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Perbedaan Efektivitas Pengurangan Residu Pestisida Organofosfat pada Cabai Rawit dengan Perendaman Jeruk Nipis dan Air Panas

Differences in the Effectiveness of Reducing Organophosphate Pesticide Residues in Chili Peppers Using Lime and Hot Water Soaking

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Abstrak

Penggunaan pestisida organofosfat di bidang pertanian, khususnya pada cabai rawit (Capsicum frutescens L.), dapat meninggalkan residu berbahaya yang dapat menyebabkan gangguan saraf, kerusakan hati, dan bahkan kanker jika dikonsumsi terus-menerus. Penelitian ini bertujuan untuk menganalisis perbedaan efektivitas antara larutan kapur dan perendaman air panas dalam mengurangi residu pestisida organofosfat pada cabai rawit. Penelitian ini menggunakan rancangan eksperimen semu dengan waktu perendaman 6, 7, dan 8 menit. Analisis residu dilakukan dengan metode spektrofotometri. Hasil penelitian menunjukkan bahwa perendaman kapur menurunkan kadar residu dari 1,487 mg/kg menjadi 1,459 mg/kg (6 menit), 1,205 mg/kg (7 menit), dan 0,972 mg/kg (8 menit), tetapi tidak mencapai batas aman yang ditetapkan oleh SNI (0,5 mg/kg). Sebaliknya, perendaman air panas secara signifikan mengurangi residu menjadi 0,130 mg/kg (6 menit), 0,037 mg/kg (7 menit), dan 0,004 mg/kg (8 menit), yang semuanya berada di bawah batas residu maksimum. Uji statistik menunjukkan perbedaan yang signifikan antara kedua perlakuan. Dapat disimpulkan bahwa perendaman air panas lebih efektif daripada larutan kapur dalam mengurangi residu pestisida organofosfat pada cabai rawit. Temuan ini memberikan rekomendasi praktis untuk mengurangi risiko paparan pestisida melalui metode pengolahan rumah tangga yang sederhana.

Kata Kunci: *Pestisida, organofosfat, cabai rawit, jeruk nipis, air panas*

Abstract

The use of organophosphate pesticides in agriculture, particularly on bird's eye chili (Capsicum frutescens L.), may leave harmful residues that can cause neurological disorders, liver damage, and even cancer if consumed continuously. This study aimed to analyze the difference in effectiveness between lime solution and hot water immersion in reducing organophosphate pesticide residues on bird's eye chili. The research employed a quasi-experimental design with immersion times of 6, 7, and 8 minutes. Residue analysis was conducted using a spectrophotometric method. The results showed that lime immersion reduced residue levels from 1.487 mg/kg to 1.459 mg/kg (6 minutes), 1.205 mg/kg (7 minutes), and 0.972 mg/kg (8 minutes), but did not reach the safe limit set by SNI (0.5 mg/kg). In contrast, hot water immersion significantly reduced residues to 0.130 mg/kg (6 minutes), 0.037 mg/kg (7 minutes), and 0.004 mg/kg (8 minutes), all of which were below the maximum residue limit. Statistical tests indicated a significant difference between the two treatments. It can be concluded that hot water immersion is more effective than lime solution in reducing organophosphate pesticide residues on bird's eye chili. These findings provide practical recommendations for reducing pesticide exposure risk through simple household processing methods.

Keywords: Pesticides, organophosphates, bird's eye chili, lime, hot water

BACKGROUND

The use of organophosphate pesticides in agriculture remains a primary choice for farmers due to their effectiveness in controlling pests and ease of application. However, residues left on crops, including cayenne peppers (Capsicum frutescens L.), can cause serious health impacts, including acute and chronic poisoning, neurological

disorders, liver damage, and even cancer risk. WHO data indicates that more than 168,000 people die each year from pesticide poisoning, and Indonesia has one of the highest rates of pesticide use in the world.

Cayenne pepper is a horticultural commodity with high economic value and widespread consumption. However, initial testing results indicate that organophosphate pesticide residue levels in cayenne pepper exceed the maximum residue limit (MRL) set by the Indonesian National Standard (SNI), which is 0.5 mg/kg. This situation raises an urgent need for simple and effective methods to reduce pesticide residue levels before the chilies are consumed.

Several studies have reported that the citric acid in limes has the ability to degrade pesticide residues, while soaking in hot water can dissolve some pesticide compounds. Therefore, this study was conducted to analyze the differences in effectiveness between lime and hot water soaks in reducing organophosphate pesticide residues in cayenne pepper, thus providing a safer food processing alternative for consumers.

METHODS

Location and Time of Research

The location of the research was at the Laboratory of the Department of Agrotechnology, Gorontalo State University, and the research time was May 13 – May 30, 2025.

Research Design

This study uses a quasi-experimental research design with the aim of determining the differences in the effectiveness of two treatment groups.

Population and Sample

The population of this study was all the harvests of cayenne pepper plants taken randomly, on the first day in the afternoon and the second day in the morning the following day on cayenne pepper plantations in Tumbihe Village, Kabila District, Bonebolango Regency, Gorontalo, which had undergone pre-lab tests for organophosphate pesticide residues..

Data analysis

The data obtained in this study were analyzed using a computer program. The statistical testing stages used were data normality testing, data homogeneity testing, and then two-way analysis of variance (ANOVA).

RESULTS

Univariate Analysis Results

Table. 1 Pesticide Residues After Lime Soaking

Time	Control	Residue Levels after Soaking Lime	Percentage of Decrease
6 minutes	1,487	1,459 mg/kg	1,88%
7 minutes	1,487	1,205 mg/kg	18,96%
8 minutes	1,487	0,972 mg/kg	34,63%

Source: Primary Data 2025

After a 6-minute soaking, organophosphate pesticide residue levels decreased by 1.88% to 1.459 mg/kg. After a 7-minute soaking, residue levels decreased by 18.96% to 1.205 mg/kg. After an 8-minute soaking, residue levels decreased by 34.63% to 0.972 mg/kg. The lime soaking treatment did not reach the safe limit set by the Indonesian National Standard (SNI).

Table 2. Pesticide Residue After Hot Water Soaking

Time	Control	Residue Levels after Hot Water Soaking	Percentage of Decrease
6 minutes	1,487	0,130 mg/kg	91,23%
7 minutes	1,487	0,037 mg/kg	97,51%
8 minutes	1,487	0,004 mg/kg	99,73%

Source: Primary Data 2025

After a 6-minute soaking, the residue level dropped 91.23% to 0.130 mg/kg. After a 7-minute soaking, the residue level dropped drastically by 97.51% to 0.037 mg/kg, which is well below the maximum residue limit according to the Indonesian National Standard (SNI). After an 8-minute soaking, the residue level dropped even further, dropping by 99.73% to 0.004 mg/kg.

Bivariate Analysis Results

Table 3. Data Normality Test

Variables	*p-value*
Lime soak and hot water soak	0,828

Source: Primary Data 2025

Based on the results of the data normality test that has been carried out, it shows that the p-value of the pesticide residue reduction data is stated with Sig. 0.828 > 0.05 (can be seen in attachment 4), because the p-value is > 0.05 then H0 is accepted, so it can be concluded that the data is normally distributed.

Table 4. Data Homogeneity Test

Variables	*p-value*
Lime soak and hot water soak	0.222

Source: Primary Data 2025

From the homogeneity results, it shows that the p-value or Sig, namely 0.222 > 0.05 (can be seen in appendix 4), because the p-value > 0.05, the homogeneity test is fulfilled, followed by the Two Way Anova test.

Table 5. Uji Two Way Anova

Variabel	*p-value*
Lime soak and hot water soak	0,001

Source: Primary Data 2025

Based on the results of the Two Way Anova test, where the data shows a significant value of 0.001 < 0.05 (can be seen in appendix 4), which can be interpreted that there is a significant difference in the treatment of lime soaking with hot water soaking.

DISCUSSION

Percentage Reduction of Organophosphate Pesticide Residues in Chili Peppers with Lime Soaking

This decrease indicates that the lime soaking treatment has an effect on pesticide residue levels. This is because the content in lime, such as citric acid, is a weak acid that can break down the bonds between pesticide molecules and the surface of the chili skin, so that some residue can be released. It acts as a natural cleaning agent or detergent that helps loosen the bonds between pesticide particles and the surface of the chili skin, so that residue is more easily physically removed when rinsed (Wang et al., 2023).

Percentage of Organophosphate Pesticide Residue Reduction in Chili Peppers by Soaking in Hot Water

Pesticides attached to the surface of cayenne pepper skin, especially those with moderate solubility in water, will dissolve more easily in hot water. Higher temperatures increase the kinetic energy of water molecules, accelerating the dissolution process of residues so they can be rinsed away. Organophosphate compounds are generally unstable to heat. Exposure to high temperatures in hot water can accelerate the hydrolysis or chemical degradation of pesticides. Hot water can dissolve residues attached to the surface of cayenne pepper skin, making them easier to rinse away. In addition, heat can also expand the pores of the chili skin, breaking the bonds between the pesticide and the surface tissue, so that residues are more easily released into the water (Kumar et al., 2024).

The Difference in Effectiveness of Lime Soak and Hot Water

The results of the study showed a difference in effectiveness between soaking in lime and hot water in reducing organophosphate pesticide residues in cayenne peppers. Soaking in lime was proven to reduce pesticide residue levels, but did not meet the 2008 Indonesian National Standard (SNI) maximum residue limit (MRL). This is suspected because the citric acid content in lime plays a role in dissolving some of the chemical bonds of pesticides, but is unable to completely decompose the more stable organophosphate structure.

Soaking in hot water demonstrated greater effectiveness in reducing organophosphate pesticide residues. The high temperature of hot water directly affects the degradation of pesticide compounds, both through hydrolysis and evaporation of chemical compounds that readily decompose at certain temperatures. This condition makes hot water more effective than lime in reducing pesticide residue levels in cayenne peppers. Based on the results, organophosphate pesticide residue levels after soaking in hot water decreased to below the maximum residue limit (MRL) set by the Indonesian National Standard (SNI). This means that cayenne peppers soaked in hot water are safe for consumption because their residue levels comply with national food safety standards

CONCLUSION

1. Lime immersion demonstrated effectiveness in reducing organophosphate pesticide residue levels in cayenne peppers. The initial residue level of 1.487 mg/kg decreased to 1.459 mg/kg after 6 minutes of immersion (a 1.88% reduction), 1.205 mg/kg after 7 minutes (an 18.96% reduction), and 0.972 mg/kg after 8 minutes (a 34.63% reduction). The longer the immersion time, the greater the reduction in residue levels. However, it did not meet the 2008 Indonesian National Standard (SNI) 2008 MMR standard of 0.5 mg/kg.
2. Soaking cayenne peppers in hot water proved effective in reducing organophosphate pesticide residue levels. The initial level of 1.487 mg/kg decreased drastically to 0.13 mg/kg after 6 minutes (a 91.23% reduction), 0.037 mg/kg after 7 minutes (97.51%), and reached 0.004 mg/kg after 8 minutes (99.73%). The longer the soaking time, the greater the reduction in residues. This treatment met the 2008 Indonesian National Standard (SNI) 2008 MMR standard of 0.5 mg/kg.
3. The p-value indicates a difference in effectiveness between lime soaking and hot water soaking in reducing organophosphate pesticide residues, with a p-value of 0.001 < 0.05..

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