaricides (IN/AC):

1) IN/AC: acephate, clothianidin, cypermethrin, imidacloprid, methamidophos, permethrin, phorate sulfoxide and thiamethoxam
2) FU: carbendazim, chlorothalonil, difenoconazole and propiconazole

The number of residues detected varied widely between the different types of vegetable. Fifteen of the 25 positive samples were tomato samples, while

no residues were found in any of the head cabbage samples. This was a surprising result, due to the vegetable's high susceptibility to pests. According to discussions with CEDAC, cabbage is typically treated with pesticides by farmers, so to find no detectable residues was unexpected.

Comparing the test results to the allowed Maximum Residue Levels (MRLs) from: the European Union; the CODEX Alimentarius Commission (CAC); and the USA reveals the following:

- Fourteen pesticide residues in ten samples exceeded the EU MRLs and would be rejected by the EU for safety reasons. Of those 10 samples: four tomato samples were stated to be sourced from Vietnam and contained residues of acephate & methamidophos, four tomato samples were stated to be sourced from Phnom Penh and contained residues of permethrin and two carrot samples were stated to be sourced from Vietnam and contained residues of phorate sulfoxide.

Table 3 Detections above EU and CAC MRLs and US tolerances

Sample	Item	Pesticide	Residue mg/kg	CAC MRL mg/kg	% CAC MRL	EU MRL mg/kg	% EU MRL	US Tolerance mg/kg
I005-2	Carrot	phorate sulfate	0.018	not set		0.01	180	0
I005-1	Carrot	phorate sulfate	0.016	not set		0.01	160	0
E002-2	Tomato	permethrin	0.260	1	26.0	0.05	520	2
E002-1	Tomato	permethrin	0.140	1	14.0	0.05	280	2
D002-2	Tomato	permethrin	0.092	1	9.2	0.05	184	2
D002-1	Tomato	permethrin	0.160	1	16.0	0.05	320	2
B002-2	Tomato	acephate	0.079	1	7.9	0.01	790	0
B002-2	Tomato	methamidophos	0.026	not set		0.01	260	2
B002-1	Tomato	acephate	0.093	1	9.3	0.01	930	0
B002-1	Tomato	methamidophos	0.039	not set		0.01	390	2
A002-2	Tomato	acephate	0.062	1	6.2	0.01	620	0
A002-2	Tomato	methamidophos	0.017	not set		0.01	170	2
A002-1	Tomato	acephate	0.061	1	6.1	0.01	610	0
A002-1	Tomato	methamidophos	0.020	not set		0.01	200	2

[2] Methamidophos is a pesticide, but also a metabolite of acephate. The residue definition cypermethrin includes residues that may come from uses of different isomers (e.g. alpha-cypermethrin; zeta-cypermethrin [banned in Cambodia])

- No CODEX MRLs were exceeded for those pesticide/vegetable combinations where MRLs exist. It should be noted that CODEX MRLs do not exist for morning glory (water spinach) and water lily. For the pesticides phorate and methamidophos, CODEX MRLs have not been set for any of the five tested vegetables.

- Twenty of the 25 samples that contained pesticide residues would not have been permitted into the USA as they contained carbendazim, acephate or phorate residues. The USA has zero tolerance for these pesticides, meaning that no amount of the pesticide chemical may remain on the raw agricultural commodity when it is offered for shipment.[XXXVII]

Pesticides that are banned from use in Cambodia were found in up to 8 samples. However, the source of the pesticide chemical is not always clear as some are degradation products of other chemicals. The banned pesticides were:

1) Methamidophos was detected in four tomato samples, stated to be sourced from Vietnam. However, methamidophos could also be a metabolite of acephate, which is not officially banned in Cambodia.

2) Phorate sulfoxide, a metabolite of the highly toxic substance phorate, was detected in two carrot samples, also stated to be from Vietnam. Phorate sulfoxide itself is not used as a pesticide, which indicates that phorate was applied to the vegetable.

3) Cypermethrin was detected in two morning glory samples stated to be from Kampong Chhnang. The residue definition of cypermethrin includes residues that may come from uses of different isomers (e.g. alpha-cypermethrin; zeta-cypermethrin). If zeta- cypermethrin was used, this would not have been legal in Cambodia.

Out of 100 samples, 68 (68%) were stated to be sourced from within Cambodia. Eleven of those had residues of seven different chemicals and four were above the EU MRLs – all were tomato samples with permethrin residues. The EU MRL is 0.05 mg/kg, but the residues in the samples ranged from 0.092 - 0.26, so up to 5 times the limit.

Twenty-four (24%) of the samples were stated to be sourced from Vietnam. Ten contained residues of eight different chemicals, with six samples exceeding the EU MRLs.

Four samples were stated to be sourced from Thailand, all were tomatoes and all contained carbendazim residues, but below the EU MRLs.

Four samples were stated to be sourced from China, but did not contain any detectable residues.

3.2 Discussion of Results

While at first glance, the results with no detection in 75% of the samples might give the impression that the situation is not too alarming, the focus still has to be set on the detections in the last 25% - and they unfortunately still give reasons for concern and emphasise that more has to be done to achieve improved pesticide management in the country.

Like already discussed, up to three different banned pesticides were detected in the samples, though primarily two substances give main reasons for concern.

Phorate sulfoxide as a metabolite of the extremely toxic substance phorate was detected as well as metamidophos, though it could also be a metabolite of acephate, which officially is not banned in Cambodia. Lastly, the detection of cypermethrin could also indicate the use of zeta-cypermethrin, which is on the banned list, though also other isomers or the pesticide itself could have been used and it is not possible to detect the actual substance.

Since the banned and restricted list of the MAFF has last been updated in 2012, another indicator to pin down possible risks of the individual substances is to compare it to residue limits of other countries or economic regions. Several samples exceeded EU MRLs as well as US tolerances. This already demonstrates that 20 out of 100 samples (20%) would not have been considered safe enough for consumption in many Western countries – surely, the same should apply for other countries as well.

Next to the zero import tolerances for acephate, carbendazim and phorate in the U.S., the EU has prohibited several detected pesticides as well: acephate is not approved for use, carbendazim is only allowed on national level in four countries, but generally prohibited, methamidophos, permethrin and phorate are again not approved at all.

According to the independent pesticide expert Mr. Neumeister, limit systems, or parts of them, are likewise not necessarily an indicator for consumer safety, especially when looking at the CAC MRLs. They are, for example, not set to protect sensitive consumer groups, above all children, but also older or sick people. In addition, the Joint Meeting on Pesticide Residues (JMPR) responsible for setting the CAC MRLs ignores the fact that people – specifically rural children in developing countries – are exposed to a range of similar pesticides through different exposure pathways. With some limits, an acute health risk cannot be excluded when residues achieve the MRLs. Therefore, taking these limits only as reference to assess risks about detections is still not enough.

Aside from checking maximum residue limits or tolerances, there are also other

classifications. One of the most known ones is the classification system by the WHO, which divides substances into three categories (see Table 4).

A more independent and critical analysis is the Highly Hazardous Pesticides (HHP) list of the Pesticide Action Network (PAN), which followed a HHP list already done by FAO/WHO, but included more criteria for substances that should be defined as highly hazardous. The definition of HHPs in the new Code of Conduct on Pesticide Management (adopted by FAO and WHO in 2013) and in the Guidelines on Highly Hazardous Pesticides , adopted in 2016 is:

"Highly Hazardous Pesticides means pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health or environment according to internationally accepted classification systems such as WHO or GHS or their listing in relevant binding international agreements or conventions. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under conditions of use in a country may be considered to be and treated as highly hazardous." [XXXVIII]

In the samples of the study, nine out of 12 detected pesticides are currently classified as being highly harmful to human health, the environment and specifically to bees, which eventually also causes concerns when talking about food safety in terms of availability of food.

It is remarked that already six pesticides are classified as being harmful to bees by the HHP list and just recently the US EPA (Environmental Protection Agency) admitted for the first time that three commonly used neonicotinoid pesticides – clothianidin, thiamethoxam and dinetofuran – pose a significant risk to bee populations as well, which would add clothianidin, even if not on the HHP list. However, the US Environmental Protection Agency also announced that it had withdrawn its support for a proposal to introduce limited restrictions on the use of neonicotinoids in fields where honey bees are present.

The detection and use of phorate in two carrot samples is clearly concerning. This substance is categorized as class Ia, the

Table 4 WHO and HHP list classification of detected pesticides

Pesticide	WHO classification	PAN HHP list	>EU MRLS	Impacts according to HHP list
acephate	III	Yes	Yes	Toxic to bees
carbendazim	Unclassified	Yes	No	Induces inherited mutations Human reproductive toxicant
chlorothalonil	III	Yes	No	Fatal if inhaled Likely carcinogen
clothianidin	III	No	No	
cypermethrin	II	Yes	No	Toxic to bees
difenoconazole	III	No	No	
imidacloprid	II	Yes	No	Toxic to bees
methamidophos	Ib	Yes	Yes	Fatal if inhaled
permethrin	II	Yes	Yes	Toxic to bees Likely carcinogen
phorate (sulfoxide)	Ia	Yes	Yes	Toxic to bees
propiconazole	II	No	No	
thiamethoxam	III	Yes	No	Toxic to bees

WHO classification: Ia = Extremely hazardous Ib = Highly hazardous
II = Moderately hazardous III = Slightly hazardous

most dangerous of all categories defined as extremely hazardous by the WHO. It is also highly toxic to bees according to the HHP list (source: US EPA).

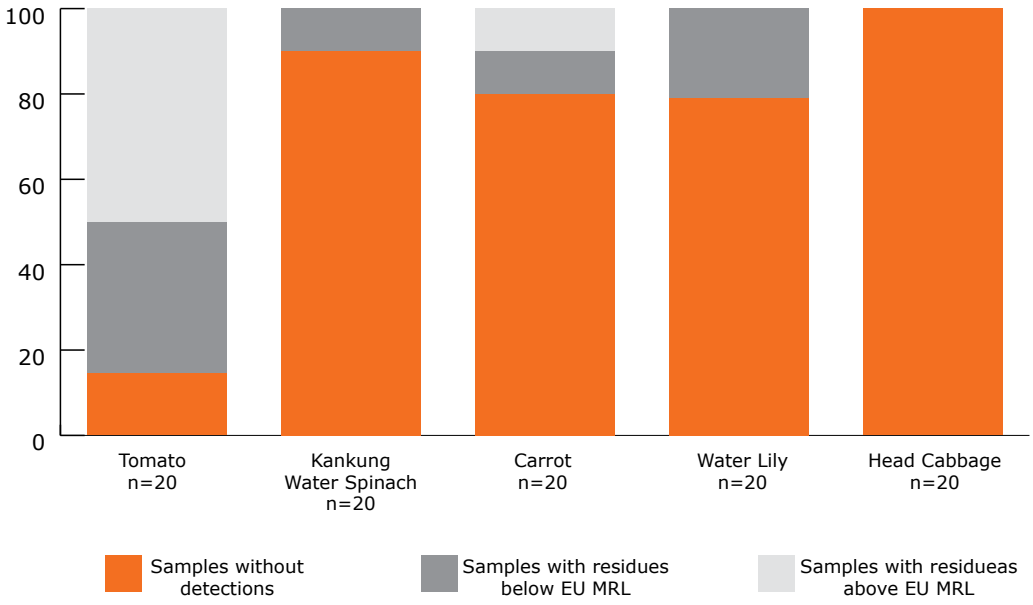
Metamidophos itself is classified as highly hazardous (class 1b) by the WHO and fatal if inhaled according to the HHP list (source: The Globally Harmonised System (GHS) by the United Nations). Though it could also be a metabolite of acephate, this would only increase the residues found in the same samples for this pesticide, which is also highly hazardous to humans according to the consulted independent pesticide expert as well as highly toxic to bees according to the HHP list (source: US EPA).

According to the independent pesticide expert Mr. Neumeister, pesticides such as phorate and acephate should generally not be used – they are not only highly hazardous to humans, but also do not fit in any integrated pest program, because they extinct beneficial organisms.

When looking at individual vegetables, the tomato samples are the highest cause for concern. Fifteen out of 20 samples (75%) had detectable pesticide residues, as shown in Figure 2.

In four of the tomato samples, testing found residues of the highly toxic pesticide metamidophos. Residues of permethrin were also detected in tomato samples, with four samples containing permethrin residues above the EU MRLs. The EU MRL is 0.05 mg/kg, the exceeding residues in

Figure 2: Residues in five vegetables in Cambodia (2016)



Source: Alliance2015/SUPA71

the samples ranged from 0.092 - 0.26, so up to 5 times the limit. Permethrin is ranged as class II (moderately toxic) by the WHO and as a HHP and likely carcinogen by PAN (source EPA).[XXXVIII] All four samples thus pose a risk for consumers.

Though the detected levels of the fungicide carbendazim did not exceed any MRLs in tomatoes (or water lily), it was detected in 14 tomato samples and in 18 samples in total. Carbendazim is prohibited in most European countries (authorised only in ES, PL, PT and the former member UK) and cannot be present at all (in the produce tested) if that produce is to be imported into the US. According to the HHP list (source: EU GHS), the substance is known to induce heritable mutations or to be regarded as if they induce heritable mutations in the germ cells of humans

and is also a known or presumed human reproductive toxicant.[XXXVIII]

The study results suggest that tomatoes appear to be the largest risk to consumers. Tomatoes had the most variety of pesticide residues as well as the highest concentrations. In a single tomato sample from a market in Takeo, six different pesticide residues were detected. One concern highlighted in the literature review done by SUPA71 was the use of a pesticide cocktail by farmers in the region, who mix different pesticides together or already get this mix sold by non-specialized stores.[I] This may or may not be the reason that some vegetables had numerous pesticide residues on them. Tomatoes are particularly risky as they are typically eaten raw and unpeeled. This means any pesticide residues present will not be broken down by heat or removed by peeling. Washing or soaking in water might not decrease pesticide residues enough or at all when systemic pesticides have been applied, for example.

Multiple pesticide residues in produce could be a reason for more concern, as certain chemicals are more toxic when combined than alone. Currently, pesticides are still classified individually by authorities responsible for setting limits, although some studies[XI] have shown that an increased health risk exists when certain pesticide combinations are present.[XVI] With this potential synergistic effect between pesticides, more studies are required to assess the health risks of pesticide cocktails.

Necessities like this, however, only show the gap in adhering to good agricultural practices and it does demonstrate the further need for regulations, constant monitoring and evaluation as well as stronger law enforcement.

3.3 Preconditions and Limitations

Time and budget constraints and some unforeseeable events lead to the study having some limitations. Several unexpected delays pushed the sample collection into the early rainy season. Testing only in rainy season compared to the dry season is not ideal for several reasons:

- Farmers in the region tend to grow less vegetables, as it is not planting season.
- Less pests occur during this time which results in the application of less pesticides.
- Heavy rain washes off pesticides in the wet season, potentially lowering the pesticide residue concentrations.

Testing from the market rather than directly from the field also brings some limitations as well. The handling of the vegetables from producer to the vendor is unknown. Therefore, it is uncertain if the vegetables were cleaned or subjected to any processes before they were presented

for sale in the market where they were purchased. Another factor impacting the pesticide residues detected might be the practice of soaking vegetables in a water bath at the markets to keep them fresh. Transportation time from the field to the market is also unknown, which could result in degradation of applied or potentially applied substances.

The study represents a snap shot in time of the pesticide residues in produce that Cambodians buy and consume – that which they purchase from fresh markets.

3.4 Potential Risks of the Pesticide Residues for Cambodians

In order to assess the risk associated with pesticide residues in food it is necessary to know the dietary exposure of Cambodians to those pesticides. This requires studying how much of each food type Cambodians eat and the pesticide residue content of those foods. Such a study would need to assess the dietary exposure of various age and gender groups, particularly groups such as young children who are particularly at risk due to their developing organ systems, low body weight, and high metabolism. Unfortunately, very little such data exists and collecting it was beyond the scope of this study.

The pesticide risk assessment expert, engaged to assess the results of the study, used data derived from a 2011 study of weekly food consumption in three Cambodian provinces as well as published data from other countries and toxicological reference values, called Acceptable Daily Intake (ADI) and Acute Reference Dose (ARfD). The fact that the food consumption data used for the calculations is not directly related to the geographical areas the vegetable samples were collected from introduces uncertainty. This, plus the numerous uncertainties associated with the study, mean that no definitive conclusions can be drawn specifically from the study results in terms of the risks to consumers that the pesticide residues identified in the study present.

In the assessment, European Food Safety Authority (EFSA) values were used for all pesticides except for acephate and permethrin (no EFSA data available). For acephate and permethrin, ADI/ARFD values from the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) were used. Low ADI and ARfD values imply high toxicity and vice versa. Phorate and methamidophos are therefore the pesticides with highest toxicity among the detected pesticides, as can be seen in Table 5. The table also shows that nine of the 12 pesticides detected affect the human nervous system.

What are toxicological reference values (ADI and ARfD)?

The Acceptable Daily Intake (ADI), generally expressed in milligram (mg)/kg body weight per day, is defined as the daily intake which, over an entire lifetime, appears to be without adverse effects or harm to the health of the consumer (chronic exposure).

The Acute Reference Dose (ARfD) is also expressed in mg/kg body weight and is the maximum short term exposure (acute exposure) that will have no observed effect.

These reference values are determined by national and international organizations, including the FAO and WHO and EFSA. The values may vary among different organization for several reasons.

Table 5 Toxicological reference values (ADI/ARfD) for the pesticides detected in the study

Pesticide	Chemical Group	ADI mg/kg bw	ARfD mg/kg bw	CAG Group
acephate	Organophosphate	0.03	0.1	Nervous system* (ChE)
carbendazim	Benzimidazole	0.02	0.02	not evaluated by EFSA
chlorothalonil	Chloronitrile/ Substituted Benzene	0.015	0.6	not evaluated by EFSA
clothianidin	Neonicotinoid	0.097	0.2	Nervous system
cypermethrin	Pyrethroid	0.02	0.04	Nervous system
difenoconazole	Triazole	0.01	0.16	Nervous system
imidacloprid	Neonicotinoid	0.06	0.08	Nervous system
methamidophos	Organophosphate	0.001	0.003	Nervous system (ChE)
permethrin	Pyrethroid	0.05	No acute toxicity expected	Nervous system (Pyrethrins)
phorate (sulfoxide)	Organophosphate	0.0007	0.003	Nervous system* (ChE)
propiconazole	Triazole	0.04	0,3	not evaluated by EFSA
thiamethoxam	Neonicotinoid	0.026	0.5	Nervous system

**not included in EFSA CAG Assessment, but known neurotoxins*
ChE = Cholinesterase Inhibitor
CAG = Cumulative Assessment Group
EFSA ADI/ARfD values were used for all pesticides except for acephate and permethrin (no data by EFSA). For acephate and permethrin ADI/ARFD values of the JMPR were used

The ADI and ARfD values provide guidance on the recommended maximum acute and chronic intake of pesticides. It is considered unsafe if the calculated intake of a pesticide exceeds 100% of the ADI and/or the ARfD values. Calculated values below 100% are considered acceptable. [XII]

Modelling the worst-case scenario, the consultant used the highest published regional dietary intakes for the vegetables tested and used a body weight of 16.1 kg to represent the most sensitive population group (children). This scenario resulted in one methamidophos residue in one

tomato sample being above the ARfD. The same residue also resulted in the highest calculated percentage of the ADI (11.08%). Almost five other residues exceed 50% (between 47.3% and 72.3%).

When samples with multiple residues from the same cumulative assessment group are evaluated together, there is little change in the outcome. The cumulative assessment does not cause any additional exceedance of the ARfD or the ADI. However, in five other samples (three tomato and two carrot samples) with multiple residues, the sum of the ARfD reaches over 50% (between 52.5% and 78.9%).

In the opinion of the pesticide expert, the single (or cumulative) ARfD should never achieve 20% in an individual sample. Other food items consumed over the day or other exposures to the same pesticide or similar chemicals will increase the risk of side effects. This is particularly a risk for rural children in developing countries – who may be exposed to a range of similar pesticides through different exposure pathways. Pesticide residues in food should therefore be as low as possible. If we use 20% as the limit for calculated ARfD values this means 14 out of 42 calculated ARfD values exceed this limit as well as six out of 11 calculated cumulative ARfD values. The results indicate that all samples containing phorate and metamidophos pose the highest acute risks for consumers, since all individual and cumulative calculations containing these substances, exceed 50% of the ARfD, with one sample exceeding 100% (as previously mentioned).

These calculations indicate that a potentially unsafe level of pesticides was present in the samples collected for the study in July 2016. However, this conclusion must be treated with great caution. The data used for the calculations may not represent actual consumer behaviour in Cambodia and the study's sample size is likely to be not representative. Further studies are needed to have confidence in the results. However, one concerning result of the study can still be highlighted:

Most of the pesticide residues in the study samples are neurotoxic and widespread exposure to these pesticides in Cambodia is very likely according to various sources (refer to the detailed risk assessment report for full details).

3.5 Food Preparation Techniques for Reducing Risks of Pesticide Residues

Food preparation can reduce the health risks associated with pesticide residues, but it should not be seen as a solution for pesticide issues.

The study included a literature review to identify the most effective methods for Cambodian households to reduce the risk of pesticide consumption associated with fresh vegetables. Based on that review and with consideration to lifestyle factors in Cambodia, the most practical way for Cambodian consumers to reduce the amount of pesticide residues on their vegetables is for them to soak the vegetables for 20 minutes in a large volume of water, preferably with agitation and salt (10% salt solution). Following this, the vegetables should be rinsed, peeled if appropriate, and then either blanched in boiling water for five minutes or stir fried or baked. Further studies would be necessary to confirm the amount of each pesticide on each vegetable that these processes would remove, but based on the literature, the combination of those processes would remove more than 50% of each residue.

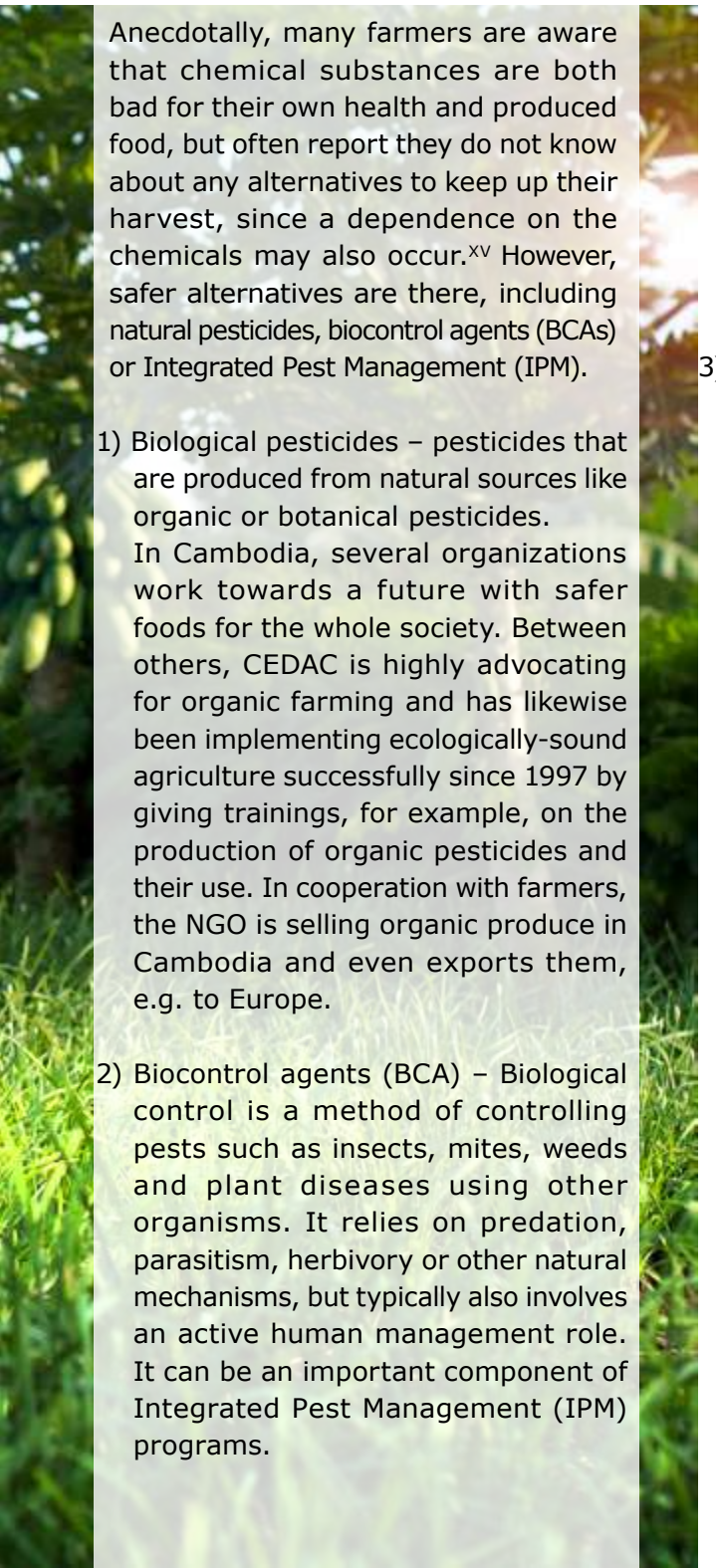
These food preparation techniques have the added advantage of reducing other contaminants e.g. bacteria and potentially food-borne diseases.

This 'Wash/Peel/Cook" message could be incorporated into school curricula and promoted as a public health message.

Wash and soak your vegetables for 20 minutes in salted water with lots of movement.
Use about 1.5 cups of salt in 5 litres of water.
Peel the ones that can be peeled.
Put them into boiling water for 5 minutes or cook, stir fry or bake them.
Most important is that you apply heat.

4. Improving Agricultural Practices

The best way of controlling residues in food is to increasingly reduce or avoid using synthetic pesticides at all. As reported by Environmental Justice Foundation in a study conducted in collaboration with CEDAC, much of Cambodian pesticide use is non-essential[II] and might thus not even benefit any harvest, but rather has harmful short or long-term effects on the crop and the soil next to all hazards already discussed.[XVI]



Anecdotally, many farmers are aware that chemical substances are both bad for their own health and produced food, but often report they do not know about any alternatives to keep up their harvest, since a dependence on the chemicals may also occur.[xv] However, safer alternatives are there, including natural pesticides, biocontrol agents (BCAs) or Integrated Pest Management (IPM).

1) Biological pesticides – pesticides that are produced from natural sources like organic or botanical pesticides.
   In Cambodia, several organizations work towards a future with safer foods for the whole society. Between others, CEDAC is highly advocating for organic farming and has likewise been implementing ecologically-sound agriculture successfully since 1997 by giving trainings, for example, on the production of organic pesticides and their use. In cooperation with farmers, the NGO is selling organic produce in Cambodia and even exports them, e.g. to Europe.

2) Biocontrol agents (BCA) – Biological control is a method of controlling pests such as insects, mites, weeds and plant diseases using other organisms. It relies on predation, parasitism, herbivory or other natural mechanisms, but typically also involves an active human management role. It can be an important component of Integrated Pest Management (IPM) programs.
   In Cambodia, the German development agency GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) is promoting and supporting farmers and suppliers alike in order to further implement this way of pesticide control as an alternative to synthetic pesticides.

3) Integrated Pest Management – IPM uses a combination of practices for an effective and environmentally sensitive approach to pest management, rather than being a single pest control method. IPM programs use information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, including the reasonable use of chemical pesticides, if needed, is used to manage pest damage with the least possible hazard to people and the environment.

   In Cambodia, the Centre for Agriculture and Bioscience International (CABI), supported by PLANTWISE, runs plant clinics in cooperation with The General Directorate of Agriculture (GDA) and the Royal University of Agriculture. Plant clinics are a meeting place where local plant health extension officers, known as plant doctors, help farmers struggling with plant pests and diseases. They provide diagnoses and management advice for any problem and any crop.

5. Conclusion and Recommendations

The study was a pioneer study in the Cambodian context. Due to the uncertainties associated with the study data, the results cannot be used to make definitive conclusions about the risks associated with pesticide residues in fresh produce in Cambodia, but they can be used as a starting point for further research.

Whilst the study was small in scale and does not represent the situation across all parts of Cambodia at all times, it did identify that between one and three banned pesticides were present at potentially unsafe levels in up to three types of vegetables in the samples that were collected.

Based on the study results, risk assessment and literature review, the following actions are recommended for reducing the risks associated with contaminants in vegetables and also fruits available to consumers in Cambodia.

1) PROMOTE DOMESTIC FOOD PRODUCTION & SUSTAINABLE FARMING

Decreasing pesticide residues starts at the field. Safer and more sustainable alternatives should be further promoted in Cambodia by encouraging farmers to switch to natural pesticides, Integrated Pest Management (IPM) or biocontrol agents (BCAs) under initial advisory. If feasible for farmers, the safest option still remains with organic farming, benefitting both health and environmental issues. Especially small-scale farmers should be further supported to yield organic produce. Moreover, the promotion of organic home gardening, both in rural and urban settings, could increase availability of safe and locally grown produces in the country and decrease the need to import fresh produce to meet demands.

2) PROMOTE CONSUMPTION OF DOMESTICALLY GROWN VEGETABLES

Demands drive the market – by encouraging Cambodian's to ask for locally grown or organic in the markets, this will encourage farmers to expand their production of vegetables and sustainable farming. This will likewise decrease imports of fresh produces. Imports are taking market share away from local farmers as they are cheaper, although they are not always fulfilling consumers' demands. If farmers increase their output of local/organic vegetables and fruit, sales of imported foods can drop. The less gets imported, the more can local prizes compete on the market eventually.

3) PROMOTE CAMBODIA AS A SOURCE OF 'CLEAN & GREEN' PRODUCE

Once it is established through routine testing that Cambodia does in fact produce fresh produce that contains pesticides below international recommended limits or are even organic, there is an opportunity to promote this both domestically and internationally. By encouraging Cambodian's to consume locally grown products and by promoting Cambodia as a source of safe fresh produce, this will drive market demand and support domestic production and sustainable farming.

4) IMPLEMENT A REGULAR TESTING REGIME

Only with a formal monitoring program in place will the Cambodian Government be able to assure both consumers in Cambodia and export customers that produce grown or available for sale in Cambodia is safe from harmful levels of pesticide residues.

Testing should take place in both wet and dry seasons and in the field and in markets, to produce the data required to make informed decisions about pesticide management.

5) IMPROVE CONTROLS ON IMPORTED PESTICIDES AS WELL AS VEGETABLES

By strengthening controls on imports of vegetables, particularly tomatoes and carrots, Cambodia could reduce the risk of consumer exposure to hazardous pesticide residues.

Likewise, controls of imported pesticides could reduce the risk of harmful and banned pesticides ending up on the market and thus in the food produced and consumed by Cambodians.

As free trade agreements are created between countries in the Association of Southeast Asian Nations (ASEAN), controls on pesticides and pesticide residues will become stronger. Cambodia will need to address the importation and use of pesticides in order to meet ASEAN requirements.

6) INFORM PUBLIC AND INVESTIGATE FURTHER ABOUT THE STATE OF TOMATOES

As identified in the study, pesticide residues on tomatoes represent the highest risk to Cambodian consumers. Three specific actions are recommended to reduce this risk:

Tighten border controls on tomato imports

Tomatoes should be prioritized for testing for the presence of pesticide residues at border crossings.

Investigate the Use of Permethrin on Tomatoes Grown near Phnom Penh

The study identified that tomato samples, reported to be from Phnom Penh, contained up to five times the maximum residue level (using the EU MRLs) of the pesticide permethrin. This may be an isolated case, but an investigation of the farming practices used by farmers growing tomatoes near Phnom Penh is warranted.

Investigate and Promote Alternatives for Pest Management in Tomato Growing

Provide agricultural extension services focusing on ways to overcome tomato pest issues using good agricultural practice and eco-friendly alternatives to synthetic pesticides.

7) PROMOTE WAYS HOUSEHOLDS CAN REMOVE PESTICIDE RESIDUES FROM FRESH PRODUCE

This study found that washing, preferably in salted water, and/or peeling and cooking of vegetables before consumption reduces pesticide residues. This "Wash/Peel/Cook" message could be incorporated into school curricula and promoted as a public health message.

8) STRENGHTEN THE REGULATORY ENVIRONMENT & LAW ENFORCEMENT

Whilst the MAFF has made strong efforts in pesticide management in Cambodia, there are still many challenges which remain unresolved. These include the insufficient enforcement of rules and regulations, uncontrolled importation, and broad availability of undesirable pesticides, misuse and over use, limited data on health and environmental effects and pesticide residues in food.[v]

Promotion of the Law on the Management of Pesticides and Fertilizers, enforcing the law and educating those in the agriculture sector about the proper use of pesticides are all ongoing recommendations.

Finalizing and implementing the proposed Food Law, the first draft of which was published mid-2015, is also recommended. The law includes the establishment of a Food Safety Authority, which shall advise the responsible Ministers on food control and food safety matters.

9) CONDUCT FURTHER STUDIES ON FOOD SAFETY

This study assessed only the pesticide residues present in five vegetables in Cambodia. Further studies of other types of contamination, such as microbiological contaminants and chemical contamination e.g. lead and arsenic are recommended.

Further studies are also needed to determine the dietary exposure of Cambodians to pesticides based on the amount of each vegetable consumed by various age and gender groups.

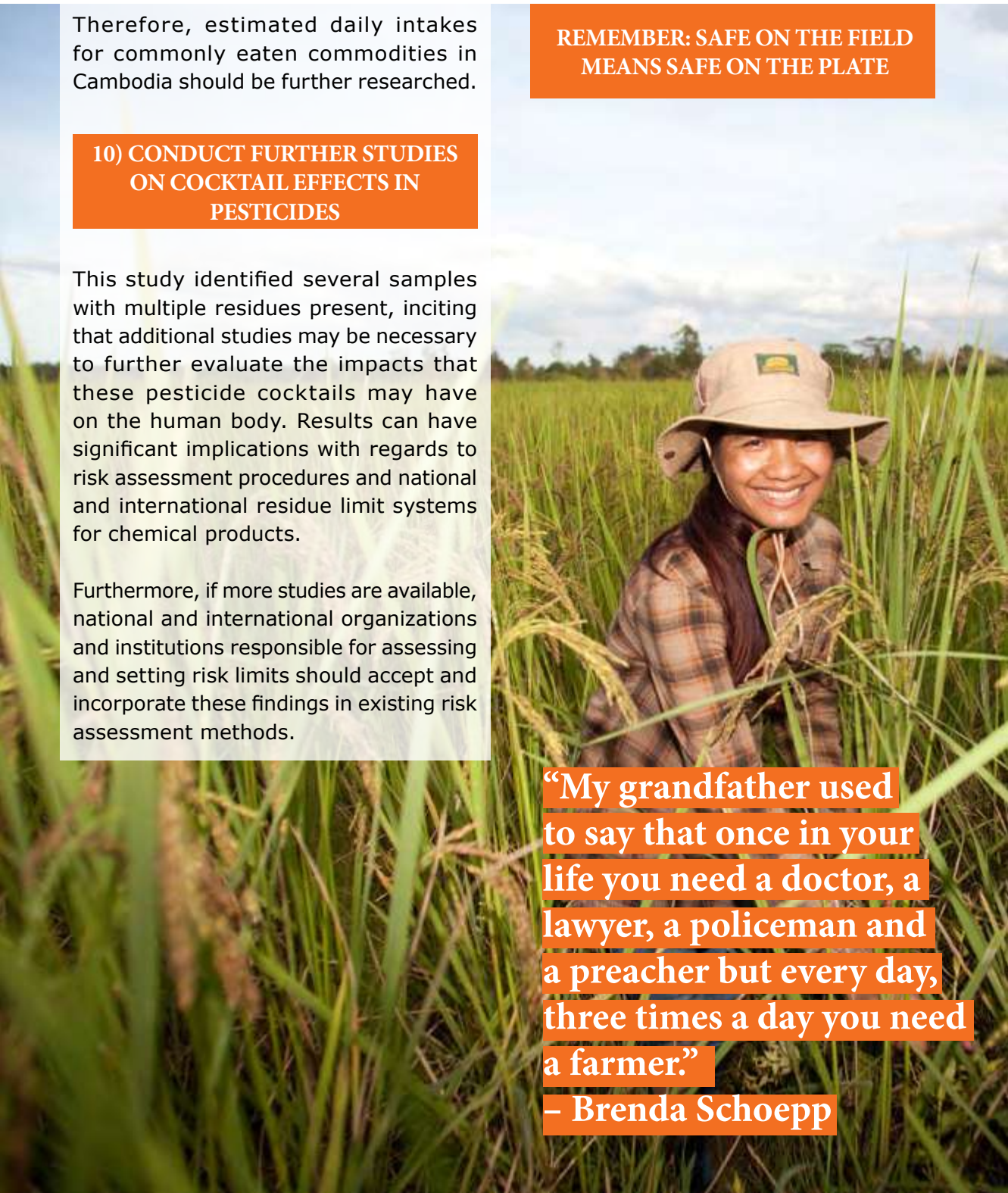
Therefore, estimated daily intakes for commonly eaten commodities in Cambodia should be further researched.

10) CONDUCT FURTHER STUDIES ON COCKTAIL EFFECTS IN PESTICIDES

This study identified several samples with multiple residues present, inciting that additional studies may be necessary to further evaluate the impacts that these pesticide cocktails may have on the human body. Results can have significant implications with regards to risk assessment procedures and national and international residue limit systems for chemical products.

Furthermore, if more studies are available, national and international organizations and institutions responsible for assessing and setting risk limits should accept and incorporate these findings in existing risk assessment methods.

REMEMBER: SAFE ON THE FIELD MEANS SAFE ON THE PLATE



"My grandfather used to say that once in your life you need a doctor, a lawyer, a policeman and a preacher but every day, three times a day you need a farmer."
– Brenda Schoepp

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Country Office Cambodia
#113 (Parkway Square 1st Floor),
Mao Tse Toung Boulevard,
Toul Svay Prey I, Chamkar Morn,
Phnom Penh, Cambodia
Phone + 855 (0)23 216 594
www.acted.org

Deutsche Welthungerhilfe e. V.
Country Office Cambodia
#331 (Time Tower 4th Floor), Street 271,
Toul Tumpong II, Chamkar Morn,
Phnom Penh, Cambodia
Phone +855 (0)23 885 229
www.welthungerhilfe.de

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Country Office Cambodia
#33 (4th floor), Street 71,
Tonle Bassac, Chamkar Morn,
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