Original article

Assessment of Organophosphate and Carbamate residues in vegetables marketed as pesticide-free in Pathum Thani Province

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Abstract

Organic vegetables are widely regarded as safer and healthier alternatives to conventionally farmed produce. However, concerns persist regarding contamination from organophosphate and carbamate pesticide residues, especially in Thailand, where consumer demand for organic foods continues to grow. Despite certification standards, environmental exposure, post-harvest practices, and supply chain variability may compromise the safety of pesticide-free products. This study aimed to assess the prevalence of organophosphate and carbamate residues in six commonly consumed vegetables marketed as pesticide-free in Pathum Thani Province and to compare contamination levels between certified supermarkets and fresh markets.

A cross-sectional study was conducted using 48 vegetable samples—Napa cabbage, cabbage, bok choy, kale, water spinach, and garlic—collected through convenience sampling from four supermarkets and four fresh markets. Pesticide detection was performed using the MJPK test kit, a colorimetric cholinesterase inhibition assay with an 85% detection accuracy. Results were classified as Safe, Harmful, or Severely Harmful. Descriptive statistics were used to analyze residue prevalence by vegetable type and distribution source.

Of the samples, 83.00% were classified as Safe, 2.08% as Harmful, and 12.50% as Severely Harmful. All leafy vegetables were 100% pesticide-free, while garlic showed the highest contamination, with 75.00% of samples classified as Severely Harmful. Contamination was found exclusively in supermarket-sourced vegetables; all fresh market samples were safe.

Although most pesticide-free vegetables were safe for consumption, significant contamination in supermarket-sourced garlic highlights weaknesses in current monitoring and certification systems. Stricter regulatory oversight, enhanced residue testing, and improved consumer education are essential to ensure food safety and protect public health.

Keywords: Organic vegetables, pesticide residues, food safety

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Introduction

The global demand for organic produce has grown substantially over the past few decades, driven by rising consumer awareness of health, food safety, and environmental sustainability. In Thailand, this trend has been supported by national initiatives promoting organic agriculture since the 1980s, and further accelerated by the COVID-19 pandemic, which strengthened public interest in immunity-boosting foods and chemical-free consumption. According to Statista (2023), 59% of Thai consumers purchase organic food based on its perceived health benefits, contributing to a market where consumers are willing to pay a premium for produce labeled as pesticide-free.

Despite the appeal of organic products, concerns remain about their actual safety—particularly regarding contamination from pesticide residues such as organophosphates and carbamates. These pesticides are commonly used in conventional agriculture to control pests but pose significant health risks to humans, functioning as cholinesterase inhibitors that can disrupt the nervous system and cause acute and chronic toxic effects. Studies have documented persistent residues in conventionally grown produce in Southeast Asia, including Thailand, with long-term exposure linked to neurological, respiratory, and hormonal disorders (Gupta et al., 2017; Wananukul et al., 2016).

While organic farming standards prohibit the use of synthetic pesticides, the risk of contamination remains due to environmental exposure, cross-contamination, or fraudulent labeling. Particularly concerning is the contamination of garlic, which has been reported as a high-risk crop in past studies. For example, research in Bangkok showed that garlic had the highest percentage of unsafe pesticide residues among organic vegetables tested (Panyarittisorn et al., 2022). Garlic is susceptible due to post-harvest treatment, long storage periods, and its structure, which retains residues more effectively than leafy greens.

Although public trust in organic labeling is high, empirical studies verifying the safety of pesticide-free vegetables in local Thai markets are limited. Especially lacking are comparative assessments between different distribution sources—such as fresh markets and certified supermarkets—which may vary in supply chain rigor, storage practices, and inspection standards.

Given these concerns, this study aims to assess the presence of organophosphate and carbamate residues in vegetables marketed as pesticide-free in Pathum Thani Province. By analyzing both leafy greens and garlic from fresh markets and supermarkets, this research contributes to closing the data gap on organic food safety and supports improved consumer protection and regulatory oversight.

Objective of the study

1.To determine the prevalence of organophosphate and carbamate pesticide residues in six commonly consumed vegetables (Napa cabbage, cabbage, bok choy, kale, water spinach, and garlic) marketed as pesticide-free in Pathum Thani Province.

2. To compare the levels of pesticide residues across different distribution sources, specifically between certified supermarkets and major fresh markets, to assess variations in contamination risks.

Study Method

Study Design

This study employed a quantitative, cross-sectional design to investigate the presence of organophosphate and carbamate pesticide residues in vegetables marketed as pesticide-free. The primary objective was to evaluate contamination levels and compare residue prevalence across distribution sources in Pathum Thani Province, Thailand.

Sample Selection and Justification

A total of 48 vegetable samples were selected using convenience sampling from eight distribution sources—four certified supermarkets and four major fresh markets. The six vegetable types included Napa cabbage, cabbage, bok choy, kale, water spinach, and garlic. These vegetables were chosen due to their widespread consumption, high market turnover, and representation of both leafy greens and bulb crops, which differ in contamination susceptibility.

While convenience sampling allowed practical access to a variety of vendors, it introduces potential sampling bias. Therefore, the generalizability of the findings is limited, and results should be interpreted with caution. Future studies employing randomized sampling are recommended.

Pesticide Detection Instrument

Residue detection was performed using the MJPK Test Kit, a colorimetric cholinesterase inhibition assay developed by the Department of Medical Sciences, Thailand. The test kit detects acetylcholinesterase inhibition caused by organophosphates and carbamates, with a reported detection accuracy of 85%, a 15% false-positive rate, and 0% false-negative rate.

Residue levels were categorized based on colorimetric interpretation as follows:

1) Safe: No significant enzyme inhibition;

2) Harmful: Moderate inhibition (~15%), aligning with the “slightly toxic” threshold as per Thai standards;

3) Severely Harmful: Significant inhibition, exceeding established safety limits, indicating unsafe levels of pesticide residues for consumption.

Sample Preparation and Analytical Procedure

Each vegetable sample (300g) was chopped into small pieces and placed in a sterile container. The MJPK test protocol was conducted as follows:

1) Extraction: 6 mL of extraction solution was added; samples were shaken vigorously for 2 minutes.

2) Extracted liquid was transferred to test tubes.

3) Evaporation: Samples were heated in a water bath to reduce volume to a single drop, then air-dried.

4) Reagent Mixing: Test solutions were mixed and added according to the manufacturer's protocol, including preparation of test and control tubes.

5) Colorimetric Analysis: Final color change was visually interpreted to determine pesticide presence.

Data Analysis

Descriptive statistics were applied to analyze the frequency and percentage distribution of pesticide residues by vegetable type and distribution source. Results were presented as proportions of Safe, Harmful, and Severely Harmful classifications.

Results

The study analyzed 48 vegetable samples to assess the prevalence of organophosphate and carbamate pesticide residues. The results, as presented in Table 2, indicate that the majority of the tested samples were free of pesticide residues, classified as *Safe* (83.00%). However, contamination was detected in a small portion of the samples, with 1 sample (2.08%) categorized as Harmful and 6 samples (12.50%) categorized as Severely Harmful.

Among the tested vegetables, Napa cabbage, cabbage, bok choy, kale, and water spinach were all 100% safe, showing no detectable pesticide residues. However, garlic displayed a significantly higher contamination risk, with only 12.50% of garlic samples categorized as Safe, while 12.50% were Harmful and 75.00% were Severely Harmful. This finding suggests that garlic, despite being marketed as pesticide-free, may be more prone to pesticide contamination than leafy vegetables. The possible reasons for this include post-harvest pesticide application, cross-contamination, or unregulated pesticide use in garlic farming (Table 2).

The study also examined pesticide residue levels based on distribution sources, comparing samples obtained from certified supermarkets and major fresh markets. As shown in Table 3, 85.42% of all tested samples were classified as Safe, while 2.08% were Harmful and 12.50% were Severely Harmful. Notably, all samples from fresh markets were classified as Safe, with zero detections of harmful or severely harmful pesticide residues. In contrast, supermarket samples exhibited higher contamination rates, with 1 sample (2.08%) categorized as Harmful and 6 samples (12.50%) categorized as Severely Harmful.

Among supermarket samples, Supermarket 1 had 1 harmful sample (2.08%), while Supermarkets 2, 3, and 4 each had 2 severely harmful samples (4.17%). These findings suggest that supermarket-sourced organic vegetables may be more susceptible to pesticide contamination, possibly due to supply chain handling, storage practices, or less rigorous monitoring compared to local fresh markets. (Table 3).

Discussion

The findings of this study indicate that the majority of organic-labeled vegetables tested in Pathum Thani Province were free from detectable levels of organophosphate and carbamate pesticide residues. Out of 48 tested samples, 83.00% were classified as Safe, 2.08% as Harmful, and 12.50% as Severely Harmful. However, a notable discrepancy in pesticide contamination was observed among different vegetable types and distribution sources.

Absence of Pesticide Residues in Leafy Vegetables

The complete absence of pesticide residues in Napa cabbage, cabbage, bok choy, kale, and water spinach (100% Safe) suggests that these vegetables are either cultivated with strict adherence to Good Agricultural Practices (GAP) or undergo sufficient degradation of pesticides before reaching consumers. Previous research has demonstrated similar findings. For instance, a study conducted by Chaninat Panyakiatikun et al. (2023) found no detectable pesticide residues in organic strawberries, reinforcing the idea that certain crops, particularly leafy vegetables, may be less prone to residue accumulation. Another study on chili peppers in Nonthaburi confirmed the absence of unsafe levels of organophosphate and carbamate residues in properly managed organic crops.

A key factor contributing to these results may be pesticide application timing. Research suggests that applying pesticides at least 7–14 days before harvest allows sufficient degradation, reducing residue levels to below detectable limits (Leskovac & Petrović, 2023) Additionally, leafy greens have shorter growing cycles and high market turnover rates, which may further reduce the risk of pesticide accumulation. These factors collectively explain why leafy vegetables in this study showed no detectable pesticide residues.

High Contamination Levels in Garlic

Unlike the leafy vegetables, garlic exhibited the highest contamination levels, with only 12.50% of samples classified as Safe, 12.50% as Harmful, and a significant 75.00% as Severely Harmful. This indicates that garlic may be at a higher risk of pesticide contamination compared to other vegetables in the study.

Several factors could contribute to this contamination. First, post-harvest pesticide application is commonly used on garlic to prevent sprouting and extend shelf life. Unlike leafy greens, which are harvested and consumed quickly, garlic undergoes longer storage and transportation periods, increasing the likelihood of chemical treatment. Second, garlic, being a bulb crop, has a greater tendency to absorb and retain pesticide residues within its structure, making it harder to wash off contaminants compared to leafy vegetables. Lastly, variability in farming practices may also play a role. Not all organic-labeled garlic in markets may come from truly organic farms, as fraudulent labeling or cross-contamination during storage and processing may contribute to these high contamination levels.

This trend is consistent with the findings of Pakhin Panyarittisorn et al., who reported that garlic had the highest pesticide residue levels among organic vegetables tested in Bangkok. Their study found that 61.54% of contaminated samples belonged to garlic, highlighting the urgent need for stricter monitoring of pesticide-free claims in garlic and similar bulb crops.

Variation in Contamination Between Supermarket and Fresh Market Samples

A major finding of this study was that pesticide contamination was detected exclusively in supermarket samples, while all fresh market samples were classified as Safe. Among supermarket samples, contamination rates were highest in Supermarket 2, 3, and 4, with each showing 28.57% of samples classified as Severely Harmful.

One possible explanation for this disparity is the longer supply chains in supermarkets. Unlike fresh markets, where produce is often sourced directly from local farmers, supermarkets rely on larger distribution networks, increasing the risk of cross-contamination or post-harvest pesticide application. Additionally, storage and handling practices may differ. While fresh market produce is sold quickly after harvest, supermarket vegetables may be stored for extended periods, necessitating chemical treatments to prevent spoilage.

Consumer preferences may also influence contamination levels. In fresh markets, customers often prioritize purchasing from known farmers or certified organic sources, reducing the risk of exposure to mislabeled products. Supermarkets, on the other hand, rely heavily on certifications and supplier compliance, which may not always guarantee strict adherence to organic farming standards. These findings emphasize the need for stricter quality control measures in supermarkets to ensure compliance with organic labeling regulations.

Reliability and Limitations of the MJPK Kit

The MJPK test kit, a colorimetric cholinesterase inhibition assay, offers a practical tool for preliminary pesticide screening. With an 85% accuracy rate, it is easy to use but has notable limitations, including a 15% false-positive rate, lack of compound-specific detection, and no quantification of residue levels. Therefore, results should be interpreted with caution and ideally confirmed using GC-MS for greater accuracy and specificity.

Comparison with Other Studies

The results of this study align with previous research highlighting the inconsistency of pesticide contamination in organic-labeled produce. A study by Pannatat Suttirak et al. in Thailand found 12.5% of organic vegetable samples contained unsafe pesticide residues, a figure comparable to the 12.50% Severely Harmful classification in this study (Suttirak et al., 2022). Additionally, studies from Nepal and Cambodia indicate that organophosphate and carbamate contamination is a persistent issue in Southeast Asia, supporting the argument that stringent monitoring and residue testing are essential for consumer protection (Neufeld et al., 2010; Zhang, 2022).

Limitations

This study's convenience sampling may not fully represent all organic vegetable sources, and a larger, randomized sample would improve generalizability. The MJPK test kit, with 85% accuracy, requires confirmatory testing via gas chromatography-mass spectrometry (GC-MS) for precision. Additionally, seasonal and regional variations in pesticide use highlight the need for longitudinal studies across different locations.

Recommendations

Supermarkets should strengthen pesticide monitoring, especially for organic-labeled garlic and high-risk crops. Regulatory bodies must enforce randomized residue testing and farm inspections to prevent fraudulent organic labeling. Consumers should be encouraged to buy from trusted local markets, where lower contamination rates were observed. Stronger partnerships between supermarkets and certified organic farmers would improve traceability. Public awareness campaigns on pesticide risks, proper washing techniques, and reliable organic sources are essential. Strengthening organic certification and residue testing regulations will ensure food safety and compliance.

Conclusion

This study revealed that while the majority of organic-labeled vegetables were free from detectable pesticide residues, garlic and supermarket-sourced produce posed significantly higher contamination risks. These results highlight critical vulnerabilities in the organic supply chain—particularly for high-risk crops and large retail environments. To ensure consumer safety and uphold trust in organic labeling, there is a pressing need for stricter regulatory enforcement, routine residue testing, and clearer certification standards. Additionally, improving transparency across the distribution chain and raising public awareness about contamination risks—especially in products like garlic—will be essential to strengthening food safety and consumer confidence in pesticide-free produce.

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The colorimetric assay results were classified into the following categories:

Color	Interpretation
Orange (Control)	Baseline/Reference Sample
Orange (Safe)	Safe, no significant enzyme inhibition detected
Pinkish-Orange	Harmful (15% enzyme inhibition)
Pink	Severely Harmful (Significant inhibition)

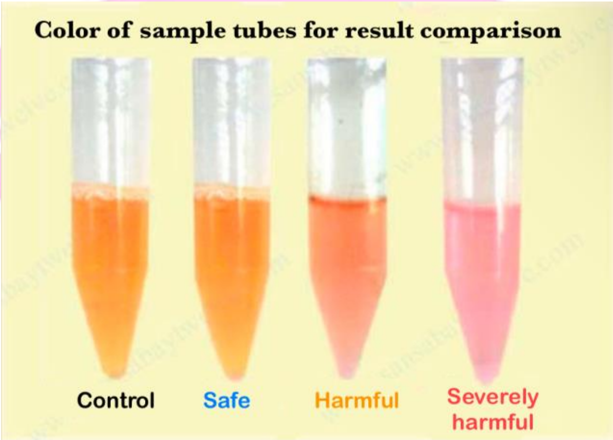

Figure 1 presenting color of sample tubes for result comparison and its representation of safety level.

Figure 2 Test Result: Severely Harmful

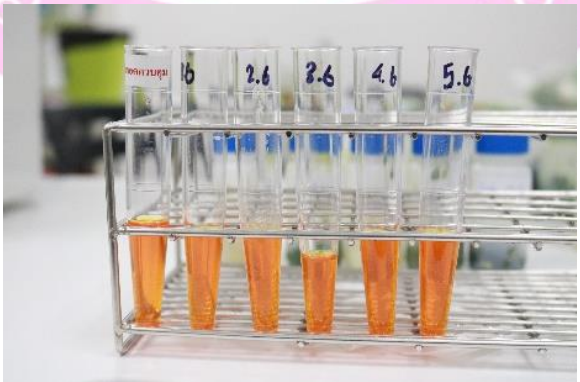

Figure 3 Test Result: Safe

Table 1 presents the sample distribution (n = 48)

Type	Quantity
Napa Cabbage	8
Cabbage	8
Bokchoy	8
Kale	8
Water Spinach	8
Garlic	8
Total	48

Table 2 presenting results obtained from investigation of each sample ofvegetable types (n = 48).

Type	Quantity	Result		
		Safe n (%)	Harmful n (%)	Severely Harmful n (%)
Napa Cabbage	8	8 (100.00)	0 (0.00)	0 (0.00)
Cabbage	8	8 (100.00)	0 (0.00)	0 (0.00)
Bok choy	8	8 (100.00)	0 (0.00)	0 (0.00)
Kale	8	8 (100.00)	0 (0.00)	0 (0.00)
Water Spinach	8	8 (100.00)	0 (0.00)	0 (0.00)
Garlic	8	1 (12.50)	1(12.50)	6 (75.00)
Total	48	40 (83.00)	1 (2.08)	6 (12.50)

Table 3 presenting the test result compared by vegetable distribution sources (n = 48)

Distribution source	Quantity	Result		
		Safe n (%)	Harmful n (%)	Severely Harmful n (%)
Supermarket market 1	7	6 (100)	1 (2.08)	0 (0.00)
Supermarket market 2	7	5 (100)	0 (0.00)	2 (0.04)
Supermarket market 3	7	5 (100)	0 (0.00)	2(0.04)
Supermarket market 4	7	5 (100)	0 (0.00)	2 (0.04)
Fresh market 1	5	5 (100)	0 (0.00)	0 (0.00)
Fresh market 2	5	5 (100)	0 (0.00)	0 (0.00)
Fresh market 3	5	5 (100)	0 (0.00)	0 (0.00)
Fresh market 4	5	5 (100)	0 (0.00)	0 (0.00)
Total	48	41 (85.42)	1 (2.08)	6 (12.50)