Pesticide Residues in Local Vegetables in Sarawak is under Control: Trend analysis from 2000 to 2006

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ABSTRACT

From year 2000 to 2006, a total of 8,971 vegetable samples had been analyzed for pesticide residues. These samples were screened for organophosphorus (OP), organochlorine (OC), synthetic pyrethroid (PY), dithiocarbamate (EBDC) and carbamate (CA) pesticides using gas chromatograph (GC) and liquid chromatograph (LC). The analysis results shown that OP pesticides were frequently found exceeding the Maximum Residue Limit (MRL) with acephate, methamidofos and chlorpyrifos accounted for 46.5% of the total samples violation. Other pesticides OC, PY and EBDC were also commonly exceeding the MRL. Nevertheless, only about 4.9% of the samples were found to contain excessive residues.

INTRODUCTION

Commercial production of vegetables in Sarawak is estimated about 2,445 ha (Anon, 2006) with an annual production ranging between 30,000 to 50,000 metric tan per year. With more than 2.2 million populations, consumption of vegetables in Sarawak is only about 13.6 to 22.7 kg per capita per year. These indicate that there are avenues for increased in production and consumption of local vegetables (Chai, 2006). Most of these vegetables are supplied to major towns in Sarawak with a small percentage exported to the neighbouring country, Brunei.

Apart from some farmers who had adopted nethouse system for vegetable cultivation, most of the vegetables are still grown in open field. The open field cultivation system is a high risk method because it is liable to the vagaries of the environmental conditions. Therefore, in order to produce unblemished and marketable products, some vegetable farmers have resorted to using pesticides as fast and effective measures for controlling pests and diseases. The indiscriminate use of pesticides may lead to excessive residues in the harvested produces especially if farmers do not adhere to the postharvest intervals of the pesticides they used. Depending on the amount of the contaminated produces that we consumed, we may be exposed to both short and long terms health problems.

Realizing the important of safe food for consumers, particularly in Sarawak, monitoring of pesticide residues in vegetables was initiated by the Department of Agriculture Sarawak in 1987. For the first two years, all the preparatory steps were carried out here, while the determination steps were performed by the Pesticide Residues Laboratory of the Department of Agriculture, Kuala Lumpur. Subsequently, a Pesticide Residue Laboratory was set up in 1990 in the Agriculture Research

Centre Semongok, Department of Agriculture Sarawak, with an aid from the German Technical Service (GTZ) programme.

Currently, an average of 1,200 local vegetable samples was collected annually for pesticide residues analysis. Initially, only about 40 types of pesticides were being analyzed. However, the number has increased to 70 types as a result of continuous efforts in development and improvement of detection methods carried out by the Pesticide Residue Laboratory.

Over the years, the Department of Agriculture Sarawak has carried out various programmes to address pesticide residue problems in vegetables in Sarawak. These include training of vegetable farmers on safe use of pesticides, nethouse cultivation system, Vegetable Certification Scheme (VCS), Skim Amalan Ladang Baik Malaysia (SALM) and Skim Organik Malaysia (SOM). Therefore, the objectives of this paper are to provide brief information on sampling and analysis methods, and also the status of pesticide residues in local vegetables throughout Sarawak from year 2000 to 2006.

SAMPLING AND DETECTION METHODS

Vegetable samples were collected from major vegetable growing areas in Kuching, Samarahan, Sri Aman, Betong, Sibu, Sarikei, Bintulu, Miri and Limbang divisions. Collected samples were analyzed particularly for organophosphorus (OP), organochlorine (OC), synthetic pyrethroid (PY), carbamate (CA) and ethylene-bis dithiocarbamate (EBDC) pesticides.

OP, OC and PY Pesticides

Vegetable samples were chopped and sub-sampled to 50 g each. The analyses of OP, OC and PY pesticides were carried out using the Steinwandter method (1982).

For the analysis of the OP pesticides, individual sample was extracted with acetone and dichloromethane. Then, the raw extract was injected directly into the gas chromatograph (GC) equipped with flame photometric detector (FPD). The GC conditions were as follows: column temperature, 120 ºC to 270 ºC; detector temperature, 280 ºC; injector temperature, 260 ºC; column flow, 6.8 ml/min; air flow, 80 ml/min; hydrogen flow, 33 ml/min and auxiliary flow, 30 ml/min. HP5 mega bore column was used for screening while confirmation was carried out on HP1701 megabore column

For the determination of OC and PY pesticides, the clean-up was performed using the deactivated silica gel. Hexane and dichloromethane were used as eluent. The collected eluate was injected into the GC equipped with electron capture detector (ECD). The GC conditions were as follows: injector temperature, 260 ºC; detector temperature, 300 ºC; column temperature, 70 ºC to 270 ºC; column flow, 1 ml/min

and auxiliary flow, 30 ml/min. Screening was carried out on Ultra 1 capillary column while confirmation was done using Ultra 2 capillary column.

EBDC Pesticides

The EBDC pesticides analysis was carried out using McLeod and McCully headspace method (1969). Vegetable samples were chopped, sub-sampled to 10 g each and put in a 250 ml glass reaction bottle fitted with a Teflon seal screw cap. Forty milliliters of deionised water was added to the sample followed by 50 ml of 2 % tin chloride-hydrochloride acid solution.

For fruit vegetables, only 20 ml of distilled water was added since 30 g of sub-sample was used. The bottle was placed in a water bath that was set at 80 ºC and shaken for 2 minutes at 30 minutes intervals. Then, the sample was kept in an oven at 30 ºC to equilibrate. An aliquot of the headspace was taken and injected into the GC equipped with an electron capture detector (ECD). The column used was HP5 megabore column. The GC conditions were as follows: oven temperature, 60 ºC, detector temperature, 80 ºC, carrier flow, 1.2 ml/min and auxiliary flow, 30 ml/min.

CA Pesticides

For samples preparation and extraction, the method used was similar to that of OP pesticides. The co-extractives were removed using either deactivated florisil, prior to GC determination or gel permeation chromatograph (GPC) when liquid chromatograph (LC) was used.

For LC, sample was analyzed on C18 column with distilled water and methanol as mobile phases. Detection was performed using fluorescence detector with excitation at 330 nm and emission at 465 nm.

For GC, sample was analyzed on Ultra 1 column using nitrogen phosphorus detector (NPD). The GC conditions were; column temperature, 100 ºC to 270 ºC; detector temperature, 280 ºC; injector temperature, 260 ºC, column flow, 1.2 ml/min; air flow, 73 ml/min and hydrogen flow, 54 ml/min.

STATUS OF PESTICIDE RESIDUES IN LOCAL VEGETABLES

Sample Violation in Open System

A total of 6,552 vegetable samples were collected from the major vegetable growing areas in Kuching, Samarahan, Sri Aman/Betong, Sibu, Sarikei, Bintulu, Miri and Limbang/Lawas divisions for pesticide residues analyses from year 2000 to 2006. The number of samples collected from each division and their violation rates were as per *Table 1*. Of the 6,552 vegetable samples analyzed 5.6 % were found to contain pesticide residues exceeding the Maximum Residue Limit (MRL) as stipulated in Food Regulation 1985.

***Table 1*:** Total vegetable samples exceeding Maximum Residue Limit (MRL)

Year	Total Samples		With Residues		With Violation	
	Open	Netting	Open	Netting	Open	Netting
2000	682	367	138 (20.2%)	90 (24.5%)	25 (3.7%)	15 (4.1%)
2001	1043	447	263 (25.2%)	98 (21.9%)	52 (5.0%)	12 (2.7%)
2002	1248	296	447 (35.8%)	81 (27.4%)	41 (3.3%)	10 (3.4%)
2003	1095	445	258 (24.6%)	146 (32.8%)	38 (3.5%)	11 (2.5%)
2004	722	327	289 (40.0%)	88 (26.9%)	40 (5.6%)	10 (3.1%)
2005	739	404	185 (25.0%)	120 (29.7%)	94 (12.7%)	38 (9.4)
2006	1023	133	258 (25.2%)	22 (16.5%)	50 (4.9%)	7 (5.3%)
Total	**6552**	**2419**	**1838 (28.1%)**	**645 (26.7%)**	**367 (5.6%)**	**101 (4.2%)**

The violation rate over the 7-year period is about 3.3% to 5.6% from year 2000 to 2004. However, in 2005 the violation rate increased to 12.7%. This was most probably due to lack of knowledge and awareness among the farmers that several pesticides either have been withdrawn from the approved list or banned for used in vegetables since 2004 and 2005. However, due to hard work carried out by the extension staff and cooperation from farmers and relevant authorities, the violation rate was brought down to 4.9% in 2006.

Sample Violation in Nethouse System

Under the nethouse cultivation system, a total of 2,419 vegetable samples were collected from Kuching, Samarahan, Sri Aman, Betong, Sarikei, Sibu, Bintulu, Miri and Limbang divisions for pesticide residue analyses from year 2000 to 2006. Samples collected in 2005 recorded the highest violation rate with 9.4% of the sample found exceeding the MRL (*Table 1*).

The violation rate of vegetables cultivated under the nethouse system was found to be relatively lower compare to the open system. These results indicated that nethouse cultivation system may help in reducing the problem of excessive usage of pesticide in vegetable cultivation.

Type of Vegetables Exceeding the Maximum Residue Limit (MRL)

A total of thirty-six types of vegetables have been collected for pesticide residues analysis (*Table 2*)

***Table 2*:** Types of vegetables analyzed and exceeding MRL

Type of vegetables	Total sample analyzed	Total samples with residues	Total sample with violation
Angle loofah / Petola *(Luffa acutangula)*	396	35 (8.8%)	14 (3.5 %)
Chinese spinach / Bayam (*Amaranthus viridis)*	221	37 (16.7%)	13 (5.9 %)
Bitter gourd / Peria *(Momordica charantia)*	323	36 (11.1%)	5 (1.5 %)
Bottle gourd / Labu Air *(Lagenaria siceraria)*	144	25 (17.4%)	2 (1.4 %)
Brinjal / Terung *(Solanum melongena)*	423	168 (39.7%)	66 (15.6 %)
Cabbage / Kobis bulat *(Brassica oleeacea)*	7	0 (%)	0 (0%)
Cekur Manis *(Sauropus andogynus)*	75	7 (9.3%)	4 (5.3%)
Chai Sim / Sawi Hijau *(Brassica chinensis)*	1354	495 (36.6%)	56 (4.1%)
Chilli / Lada Merah *(Capsicum annum)*	281	164 (58.4%)	72 (25.6%)
Chinese celery / Sadri cina *(Apium graveolen)*	13	3 (23.1%)	2 (15.4%)
Chinese raddish / Lobak putih *(Raphanus sativus)*	18	3 (16.7%)	1 (5.6%)
Cucumber / Timun *(Cucumis sativus)*	575	87 (15.1%)	6 (1.0%)
Ensabi / Sawi Dayak *(Brassica sp)*	47	5 (10.6%)	2 (4.3%)
French Bean / Kacang Buncis *(Phaseolus vulgaris)*	264	72 (27.3%)	9 (3.4%)

Type of vegetables	Total sample analyzed	Total samples with residues	Total sample with violation
Kai Lan/ Chinese Kale *(Brassica alboglabra)*	201	78 (38.8%)	25 (12.4%)
Water spinach / Kang kong *(Ipomoeaa aquatica)*	256	57 (22.3%)	8 (3.1%)
Kho chai / Sawi Pahit *(Brassica juncea)*	614	185 (30.1%)	28 (4.6%)
Kiew Chai / Sawi Kerinting *(Brassica sp)*	711	264 (37.1%)	30 (4.2%)
Lady's finger / Okra / Bendi *(Hibiscus esculentus)*	485	72 (14.8%)	12 (2.5%)
Long bean / Kacang panjang *(Vigna unguiculata)*	896	190 (21.2%)	10 (10.6 %)
Pek Chai / Sawi putih *(Brassica sp)*	576	206 (35.8%)	14 (2.4%)
Lettuce / Salad *(Lactuca sativa)*	53	10 (18.9%)	4 (7.5%)
Siaw pai chai / Sawi Jepun *(Brassica chinensis)*	668	199 (29.8%)	24 (3.6%)
Terung dayak *(Solanum melongea)*	10	0 (%)	0 (0%)
Tomato *(Lycopersicum esculentum)*	62	12 (19.4%)	2 (3.2%)
Winged bean / Kacang botor *(Psophocarpus tetragonolobus)*	102	21 (20.6%)	3 (2.9%)
Yu chai sim / Sawi hybrid *(Brassica chinensis)*	154	42 (27.3%)	4 (4.6%)
Others*	42	4 (9.5%)	1 (4.8%)
Total	**8971**	**2477 (27.6%)**	**443 (4.9%)**

**Others: sweet potato, sweet pea, carrot, baby corn, pumpkin, box thorn, wax gourd, capsicum*

Leafy Vegetables

Among the vegetables analysed, Chinese celery recorded the highest violation rate with 15.4% of the samples found to contravene the Food Act 1983. However, the number of samples collected and analyzed was rather relatively small (*Table 2*). This was followed by kailan (12.4%), lettuce (7.5%), bayam (5.9%) and cekur manis (5.3%). The sample violation rates for sawi pahit, sawi dayak, sawi kerinting and sawi hijau were 4.6%, 4.3%, 4.2% and 4.1%, respectively.

Other vegetables found to contain pesticide residues exceeding the MRL were sawi jepun (3.6%) and kangkong (3.1%). The violation rates of sawi hybrid and sawi putih were 2.6% and 2.4%, respectively. Cabbage was found to be free from pesticide contamination.

Non-Leafy Vegetables

Twenty-five percent of the chilli samples were found to contain excessive pesticide residues, followed by brinjal (15.6%), Chinese raddish (5.6%) and long bean (4.0%). Angle loofah, French bean, tomato, winged bean and lady's finger recorded violation rates between 2.5% and 3.5%.

Lower violation rates of 1.5%, 1.4% and 1.0% were recorded in bitter gourd, bottle gourd and cucumber, respectively. None of the collected terung dayak samples were found to contain pesticide residue.

Pesticides Exceeding the Maximum Residue Limit (MRL)

Organophosphorus (OP) Pesticides

Among the pesticides detected, the occurrence of OP pesticides was most frequent. They accounted for about 70.0% of the total samples violation. A total of twelve types of OP pesticides were found exceeding the MRL (*Table 3*).

Of these, acephate was the most frequently detected and accounted for about 16.7% of the total sample violation. Despite the fact that acephate can only be used for coconut and oil palm since April 2004, most of the samples found to contain acephate were collected in 2005. The level of acephate residues were ranging from 0.30 mg/kg to 19.70 mg/kg.

Even though methamidofos has been withdrawn for use on vegetables since 2000, and has been listed under pesticide regulations as Dangerous pesticide since July 2004, it is still frequently being detected and approximately 15.4% of the violated samples contained its residue with concentration ranging from 0.70 mg/kg to 13.20 mg/kg.

Table 3**:** OP pesticides found exceeding the MRL

Type of Pesticides	*Total samples with violation*	*Residue range (mg/kg)*	*MRL (mg/kg)*
Acephate	91	0.30 – 19.70	1.0 (L,NL), 3.0 (Leg)
Azinfos-ethyl	2	1.50 – 2.10	0.01 (L,NL)
Chlorpyrifos	78	0.01 – 20.10	1.0(L), 0.5(NL)
Dichlorvos	4	0.60 – 0.80	0.50 (L,NL)
Dimethoate	33	1.03 – 7.00	1.0 (Leg), 2.0 (L,NL)
Methamidofos	84	0.70 – 13.20	0.1 (L), 0.5 (NL)
Monocrotofos	1	0.20	0.01 (L)
Phenthoate	39	0.10 – 1.50	0.1(NL,L)
Profenofos	2	0.10 – 1.80	0.50 (L, NL)
Prothiofos	7	0.40 – 3.40	0.20 (L,NL)
Quinalfos	23	0.05 – 2.62	0.10 (L,NL)
Tolcofos-methyl	1	0.30	0.01 (L,NL)
Triazofos	17	0.03 – 5.90	0.20 (L,NL)
Total	**382**		

L: Leafy vegetable; NL: Non-leafy vegetable; Leg: Leguminous vegetable

The usage of profenofos, prothiofos, phenthoate, triazofos and quinalfos on vegetables was withdrawn since January 2005 and yet still a number of them were detected and exceeded the MRL. It was of great concern to note that azinfos-ethyl and monocrotofos were used by vegetable farmers in spite the fact that both pesticides were not recommended for use on vegetables.

Other pesticides commonly exceeded the MRL were chlorpyrifos (14.3%) and dimethoate (6.1%) with residues ranging between 0.01 mg/kg and 20.10 mg/kg.

Organochlorine (OC) Pesticides

OC pesticides accounted for 15.3% of the total samples violation (*Table 4*). Among the OC pesticides, only endosulfan residue was detected and found exceeding the MRL. The concentration of endosulfan residue was recorded between 0.01 mg/kg and 3.60 mg/kg. Approximately 72% were detected in the monitoring work carried out in 2005. The usage of endosulfan on vegetables has been banned since 15 August 2005.

Synthetic Pyrethroid (PY) and EBDC Pesticides

Synthetic pyrethroids which were widely used by vegetable farmers accounted for 11.6% of the total samples violated. This was due to their shorter pre-harvest intervals of 3 – 5 days and thus, likely to degrade within a short period of time. The most frequently detected PY pesticide was cypermethrin with residue ranging from 0.20 mg/kg to 3.60 mg/kg. This was followed by cyfluthrin and lamda cyhalothrin with concentrations ranging between 0.01 mg/kg and 0.30 mg/kg. Other occasionally detected PY pesticides were deltamethrin and permethrin with residual levels of 0.01 mg/kg to 1.40 mg/kg.

The dithiocarbamates fungicides accounted for 2.9% of the total samples violation in vegetables. High fungicide residues were detected with level ranging from 7.10 mg/kg to 40.60 mg/kg. These levels were far exceeded the MRL of 3.0 mg/kg and 5.0 mg/kg for non-leafy and leafy vegetables, respectively. This could be due to misuse of the fungicides by the farmers and inadequate knowledge on the chemicals.

***Table 4*:** OC and PY pesticides found exceeding the MRL

Type of Pesticides	***Total samples with violation***	***Residue range (mg/kg)***	***MRL (mg/kg)***
	Organochlorine (OC)		
Endosulfan	83	0.01 – 3.60	2.0 (L,NL)
	Synthetic Pyrethroid (PY)		
Cyfluthrin	14	0.01 – 0.30	0.01 (L,NL), 0.5 (Leg)
Cypermethrin	19	0.20 – 3.60	2.0(L), 0.5(NL), 0.20 (Brinjal)
Deltamethrin	8	0.02 – 1.40	0.20 (NL), 0.1(Leg), 0.50 (L)
Lamda cyhalothrin	17	0.02 – 0.30	0.01(NL,L), 0.1(Leg)
Permethrin	5	0.01 – 0.06	5.0 (L)
Total	**63**		
	Ethylene-bisdithiocarbamate (EBDC)		
Dithio-carbamate	16	7.10 – 40.60	5.0 (L), 3.0 (NL)

L: Leafy vegetable NL: Non leafy vegetable Leg: Leguminous vegetable

CONCLUSION

The occurrence of high residues in vegetables was due to injudicious use of pesticides by farmers. The analyses results showed that OP pesticides were frequently found exceeding the MRL with acephate, methamidofos and chlorpyrifos accounted for 69% of the total samples violation. Endosulfan was the only pesticide of OC group that was found to contravene the Food Act 1983, which has been banned for use in vegetables since 2005. Besides OP and OC, PY and carbamate pesticides were also commonly found exceeding the MRL.

Various measures and schemes are currently being pursued by the Malaysian Government such as Skim Amalan Ladang Baik Malaysia (SALM) and Skim Organik Malaysia (SOM) for the production of pesticide-safe vegetables. In Sarawak, we have vegetable certification scheme and nethouse cultivation system in place. Adoption of these schemes by the vegetable farmers should be encouraged coupled with continuous monitoring by the relevant agencies in order to alleviate the problem of vegetables exceeding the MRL being sold to the consumers.

Based on the collected and compiled data, it may be concluded that the current situation of pesticide residues in vegetables in Sarawak is still under control. The Department of Agriculture Sarawak will continue to monitor the level of pesticide residues in vegetables to ensure that vegetables in the markets are safe for consumption. In addition, there is a need for a changed in attitude of the vegetable farmers to follow all the necessary rules and regulations with regards to the usage of pesticides on vegetables.

ACKNOWLEDGEMENT

The authors wish to acknowledge the hard work of the staff of Pesticide Residue Laboratory, Semongok and Acting Senior Assistant Director (Research) for his permission to present this paper.

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