



Literature Review: Pesticide Residues on Vegetables in Indonesia

Dhea Rhamadini¹, Fayza Meutia¹, Yusfida Mariatul Husna¹, Nafka Shafira¹, Firdus^{2*},
Muhammad Nasir², Alia Rizki²

¹ Master of Biology Study Program, Faculty of Mathematics and Natural Sciences, Syiah Kuala University, Indonesia

² Department of Biology, Faculty of Mathematics and Natural Sciences, Syiah Kuala University, Indonesia

Abstract

Pesticides are often used to control pests and improve the quality of agricultural products such as vegetables. However, excessive use of pesticides can leave residues on vegetables, which can harm the environment and human health. In addition, the Indonesian government's ban on using harmful pesticides on vegetables and the health risks associated with eating pesticide-contaminated food. Then strategies to manage pesticide residues, such as the use of organic fertilizers as pesticide substitutes, standardization of maximum limits of pesticide residues, monitoring pesticide residues, encouraging the use of pesticides separately, and training farmers. The conclusion in pesticide residues on vegetables is how important it is to manage pesticide residues on vegetables to maintain public safety and health.

Keywords: Residues, Pesticides, Vegetables

*Corresponding Author: Firdus

*Email: firdus@usk.ac.id

1. Introduction

Pesticides are compounds used to protect agricultural plants by killing, repelling and controlling pests before and after harvest. Pesticides are widely used to improve the quality and productivity of agricultural products such as vegetables. One type of pesticide, insecticide, will harm the target organism. However, the mode of action of this type of pesticide is not always species-specific. The most commonly used pesticides are organophosphate, carbamate, and pyrethroid pesticides (Mensah, F, *et al*, 2016). According





to Telo *et al.* (2017) Pesticides found in vegetables are one of the most important human health problems, several studies have analyzed the content of pesticide residues in rice, spinach, cabbage, broccoli, beans and other vegetables.

The Indonesian Minister of Agriculture Regulation has established a ban on the use of hazardous pesticides on foodstuffs such as vegetables because they can be detrimental to public health and the environment (MOA, 2011). Studies show that pesticides present on vegetables can harm consumers' health if eaten (Amilia *et al.*, 2016). Eating food that has been contaminated with pesticides has potential health risks for the human body. Recently, a cumulative risk research study on the possibility of pesticide exposure can cause unexpected side effects on human health (Chen *et al.*, 2006).

Excessive use of pesticides can lead to pesticide residues on food that can cause health problems, even to an extreme level that can cause death. Therefore, understanding the types of pesticides used, the dosage, and frequency of use as well as their effects on the environment and human health is very important (Amilia, *et al.*, 2016). In addition, research shows that the continued use of synthetic pesticides can leave residues on agricultural products, cause pest resistance, and pollute the environment. Therefore, to reduce the risk of pesticide residues on food, good agricultural practices and integrated pest control should be implemented (Satyani, T, *et al.*, 2019).

Reducing the use of pesticides for beneficial functions and minimizing the harm to human health and the environment is a very important goal, it is important to see the correlation between reducing pesticide use and reducing the adverse effects of pesticides on human health and the environment (Damalas, C. A, *et al.*, 2011). The purpose of this literature review is to provide a better understanding of how pesticide residues impact the environment and human health, as well as sustainable management strategies to reduce the risk of pesticide residues on food.

2. Research Method

The method used in this research is a literature study sourced from Google Scholar, Science Direct, and Science and Technology Index (SINTA) databases from 2008-2024. This study focuses on the use of pesticides on vegetables. The keywords "pesticide residues





on vegetables", "pesticide pollution on vegetables" became a reference in finding cases of pesticide residues on vegetables in Indonesia. Journals were selected based on the year of publication, quantitative research, journals that are entirely accessible, and discuss pesticide residues on vegetables in Indonesia, solutions to the impacts, and management strategies. This research will describe pesticide residues contaminated vegetables in Indonesia.

3. Results And Discussions

A. Pesticides

Pesticides are categorized based on their chemical structure, organism of origin and target. These pesticides can be either synthetic inorganic pesticides (synthetically produced) or biological pesticides (bio-pesticides). Basically, synthetic inorganic pesticides are of synthetic origin that kill pests directly. They are mostly classified as insecticides, herbicides, fungicides, rodenticides, nematocides. Furthermore, bio-pesticides are also present from natural sources of plants and bacteria. In addition, pesticides are categorized into four major groups, namely organochlorines (OCs), organophosphates (OPs), carbamates and pyrethroids (Sarath *et al.*, 2019).

Organochlorine pesticides are commonly used pesticides that have high toxicity and bioaccumulation (Sparling, 2016). Organochlorines are also found to be carcinogenic, estrogenic and resistant to environmental degradation cycles, with a half-life of 10-30 years (Taylor *et al.*, 2013). In Indonesia, organochlorine insecticides have been banned due to their harmful effects on the environment and human health. But even in modern farmlands, residual organochlorine pesticides are still present, mainly due to their previous use since the 60s. The defense of organochlorines in the environment is aided by their long-lasting nature. Because of their persistence, toxicity and ability to accumulate, organochlorine residues in soil, water and crops must be checked. Although other types of insecticides, such as pyrethroids, organophosphates and carbamates, are still used in agriculture, residue levels in food commodities are usually below the maximum residue limit (MRL) set by national standards (Ardiwinata *et al.*, 2018).





OPs and carbamate pesticides are widely used due to their cost, low resistance to environmental conditions, and ability to kill a large number of pests. OPs and carbamates work by inhibiting the enzyme acetylcholinesterase (AChE) in the central nervous system (CNS) of humans and insects, leading to disruption of normal CNS function (Robb & Baker, 2019). Organophosphate pesticides are classified based on their toxicity as recommended by the World Health Organization (WHO) as shown in Table 1.

Table 1.
Classification of Organophosphate Pesticides by Level of Toxicity

Class	Toxicity Level	Pesticide Name
Ia	Very dangerous	Phosphamidon; Parathion-methyl; Terbufos
Ib	Dangerous	Monocrotophos; Propetamphos; Fenamiphos; Oxydemeton-methyl; Triazophos
II	Quite dangerous	Chlorpyrifos; Dichlorvos; Fenitrothion; Fenthion; Acephate; Anilophos; Diazinon; Dimethoate; Ethion; Quinalphos; Profenofos; Phenthoate; Phorate;
III	Slightly dangerous	Phosalone; Pirimiphos-methyl; Trichlorfon, Chlorpyrifos-methyl; Malathion; Temophos

Source: WHO, 2010

In addition to synthetic pesticides, pyrethroids are pesticides derived from natural chrysanthemum flower esters that contain natural chemicals known as pyrethrins (Ensley, 2018). Synthetic pyrethroids have environmental stability and a longer half-life than natural pyrethroids. Specifically, they work as insecticides with low toxicity. These pyrethroids work by blocking the activity of voltage-gated sodium channels in the nerve membrane so that nerve impulses do not function. Nerve cells will produce a repetitive effect that leads to death as a result of pyrethroid action (Arfiati *et al.*, 2018).

Although in agriculture there are various types of pesticides that can be used as pest control, the accumulation of these pesticides in food commodities as residues makes them harmful to consumers and to the environment. When these residues are consumed and have accumulated in human tissues and affect human health, it will cause muscle weakness, respiratory disorders, paralysis, cancer, endocrine gland disorders and others (Mostafalou & Abdollahi, 2017; Upadhayay *et al.*, 2020).





B. Pesticides Residues in Vegetables

Vegetables are foodstuffs that are high in contamination with pesticides, because these types of plants are susceptible to pest and fungal attacks, so farmers spray insecticides and fungicides on these vegetables (Duniaji, A. S, *et al*, 2021). Pesticides are an option to eradicate pests because they have a high success rate. The benefits of pesticides are proven by good product quality and high yields in vegetable production. pesticides are proven to quickly reduce the results of searching some literature regarding the content of pesticide residues in vegetables, there are several types that are often found, namely:

Table 2.
Reference Pesticides Residues Content of Vegetables in Indonesia

No	Regional	Pesticide Type		Types of Vegetables	Reference
		Category	Brand		
1.	Bali	Organophosphate	Chlorpyrifos	Cabbage, Long Beans	Sudewa, K. A, <i>et al.</i> , 2008; Tuhumury, <i>et al.</i> , 2012
2.	South Sulawesi	Organophosphate	Chlorpyrifos	Chili	Damaiyanti, D, <i>et al.</i> , 2019; Dewi, I.S.U, <i>et al.</i> , 2017; Anita, S, <i>et al.</i> , 2023; Sutomo, S, <i>et al.</i> , 2019
3.	Jakarta	Organophosphate	Diazinon	Long Bean	Harsojo, H, <i>et al.</i> , 2011
4.	Riau		Chlorpyrifos	Long Bean	Sari, N. P, <i>et al.</i> , 2020
5.	North Sumatera		Profenophose	Chili	Dalimunthe, K.T, 2012; Tamba, 2022; Sutomo, S, <i>et al</i> , 2019
6.	North Sulawesi	Organophosphate	Profenophose	Tomato, Cabbage	Oessoe, Y. Y. 2019; Januati, 2020
7.	West Java	Organophosphate, Organoklorin	Endrin	Onion, Potato	Kurnia, A. 2018; Widada <i>et al.</i> , 2022
			Heptaklor	Onion	
			BHC	Cucumber	
			Chlorpyrifos	Potatoe, Cabbage	
			Diklorfos	Cabbage	





	Organophosphate	Chlorpyrifos	Chili	Syarifuddin, K.A, <i>et al.</i> , 2021	
8.	Riau	Organophosphate	Dimethoat	Chili	Sapitri <i>et al.</i> , 2019
9.	West Java	Organophosphate	Chlorpyrifos	Broccoli	Amilia <i>et al.</i> , 2016
10.	North Sulawesi	Piretroid	Alfametrin	Cabbage, Tomato	Oessoe, Y. Y. E., 2019
11.	Maluku	Organoklorin	Heptaklor	Spinach	Tuhumury <i>et al.</i> , 2012
12.	North Sumatera	Triazol	Difenokonazol	Lettuce	Monitria & Indirawati, 2021
13.	Lampung	Triazol	Difenokonazol	Caisim, pakcoy	Widowati <i>et al.</i> , 2019
14.	East Java	Dithiokarbamat	Mankozeb	Red onion	Syamsulhadi <i>et al.</i> , 2023
15.	Central Java	Dithiokarbamat	Mankozeb	Potato	Fatmawati & Suparmin, 2015;
		Karbamat	Karbofun	Long Bean	Sulistyaningsih, T, 2009

Based on the table above, it can be seen that the residues of pesticide use on vegetables in Indonesia. Pesticides that are often used in Indonesia are organochlorine, organophosphate and carbamate groups. Organophosphates are a class of pesticides favored by farmers because they have a strong, fast killing power and the results are clearly visible on plants. Inappropriate and dangerous use of pesticides can endanger human health due to direct contact with pesticides (Shaleha *et al.*, 2023). Although pesticide residue levels may be below the permissible threshold, continued use of pesticides can lead to bioaccumulation in living organisms and biomagnification in the food chain. Bioaccumulation refers to the build-up of toxic substances, such as pesticide residues, in the tissues of living organisms over time. It mainly affects organisms that are continuously exposed to pesticides, such as plants and animals that eat contaminated crops. At certain levels, bioaccumulation can result in higher levels of pesticide residues than are present in the surrounding environment (Syamsulhadi *et al.*, 2023).

Each pesticide has different physiological effects depending on the active substance content and physical properties of the pesticide. The many types of pesticides used cause various exposures to the human body which result in synergic reactions in the body. Long-





term exposure to pesticide residues that exceed the maximum threshold can have a negative impact on human health (Fatmawati and Suparmin, 2015).

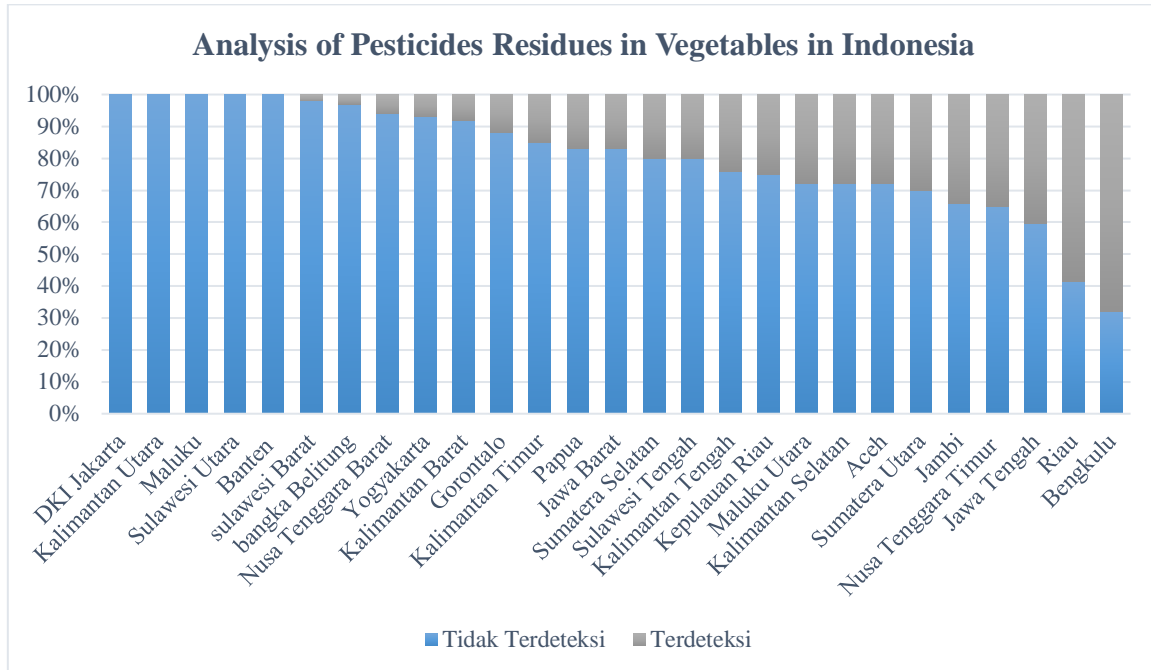
The results of the Rapid Test Kit trials in 2018 in 26 provinces were able to detect active ingredients from the Carbamate group up to 2 ppm and Organophosphates up to 0.5 ppm. The total samples tested were 3,047 fruit and vegetable samples. From the test, the following results were obtained :

1. Of the 2,698 samples examined, 88.55% showed no residues of Carbamate and Organophosphate (OP) pesticides. This class generally replaces the use of organochlorines due to concerns about their impact on the environment and human health. Two frequently used OPs with high acute toxicity are parathion (banned) and chlorpyrifos (no longer allowed for residential applications). Some OPs that are still commonly used include dichlorvos, acephate, methylparathion, and malathion which have lower acute toxicity. Carbamates that are widely used include carbaryl and pyrimicarb (Roberts & Karr, 2012).
2. About 349 samples (about 11.45% of the total samples) showed the presence of pesticide residues from the Carbamate/Organophosphate group. The five commodities with the highest intensity detected by the two pesticide compounds were tomato (19.20%), chili (17.77%), grape (7.45%), spring onion (5.44%), and long bean (5.16%).
3. The five provinces with the highest intensity of pesticide residues (Figure 1) are Bengkulu (68.09%), Riau (58.53%), Central Java (40.4%), East Nusa Tenggara (35.14%), and Jambi (34.21%). The number of samples reported from each province varied, where for these five provinces the total number of samples for each test was 47, 41, 146, 37, and 114, respectively.





Image 1.
 Pesticides Residues Analysis of Vegetables in Indonesia



In general, the level of pesticide residues on vegetables in Indonesia is still quite high. This is caused by several factors, including: 1) Excessive use of pesticides by farmers; 2) Lack of knowledge of farmers about the safe use of pesticides; 3) The absence of strict supervision from the government. Vegetables that contain the most pesticide residues are kale, spinach, and mustard greens. While the vegetables that contain the least pesticide residues are carrots, potatoes, and sweet potatoes (Amilia *et al.*, 2018).

The level of pesticide residues on vegetables also varies depending on the region. The regions with the lowest level of pesticide residues on vegetables are DKI Jakarta, North Kalimantan, Maluku, North Sulawesi and Banten. While the areas with the highest level of pesticide residues on vegetables are Central Java, Riau and Bengkulu (Miskiyah & Munarso, 2009).

The Indonesian government has actually set a Maximum pesticide Residue Limit (MRL) on vegetables. However, there are still many farmers who do not know or do not comply with these regulations. To reduce pesticide residues on vegetables, there are several things that can be done, among others:





- Farmers should use pesticides in accordance with the recommended dosage.
- Farmers should use safe and environmentally friendly pesticides.
- The government should conduct stricter supervision of the use of pesticides.
- Consumers should choose vegetables that are fresh and not wilted.
- Consumers should wash vegetables thoroughly before processing them.

C. Potential Health Problems

Residues in food, such as deposits of pesticide active ingredients, have the potential to cause adverse effects on human health. Therefore, it is important to educate consumers about the potential risks of consuming these pesticides in their daily diet. Various reports show the risks behind continuous exposure to pesticides causing depression and neurological deficits, diabetes, respiratory diseases such as rhinitis and more severely causing cancer, fetal death, spontaneous abortion and genetic diseases (Ntzani *et al.*, 2013). The effects of pesticide poisoning can cause symptoms of vomiting, diarrhea, dyspnea, blurred vision, paresthesia, slurred speech, and chest pain (Kim *et al.*, 2013). In addition to the effects of consumption, it is also evident that exposure to pesticides also has an impact on the health of workers who spray pesticides.

Pesticides can enter the farmer's body in several ways, including dermal, inhalation, digestion, clothing and tools. Farmers can be exposed to pesticides through the skin when touching pesticides contained in crops or during processes such as mixing, spraying or cleaning spray equipment. Pesticide exposure can also occur when farmers inhale pesticide vapors or dust during pesticide application or handling. Pesticides can enter the farmer's body through the digestive process if the farmer does not wash his hands properly after handling pesticides or if food or drinks are contaminated with pesticides. Direct contact with the eyes can also cause pesticides to enter the farmer's body and cause irritation or damage to the eyes. It is important for farmers to use appropriate personal protective equipment, such as gloves, masks and protective clothing, and follow safe pesticide use procedures to reduce the risk of unwanted pesticide exposure (Yuantari *et al.*, 2015).

D. Management Strategy





Pesticide residue management strategies in vegetables in Indonesia involve several key aspects that are important to reduce health and environmental risks. Here are some pesticide residue management strategies:

1. Pesticide Maximum Residue Limit (BMR) standardization is established and based on SNI 7313:2008. Indonesian National Standard (SNI) 7313: 2008 is the nation foundation in monitoring pesticide residues on vegetables in Indonesia, with this standard, the government, farmers and related parties can monitor and contrpesticide residues effectively to maintain the safety of vegetables in Indonesia (BudG. P, 2021).
2. Regular pesticide residue monitoring and associated health risk analysis. Health risk analysis related to pesticide residues is useful for adverse effects of residues on human health and identifying aspects that need to be optimized in the pesticide residue management process, while monitoring is useful for knowing the current situation related to pesticide residues in the market and monitoring the effectiveness of efforts that have been made to control pesticide residues (Suluh, D. G, 2021; Amilia, R, 2016).
3. Promote the discrete use of pesticides, i.e. only use pesticides that are necessary and at the correct dosage, in this way farmers are directed to use pesticides according to the needs of the crop and the level of pest or disease attack present, thereby reducing the risk of accumulation of excess pesticide residues in vegetables. In addition, the use of the correct dosage of pesticides is also important.
4. Farmer training, where farmers are trained on the use of pesticides. This training will give farmers a better understanding of the dangers and side effects of inappropriate pesticide use. Continuous training will increase farmers' awareness and skills in managing pesticides wisely, which will result in safe and healthy vegetables in the future.
5. Increased use of organic fertilizers, using organic fertilizers as an alternative to pesticides can help reduce the impact of pesticide residues on vegetables. Organic fertilizers can improve soil fertility, soil structure and plant health without leaving





harmful residues. By using more organic fertilizers, farmers can reduce reliance on chemical pesticides that leave harmful residues on vegetables. In addition, the use of organic fertilizers can improve agricultural sustainability by maintaining the ecosystem balance between soil and plants.

4. Conclusion

The conclusions in this literature study. Indonesia is still very much using organophosphate class insecticides, because insecticides are very effective in controlling pests, in addition to affordable prices, farmers are less familiar with alternative pest control methods that are more environmentally friendly because access to biopesticides is still limited. The authority of midwives in Early Breast feeding Initiation is still not optimal. Information given to pregnant women during pregnancy checks, only explains counseling, breastfeeding hygiene, immunization, nutrition, dangers of pregnancy, place of delivery and so on without socializing early initiation of breastfeeding.

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