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Research article

Food safety risk assessment of pesticide residues in Chinese kale grown in Khon Kaen province, northeast Thailand

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Abstract

Pesticide residues in Chinese kale were monitored and assessed to investigate their risk to food safety. In total, 60 samples of Chinese kale under Good Agricultural Practice (GAP) and non-GAP production were analyzed for the presence of 146 pesticides using the quick, easy, cheap, effective, rugged and safe multi-residue extraction method, followed by liquid chromatography-tandem mass spectrometry. A Chinese kale sample in each plot was taken during harvesting in the winter, summer and rainy seasons of 2018. From the 60 Chinese kale samples, no pesticide residues were detected in 10 samples (16.7%) while 50 samples (83.3%) had detectable pesticide residues, with relatively higher proportions in non-GAP samples that exceeded the maximum residue limits levels established by the Thai Agricultural Standard and Codex Alimentarius Commission, especially in the rainy season. Assessment of consumption risk in terms of a hazard index (%HI) showed that the average %HI of Chinese kale from the GAP samples was in the range 0.04–0.57%, while for Chinese kale from non-GAP samples the range was 0.62–2.66%. As the HI values were less than 100, the sampled Chinese kale could be considered acceptable regarding food safety. However, detected pesticide levels in the Chinese kale from non-GAP plots were higher than from GAP plots, indicating that consumers are less exposed to pesticide toxicity from consuming Chinese kale from GAP farms than from non-GAP farms.

Introduction

Pesticides are chemical substances, which are commonly used in modern agriculture practices to protect the crops from different pests and diseases. Pesticide use in agriculture is rapidly increasing in many developing countries, especially in Southeast Asia (Schreinemachers and Tipraqsa, 2012). The fast rate of increasing pesticide usage poses enormous challenges to manage the associated risks to people and ecosystems (Harnpicharnchai et al., 2013; Schreinemachers et al., 2017). For example, Thailand is one of the exporters of agricultural products in the world and pesticides have been widely used in agriculture in Thailand, with the quantity of pesticide imported likely to increase. For example, in 2016, the volume of imported pesticides

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increased to 160,687 t, with most pesticides being imported from China (Department of Agriculture, 2016). The effects of pesticide on human health showed an upward trend of patients affected by pesticide toxicity from 3.19 per 100,000 population in 2010 to 17.12 per 100,000 population in 2017 (Department of Disease Control, 2017). Fruits and vegetables imported from Thailand by European countries were reported to contain pesticide residues that exceeded the maximum residue limits (MRLs) in 9% of samples (Skretteberg et al., 2015). Pesticide residues in vegetables above the MRL have also been reported in central Thailand (Wanwimolruk et al., 2016). Nowadays, consumers are increasingly concerned about food safety and looking for safer food products. To reduce potential food hazards and increase the good image of Thai horticultural products abroad, the Thai government introduced public standards known as Good Agricultural Practice (GAP) (Schreinemachers et al., 2012).

This study aimed to assess whether vegetables from sampled plots followed the standard for GAP produce better than the product from farmers who did not participate in this scheme in one of the main vegetable growing area in Khon Kaen province. Chinese kale was purposively selected for the study since it is one of the major vegetables consumed in the region (National Bureau of Agricultural Commodity and Food Standards, 2016a). At the same time, it is also susceptible to a substantial number of arthropod pests and plant diseases for which farmers need a lot of pesticides to prevent crop damage; Chinese kale is reported to have a high incidence of pesticide residues exceeding the MRLs in Thailand (Wanwimolruk et al., 2015). Thus, Chinese kale is one of the watch-list plants that must be monitored for pesticide residues. Therefore, the objective of this study was to monitor and assess the risk of pesticide residues regarding food safety by focusing on consumer risk across different seasons and comparing the products from GAP and non-GAP farmers. The results may also be used to help government agencies to implement better GAP programs for this region in the future.

Materials and Methods

Data collection

The commercial vegetable growing village in Muang district, Khon Kaen province, Thailand was purposively selected as a study site in this research as it has extensive vegetable production as farmers have been growing vegetables there for more than 30 yr as their main source of income. At the same time, this village is one of the Thai government's pilot GAP vegetable production areas. Since it is a voluntary scheme, there are both GAP farmers and non-GAP farmers in this village. In this study, Chinese kale was purposively collected from plots on 10 GAP farms and 10 non-GAP farms scattered across the village. At each farm, pesticide residues in Chinese kale were monitored during three seasons (winter, summer, rainy season) and data on the pesticides used were collected using a short questionnaire and from observations. In total, 60 samples were taken at harvesting of Chinese kale in each season, starting during January–October 2018 in the GAP and non-GAP plots. The sampling was done according to guidelines on sampling for pesticide residues analysis (National Bureau of Agricultural Commodity and Food Standards, 2008). Samples were analyzed within 24 hr of collection and stored at 4°C until the moment of extraction.

Analytical methods

Pesticide residues analysis

Samples were analyzed for the presence of 146 pesticides (insecticides, herbicides, fungicide, acaricides) in Chinese kale samples using the quick, easy, cheap, effective, rugged and safe (QuEChERS) multi-residue extraction, followed by liquid chromatography-tandem mass spectrometry (LC-MS/MS). The standard methods of British Standards (2008) for the determination of pesticide residues from plant products were applied using gas chromatography with tandem mass spectrometry (GC-MS) or LC-MS-MS or both following acetonitrile extraction/partitioning and clean up using dispersive-solid-phase extraction (DSPE) according to British Standards (2008). The method used a single-step buffered acetonitrile extraction and salting out liquid-liquid partitioning from the water in the sample with MgSO4. DSPE cleanup was carried out to remove organic acids, excess water and other components using a combination of primary secondary amine (PSA) sorbent and MgSO4 (Anastassiades et al., 2003).

Validation and quality assurance

The analytical method and instruments were carefully validated as a part of the laboratory quality assurance system and were accredited to ISO/IEC 17025: 2005 (International Organization for Standardization, 2019) by the Bureau of Laboratory Accreditation, Department of Science Service, Ministry of Science and Technology. Bangkok, Thailand.

Method performance

The criteria of quality assurance were followed to determine the performance of the standard method. The average recovery (n = 10) tests on different types of pesticides at different concentration levels varied in the range 70–120%. The reproducibility expressed as relative standard deviation was less than 20% in accordance with the SANTE/11813/2017 documentation (European Commission, 2017). The limit of quantification started at 0.01 mg/kg upward, depending on the pesticide type and detected module.

Apparatus

LC-MS/MS: A compact ESI-Q-TOF series (Bruker Daltonik GmbH.; Bremen, Germany) and a liquid chromatography system (HPLC Ultimate 3000 series; Thermo Scientific; Sunnyvale, CA, USA) tandem mass spectrometer with an electrospray ionization (ESI) interface were used. Separation was performed on a C18 column Thermo Scientific AcclaimTM RSLC C18 120, 120A° 2.1 mm × 100 mm, with 2.2 μm particle sizes. The column temperature was 30°C and the injection volume was 5 μL. The mobile phase was at a 0.2 mL/min flow rate, in which one reservoir contained 10 mM ammonium formate solution in MeOH: H2O (1:9 volume per volume). The ESI source was used in the positive mode and nitrogen was used as the nebulizer gas, with the collision cell according to the manufacturer's settings (Bruker, 2019); Mass spectrometry conditions were at source, the ES end plate offset was 500 V, the capillary was 4,500 V, the spray condition was in positive mode, the dry gase rate was 8.0 L/min, the dry temperature was 180°C and the nebulizer was set at 2.0 Bar.

Pesticide reference standards

Magnesium sulfate anhydrous, sodium chloride, PSA (particle size 40 µm), graphite carbon black and C18 sorbent were obtained from Supelco (Sigma-Aldrich; Darmstadt, Germany). HPLC-grade acetonitrile was purchased from Merck (Darmstadt, Germany). The 146 pesticide standards were purchased from Dr. Ehrenstorfer (Augsburg, Germany). The purity of the pesticide standards was > 98%. Individual stock of standard solutions (1,000 mg/L) was prepared in acetonitrile.

Risk assessment of pesticide residues in Chinese kale

The evaluation of pesticide residues for estimation of the MRLs and calculation of dietary intake was based on the guidelines of Food and Agricultural Organization (2016). The assessment involved comparing the concentrations of residue detected with the established acceptable daily intake (ADI). The level of residue concentration in kale was determined as the arithmetic mean of all the results obtained. The pesticide residues in Chinese kale were used in the calculation of exposure in order to avoid overestimation of the estimated daily intake (EDI). The EDI (in milligrams per kilogram body weight) of each pesticide residue was calculated by multiplying the concentration of pesticide residue (in milligrams per kilogram), the food consumption rate (in kilograms per day) and dividing by the body weight. This model is considered especially useful for developing countries (Alla et al., 2015). The EDI of pesticide residues was calculated using Equation 1:

$$EDI = \sum (Fi\ RLi/BW) \tag{1}$$

where Fi is food consumption of people aged 15–59 yr in northeast Thailand for Chinese kale at 0.01 kg/day according to food consumption data of Thailand. (National Bureau of Agricultural Commodity and Food Standards, 2016a), RLi is the pesticide residue level in vegetables (Chinese kale) and BW is the average body weight for adults in Thailand (62.8 kg; based on male at 68.9 kg and female at 56.6 kg) according to SizeThailand (Wells et al., 2012).

The long-term risk assessment of the intakes compared to the pesticide toxicological data was based on the hazard quotient (HQ), by dividing the estimated daily intake by the relevant acceptable daily intake (Łozowicka et al., 2013). Risk assessment was based on HQ using data for estimated daily intake (EDI) and acceptable daily intake (ADI) according to the Codex Alimentarius (Food and Agricultural Organization/World Health Organization, 2016). The risk was calculated using Equation 2:

$$HQ = (EDI/ADI) \times 100\% \tag{2}$$

The HQ values were summed to provide the chronic hazard index (cHI) calculated using Equation 3:

$$cHI = \sum HQi \tag{3}$$

where cHI is the total hazard for a specific exposure pathway and HQi is the hazard quotient for pesticide i, When cHI >100, the food involved should be considered as a risk to the consumers, while HQ <100 indicates that the food involved is considered acceptable.

Results and Discussion

Pesticide residues in Chinese kale samples

In each season, different frequencies of different types of pesticides were detected on both the GAP and non-GAP plots. However, insecticides were commonly found in all seasons for both plots, indicating that insect damage in Chinese kale production in this area was critical and approaches to reduce the infestation of insects must be seriously taken into account. The types of pesticides used by farmers (GAP and non-GAP) were not different because most farmers buy pesticides at agrochemical shops in the village. In the rainy season, the most frequently detected pesticide residue was tolfenpyrad (4 samples in both plots), with ranges of 0.03–0.31 mg/kg for GAP plots and 0.04–0.74 mg/kg for non-GAP. The tolfenpyrad concentrations in both plots also exceeded the MRLs levels as did profenofos and cypermethrin in the GAP plots, while in the non-GAP plots diazinon and chlorfenapyr ex ceded the MRL levels (Table 1).

In the winter season, imidacloprid was commonly found in GAP plots, followed by metalaxyl. At the same time, non-GAP plots commonly contained imidacloprid and profenofos. However, the highest pesticide residues exceeding the MRLs in the GAP kale were profenofos (0.62–1.15 mg/kg) and cypermethrin (1.60–8.79 mg/kg). At the same time, for non-GAP kale, the highest pesticide residues exceeding the MRLs were profenofos (0.05–5.56 mg/kg) and tolfenpyrad (0.10–0.57 mg/kg), as shown in Table 2.

In the summer season, imidacloprid was frequently detected in GAP plots. However, tolfenpyrad exceeded the MRL level (0.05 mg/kg). Non-GAP plots commonly had profenofos and imidacloprid; however, MRLs were exceed in these plots for tolfenpyrad (0.05–0.24 mg/kg), cypermethrin (0.27–3.78 mg/kg) and profenofos (0.01–0.91 mg/kg), as shown in Table 3.

From the farmer interviews, imidacloprid was commonly used for the control of worms and aphids because this product was inexpensive and easy to obtain from shops in the village. In the rainy season, during high pest frequency epidemics, farmers used pesticides with higher toxicity levels, such as tolfenpyrad, profenofos and cypermethrin. However, considering the number of chemicals used, GAP farmers used fewer than non-GAP farmers.

Based on a survey of pest control in the field, the GAP farmers tried to use integrated pest management methods involving bio pesticides such as azadirachtin, *Baciluss thuringiensis*, *Trichoderma harzianum* and *Steinernema sp.* Moreover, they also used an insect net for protection against pests with government support, which was not available to non-GAP farmers. This may have meant that fewer pesticides were used by non-GAP farmers and also indicated the importance of intervention by government agencies in terms of reducing pesticide use. However, other factors affecting farmer decisions to use pesticides included: labor, market motivation, disease and insect outbreaks and the size of their vegetable plots.

Dietary risk assessment

Chronic risk assessment was performed for all pesticides. The average pesticide residues levels were calculated using residue data from the monitoring data. Details of the calculation of HI values in some seasons are shown in Tables 4 and 5. If HI > 100, there is a risk to consumers. The HI results for assessing consumption risk (Fig. 1) indicated that %HI (n = 10) of Chinese kale from GAP was in the range 0.04–0.57% (winter = 0.49%, summer = 0.04%, rainy season = 0.57%), while the %HI (n = 10) of Chinese kale from non-GAP was in the range 0.62–2.66% (winter = 0.62%, summer = 0.62%, rainy season = 2.66%). Thus, even the high incidence of levels exceeding MRLs, the Chinese kale in the current study could be considered as low risk to consumers. Łozowicka et al. (2013) also reported high occurrences of pesticide residues over the EU MRLs levels of fruits but with no health risk concerns for consumers when the acute hazard index was used to estimate intake in Poland. Alla et al. (2015) indicated that MRLs alone may not reflect the health risk to consumers, but rather such assessment should include the amount consumed and the body weight of the consumer which are indicated by HI. However, the HI value depends on the acceptable daily intake value (ADI) of each pesticide, which is low if a pesticide has a high toxicity level such as for tofenpyrad which has an ADI of 0.006 (Food and Agricultural Organization/World Health Organization, 2016), so based on the HQ equation, the result will be a higher HQ value compared to other pesticides detected at the same amount. There have been reports that exposure to pesticides was related to increased cancer risks and reproductive dysfunctions in humans (Clostre et al., 2014; Salerno et al., 2014). The current study indicates quite clearly that consumers are less likely to be exposed to pesticide toxicity from GAP Chinese kale than non-GAP Chinese kale. Furthermore, the results showed that in terms of health risk assessment, Chinese kale under GAP and non-GAP production were not a serious health risk for consumers based on the long-term assessment (%HI < 100). However, consumers would be less exposed to pesticide toxicity by consuming GAP Chinese kale than by non-GAP Chinese kale. Aside from the proper handling of pesticide, it may be worth considering intervention from government agencies to support farmers to produce crops less vulnerable to pests and diseases such as by subsidizing insect nets.

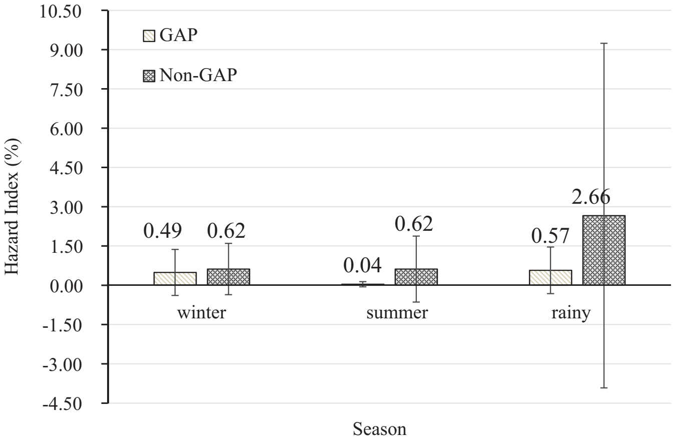

Fig . 1 Average hazard index for consumer risk assessment of good agricultural practice (GAP) and non-GAP Chinese kale collected in winter, summer and rainy seasons in 2018, where error bar = ± SD

Table 1 Frequencies of detected pesticides in Chinese kale of good agricultural practice (GAP) and non-GAP plots in rainy season

Pesticides detected	Type	MRL (mg/kg)	GAP plots		Non-GAP plots	
			Number of samples found	Amount of pesticide found (mg/kg)	Number of samples found	Amount of pesticide found (mg/kg)
Acetamiprid	INS	0.7[b]	0	-	1	0.05
Chlorantraniliprole	INS	20[b]	0	-	2	0.06–1.51
Chlorfenapyr	INS	0.01[a]	0	-	2	0.35
Chlorpyrifos	INS	1[b]	0	-	2	0.05–0.12
Cypermethrin	INS	1[a]	2	0.15–2.58	2	0.08–0.16
Diazinon	INS	0.05[b]	0	-	2	0.20–0.35
Dinotefuran	INS	2[b]	1	0.02	2	0.03
Imidacloprid	INS	5[b]	3	0.01–0.13	3	0.07–0.27
Indoxacarb	INS	0.01[a]	1	0.21	0	-
Metalaxyl	FUC	5[b]	2	0.01	2	0.01–0.22
Profenofos	INS	0.5[a]	3	0.01–2.64	0	-
Thiamethoxam	INS	0.01[a]	0	-	1	0.02
Tolfenpyrad	INS	0.01[a]	4	0.03–0.31	4	0.04–0.74

MRL = maximum residue limit; INS = insecticide; FUC = fungicide

[a] Thai Agricultural Standard TAS 9002-2016 (National Bureau of Agricultural Commodity and Food Standards, 2016b), [b]Codex Alimentarius (Food and Agricultural Organization/World Health Organization, 2016)

Recognition of the role of GAP was assessed by the satisfaction score of the change after applying the GAP guidelines to farmers. If farmers receive more benefits from economic, social, environmental, food, safety and health aspects, they have a better quality of life and the village has a better reputation. A better general environment in the community and in their vegetable plots means greater food security as well as reducing the risk of pesticide residues impacting adversely on farmers and communities. Factors affecting the decision to not participate in the GAP project are related to production and management. However, food safety has become a major concern all over the world and mitigation is pressuring for GAP farmers to become certified. Most farmers find it very difficult to meet these standards, without affordable educational programs to help them make sound food safety risk management decisions. Therefore, agricultural extension should be involved in the process of implementing an educational food safety training program for vegetable producers as a major aim of GAP for food safety requirements. Training should be conducted so that farmers understand risk assessment and the GAP manuals on food safety.

Table 2 Frequencies of detected pesticides in Chinese kale of good agricultural practice (GAP) and non-GAP plots in winter season

Pesticide detected	Type	MRL (mg/kg)	GAP plots		non-GAP plots	
			Number of samples found	Amount of pesticide found (mg/kg)	Number of samples found	Amount of pesticide found (mg/kg)
Acetamiprid	INS	0.7[b]	2	0.01–0.16	2	0.11–0.23
Chlorantraniliprole	INS	20[b]	0	-	2	0.23–2.47
Chlorpyrifos	INS	1[b]	0	-	2	0.003–0.04
Cypermethrin	INS	1[a]	2	1.60–8.79	1	0.14
Dinotefuran	INS	2[b]	3	0.04–0.12	2	0.08–0.23
Imidacloprid	INS	5[b]	8	0.02–0.29	5	0.002–0.11
Indoxacarb	INS	0.01[a]	0	-	1	0.07
Metalaxyl	FUC	5[b]	5	0.01–0.25	0	-
Prochloraz	FUC	0.01[a]	1	0.02	1	0.02
Profenofos	INS	0.5[a]	2	0.62–1.15	4	0.05–1.58
Promecarb	INS	0.01[b]	1	0.16	0	-
Tolfenpyrad	INS	0.01[a]	0	-	2	0.10–0.57

MRL = maximum residue limit; INS = insecticide; FUC = fungicide

[a] Thai Agricultural Standard TAS 9002-2016 (National Bureau of Agricultural Commodity and Food Standards, 2016b), [b] Codex Alimentarius (Food and Agricultural Organization/World Health Organization, 2016)

Table 3 Frequencies of detected pesticides in Chinese kale of good agricultural practice (GAP) and non-GAP plots in summer season

Pesticide detected	Type	MRL (mg/kg)	GAP plots		non-GAP plots	
			Number of samples found	Amount of pesticide found (mg/kg)	Number of samples found	Amount of pesticide found (mg/kg)
Acetamiprid	INS	0.7[b]	1	0.03	3	0.01–0.37
Bifenthrin	INS	0.4[b]	0	-	1	0.12
Carbaryl	INS	1[a]	0	-	1	0.55
Chlorantraniliprole	INS	20[b]	0	-	2	0.45
Chlorpyrifos	INS	1[b]	0	-	1	0.01
Cypermethrin	INS	1[a]	1	0.25	2	0.27–3.78
Dinotefuran	INS	2[b]	0	-	2	0.18–0.28
Imidacloprid	INS	5[b]	3	0.02–0.05	5	0.02–0.28
Indoxacarb	INS	0.01[a]	0	-	1	0.09
Profenofos	INS	0.5[a]	0	-	6	0.01–0.91
Tolfenpyrad	INS	0.01[a]	1	0.05	4	0.05–0.24

MRL = maximum residue limit; INS = insecticide

[a] Thai Agricultural Standard TAS 9002-2016 (National Bureau of Agricultural Commodity and Food Standards, 2016b), [b] Codex Alimentarius (Food and Agricultural Organization/World Health Organization, 2016)

Table 4 Assessment of consumption risk for Chinese kale from GAP plots in winter season

Plot number	Pesticide	Residue (mg/kg)	EDI (mg/kg-day)	ADI* (mg/kg-day)	HQ (%)	%HI = ∑HQ	Health risk**
1	Imidachoprid	0.02	3.82×10^{-6}	0.06	6.37×10^{-3}	6.37×10^{-3}	No
2	Dinotafuran	0.06	9.39×10^{-6}	0.20	4.70×10^{-3}	1.86×10^{-2}	No
	Imidachoprid	0.03	5.25×10^{-6}	0.06	8.76×10^{-3}		
	Metalaxyl	0.03	4.14×10^{-6}	0.08	5.18×10^{-3}		
3	Dinotafuran	0.04	5.89×10^{-6}	0.20	2.95×10^{-3}	6.53×10^{-2}	No
	Imidachoprid	0.24	3.74×10^{-5}	0.06	6.24×10^{-2}		
4	Dinotafuran,	0.12	1.85×10^{-5}	0.20	9.24×10^{-3}	1.85×10^{-2}	No
	Imidachoprid	0.04	5.57×10^{-6}	0.06	9.29×10^{-3}		
5	Profenofos	0.62	9.82×10^{-5}	0.03	3.27×10^{-1}	3.27×10^{-1}	No
6	Acetamiprid	0.16	2.53×10^{-5}	0.07	3.62×10^{-2}	6.23×10^{-1}	No
	Cypermethrin	1.60	2.54×10^{-4}	0.05	5.09×10^{-1}		
	Imidachoprid	0.29	4.55×10^{-5}	0.06	7.59×10^{-2}		
	Metalaxyl	0.01	1.11×10^{-6}	0.05	2.23×10^{-3}		
7	Imidachoprid	0.07	1.11×10^{-5}	0.06	1.86×10^{-2}	8.64×10^{-1}	No
	Metalaxyl	0.05	7.96×10^{-6}	0.08	9.95×10^{-3}		
	Prochloraz	0.02	3.18×10^{-6}	0.01	3.18×10^{-2}		
	Profenofos	1.51	2.41×10^{-4}	0.03	8.04×10^{-1}		
8	Acetamiprid	0.01	2.23×10^{-6}	0.07	3.18×10^{-3}	4.44×10^{-2}	No
	Imidachoprid	0.06	1.00×10^{-5}	0.06	1.67×10^{-2}		
	Metalaxyl	0.12	1.96×10^{-5}	0.08	2.45×10^{-2}		
9	Cypermethrin	8.84	1.41×10^{-3}	0.05	2.80	2.86	No
	Metalaxyl	0.25	3.96×10^{-5}	0.08	4.96×10^{-2}		
10	Imidachoprid	0.13	2.04×10^{-5}	0.06	3.40×10^{-2}	3.40×10^{-2}	No
				Average %HI (± SD)		0.49 (± 0.88)	No

EDI = estimated daily intake; ADI = acceptable daily intake

*ADI values according to the Codex Alimentarius (Food and Agricultural Organization/World Health Organization, 2016)

** %HI > 100 = risk to consumers

Table 5 Assessment of consumption risk for Chinese kale in non-good agricultural practice plots in winter season

Plot number	Pesticide	Residue (mg/kg)	EDI (mg/kg-day)	ADI* (mg/kg-day)	HQ (%)	%HI = ∑HQ	Health risk**
1	Imidachoprid	0.002	3.18×10^{-7}	0.06	5.31×10^{-4}	2.55×10^{-2}	No
	Profenofos	0.05	7.48×10^{-6}	0.03	2.49×10^{-2}		
2	Profenofos	0.30	4.75×10^{-5}	0.03	1.58×10^{-1}	4.29×10^{-1}	No
	Tolfenpyrad	0.10	1.62×10^{-5}	0.006	2.71×10^{-1}		
3	Imidachoprid	0.10	1.61×10^{-5}	0.06	2.68×10^{-2}	2.98	No
	Profenofos	5.56	8.86×10^{-4}	0.03	3.00		
4	Chlorantraniliprole	0.23	3.63×10^{-5}	2	1.82×10^{-3}	3.53×10^{-2}	No
	Chloypyrifos	0.003	4.78×10^{-7}	0.01	4.78×10^{-3}		
	Imidachoprid,	0.11	1.72×10^{-5}	0.06	2.87×10^{-2}		
5	Imidachoprid,	0.01	1.75×10^{-6}	0.06	2.92×10^{-3}	2.92×10^{-3}	No
6	Imidachoprid	0.03	4.62×10^{-6}	0.06	7.70×10^{-3}	7.70×10^{-3}	No
7	Acetamiprid	0.23	3.73×10^{-5}	0.07	5.32×10^{-2}	9.53×10^{-1}	No
	Chlorpyrifos	0.04	6.37×10^{-6}	0.01	6.37×10^{-2}		
	Profenofos	1.58	2.51×10^{-4}	0.03	8.36×10^{-1}		
8	Cypermethrin	0.14	2.15×10^{-5}	0.02	1.07×10^{-1}	1.62	No
	Dinotefuran	0.08	1.34×10^{-5}	0.20	6.69×10^{-3}		
	Tofenpyrad	0.57	9.06×10^{-5}	0.006	1.50		
9	Dinotefuran	0.23	3.69×10^{-5}	0.20	1.80×10^{-2}	1.28×10^{-1}	No
	Indroxacarb	0.07	1.10×10^{-5}	0.01	1.10×10^{-1}		
10	Acetamiprid	0.11	1.69×10^{-5}	0.07	2.41×10^{-2}	5.30×10^{-2}	No
	Chlorantraniliprole	2.47	3.93×10^{-4}	2	1.97×10^{-2}		
	Imidachoprid	0.03	5.41×10^{-6}	0.06	9.02×10^{-3}		
				Average %HI (± SD)		0.62 (± 0.98)	No

EDI = estimated daily intake; ADI = acceptable daily intake

*ADI values according to the Codex Alimentarius (Food and Agricultural Organization/World Health Organization, 2016)

** %HI > 100 = risk to consumers

Conflict of Interest

The authors declare that there are no conflicts of interest.

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