Evaluation of factors affecting pesticide residue levels in Japanese raw agricultural commodities#

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To evaluate the various factors affecting pesticide residue levels in Japanese raw agricultural commodities (RACs), acetamiprid and cypermethrin residues in apple, broccoli, cabbage, grape, and sweet pepper samples were investigated. The individual variations of pesticide residue levels in apples were greater than other factors, such as field-to-field variations and separate analyses of edible and inedible portions. The results from various RACs indicate that differences in the distributions of the two pesticides might be due to the influence of various factors, such as differences in crop species, plant cultivation methods, and physico-chemical properties of the pesticides. The statistical results indicate that a sufficient sampling size is required to obtain accurate analytical results. This study provided valuable information on estimating variations in pesticide residue levels in RACs in accordance with Japanese common agricultural practices. © Pesticide Science Society of Japan

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Introduction

Field-to-field variations in pesticide residue levels in RACs are widely recognized and are known to be due to various parameters, such as geographical location, weather conditions, growing season, and growth rates. According to the Organization for Economic Co-operation and Development (OECD) guidelines for crop field trials, a minimum of eight field trials is required for data generation on any crop grown in an OECD country. Recently, the Japanese test guideline for the pesticide residue trial for major and semi-major crops was revised to increase the numbers of test fields from the previous regulation of more than two test fields. However, limited data are available on field-to-field variations in pesticide residue levels under Japanese common agricultural practices.

International harmonization of sample processing for pesticide residue analysis is one of the most important tasks for international trade and effective utilization of residue data. Codex maximum residue limits (MRLs) are typically stated in terms of a specific, whole, raw agricultural commodity as it moves through international trade. Japanese test guidelines for pesticide residue trials were recently refined to recommend separate analyses of edible and inedible portions of fruits, such as apples. This modification based on the international method allows the calculation of residue levels in whole fruit based on levels in the edible and inedible portions. However, little data are available regarding Japanese common agricultural procedures.

In a commodity previously treated with a pesticide, the level of pesticide residue remaining on or in a single unit varies depending on many factors. These variations should be taken into consideration when acute dietary exposure of consumers to pesticides is evaluated for risk assessment. Many reports on the variability of pesticide residue levels in agricultural commodities were aimed at predicting the acute reference dose for human health. Those reports provided information on individual pesticide residue variations for an index in the variability factor (VF), which is calculated as the 97.5th percentile of the residue population divided by the average residue levels in the lot. Agriculture in Japan yields good crops even in small farms because of the favorable climate and efficient, mechanized agricultural procedures. However, little information is available on some of the local agricultural practices based on geographical conditions.

On the basis of the above-mentioned requirements, acetamiprid and cypermethrin residues in apple, broccoli, cabbage, grape, and sweet pepper samples were investigated to consider the factors affecting pesticide residue levels in Japanese RACs. The two pesticides that were investigated differ significantly in their respective physiochemical properties, and were chosen to facilitate an accurate determination of the variations in the indi-
vidual pesticide residues. These investigations provided valuable information on the estimation of variations in pesticide residue levels in RACs in accordance with Japanese common agricultural practices.

1. Factors affecting cypermethrin residue levels in apples from Japanese orchards

Cypermethrin residues in apples were evaluated to consider the variation factors based on sample-to-sample portions, field-to-field portions, and edible-to-inedible portions. The VF values obtained from the 97.5th percentile and the mean pesticide residue levels of 130 individual apple samples were 1.76 and 1.75, respectively, and the highest residue level was approximately 10 times higher than the lowest level. The results suggest that in order to obtain reliable values of pesticide residue levels, a sufficient number of samples are essential. Regarding field-to-field variability, the highest mean residue level from eight orchards was approximately 2.3 times higher than the lowest level. The pesticide residue level determined for an entire fruit was slightly higher than that for the edible portions, and there was no significant statistical difference between the two. The results of this study suggest that individual variations of pesticide residue levels in apples were greater than other variation factors, such as field-to-field portions and edible-to-inedible portions.

2. Comparison of the variability in levels of pesticide residue observed in units of Japanese cabbage and grape samples

To estimate variations in pesticide residue levels in crops, the VF values in residue levels of acetamiprid and cypermethrin applied to cabbage and grape samples were investigated. The VFs in the residue levels of acetamiprid and cypermethrin in cabbage samples (2.00 and 2.39, respectively) were clearly higher than those in grapes (1.82 and 1.63, respectively). Although the residue levels of both pesticides in grapes showed a normal distribution, values in cabbage samples were slightly skewed at lower residue levels. Individual residue levels in grapes had good agreement between acetamiprid and cypermethrin. In contrast, the distribution of cypermethrin residue levels in cabbage samples was slightly skewed at higher residue levels compared to that of acetamiprid. These results indicate that differences in the relative distributions of the two pesticides between cabbage samples and grapes might be due to the influence of various factors, such as differences in crop species, plant cultivation methods, and physicochemical properties of the pesticides.

3. Effect of sampling size on the determination of accurate pesticide residue levels in Japanese agricultural commodities

The uncertainty in pesticide residue levels (UPRL) associated with sampling size was estimated using individual acetamiprid and cypermethrin residue data from preharvested apple, broccoli, cabbage, grape, and sweet pepper samples. The relative standard deviation from the mean of each sampling size ($n=2^x$, where $x=1-6$) of randomly selected samples was defined as the UPRL for each sampling size. The estimated UPRLs, which were calculated on the basis of the regulatory sampling size recommended by the OECD Guidelines on Crop Field Trials (weights from 1 to 5 kg and commodity unit numbers from 12 to 24), ranged from 2.1% for cypermethrin in sweet peppers to 14.6% for cypermethrin in cabbage samples. The percentages of commodities exceeding the MRLs specified by the Japanese Food Sanitation Law may be predicted from the equation derived from this study, which was based on samples of various size ranges with mean residue levels below the MRL. The estimated UPRLs have confirmed that sufficient sampling weights and numbers are required for analysis and/or reexamination of sub-samples to provide accurate values of pesticide residue levels for the enforcement of MRLs. The equation derived from the present study would aid in the estimation of more accurate residue levels even from small sampling sizes.

4. Effect of seed weight on estimation of pesticide residue levels in stone fruits

Flesh and seed weights of stone fruits, such as cherries, sumomo (Japanese apricots), sumomo (Japanese plums), nectarines, and peaches were investigated for determining calculations of pesticide residue levels using both the Japanese and international definitions regarding portions for analysis. The calculated correction factors ranged from 0.88 for sumomo to 0.96 for sumomo. Small fruit commodities, such as cherries and sumomo, are affected more by calculation procedures based on whole commodity conversions. These results indicate that calculated pesticide residue levels in whole commodities (international standard) are slightly lower than the actual concentrations without seeds (current Japanese regulations).

Conclusion

The first study suggests that individual variations of pesticide residue levels in apples were greater than other variation factors based on field-to-field portions and edible-to-inedible portions. The second study demonstrated that the distribution patterns of the residue levels of two pesticides in cabbage and grape samples were influenced by complex factors, such as differences in crop species, plant cultivation methods, application rates, preharvest intervals, and physicochemical properties of the pesticides. The results of the third study indicate that in a statistical analysis, a sufficient sampling size is required to obtain accurate analytical results. The results of the fourth study indicate that calculated pesticide residue levels in stone fruits made on a whole commodity basis are slightly lower than the actual concentrations without seeds; however, there is no significant difference between the two calculation methods. These studies provided valuable information on estimating variations in pesticide residue levels in RACs in accordance with Japanese common agricultural practices.