ORIGINAL ARTICLE

Occurrence of Pesticides in Polished Rice Samples From Tanjung Karang and Sekinchan and the Health Risk among Consumers

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ABSTRACT

Introduction: One of the key staple foods in many different countries, including Malaysia, is rice (*Oryzae sativa L.*). Pesticides are used to reduce weed growth and safeguard crops from insect attacks in order to boost paddy output. **Objective:** This research quantifies the concentration of pymetrozine, chlorantraniliprole, and difenoconazole, along with any potential health risks to consumers. **Methods:** Samples of polished rice from three rice milling factories in Tanjung Karang and Sekinchan were extracted using the QuEChERS (Quick Easy Cheap Effective Rugged Safe) technique. The amount of pesticide residue in polished rice was then measured using ultra-high performance liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS). A health risk assessment was conducted utilizing the Hazard Quotient (HQ) and Lifetime Cancer Risk (LCR) to estimate the non-carcinogenic and carcinogenic health risks. **Results:** The mean concentration of pesticides in polished rice ranged from less than the detection limit (difenoconazole) to 1.122 μg/kg (pymetrozine). No rice samples above the Maximum Residue Limit (MRL) specified in the Food Act 1983 as implemented by Malaysia's Food Regulations 1985. Pymetrozine, chlorantraniliprole, and difenoconazole in rice had respective MRLs of 50 μg/kg, 2000 μg/kg, and 100 μg/kg. For all age groups, no significant non-carcinogenic health risk was associated with consuming polished rice from the study area, where the HQ and Hazard Index (HI) were less than one. When LCR values were less than 10^{-6}, carcinogenic health risks of consuming polished rice from the study area were at a clearly acceptable risk level. **Conclusion:** As no sample exceeded the MRL, the findings indicated that all rice samples collected from Tanjung Karang and Sekinchan were safe for consumption.
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Keywords: Pesticide residues; QuEChERS; UHPLC-MS/MS; Health Risk Assessment

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INTRODUCTION

The scientific name for rice is *Oryzae Sativa L*. It is the most common staple food worldwide, notably in Asia, Africa, and Latin America. Because rice offers 20% of the daily calories required by the body, more than half of the world's population, or roughly 3.5 billion people, consume it as a staple diet. China and India produced more than 212.8 and 195 million metric tons of paddy rice in 2021 (1), while Malaysia produced around 1.68 million metric tons of rice (2). Before being marketed, whole rice is milled. Brown rice, hull, white rice, and bran are the four fractions produced by the milling process. The chemical composition of each of these fractions can vary depending on the type of rice used and the milling method used. Despite the great nutritional value of brown rice, the majority of rice is ingested as white polished grain (3).

The third largest paddy field in Peninsular Malaysia, located in Tanjung Karang and Sekinchan in the State of Selangor, they live up to their name as "the rice bowl of Selangor" (4). The primary source of income for the people living in these two areas was agriculture, specifically rice cultivation. Farmers have been employing pesticides in their rice farming operations to maintain high rice production for local consumption. As part of the Food Security Policy (5), the government of Malaysia provides subsidies for pesticides in order to produce crops that will generate income for the country. Although applying pesticides in paddy fields has increased crop output, a number of potential issues could arise such as contaminating the surrounding soil, water or air by mitigating from the application point. Depending on their solubility and octanol-water partition coefficient (Log Kow), these compounds can remain in the environment or bioaccumulate in biota.

Pests and other kinds of organisms that serve as biological controls surrounding the rice paddy fields are seriously impacted by the pesticide. Additionally, it sets farmers, communities, and consumers' health in danger. Pesticides may be toxic to humans. They may cause negative health impacts on the immunological, neurological, or reproductive systems as well as cancer. They are extremely dangerous when exposed because of their capacity to readily bioaccumulate in the human body through penetration into meat, milk, and blood and to remain there as residue over time (6).

Pesticide residues may be detrimental to both the environment and human health. There are several studies that reported pesticide contamination in the environment near Tanjung Karang's vicinity and its health risks to the population. Raihanah et al. (7) found that white rice, brown rice, and paddy samples from Tanjung Karang all contained residues of imidacloprid in quantities of 0.03 mg/kg, 0.04 mg/kg, and 0.14 mg/kg, respectively. The hazard quotient (HQ) value of adults was 1.32 showing that the population was exposed to non-carcinogenic health risks through the consumption of imidacloprid-contaminated rice (7). Additionally, pesticide residues were discovered in water samples taken from Tanjung Karang's Tengi River (8). The findings indicated that eleven pesticides contaminated the Tengi River at amounts ranging from 1.3 ng/L to 4493.1 ng/L. However, the HQ and hazard index (HI) for all target pesticides were less than one, showing that there was no significant chronic non-carcinogenic health risk associated with drinking water intake.

In order to assure consumer safety and global commerce, pesticide residues in food items must be managed and monitored. To control pesticide residues in food items, many countries and international organizations have adopted maximum residue limits (MRLs). In this research, the concentration of three pesticides (chlorantraniliprole, pymetrozine, and difenoconazole) in polished rice was determined in order to assess the possible health risks of ingesting them among Tanjung Karang and Sekinchan rice consumers. Detailed information on the target compounds is summarised in Table I.

MATERIALS AND METHODS

Chemicals and Standards

The reference standards for pymetrozine (99.0%), difenoconazole (98.7%), and chlorantraniliprole (99.5%) were obtained from Dr. Ehrenstorfer (Germany). Imidacloprid-d4 (99.9%), which served as internal standard (IS), was sourced from Sigma-Aldrich (Germany) Acetonitrile of HPLC quality was purchased from Avantor Performance Material (USA), while HPLC quality of methanol, dichloromethane, and acetone were obtained from Fisher Scientific (UK). We purchased analytical reagent grade dichloromethane, acetone, and methanol from Fisher Scientific in the UK. R&M Chemicals (UK) provided us with acetic acid. Decon 90 was purchased from Decon Laboratories Limited (England). Agilent Bond Elut QuEChERS Buffered Extraction kits, ceramic homogenizers, and Bond Elut QuEChERS AOAC dispersive SPE kits for fruits and vegetables with fats and waxes were sourced from Agilent Technologies Inc. (DE, USA).

Study Location

Cross-sectional research was conducted in Tanjung Karang and Sekinchan, Selangor (Figure 1). Tanjung Karang is the biggest sub-district in the state of Selangor, located in the north of Kuala Selangor district, with an area of 43,125.48 hectares. At the same time, Sekinchan is located in the district of Sabak Bernam with an area of 300.23 hectares. These two locations were chosen because they represented the widest paddy field in Peninsular Malaysia and achieved the highest production yield in Selangor. Four rice mills participated in this study in Tanjung Karang and Sekinchan. The rice mills processed the paddy plant sent by farmers surrounding Tanjung Karang and Sekinchan. The local community also consumes polished rice.

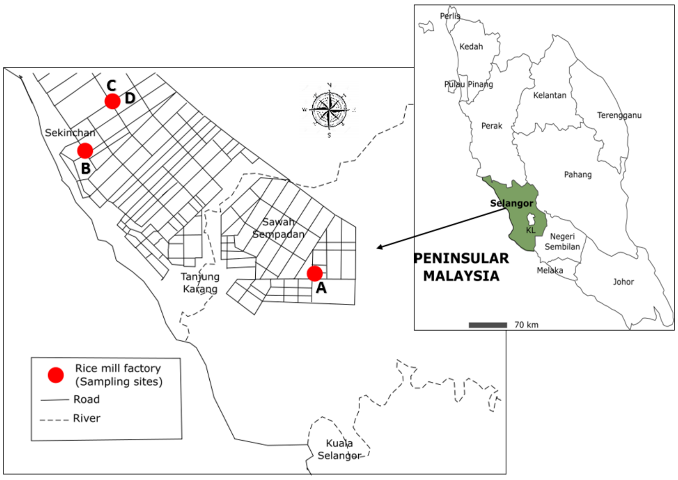


Figure 1 : Location of rice milling factory in Tanjung Karang and Sekinchan.

Sample collection

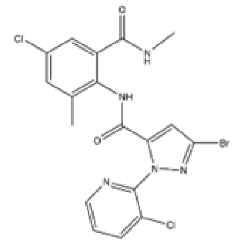
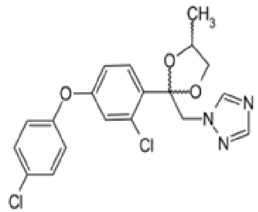
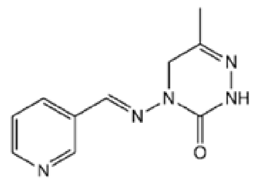
Rice samples were purchased in quadruplicates from four Tanjung Karang and Sekinchan milling factories from February – March 2017. All samples were kept in plastic zip-lock bags and temporarily stored in a cooler box. The samples were brought to the lab and preserved at -20°C until further analysis.

Sample extraction and analysis

QuEChERS

The pesticide extraction in rice samples was modified according to Agilent Technologies Application Note (14). Rice samples were homogenized by grounding. Then, 50 mL screw-cap centrifuge tubes were filled with 5 g of the comminute homogeneous sample. Prior to extraction, an internal standard (imidacloprid-d4) was added to each sample to produce a 10 ng/g concentration. Next, the centrifuge tubes were vortexed

Table I : Information on the target compounds

Common Name, IUPAC Name, Pesticide Type, Chemical Class, CAS Number	Molecular formula	Molecular structure	Molecular weight (g/mol)	Log Kow	Cancer classification
Chlorantraniliprole[1] 3-Bromo-*N*-[4-chloro-2-methyl-6-(methylcarbamoyl) phenyl]-1-(3-chloro-2-pyridine-2-yl)-1H-pyrazole-5-carboxamide[1] Insecticide[1] Anthranilic diamide (Anthranilic)[1] 500008-45-7[1]	$C_{18}H_{14}N_5O_2BrCl_2$[1]		483.15[1]	2.76[3]	Not Likely to Be Carcinogenic to Humans[2]
Difenoconazole[4] 1-[2-[2-chloro-4-(4-chlorophenoxy)-phenyl]-4-methyl[1,3]dioxolan-2-ylmethyl]-1H-1,2,4-triazole4 Fungicide[4] Traizole (Azole)[4] 119446-68-34	$C_{19}H_{17}C_{l2}N_3O_3$[4]		406.264	4.24	Group C. Possible Human Carcinogenic[2]
Pymetrozine[5] 6-methyl-4-[(E)-pyridin-3-ylmethylideneamino]-2,5-dihydro-1,2,4-triazin-3-one[5] Insecticide[5] Pyridine Azomethines (Triazine)[5] 123312-89-0[5]	$C_{10}H_{11}N_5O$[5]		217.235	-0.185	Likely to Be Carcinogenic to Humans[2]

[1]USEPA, (9)
[2]USEPA, (10)
[3]FAO, (11)
[4]USEPA, (12)
[5]USEPA, (13)

for one minute. Each tube received 10 mL of ultrapure water, which was then vortexed for another minute.

After that, each tube was filled with two ceramic homogenizers. A dispenser filled the tube with 15 mL of ACN (0.1% AA). In the centrifuge tube, 6 g of anhydrous magnesium sulfate (MgSO4) and 1.5 g of sodium acetate from the Agilent Bond Elut QuEChERS AOAC extraction kit were added and forcefully agitated by hand for 1 minute. The solid components were separated from the liquid layers by centrifuging the tube for five minutes at a speed of 4,000 rpm.

Rapid dispersive solid-phase extraction (d-SPE) was performed to clean up and remove excessive water. Eight milliliters of supernatant were pipetted into 15 mL Agilent Bond Elut QuEChERS AOAC dispersive SPE screw cap tubes containing 1200 mg of MgSO4, 400 mg of C18, and 400 mg of PSA. To separate the solid components from the liquid layer, the tubes were firmly closed, vortexed for one minute, and then centrifuged for 5 minutes at 4000 rpm. The extracts were placed into 10 mL tubes, dried under nitrogen, and then reconstituted with 1 mL of a 1:3 methanol to water solution. Before the UHPLC-MS/MS analysis, the extract was placed into 2 mL amber vials after being filtered with a 0.22 m nylon syringe filter.

UHPLC-MS/MS Analysis
Ultra high-performance liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS) was employed to analyze the extracts based on Zaidon et al., (15). Chromatographic separation was performed using an Eclipse Plus C18 column from Agilent Technologies (CA, USA) (2.1 mm, 50 mm, 1.8 µm particle size). The mobile phase mixtures were A (0.1% formic acid and 5 mM ammonium formate in ultrapure water) and B (methanol with the same ingredients). The mobile phase was divided into the following intervals: 0 min (94% A, 6% B); 15 min (2% A, 98% B); 18 min (2% A, 98% B); 18.01 min (94% A, 6% B); and 20 min (94% A, 6% B). The whole runtime was 20 minutes, with a 0.5 mL/min flow rate. Then, the injection volume was set to 2 µL, and the column's temperature was 40 ^{o}C. Positive electrospray ionization (ESI) mode was used to detect all pesticides. For optimum performance, the capillary voltage was adjusted to 3500 V, the gas temperature to 220°C, the gas flow to 11 L/min, and the nebulizer pressure to 30 psi.

Quality Control
The equipment was calibrated with each pesticide standard using a five-point calibration curve with concentrations ranging from 0.1 ng/mL to 500 ng/mL (Table IV). At each calibration point, a labelled internal standard (imidacloprid-d4) was added at 50 ng/mL to produce relative response factors (RRF). All target analytes displayed excellent linearity in their calibration curves; the regression coefficients (R2) were between 0.9988 to 0.9999.

Organic rice samples were spiked with 10, 50, and 250 ng/g of each analyte to assess the extraction recovery in percentages in order to verify the analytical method. Using information from Ho et al., (16), the recovery (%) was computed. In the same sample matrix, the concentration of each pesticide added before extraction was compared to its concentration added after extraction to determine the recovery percentage. Pymetrozine's recovery rates varied from 74 to 82%, chlorantraniliprole's from 62 to 66%, and difenoconazole's from 70 to 77% (Table IV).

Health Risk Assessment
180 residents of Tanjung Karang and Sekinchan who consumed rice were given questionnaires. We collected data such as demographic information, rice frequency intake, length of intake, ingestion rate, and body weight of children (under 12 years old), adolescents (13–18 years old), adults (19–60 years old), and the elderly (>60 years old). The information from the questionnaire was applied to assess the health risk associated with rice intake. In the questionnaire, parents were obliged to respond on behalf of their kids.

The concentration of pesticides detected in polished rice samples and the information reported by the rice consumers were subsequently used to evaluate the non-carcinogenic and carcinogenic risks associated with rice consumption. The hazard quotient (HQ) in Eq. 1 is employed for expressing non-carcinogenic risk (17):

$$HQ = \frac{ADD}{RfD} \qquad \text{Eq. 1}$$

Where HQ indicates the hazard quotient, and ADD indicates the average daily potential dose (mg/kg/day). RfD stands for reference dosage, and it is 1.56 mg/kg/day for chlorantraniliprole (18), 0.01 mg/kg/day for difenoconazole (19), and 0.03 mg/kg/day for pymetrozine (20).

ADD for food ingestion is calculated in Eq. 2 (16):

$$ADD = \frac{C \times IngR \times EF \times ED}{BW \times AT} \qquad \text{Eq. 2}$$

Where C indicates the contaminant concentration (mg/kg), IngR indicates the ingestion rate (kg/day, according to the questionnaire), EF indicates exposure frequency (days/year, according to the questionnaire), ED indicates exposure duration (years, according to the questionnaire), BW indicates body weight (kg, according to the questionnaire), and AT indicates the averaging time (equal to ED x 365 days/year). Detailed information on IngR, EF, ED BW and AT is summarized in Table II.

Pymetrozine has been classified as "likely to be

Table II : Values for HQ and LCR calculation (n=180)

Age group	Ingestion rate (kg/day)	Exposure frequency (days/years)	Exposure duration (years)	Mean body weight (kg)
Children	1.016	912.5	8.80	28.75
Adolescents	1.645	1036.6	12.04	47.92
Adults	0.960	766.5	34.70	69.81
Elderly	0.751	719.1	64.38	66.75

Children (n=20), Adolescents (n=25), Adults (n=103), Elderly (n=32)

carcinogenic to humans" (10). Using Eq. 3, the lifetime cancer risk (LCR) of pymetrozine was calculated (16).

$$LCR = LADD \times CSF \qquad \text{Eq. 3}$$

Where CSF represents the cancer slope factor (CSF pymetrozine = 0.0019 mg/kg/day) and LADD represents the lifetime average daily dose (mg/kg/day) (21).

$$LADD = \frac{C \times IngR \times EF \times ED}{BW \times AT} \qquad \text{Eq. 4}$$

Where C indicates the contaminant concentration (mg/kg), IngR indicates the ingestion rate (kg/day, according to the questionnaire), EF indicates exposure frequency (days/year, according to the questionnaire), ED indicates exposure duration (years, according to the questionnaire), BW indicates body weight (kg, according to the questionnaire), and AT indicates the averaging time (equal to 70 years x 365 days/year). Detailed information on IngR, EF and BW is summarized in Table II.

The HQ was then compared with the following acceptability of risk values for non-carcinogenic effects. When the HQ is less than unity (HQ < 1), it is presumed that no long-term health risks are associated with ingesting rice samples. The acceptability risk for carcinogenic risk, values smaller than 10^{-6} are deemed "clearly acceptable", while that larger than 10^{-4} are deemed "clearly unacceptable" (17).

RESULTS

Socio-demographic distribution of respondents

This study involved 180 residents of Tanjung Karang and Sekinchan who had agreed to participate in this study. From Table III, it was noted that the age of respondents below 12 years old or children had a frequency of 20 (11.1%), age ranged between 13 to 18 or adolescents with the frequency of 25 (13.9%), adults, aged from 19 to 64 years old, with 103 (57.2%) and elderly, 65 and above, 32 (17.8%). The result also showed that the female respondents were 22.8% of the total number, while the male respondents

Table III : Distribution of socio-demographics among respondents (n=180)

Socio-demographic Characteristic	Frequency (N)	Percentage (%)
Age (years old)		
Children, <12	20	11.1
Adolescents, 13-18	25	13.9
Adults, 19-64	103	57.2
Elderly, >65	32	17.8
Gender		
Male	139	77.2
Female	41	22.8
Race		
Malay	178	98.9
Chinese	2	1.1

Table IV : Correlation coefficient (R^2), recovery, MDL, MQL, and matrix effect of data

Analyte	Linear Range (ng/mL)	R^2	Recovery % (RSD %) n=3		
			10 ng/g	50 ng/g	250 ng/g
Chlorantraniliprole	0.1-500	0.9988	62 (14)	63 (12)	66 (13)
Difenoconazole	0.1-500	0.9995	70 (15)	74 (13)	77 (12)
Pymetrozine	0.1-500	0.9999	74 (7)	63 (10)	82 (9)

Table V : Mean concentration of pesticide residues in rice samples (n=4)

Sample	Mean ± SD (µg/kg)		
	Pymetrozine	**Chlorantraniliprole**	**Difenoconazole**
Rice mill A	0.696 ± 0.823	0.741 ± 1.061	0.429 ± 0.744
Rice mill B	0.522 ± 0.350	0.366 ± 0.142	ND
Rice mill C	0.308 ± 0.252	0.351 ± 0.174	ND
Rice mill D	1.122 ± 1.517	0.361 ± 0.081	ND
MRL (µg/kg)	50	2000	100

ND: Not detected

accounted for 77.2%. Among 180 respondents, 98.9% were Malay, while 1.1% were Chinese.

Analysis of Pesticide Residues in Polished Rice Samples

The mean concentration of pymetrozine, chlorantraniliprole and difenoconazole in polished rice samples obtained from Tanjung Karang and Sekinchan is summarised in Table V. The result was then compared with the MRL designated in Malaysia's Food Act 1983 under Food Regulations 1985 in Sixteenth Schedule.

The highest concentration of pymetrozine was observed in rice sample D, followed by sample A, while the lowest concentration was found in sample C. While the concentration of chlorantraniliprole in sample A was the highest among other samples, which was 0.741 ± 1.061 µg/kg. Difenoconazole had been detected in only sample A with a concentration of 0.429 ± 0.744 µg/kg. However, all concentration values did not exceed the MRL for pymetrozine, chlorantraniliprole and difenoconazole in rice, which were 50 µg/kg, 2000 µg/kg and 100 µg/kg, respectively.

Health Risk Assessment

The health risk assessment for these three pesticides by ingesting polished rice was conducted through Hazard Quotient (HQ) for non-carcinogenic health risk and Lifetime Cancer Risk (LCR) for carcinogenic health risk. At the same time, Hazard Index (HI) is the total of HQ, which it is used to determine the health risk for rice consumption according to age group.

Consumption of the pesticide-contaminated rice posed no significant non-carcinogenic health risk for any age group when HQ and HI were less than one. Carcinogenic health risks via rice consumption were at a clearly acceptable risk level where LCR values were less than 10^{-6}. Table VI shows rice consumers' values of HQ, HI and LCR.

DISCUSSION

Pesticides residues in rice samples

Pymetrozine, chlorantraniliprole, and difenoconazole concentrations in rice of Tanjung Karang and Sekinchan did not exceed the MRLs specified in the Malaysian Food Act of 1983 and the Food Regulations of 1985, which are 50 µg/kg, 2000 µg/kg, and 100 µg/kg, respectively. There is not much information available about the presence of pesticides in Malaysian rice samples, particularly for the currently used pesticides (CUPs) reported in this research. Azlan et al. (22) reported the concentrations of organophosphorus pesticides in 30 samples of rice from 10 different varieties of rice grains in the Asian market. According to the research, quinalphos, diazinon, and chlorpyrifos were present at quantities of 1.08, 1.11, and 1.79 µg/kg. According to Raihanah et al., (23), most of the Tanjung Karang rice samples exhibited detectable imidacloprid residues, with concentrations ranging from 0.564 to 0.792 mg/kg.

Table VI : LCR, HQ and HI of rice consumers in Tanjung Karang and Sekinchan

	HQ			HI	LCR
	Pymetrozine	Chlorantraniliprole	Difenoconazole		Pymetrozine
Children	3.30×10^{-3}	4.20×10^{-5}	3.79×10^{-3}	7.14×10^{-3}	2.37×10^{-8}
Adolescence	3.65×10^{-3}	4.63×10^{-5}	4.19×10^{-3}	7.88×10^{-3}	3.57×10^{-8}
Adult	1.08×10^{-3}	1.37×10^{-6}	1.24×10^{-3}	2.33×10^{-3}	3.05×10^{-8}
Elderly	8.29×10^{-3}	1.05×10^{-6}	9.52×10^{-4}	1.79×10^{-3}	4.35×10^{-8}

Children (n=20), Adolescents (n=25), Adults (n=103), Elderly (n=32)

The concentration of pesticides in rice is related to the rice polishing process, as pesticide residues may dissipate Pareja et al., (24). After harvesting and drying, the primary milling operation occurred before consumption, where de-husking or hulling and removing bran layers or polishing were involved. The rice is cleaned and hulled at the processing facility to produce unpolished rice, often known as brown rice. The decrease in pesticide residues could be due to the bran, brown outer layer, and layer immediately beneath the bran being removed after polishing (25). These layers often bind the surface deposited pesticide residue.

In China, Wang et al. (26) reported that difenoconazole had been detected in rice plant samples with a concentration of 0.037 mg/kg to 2.35 mg/kg. Also, in China, pymetrozine, chlorantraniliprole, and difenoconazole were detected in rice with the maximum concentrations at 0.0359 mg/kg, 0.1100 mg/kg, and 0.3221 mg/kg, respectively (27). Both of the studies above found higher concentrations of pesticides as compared to this study. However, Zhang et al. (28) revealed that the concentration of pymetrozine in rice samples from Anhui, Beijing and Zhejiang, China, were below the detection limit, thus, concluding that pymetrozine was safe in rice. The findings reported by Zhang et. al (28) were in contrast to the findings in this study, in which the maximum concentration of pymetrozine in polished rice samples of this study was 1.122 µg/kg.

In Malaysia, Pesticide Act 1974 was drafted and enforced on 1st April 1981 in Peninsular Malaysia and 1st January 1982 in Sabah and Sarawak to control various aspects related to pesticides, including the control of pesticide residue in food through crop yield (29). The enforcement was conducted by the Ministry of Health under Food Regulation 1985 since 1st April 1987, while the Agriculture Department cooperated in advising farmers about appropriate pesticide usage. Thus, they have knowledge and awareness in handling pesticides. In addition, the result of this study showed that farmers from Tanjung Karang and Sekinchan complied with the laws and regulations of Malaysia.

Health Risk Assessment

The results of this study indicated that all rice samples collected from Tanjung Karang and Sekinchan are safe for consumption as no sample exceeded the MRL. No significant non-carcinogenic or carcinogenic health risk was associated with rice intake in Tanjung Karang and Sekinchan, as HQ was less than one and LCR was less than 10^{-6}. The result in this study was comparable to Cao et al., (26), in which their study reported that the HQ for pymetrozine was 2.36×10^{-3} for children and adolescents, 1.19×10^{-3} for adults and the elderly, HQ for chlorantraniliprole was 1.07×10^{-5} for children and adolescent, 5.39×10^{-6} for adults and elderly, HQ for difenoconazole was 4.19×10^{-3} for children and adolescent, 2.11×10^{-3} for adults and elderly. There is limited information on the cancer risk posed by pymetrozine for food products. Based on Tudi et al., (30), the potential total cancer risk due to ingestion and skin exposure via soil and paddy water for people of Guangxi and Hunan Province was estimated to be less than 1×10^{-6}.

CONCLUSION

The concentration of pymetrozine, chlorantraniliprole, and difenoconazole in rice samples of Tanjung Karang and Sekinchan in Malaysia did not exceed the MRL regulated in Food Act 1983 under the Food Regulations 1985. There is no significant health concern due to the rice consumption produced in Tanjung Karang and Sekinchan, as HQ was less than one and LCR was less than 10^{-6}. However, only three target compounds were assessed in this study. HI may be greater than 1 due to ingesting more than 3 pesticides simultaneously. In actual situations, the farmers used more than three pesticides to increase the rice's productivity, and the pesticide usage pattern could be different from time. For future studies, it is recommended to analyze all other possible pesticides in rice samples to understand the actual health risk of consumption. HQ, HI and LCR can be determined for other compounds not analyzed in this study.

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