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# FOOD SAFETY QUALITY OF ORGANIC AND CONVENTIONAL VEGETABLES FROM FARMS IN MALAYSIA

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**Abstract:** The production of organic and conventional vegetables may pose risk to human health due to the accumulation of heavy metals, pesticides and the presence of bacterial pathogens. Thus, this study was conducted to assess the heavy metals, microbes and pesticides contamination in organic and conventional vegetables (mustard, spinach and kale) during harvest from the farm. A total of 108 samples of organic and conventional vegetables were collected from organic and conventional vegetable farms in the Gombak district. The highest amount of cadmium was in conventionally farmed kale which was 0.24 mg/kg. The determination of heavy metals in organic and conventional vegetables from farms showed that only mustard had significant difference ($p = 0.019$) in cadmium concentration. For the microbiological quality, the mean microbial count for *E. coli* of organic vegetables was higher than conventional vegetables with 2.58 and 0.85 respectively. There is a significant difference between organic and conventional vegetables in *E. coli* ($p = 0.006$) whereas there is no significant difference found in total coliform ($p = 0.144$). Conventional kale has been indicated as the highest prevalence with deltamethrin residue with 16.7% of the samples. For the determination of pesticide residue, there was a significant difference between organic and conventional kale ($p = 0.04$) whereas for the mustard and spinach, there was no significant difference in the two different types of farming. All the samples showed the Hazard Index (HI) below than one which means that there was no potential health impact due to the consumption of these vegetables. These assessments provide an overview of the food safety status of organic and conventional vegetables from farms in Malaysia.

Keywords: Organic, conventional, vegetables, heavy metals, pesticides, microbial pathogens.

## Introduction

Intensive conventional farming uses a significant quantity of resources to meet global needs. It has also caused negative environmental and ecological implications due to the manner in which the land is used. Sustainable organic farming uses natural resources carefully and it is viewed to be in tandem with food production process, as well as to quality of life, by providing the conditions for sustainable growth. With this viewpoint, organic food can represent a realistic option for a healthy future (Cristache *et al.,* 2018).

The consumption of organic food has grown remarkably, both in developed and developing countries as people are increasingly concerned about nutrition, health, and food quality (Shafie & Rennie, 2012; Somasundram *et al*., 2016). Organic food is generally costlier than conventional food even though they may look physically the same (Loebnitz & Aschemann-Witzel, 2016). In the production of organic food, the use of fertilizers, pesticides, animal feed additives and growth hormone regulators are prohibited, as they rely heavily on crop rotation, animal and manures, hand weeding and biological pest control (EUFIC, 2016). There is a number of natural and synthetic pesticides allowed in the USDA National List for organic farmers to use in their farms such as copper sulphate, boric acid, acetamiprid, peracetic acid and sulphur elements. These pesticides need to be used with care as they may cause undesirable side effects to human health. Therefore, to ensure that pesticide residue concentrations in organic vegetable remain within the acceptable level, the inspection and control of pesticides is carried out using various kinds of analytical methods (Sulaiman *et al*., 2019).

The consumers believe organic vegetables are free from pesticides, fertilizers, and toxins (Shafie & Rennie, 2012). The accumulation of heavy metals in the soil may exist due to the use of chemicals in crop production (Huang *et al*., 2019). The use of fertilizer may increase the risk of microbiological contamination by enteric pathogenic microorganisms and can pose foodborne diseases and outbreaks to consumers (Maffei *et al*., 2016; Kuan *et al*., 2017). The presence of opportunistic pathogens in vegetables can cause diarrhea, hemolytic uremic syndrome, haemorrhagic colitis, and other indications (Luna-Guevara *et al*., 2019). The aim of this study is to identify contaminants (heavy metals, microbes, and pesticides) in both organic and conventional vegetables from farms. The outcome should provide the profile of organic and conventional vegetables from the farms as to oversee the food safety and sustainability of vegetable farming in Malaysia.

## Materials and Methods

### Sample Collection and Preparation

#### *Heavy Metals in Organic and Conventional Vegetables from Farms*

A total of 21 organic and 21 conventional vegetables consisting of three types of vegetables (mustard, spinach and kale) were collected directly from two farms in the district of Gombak, Selangor. The samples were collected randomly and put into plastic bags and washed by using distilled water to get rid of airborne pollutants (Amin *et al*., 2013). The samples were then cut into small pieces with a knife and put into an aluminium foil tray. Then, the tray filled with samples was put in the hot-air oven (Venticell brand; USA) to remove all the moisture at a temperature of 70ºC - 80ºC. After 48 hours, the dried samples were ground to powder. The samples were diluted with 5 ml of hydrochloric acid (HCl) and added with 10 ml of distilled water according to the method shown by Zhou *et al.* (2016). The samples were placed onto hot plate (Spectrum brand, USA) to be evaporated and later filtered by using Millipore filter paper and added with distilled water to 50 ml. The acid digestion method was used for analysis of heavy metals in organic and conventional vegetable samples before analyzed using Graphite Furnace- Atomic Absorption Spectrometer (Perkin Elmer brand, USA).

#### *Health Risk Assessment for Heavy Metals*

Health risk assessment was conducted to determine the health risk for the consumption of heavy metals in the vegetables. The target hazard quotient (THQ) and hazard index (HI) were used. The THQ was calculated using the following formula by Antoine *et al*. (2017) method:

$$THQ = \frac{EFr \times EDtot \times F_{IR} \times C}{RfDo \times BWa \times ATn} \times 10^{-3} \qquad \text{Equation (1)}$$

Where $E_{FR}$ is the exposure frequency to the trace element, Ed is the exposure duration (70 years), $F_{IR}$ is the food ingestion rate in grams per day for the respective food item, C is the concentration in wet weight of the trace element in the given food item, R*f*D is the oral reference dose of the trace element in µg/g/day, BWa is the reference body weight of 70 kg and ATn is the average exposure time (365 days*70 years) and $10^{-3}$ is the unit conversion factor.

If the THQ is equal to or higher than one, there is a potential health risk for the consumers, and immediate control and preventive measures must be taken. A THQ below one means the exposure population is unlikely to experience obvious adverse effects. The HI value is the total of THQ of heavy metals for vegetables. The HI was calculated with the HQs summed up (using the following equation according to Elgueta *et al*. (2020) method:

$$HI = \sum_{n=1}^{i} THQn \qquad \text{Equation (2)}$$

## Sample Collection and Preparation

### *Microbiological Quality in Organic and Conventional Vegetables from Farms*

A total of 18 organic and 18 conventional vegetable samples were randomly collected from two farms in Gombak, Selangor. Following Tango *et al*. (2018) method, the samples were collected and put in sterile plastic bags. Then, the samples were transported in an icebox at 4°C to the laboratory for further analyzed within 24 hours upon collection of the sample according to methods by Kuan *et al*. (2017), Seow *et al*. (2012) and Szczech, *et al*. (2018). Temperatures below 4°C were kept by monitoring the reusable icepack (Sopear brand, China) temperature using food thermometer (Traceable brand, USA). According to the method by Kuan *et al*. (2017), 25 grams of each sample were placed in a stomacher bag containing 225 ml of sterile 0.1% buffered peptone water (BPW) and homogenized using a stomacher for two minutes. The sample mixture was subjected to ten-fold serial dilutions in which 1 ml of the sample mixture was diluted with 9 ml of buffered peptone water (BPW). The same procedures were repeated until the dilution factor become $10^{-4}$ according to Seow *et al*. (2012) method.

### *Enumeration of Total Coliform and E. coli*

The enumeration of total coliform and *E. coli* followed Tango *et al*. (2018) method. The sample dilution of 0.1 ml was placed on plate count agar by the spread plate technique. The plates were incubated at 37°C for 24 hours. The presence of pink colour indicates the presence of coliform while purple colour signifies the presence of *E. coli*. The microbial colonies on the plate were enumerated and the colony counts per 1 g sample were determined. Colonies with pink colour (coliform) and purple (*E. coli*) were counted and the counts were converted into log10 CFU $g^{-1}$.

## Sample Collection and Preparation

### *Pesticides in Organic and Conventional Vegetables from Farms*

A total of 15 organic and 15 conventional vegetable samples were collected in Gombak, Selangor. The sample collection and preparation were according to Abdolshahi *et al*. (2015) method. The edible portions were separated from non-edible parts and washed under running tap water. Next, the samples were air-dried at 70°C in a hot-air oven (Venticell brand; USA) for 24 hours. After that, the dried samples were powdered and passed through a size 16 sieve to obtain similar sized particles. The process was repeated by drying the samples again at 70°C to reach a constant weight. After that, the dried samples were put in a refrigerator at a temperature between 1°C – 2°C until use. The milled vegetables particle sizes are vital in this process to facilitate the analyses of mass transfer of fat during the extraction process. Analytical standard (pestanal quality) of 45423 Deltamethrin with a concentration of 500 ppm, were prepared by exact weighing and dissolving process. An automated Soxhlet extractor set (Accumax brand, India) was used to extract the oil content from the samples and the samples were analyzed using High-Performance Liquid Chromatography (HPLC) (Agilent brand, USA).

### *Health Risk Assessment for Pesticides*

The analysis for health risk assessment can be determined from the presence of pesticides in the vegetables consumed by the local population. Therefore, assessment of population health risk was analysed based on formula specifically designed for pesticide residues. Estimated Daily Intake (EDI) of pesticide residues for each combination of pesticide and commodity was calculated by multiplying the residual pesticide concentration (mg/kg) by the food consumption rate (kg/day) and dividing by a body weight of 60 kg for an adult. The average daily vegetable intake for adult was considered to be 0.345 kg/person/day. These estimations were conducted according to Wang *et al*. (2005) method.

The Hazard Quotient was determined to summarize the Hazard Index (HI). HQ was obtained by dividing the estimated daily intake (EDI) by the relevant acceptable daily intake (ADI) (Łozowicka *et al*., 2013). If HI of a pesticide residue does not exceed one, the consumer is considered to be adequately protected. If HI exceeds a value of one could indicate an unacceptable health risk (Antoine *et al.,* 2017).

$$HQ = \frac{EDI}{ADI} \quad \text{Equation (3)}$$

## Results and Discussion

### *Heavy Metals in Organic and Conventional Vegetables and Their Potential Health Risk*

Table 1 shows the t-test analysis for the concentration of heavy metals: Zinc (Zn), Lead (Pb), Copper (Cu) and Cadmium (Cd) in the three types of vegetables: spinach, kale and mustard.

Most samples showed that conventional vegetables had higher concentration of metals compared to organic vegetables. Only concentration of cadmium in mustard has

Table 1: Concentration of heavy metals in the vegetable samples

| Heavy Metal | Type of Farming | Vegetable | Mean Standard Deviation | *p-Value (Significant/Not Significant) |
|---|---|---|---|---|
| Zinc (Zn) | Organic | Spinach | 0.36 0.00 | |
| | | Kale | 0.14 | |
| | | Mustard | 0.13 | Not significant |
| | Conventional | Spinach | 0.39 0.01 | |
| | | Kale | 0.25 | |
| | | Mustard | 0.32 | |
| Lead (Pb) | Organic | Spinach | 0.15 | |
| | | Kale | 0.14 | |
| | | Mustard | 0.06 | Not significant |
| | Conventional | Spinach | 0.10 | |
| | | Kale | 0.14 | |
| | | Mustard | 0.08 | |
| Copper (Cu) | Organic | Spinach | 0.17 | |
| | | Kale | 0.02 | |
| | | Mustard | 0.02 | Not significant |
| | Conventional | Spinach | 0.03 | |
| | | Kale | 0.07 | |
| | | Mustard | 0.05 | |
| Cadmium (Cd) | Organic | Spinach | 0.13 | |
| | | Kale | 0.13 | Not significant |
| | | Mustard | 0.06 | except for mustard |
| | Conventional | Spinach | 0.22 | |
| | | Kale | 0.24 | |
| | | Mustard | 0.08 | |

**significant at p-value ≤ 0.05*

p-value less than 0.05 (p = 0.019). Therefore, it shows that there is significant difference between organic mustard and conventional mustard for cadmium. The other heavy metals showed no significant difference between organic and conventional vegetables ($p \geq 0.05$). The highest amount of cadmium was in conventionally farmed kale which was 0.24 mg/kg. The sequence for the concentration of cadmium is conventional kale > conventional spinach > organic spinach and kale > conventional mustard > organic mustard. According to Singh *et al.* (2012), leafy vegetables like kale, spinach, amaranthus, mustard and fenugreek recorded higher accumulation of both essential and non-essential heavy metals including cadmium and nickel. Cadmium was found to have accumulated more in the stems and leaves of potato, spinach and kale roots and leaves, amaranthus leaves, fenugreek roots, and mustard leaves (Singh *et al.*, 2012). Mustard leaves are round and they partially clasp the stem. The accumulation of cadmium in mustard could be due to the larger surface area of its leaves compared to other vegetables.

### *Health Risk Assessment*

Table 2 shows the heavy metal THQ values due to consumption of the organic and conventional vegetable samples in this study.

The THQ calculation value for all heavy metals in each vegetable is less than one. A THQ below one means the exposure population is unlikely to experience obvious adverse effects such as muscular and neurological degenerative process. The value indicates that the vegetables were safe to be consumed. Results showed that conventional kale had a relatively higher HI than other kinds of vegetables but the value was still less than one. Zhou *et al.* (2016) conducted a similar study on vegetables from contaminated soils and the THQ value in the vegetables was still less than one. The THQ of zinc for conventional kale was the highest compared to the rest and ultimately the highest value of HI. In general, vegetables are poor source of zinc but kale has a high percentage of zinc after potatoes (USDA, 2020). The results show that the THQ and HI value of organic vegetables for each kind of vegetable is lower than the conventional ones. From these findings, it may be inferred that organic vegetables are safer for consumption than conventional vegetables, in terms of heavy metal content.

### *Microbiological Quality Assessment in Organic and Conventional Vegetables*

Table 3 depicts the prevalence of microbial count in organic and conventional vegetables.

The prevalence of *E. coli* count was higher than total coliform ranging between two to five log10 CFU/g. Microbial count of *E. coli* results varied from two to five log10 CFU/g for both organic and conventional vegetables. The result shows that organic vegetables have higher microbial counts of *E. coli* compared to

Table 2: Target Hazard Quotient (THQ) value due to consumption of vegetables

| **Samples** | **Target Hazard Quotient (THQ)** | | | | **Hazard Index (HI)** |
|---|---|---|---|---|---|
| | **Pb** | **Cd** | **Zn** | **Cu** | |
| Organic spinach | 0.00001881 | 0.00006521 | 0.00602 | 0.000853 | 0.00696 |
| Conventional spinach | 0.0000000118 | 0.0000006525 | 0.0065217 | 0.000853464 | 0.00738 |
| Organic kale | 0.0001756 | 0.000065216 | 0.00234111 | 0.00010033 | 0.00268 |
| Conventional kale | 0.0000176 | 0.0001204 | 0.0041805 | 0.005017 | 0.00934 |
| Organic mustard | 0.000007525 | 0.0000301 | 0.00217389 | 0.00010033 | 0.00321 |
| Conventional mustard | 0.000010033 | 0.00004515 | 0.00535111 | 0.0002508 | 0.00575 |

Table 3: Prevalence of microbial counts in organic and conventional vegetables

| Count Interval (CFU/g) | *E. coli* | | Total Coliform | |
|---|---|---|---|---|
| | Conventional | Organic | Conventional | Organic |
| $10^1$ - $10^2$ | 0 | 0 | 0 | 0 |
| $10^2$ - $10^3$ | 3.8 | 5.6 | 4.9 | 5.3 |
| $10^3$ - $10^4$ | 7.3 | 11.5 | 3.2 | 7.1 |
| $10^4$ - $10^5$ | 5.6 | 10.7 | 8.6 | 9.8 |
| $>10^5$ | 0 | 0 | 0 | 0 |

conventional vegetables ranging from three to five log10 CFU/g. Total coliforms were present in smaller counts than *E. coli*, ranging from two to five log10 CFU/g in organic and conventional vegetables. The counts of coliforms of most samples varied from four to five log10 CFU/g. Organic vegetables have high prevalence of microbial counts of total coliform compared to conventional vegetables ranging from three to five log10 CFU/g.

### *Relationship Between Microbial Count and Different Types of Vegetable Farming*

Table 4 shows the t-test analysis used to indicate the difference in the mean of microbial count for organic and conventional vegetables.

The mean microbial count for *E. coli* of organic vegetables was higher than conventional vegetables with 2.58 and 0.85 respectively. Thus, those results showed that microbial count for *E. coli* in both organic and conventional vegetables from farms were significantly different with $p \leq 0.05$ ($p = 0.006$). The mean microbial count of total coliform for organic vegetables and conventional vegetables was 1.54 and 0.92 respectively. There was no significant difference in microbial count of total coliform between organic and conventional vegetables with $p \geq 0.05$ ($p = 0.144$).

### *Prevalence of Microbes in Organic and Conventional Vegetables*

Table 5 shows the microbial prevalence of *E. coli* and total coliform in three types of organic and conventional vegetables.

No trend was observed for either organic or conventional vegetables to have greater prevalence of microbial count. There was no obvious difference in the prevalence of *E. coli* between organic and conventional vegetables. From the vegetables analysed, 27.8% of *E. coli* was isolated from organic vegetables and 16.7% of *E. coli* was isolated from conventional vegetables. Besides, no trend was observed that demonstrated either organic or conventional vegetables had a greater prevalence of total coliform. From the vegetables analysed, 22.2% of total coliform was isolated from organic vegetables and 16.7% of total coliform was isolated from conventional vegetables. The prevalence of spinach from organic vegetables was double compared to the spinach from conventional farm with 33.3% as there was no presence of total coliform at the spinach from

Table 4: Microbial count of organic and conventional vegetables

| Microorganisms | Type of Farming | Mean | Standard Deviation | p-Value |
|---|---|---|---|---|
| *E. coli* | Organic | 2.58 | 0.37 | 0.006* |
| | Conventional | 0.85 | 0.70 | |
| Total coliform | Organic | 1.54 | 0.21 | 0.144 |
| | Conventional | 0.92 | 0.63 | |

**significant at p-value ≤ 0.05*

Table 5: Prevalence of *E. coli* and total coliform in organic and conventional vegetables

| Types of Samples | *E. coli* | | | Total Coliform | | |
|---|---|---|---|---|---|---|
| | Conv. | Organic | Total | Conv. | Organic | Total |
| | (np/nt) % | (np/nt) % | (np/nt) % | (np/nt) % | (np/nt) % | (np/nt) % |
| Spinach | (1/6) 16.7 | (2/6) 33.3 | (3/12) 25.0 | (0/6) 0 | (2/6) 33.3 | (2/12) 16.7 |
| Mustard | (0/6) 0 | (1/6) 16.7 | (1/12) 8.33 | (1/6) 16.7 | (1/6) 16.7 | (2/12) 16.7 |
| Kale | (2/6) 33.3 | (2/6) 33.3 | (4/12) 33.3 | (2/6) 33.3 | (1/6) 16.7 | (3/12) 25.0 |
| Total | (3/18) 16.7 | (5/18) 27.8 | (8/36) 22.2 | (3/18) 16.7 | (4/18) 22.2 | (7/36) 19.4 |

np, Total number of positive samples; nt, Total number of samples; %, Percentage of positive samples

conventional farm. Whereas, mustard from organic and conventional farms shared the same reading with 16.7% of the samples tested positive with total coliform. Besides, 33.3% of kale from conventional farms was positive with total coliform whereas 16.7% of kale from organic farm tested was positive with total coliform.

### *Relationship Between Microbial Counts in Different Types of Vegetables*

Mann-Whitney test was used to indicate the difference in the microbial count for organic and conventional vegetables from farms for *E. coli* and total coliform. Table 6 indicates the descriptive analysis for each type of microorganism with the different types of vegetables.

In this study, mean for *E. coli* count for spinach, mustard and kale from organic and conventional vegetables from farms were found to be significantly different with $p \leq 0.05$. Besides, the microbial count of total coliform for organic and conventional vegetables shows no significant difference ($p \geq 0.05$).

Total coliform and fecal coliform groups are referred to as indicator organism since their presence is used to indicate potential pathogenic microorganism in food and environment. These findings concur with the fact that organic vegetables pose a substantial risk of microbial contamination compared to conventional vegetables due to the use of manure-based fertilizers. The microbial contamination may come from various aspects starting from the use of the manure, water irrigation, usage of pesticides as well as the manual handling of the organic vegetables (Seow *et al.*, 2013).

### *Determination of Pesticides in Organic and Conventional Vegetables*

Deltamethrin is a parameter selected to analyse the content of pesticide residue among three types of vegetables: kale, mustard and spinach. Deltamethrin is a pesticide commonly used in agricultural, domestic and gardening applications (Li & Kannan, 2018). Table 7 shows the concentration of pesticide residues in the three different types of vegetable samples. Some of the pesticide residues in samples were below the detection limits whereas some of the

Table 6: Prevalence of *E. coli* and total coliform in organic and conventional vegetables

| Types of Samples | *E. coli* | | Total Coliform | |
|---|---|---|---|---|
| | Conventional | Organic | Conventional | Organic |
| Spinach | 1.38 ± 0.61 | 1.93 ± 0.98 | 0.00 ± 0.00 | 1.49 ± 0.85 |
| Mustard | 0.00 ± 0.00 | 1.59 ± 0.90 | 1.30 ± 0.00 | 1.38 ± 0.61 |
| Kale | 1.16 ± 0.28 | 4..41 ± 0.29 | 1.45 ± 0.21 | 1.75 ± 0.65 |

Results expressed as mean ± SD (log10 CFU/g).

samples, especially the conventional type, has exceeded the compliance limit. Conventional kale was the most frequently analysed with deltamethrin meanwhile both organic kale and organic spinach contain the lowest number of samples with deltamethrin residue. Each detected deltamethrin was confirmed by matching its retention time based on the standard method by López-López *et al.* (2001); Zawiyah (2007); Yuan (2014); and Yu (2017).

The prevalence of deltamethrin residue in both of organic and conventional vegetable samples is presented in Table 8.

Deltamethrin residue was detected in 15 vegetable samples. Conventional kale has been indicated as the highest prevalence with a total of five positive samples of deltamethrin residue (16.7%) followed by conventional mustard with 13.3%. Both organic mustard and conventional spinach shared the same percentage of positive sample which were 6.7%. Both organic kale and spinach has the lowest number of samples with a positive deltamethrin residue which was 3.3%.

***Comparison of Deltamethrin Concentration in Organic and Conventional Vegetables***

Table 9 shows the comparison of deltamethrin concentration between organic and conventional in each type of vegetables.

Based on the results, the concentration of deltamethrin in organic and conventional kale and organic and conventional spinach has significant difference. In organic farming, synthetic pesticides such as pyrethroids, pheromones and deltamethrin are only allowed to be used in insect traps and are not to be applied to soil or plants. However, deltamethrin was present in both organic and conventional vegetables but in significantly lower concentration in organic vegetables. It could be due to cross-contamination from non-organic agriculture, or as a result of pesticide persistence in the environment. As for the organic and conventional mustard, there was no significant difference in terms of deltamethrin residue.

Table 7: The concentration of deltamethrin detected in organic and conventional vegetable samples

| Type of Farming | Vegetable | Mean | Standard Deviation |
|---|---|---|---|
| Organic | Spinach | 0.16 | 0.003 |
| | Kale | 0.36 | 0.002 |
| | Mustard | 0.24 | 0.001 |
| Conventional | Spinach | 0.48 | 0.001 |
| | Kale | 0.37 | 0.003 |
| | Mustard | 0.22 | 0.001 |

Table 8: Number of vegetable samples with pesticide residue detected

| Type of Farming | Vegetable | No. of Samples with Residues (%) |
|---|---|---|
| Organic | Kale | 1(3.3) |
| | Mustard | 2(6.7) |
| | Spinach | 1(3.3) |
| Conventional | Kale | 5(16.7) |
| | Mustard | 4(13.3) |
| | Spinach | 2(6.7) |
| Total | | 15 |

Table 9: The comparison of deltamethrin concentration between organic and conventional vegetables

| Type of Farming | Vegetables Samples | Mean | Standard Deviation | *p*-Value |
|---|---|---|---|---|
| Organic | Kale | 0.36 | 0.002 | 0.040* |
| Conventional | | 0.37 | 0.003 | |
| Organic | Mustard | 0.24 | 0.001 | 0.058 |
| Conventional | | 0.22 | 0.001 | |
| Organic | Spinach | 0.16 | 0.003 | 0.033* |
| Conventional | | 0.48 | 0.001 | |

**significant at p-value ≤ 0.05*

### *Health Risk Assessment for the Consumption of Pesticides in Vegetables*

Table 10 shows the Hazard Index (HI) of organic and conventional farming of vegetables for three different types of vegetables.

The calculation of HI value for pesticide residues in all vegetables was less than one. HI below than one means the exposure population is unlikely to experience obvious adverse effects. The results showed that organic mustard and conventional spinach had a relatively higher HI than other kinds of vegetables but the value was still less than one. The results show that the HI value of organic vegetables for each kind of vegetable was lower than the conventional vegetables. These findings could mean that organic vegetables are safer to be consumed compared to conventional vegetables. The farmers may have mixed a number of pesticides during application to resolve the issue of insect resistance. High presence of pesticide residues could also be due to environmental contamination through water, soil and air (Curl *et al.*, 2003).

## Conclusion

Vegetables from two different types of farming (organic and conventional farming) were assessed in terms of heavy metals, microbiological and pesticide contamination. The Health Index (HI) values for organic and conventional vegetables (mustard, spinach and kale) were below one which indicate safe consumption. The microbial count of total coliform and *E. coli* were found slightly higher in organic vegetables compared to conventional vegetables. The study has provided a profile on food safety quality of organic and conventional vegetables in Malaysia as a reference point to further understand the different types of farming. This study implies that effective monitoring should be initiated to uphold the food safety quality of fresh produce sold in Malaysia irrespective of the type of farming.

Table 10: The hazard index of deltamethrin in organic and conventional vegetables

| Type of Farming | Vegetables | Hazard Index (HI) |
|---|---|---|
| Organic | Kale | 0.002 |
| | Mustard | 0.008 |
| | Spinach | 0.001 |
| Conventional | Kale | 0.007 |
| | Mustard | 0.002 |
| | Spinach | 0.008 |

Note: Acceptable Daily Intake (ADI) = 20, Estimated Daily Intake (EDI) = 0.389 mg $kg^{-1}$ bw $day^{-1}$ (Becking *et al.*, 2007)

The information gained in this study could contribute to formulation of requirements for pre-harvest and post-harvest practices to reduce the heavy metals, pesticides and microbiological contamination in vegetables.

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