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Environmental Health Risk Assessment of Consumption of Foodstuffs Containing Organophosphate Residues among Farmers

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Abstract

Background: The use of pesticides in the agricultural sector often leads to the contamination of foodstuffs by residues, which becomes a source of exposure to the body and causes health problems. **Objective**: Therefore, this study aims to analyze the health risk of consumption of foodstuffs containing organophosphate residues among farmers in the North Dempo Sub-district of Pagar Alam City, South Sumatera, Indonesia. **Method**: The study procedures were carried out with a cross-sectional method using the Environmental Health Risk Assessment (EHRA). The sample population comprised 117 farmers in the North Dempo Sub-district of Pagar Alam who were selected randomly. Environmental samples comprised 5 red chilies and 5 tomatoes, which were selected purposively. Organophosphate residues were then quantified using Liquid Chromatography Tandem Mass Spectrometry, while body weight was measured with calibrated body scales. Subsequently, activity pattern data were collected through interviews using a questionnaire, followed by analysis with EHRA formulas. **Results**: The results showed that red chillies contained chlorpyrifos at a concentration of 3,05 mg/kg, while profenofos was found at 0.0731 mg/kg and 0.0118 mg/kg. In the tomato samples, chlorpyrifos was observed at a concentration of 0.4439 mg/kg, while profenofos was present at 0.0112 mg/kg and 0.2043 mg/kg. The Risk Quotient for consumption of red chilies containing chlorpyrifos was 0.0447, while that for profenofos was 0.2476. The Risk Quotient for consumption of tomato containing chlorpyrifos was 0.0302, while a value of 2.92 was obtained for profenofos. **Conclusion**: Based on the results, the farmers were at non-carcinogenic health risk due to the consumption of foodstuffs containing profenofos.

INTRODUCTION

The growing world population is accompanied by an increase in the global demand for food. Several studies have shown that vegetable plants play an essential role in meeting the increased demand by serving as a significant source of nutrition and maintaining human health. Meeting the need for vegetable plants, including red chilies and tomatoes, is often achieved through agricultural intensification efforts. During the cultivation process, pesticides are considered an important component that plays a major role in maintaining and increasing agricultural productivity. According to FAO (2021), the use of pesticides has significantly increased around the world, as evidenced by a 50% increment between the 1990s and 2010. Market surveys have also estimated that approximately 5,684 million pounds of

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pesticide-active ingredients are used globally every year. In addition, several studies have shown that Indonesia is one of the major users of these chemicals, as indicated by the number of active ingredients registered with the Ministry of Agriculture, namely 5,675 formulations in 2021(Nining *et al.*, 2019).

Despite the importance, the use of pesticides has become uncontrolled due to a lack of education and knowledge among farmers. This includes mixing different types of pesticides, exceeding the dose, and other non-compliant behaviors. Excessive usage of these chemicals can lead to the accumulation of residues in agricultural products and other environmental media in all agroecosystems. This is proven by the results of residue monitoring and study of food safety. A previous study on fruits and vegetables commonly consumed in Kuwait revealed that the majority of samples were contaminated with concentrations above the Maximum Residue Limit (Jallow *et al.*, 2017). Several studies have also been carried out in Indonesia to assess pesticides residues in vegetable food and estimate the health risks that could occur (Martanto *et al.*, 2017).

Organophosphates are one of the most common and effective pesticides in the agricultural sector. Despite the increase in insect resistance towards other types of pesticides, organophosphates have been widespread in the farming industry due to their broad-spectrum efficacy (Perry *et al.*, 2020). These chemicals are highly toxic and are used extensively in agriculture (Naksen *et al.*, 2023)i.e., Nan, Chiang Rai, Lamphun, Lampang, and Chiang Mai provinces located in Northern Thailand. A risk assessment of OPs among adult Thai population was also evaluated by calculating the estimated daily intake (EDI due to the presence of various active ingredients, including chlorpyrifos and profenofos. The 2 active ingredients are most commonly used as insecticides on vegetable crops, including red chilies and tomatoes. According to Shabbir *et al.* (2021), chlorpyrifos is a member of the class of cholinesterase-inhibiting organophosphates, which acts by increasing the concentration of neurotransmitter acetylcholine at the nerve endings.

Acute exposure to chlorpyrifos has been reported to cause genotoxicity and mutagenic effects. In cases of short-term oral exposure to low levels, the effects can include dizziness, fatigue, hypersalivation, nausea, sweating, and changes in heart rate. Meanwhile, short-term oral exposure to higher levels can cause paralysis, seizures, loss of consciousness, and death. A study conducted in Jember revealed that pesticides exposure was associated with decreased cholinesterase levels in vegetable farmers (Halisa, Ningrum, and Moelyaningrum, 2022).

Organophosphates have been observed to cause chronic health effects, as evidenced by numerous studies. Rohlman *et al.* (2019) showed that chlorpyrifos exposure was associated with the development of symptoms of Attention Deficit Hyperactivity Disorder (ADHD) in adolescent users in Egypt. Other health issues could also be present, such as body balance disorders (Samosir, Setiani, and Nurjazuli, 2017), goiter incidence (Marwanto, Setiani, and Suhartono, 2018), and neurotoxicity (Gusti, 2017). A study conducted in 2017 in the Beringin District concluded that the working period, type of pesticides, length of spraying, and use of personal protective equipment (PPE) were associated with neurobehavioral effects among red chili farmers in the Beringin District (Meirindany, Indirawati and Marsaulina, 2021).

The North Dempo Sub-district is an area where the majority of the population derives their livelihood from the agricultural sector. In addition, the primary farming commodity is vegetable crops, including chilies, tomatoes, cabbage, and mustard greens. Pesticides are often applied to plants from the beginning of their growth until the harvest period. The intensity of pesticides spraying, which includes the frequency and numbers used, is typically higher in chilies and tomatoes. The majority of farmers in the North Dempo Sub-district consume their agricultural products or local agricultural products, which can pose health risks due to exposure through consumption. Therefore, this study aims to analyze the health risks due to the consumption of food containing organophosphate residues among farmers in the North Dempo Sub-district.

METHOD

This study applied a cross-sectional design, using the Environmental Health Risk Assessment (EHRA) method, which was used to estimate the health risks associated with consuming food (red chili and tomato fruit) containing organophosphate residues. EHRA aimed to predict the amount of risk received by individuals or subpopulations due to exposure to an agent, whether chemical, physical, or biological, within a specified time frame. This risk assessment was conducted for both the present and the future. Furthermore, this method comprised 4 distinct steps, namely hazard identification, dose-response assessment, exposure assessment, and risk characterization.

The study population comprised all farmers in the North Dempo Sub-district of Pagar Alam, South Sumatra, who were engaged in the application of pesticides. In this study, the sampling technique used was the purposive selection of 3 villages, namely Agung Lawangan, Bumi Agung, and Muarasiban, each of which had planted the greatest number of crops and used pesticides. From each of these villages, a random sample of farmers was selected. The sample criteria for this study were 117 farmers aged between 17 and 70 years, who had lived in the North Dempo Sub-district of Pagar Alam City for at least 2 years continuously, consumed food (red chilies and tomatoes) from the North Dempo Sub-district of Pagar Alam, and were willing to become respondents by signing informed consent.

Food samples were obtained from farmers' gardens in the North Dempo Sub-district. Each plot was surveyed at multiple points using a diagonal system, and samples of red chilies and tomatoes were collected from each plot. These were wrapped in aluminum foil and placed in plastic bags, which were then placed in cardboard boxes, and transported directly to the Anugerah Analisis Sempurna (AAS) Environmental Laboratory in Depok, West Java. The analysis of organophosphate residues was carried out using the Liquid Chromatography Tandem Mass Spectrometry (LC-MS/MS) method. The multi-pesticide residue test method used the AOAC 2007.01 standard.

Anthropometric data was obtained by measuring body weight using a digital body scale. Exposure pattern data, such as intake rate, exposure frequency, and exposure duration, was obtained through interviews using a questionnaire. Data processing included editing stages, namely checking the data collected to ensure it was clear, relevant, and consistent. Entry consisted of entering data into the processing device and cleaning comprised of checking all data entered to minimize errors at the data analysis stage.

The data were analyzed by calculating the mean, median, standard deviation, minimum and maximum values. Furthermore, a risk analysis was conducted by calculating intakes and Risk Quotient. The data obtained from each variable, namely organophosphate risk agents, activity patterns, and anthropometry, were calculated to determine the intake and Risk Quotient of organophosphate exposure.

The calculation of the intake value was based on the formula:

ADD = (C X IR X EF X ED)/(BW X AT)

Risk characterization was calculated based on the formula :

RQ = (Exposure estimate)/RFD

RESULT AND DISCUSSION

The Concentration of Organophosphates in Red Chilies and Tomatoes

Laboratory analysis revealed the presence of organophosphate residues, specifically chlorpyrifos (ethyl) and profenofos, in red chilies produced by North Dempo. The concentration of chlorpyrifos (ethyl) exceeded the Maximum Residue Limit in sample 3, with a value of 3.0551 mg/kg. Meanwhile, profenofos was detected in sample 1 at 0.0731 mg/kg and sample 5 at 0.0118 mg/kg. Table 1 outlined the types of active ingredients and their concentrations in red chili.

Laboratory analysis successfully identified the presence of organophosphate residues, namely chlorpyrifos (ethyl) and profenofos, in tomatoes sourced from North Dempo farms. Chlorpyrifos (ethyl) was detected in sample 5 at a concentration of 0.4439 mg/kg, while profenofos was detected in sample 1 at a concentration of 0.0112 mg/kg and sample 3 at a concentration of 0.02043 mg/kg. Table 2 provided an overview of the active ingredients and their respective concentrations in tomatoes.

The results indicated the presence of 2 types of organophosphate active ingredients in red chilies and tomatoes namely chlorpyrifos and profenofos. This finding was consistent with interviews with chili farmers and tomato farmers, who reported that these ingredients were more commonly used for chili and tomato plants compared to other types of active ingredients. However, in addition to organophosphates, farmers also used other types of pesticides with different active ingredients. Surya Utami Dewi, Mahardika, and Antara (2017)farmers use pesticides was over as impact leaving residue in the chili. The purpose of this study was to determine type, dose and frequency of pesticides used by the farmers, as well as to determine the organophospate residual in chili on different storage times. This study was conducted in two phases namely survey to 10 respondent farmers in Baturiti district, Tabanan regency used questioner and treatment pilot study used different storage time from 0, 1 and 3 days samples took from Apuan Village, Baturiti, Tabanan. Class of organophosphate pesticide residue analysis conducted in Denpasar Branch Police Forensic Laboratory. The results showed dominant pesticides used was organophosphates profenofos (curacron indicated that the most prevalent pesticides used in chili plants were profenofos (60%) and chlorpyrifos (20%).

The application of pesticides to crops resulted in the presence of its residues in food, thereby becoming a source of exposure for consumers. The increase in vegetable food production was linked to the use of chemical fertilizers and chemical pesticides throughout the growth period, until the point of harvest. Previous studies had identified the presence of pesticide residues in vegetables, both in other countries and in Indonesia (Jallow *et al.*, 2017)(Utomo and Kusnoputranto, 2018)(Martanto *et al.*, 2017). Related studies in Cikajang, Garut also observed profenofos residues in red chilies, which exceeded the Maximum Residue Limit(Martanto *et al.*, 2017). Safitri and Septiawati (2021), in South Dempo Sub-district, also revealed the presence of chlorpyrifos in tomato fruit samples.

A survey of farmers revealed that the most commonly used insecticides for tomato plants were organophosphates, which contained the active ingredients chlorpyrifos and profenofos. Chlorpyrifos was detected in 1 sample of chili, with 1 exceeding the Maximum Residue Limit (0.5 mg/kg) (SNI, 2008) and the other was within the Maximum Residue Limit. The results of interviews with chili and tomato farmers indicated that the practice of spraying plants before harvest was at least 2 or 3 times a week.

One of the factors contributing to the increased concentration of organophosphate residues in red chili was the dosage used. Previous have noted that it was not uncommon for farmers to deviate from the recommended pesticide dosage guidelines as indicated on the packaging. The application of an increased dosage of pesticides was frequently observed, particularly in instances where the yield was adversely affected by pest infestation. The utilization of a dosage derived from the accumulated knowledge and practices of successive generations and farmers was often observed, with the use of a bottle cap as a measure being a notable example. Safitri and Septiawati (2021)tomatoes can be said to be a type of vegetable that has the opportunity to contain pesticide residues that exceed the maximum residue limit (BMR indicated a statistically significant correlation between the application of pesticide doses and the concentration of organophosphate residues in tomatoes in the South Dempo Sub-district of Pagar Alam (p=0.000).

The analysis did not detect the presence of organophosphate residues (chlorpyrifos and profenofos) in 7 samples of red chili and 7 samples of tomatoes. Furthermore, it was plausible to hypothesize that the rainy season at the time of sampling could have been a contributing factor. In a study conducted by Megawati, Sulaiman, and Zakaria (2021), the concentration of organophosphate residues in chili peppers obtained from the market during different seasons was analyzed. The findings indicated that during the rainy season, the concentration remained below the Maximum Residue Limit. However, during the dry season, the concentration exceeded the limit. The degradation of organophosphate residues in chilies and tomatoes was influenced by temperature and half-life factors. The half-life of chlorpyrifos in chili was reported to be 4.93 days, while another opinion suggested 4.01 days for chlorpyrifos and 2.24 days for profenofos (Rofatin and Wijaya, 2020).

The examination of red chilies and tomato samples revealed the presence of organophosphate residues in only some of the samples. This could be attributed to the fact that chlorpyrifos and profenofos were non-systemic poisons. Non-systemic toxic pesticides, when sprayed onto plants, adhered to the external surface of the plant only, preventing their absorption by plant tissues. Consequently, the residues were confined to the external surface of the plant and were not retained for an extended period due to their susceptibility to being washed away by rainwater. The type of active ingredient, method, and time

Table 1. Organophosphate Residue in Red Chilies

Organophosphates	Concentration of Residue (mg/kg)				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Chlorpyrifos (Ethyl)	<0,001	<0,001	3,0551	<0,001	<0,001
Profenofos	0,0731	<0,00098	<0,00098	<0,00098	0,0118

Table 2. Organophosphate Residues in Tomatoes

Organophosphates	Concentration of Residue (mg/kg)				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Chlorpyrifos (Ethyl)	<0,001	<0,001	<0,001	<0,001	0,4439
Profenofos	0,0112	<0,00098	0,2043	<0,00098	<0,00098

of pesticide application determined the duration of the residue(Hudayya A, & H, 2013).

Profenofos residues in red chili and tomato samples were detected in 2 samples each, while chlorpyrifos residues were detected in only 1 red chili and 1 tomato sample. This was relevant to information obtained through interviews with farmers who mentioned that chili and tomato plants used more profenofos than chlorpyrifos.

Central Tendency of Organophosphate Concentration in Red Chilies Samples

The mean concentration of chlorpyrifos in red chilies was 0.611 mg/kg, with a standard deviation of 1.36 mg/kg. In this study, the minimum value was 0.00 mg/kg, while the maximum value was 3.05 mg/kg. The mean concentration of profenofos in red chilies was 0.017 mg/kg, with a standard deviation of 0.031 mg/kg, and the minimum value was 0.00 mg/kg, while the maximum value was 0.073 mg/kg, as shown in Table 3.

Central Tendency of Organophosphate Concentration in Tomatoes Samples

The mean concentration of chlorpyrifos in tomatoes was 0.088 mg/kg, with a standard deviation of 0.19 mg/kg. Furthermore, the minimum value was 0.00 mg/kg, while the maximum value was 0.44 mg/kg. The average concentration of profenofos in tomatoes was 0.043 mg/kg, with a standard deviation of 0.09 mg/kg, and the minimum value was 0.00 mg/kg, while the maximum value was 0.20 mg/kg, as presented in Table 4.

Chlorpyrifos was classified as a moderately hazardous chemical according to the World Health Organization (Organization, 2020)we improved the recently developed approach of Lambot et al. whose success relies on a stepped-frequency continuous-wave (SFCW. This was a broad-spectrum organophosphate insecticide that harmed insects by interfering with the activity of the enzyme acetylcholinesterase in the nervous system. The interference caused overstimulation of the nervous system, resulting in rapid twitching and muscle paralysis. Ingestion, dermal application, and inhalation of chlorpyrifos resulted in comparable poisoning effects observed with other organophosphate insecticides.

Profenofos was detected in 2 samples of red chilies and tomatoes, respectively, although the levels were below the Maximum Residue Limit and were considered safe. However, long-term consumption of chilies and tomatoes containing profenofos residues could cause adverse health effects and an increased risk of cancer (Martanto *et al.*, 2017)(Amilia, Joy, and Sunardi, 2016).

Anthropometric Characteristics of Respondents

The results demonstrated that the mean body weight of respondents was 58.811 kg, with a median of 58,89 kg and a standard deviation of 10.555 kg. In this study, the minimum body weight was 40 kg, while the maximum was 100 kg. The data normality test, conducted using the Kolmogorov-Smirnov test, yielded a p-value of 0.000 <0.05, indicating that the respondents' body weight was not normally distributed. Consequently, the value of 58,89 kg was used for analysis, as presented in Table 5.

Exposure Pattern to Red Chilies

The exposure patterns consisted of ingestion rate (in grams per day), exposure frequency (in days per year), and exposure duration (in years). Their ingestion rate of red chili averaged 33,49 grams per day, with a median value of 42,9 grams

Table 3. Central Tendency of Organophosphate Concentration in Red Chilies Samples

Organophosphates	Mean	Median	SD	Min	Max	95% CI
Chlorpyrifos	0,611	0,00	1,36	0,00	3,05	-1,08541-2,30741
Profenofos	0,017	0,00	0,031	0,00	0,073	-0,2265-0,05625

Table 4. Central Tendency of Organophosphate Concentration in Red Chilies Samples

Organophosphates	Mean	Median	SD	Min	Max	95% CI
Chlorpyrifos	0,088	0,00	0,19	0,00	0,44	-0,15739-0,33459
Profenofos	0,043	0,00	0,09	0,00	0,20	-0,6891-0,15491

Table 5. Central Tendency of Body Weight

Variable	Mean	Median	SD	Min	Max	95%CI	p-value
Body weight (kg)	58,89	58	10,555	40	100	56,89-60,74	0,000

per day and a standard deviation of 11,44 grams per day. The minimum ingestion rate was 14,3 grams per day, and the maximum was 43 grams per day. Furthermore, the results of the normality test for the ingestion rate indicated that the data were not normally distributed (p=0.000), suggesting that the value used was the median of 42.9 grams/day. The mean exposure frequency was 363.21 days/year with a median of 365 days/year and a standard deviation of 5.598. The lowest frequency was 335 days/year, while the highest was 365 days/year. According to normality testing, the data was not normally distributed (p=0.000), then the value of exposure frequency was 365 days/year. The exposure duration of respondents had an average of 24.96 years, with a median of 20 years, and a standard deviation of 16.024. In this study, the minimum exposure duration was 3 years, while the maximum was 70 years. The data normality test results indicated that the data was not normally distributed (p=0.000). Consequently, the value used was 20 years for exposure duration. The statistical results of respondents' exposure patterns to red chili were outlined in Table 6.

Exposure Pattern to Tomatoes

The mean ingestion rate of respondents on tomatoes was 204.7 grams per day, with a median value of 200 grams and a standard deviation of 88,467 grams per day. In this study, the minimum intake rate was 100 grams, while the maximum was 300 grams per day. The results of the normality test indicated that the data were not normally distributed (p=0.000). Therefore, the median value of 200 mg/day was used as the representative value. The mean exposure frequency was 362.21 days/year with a median of 365 days/year and a standard deviation of 5.598. This study showed that the lowest frequency was 335 days per year, while the highest was 365 days per year. Based on normality testing, the data was not normally distributed (p=0.000). Consequently, the value of exposure frequency was 365 days per week. The exposure duration of respondents had an average of 24.96 years, with a median of 20 years, and a standard deviation of 15.98. In this study, the minimum exposure duration was 3 years, while the maximum was 70 years. The results of the normality test indicated that the data were not normally distributed (p=0.000). Consequently, the value used was 20 years for exposure duration. The statistical results of respondents' exposure patterns to tomatoes were outlined in Table 7.

Exposure Ingestion Non-Carcinogenic

The term referred to the quantity of an agent received by respondents. This process was designed to estimate or measure the magnitude, frequency, and duration of exposure to the agent, obtained from direct measurements of organophosphate concentrations in foodstuffs (red chilies and tomatoes) and the results of questionnaires through interviews with respondents.

Exposure Ingestion of Red Chilies

Exposure Estimate of Chlorpyrifos

$$ADD = (C \text{ X } IR \text{ X } EF \text{ X } ED)/(BW \text{ X } AT)$$

$$ADD = (0{,}611 \text{ mg/kg X } 42{,}90 \text{ gram/day X } 365 \text{ day/year X } 20 \text{ years})/(58{,}89 \text{ kg X } 20 \text{ years X } 365 \text{ day/year})$$

$$ADD = (0{,}611 \text{ mg/kg X } 0{,}0429 \text{ kg/day X } 365 \text{ day/year X } 20 \text{ years})/(58{,}89 \text{ kg X } 20 \text{ years X } 365 \text{ day/year})$$

$$ADD = (0{,}611 \text{ mg/kg X } 0{,}0429 \text{ kg/day})/(58{,}89 \text{ kg})$$

$$ADD = 0{,}\ 000447 \text{ mg/kg/day}$$

Table 6. Central Tendency Exposure of Respondent to Red Chilies Samples

Variables	Mean	Median	SD	Min	Max	95%CI	p-value
Ingestion rate (gram/day)	33,49	3 42,9	11,44	14,3	43	31,3958-35,5888	0,000
Exposure frequency (day/year)	363,21	3 365	5,598	335	365	362,18-364,23	0,000
Exposure duration (year)	24,96	2 20	16,024	3	70	22,02-27,89	0,000

Table 7. Exposure Pattern to Tomatoes

Variables	Mean	Median	SD	Min	Max	95%CI	p-value
Ingestion rate (gram/day)	204,7	200	88,467	100	300	188,07-220,47	0,000
Exposure frequency (day/year)	363,21	365	5,598	335	365	362,18-364,23	0,000
Exposure duration (year)	24,96	20	16,024	3	70	22,02-27,89	0,000

Exposure Estimate of profenofos

ADD = (C X IR X EF X ED)/(BW X AT)

ADD = (0,017 mg/kg X42,90 gram/day X 365 day/year X 20 years)/(58,89 kg X 20 years X 365 day/year)

ADD = (0,017 mg/kg X 0,0429 kg/day X 365 day/year X 20 years)/(58,89 kg X 20 years X 365 day/year)

ADD = (0,016 mg/kg X 0,0429 kg/day)/(58,89 kg)

ADD = 0,00001238 mg/kg/day

Exposure Ingestion of Tomatoes

Exposure Estimate of Chlorpyrifos

ADD = (C X IR X EF X ED)/(BW X AT)

ADD = (0,089 X 200 gram/day X 365 day/year X 20 years)/(58,89 kg X 20 years X 365 day/year)

ADD = (0,089 mg/kg X 0,2 kg/day X 365 hari/year X 20 years)/(58,89 kg X 20 years X 365 day/year)

ADD = (0,089 mg/kg X 0,2 kg/day)/(58,89 kg)

ADD = 0,000302 mg/kg/day

Exposure Estimate of Profenofos

ADD = (C X IR X EF X ED)/(BW X AT)

ADD = (0,043 X 200 gram/day X 365 day/year X 20 years)/(58,89 kg X 20 years X 365 day/year)

ADD = (0,043 mg/kg X 0,2 kg/day X 365 day/year X 20 years)/(58,89 kg X 20 years X 365 day/year)

ADD = (0,043 mg/kg X 0,2 kg/day)/(58,89 kg)

ADD = 0,000146 mg/kg/day

Risk Estimate of Red Chilies Consumption

The final stage of the EHRA process was risk characterization. This stage included calculating the Risk Quotient for the non-carcinogenic effect category. The risk level was determined by dividing the intake by the Reference Dose. In this study, the RfD value of chlorpyrifos was 0,001mg/kg/day, derived from a NOEL of 0.1 mg/kg/day(Wołejko *et al.*, 2022)this compound is still being applied in other parts of the world. National monitoring of pesticides conducted in various countries indicates the presence of CPF in soil, food, and water, which may have toxic effects on consumers, farmers, and animal health. In addition, CPF may influence changes in the population of fungi, bacteria, and actinomycete in soil and can inhibit nitrogen mineralization. The mechanisms of CPF activity are based on the inhibition of acetylcholinesterase (AChE. Meanwhile, the RfD of profenofos was known to be 0.00005 mg/kg/day (EPA, 2006). The following was a calculation of the Risk Quotient (RQ) for the estimated health risk due to the risk agents chlorpyrifos and profenofos in red chili food.

Risk Estimate of Chlorpyrifos

RQ = (Exposure estimate)/RFD

RQ = (0,000447 mg/kg/day)/(0,001 mg/kg/day)

RQ = 0,447

Risk Estimate of Profenofos

RQ = (Exposure estimate)/RFD

RQ = (0,00001238 mg/kg/day)/(0,00005 mg/kg/day)

RQ = 0,2476

The calculation of the Risk Quotient yielded an RQ of less than 1, indicating that there was no health risk associated with the consumption of red chilies containing chlorpyrifos and profenofos residues. The RQ value that did not exceed 1 was attributed to the large number of red chili samples that did not contain chlorpyrifos and profenofos residues. This affected the average residue concentration of the 2 types of organophosphate.

Red chili samples that did not contain residues of chlorpyrifos and profenosfos were because these residues were not absorbed into the chili, but only stuck to the skin of the fruit ensuring that it was washed away by rainwater. This could happen because both types of active ingredients were non-systemic. Factors such as the type of active ingredient, method, and timing of pesticide application determined how long residues remained on the plant (Hudayya A, & H, 2013). Although the average intake of red chili was also relatively low. This could also influence the low intake ensuring that the RQ was also low.

Risk Estimate of Tomatoes Consumption

This was a calculation of the Risk Quotient (RQ) for the estimated health risk due to the risk agents chlorpyrifos and profenofos in tomatoes. The result obtained was RQ < 1, indicating that there was no non-carcinogenic health risk due to the consumption of tomatoes containing chlorpyrifos and profenofos residues.

Risk Estimate of Chlorpyrifos

RQ = (Exposure estimate)/RFD

RQ = (0,000302 mg/kg/day)/(0,001 mg/kg/day)

RQ = 0,302

Risk Estimate of Profenofos

RQ = (Exposure estimate)/RFD

RQ = (0,000146 mg/kg/day)/(0,00005 mg/kg/day)
RQ = 2,92

The Risk Quotient of consumption of tomatoes containing chlorpyrifos residue <1 indicated that there was no non-carcinogenic health risk due to consumption of tomatoes containing chlorpyrifos residue. However, the Risk Quotient of consumption of tomatoes containing profenos residue (RQ) >1 showed that there was a non-carcinogenic health risk due to the consumption of tomatoes containing profenofos residue. The results of the calculations revealed that only 1 Risk Quotient exceeded 1, namely the consumption of tomatoes containing profenofos, at 2.92. When viewed from the average intake rate in grams per day, tomatoes were much larger than red chilies. This greatly affected the intake of Average Daily Dose (ADD). Furthermore, the Reference Dose (RfD) of profenofos was much smaller than the RfD of chlorpyrifos. This study revealed that the consumption of tomatoes containing organophosphate residues could pose a non-carcinogenic health risk.

The acute effects of organophosphates were extensively studied. High-level acute exposure resulted in the inactivation of acetylcholinesterase, leading to the unregulated release of acetylcholine. The acute symptoms associated with organophosphate poisoning included blurred vision, lacrimation, salivation, bronchorrhea, pulmonary edema, nausea, vomiting, diarrhea, confusion, convulsions, loss of consciousness, and respiratory distress (Perry *et al.*, 2020)(English K, Jagals P, Ware RS, Wylie C, 2016).

One of the methods of reducing the health risks associated with consuming tomatoes was to thoroughly wash them before ingestion. Organophosphates were not absorbed into the tomatoes but into the skin. Washing the tomatoes effectively removed the organophosphates, rendering them safe for consumption.

CONCLUSION

In conclusion, the presence of organophosphate residues of chlorpyrifos and profenofos was identified in red chilies and tomatoes produced in the North Dempo Sub-district of Pagar Alam. The results of the EHRA showed that respondents who consumed red chilies containing chlorpyrifos and profenofos had no non-carcinogenic health risk. Similarly, the consumption of tomatoes containing chlorpyrifos was also not a non-carcinogenic health risk. However, the consumption of tomatoes containing profenofos residues was found to pose a non-carcinogenic health risk. For this reason, it was still necessary to conduct risk control to minimize pesticide exposure through food consumption. Farmers needed to get guidance on the rules of using pesticides on crops such as rules for mixing pesticides, spraying frequency, dosage, interval between spraying and harvesting, and other information to reduce pesticide residues in food.

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