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OPTIMUM USE OF AVAILABLE RESIDUE DATA IN THE ESTIMATION OF DIETARY INTAKE OF PESTICIDES

(Technical Report)

Prepared for publication by

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Pesticides report 39. Optimum use of available residue data in the estimation of dietary intake of pesticides (Technical Report)

Synopsis: Prediction of pesticide residue intake in human diets is vital for approving the use of pesticides and for gaining official acceptance of pesticide residue levels which occur in food commodities in international trade.

Estimates for pesticide residue levels likely to be present in food as consumed are derived from supervised pesticide residue trials, residue monitoring, pesticide metabolism and food processing studies. The results of properly conducted total diet studies should generally displace other estimates, but they do not cover all pesticides and, in particular, are not available for a pesticide at its initial registration.

Information was compiled on the range of residues occurring in a set of supervised residue trials with identical application rate, number of applications and pre-harvest interval, but at different sites with various crop varieties, operators, equipment and cultural practices. Where there were 8 or more trials in a set (one data point per trial) the median residue was commonly 20-40% of the maximum and 80-100% of the mean. The median was generally a good measure of the modal or most commonly occurring value.

The median residue in the edible portion of the commodity in the supervised trials (supervised trials median residue, STMR) was chosen as the starting point for chronic dietary intake estimation.

The residue definition for dietary intake purposes should include metabolites and degradates of toxicological concern.

Dietary intake for acute effects is best related to residue levels in a single serving of a food, or at least the average residue level in servings of the food over a day or so. The maximum residue occurring in the edible portion is the preferred starting point for intake estimates for potential acute effects.

Residue levels in prepared food are often much reduced when the raw commodity is subject to trimming, washing, cooking, milling and refining. Food preparation and processing studies provide the basic information on the reduced or increased levels of residues in passing from the raw agricultural commodity to a processed commodity. The mean or median processing factors for residues in processing studies are combined with the STMR to provide the STMR-P (supervised trials median residue - prepared and processed food).

Examples of data evaluation for captan and parathion-methyl are included in the paper.

Residue monitoring data for 17 common pesticides on raw agricultural commodities were assembled in terms of incidence of residue detection. Within certain criteria the incidence of residue detection can be taken as a measure of percentage of crop treated.

The majority of cases showed less than 1% incidence of pesticide residues (median value 0.5%). The incidence of residue detection exceeded 10% in 25 cases of the 208 pesticide/commodity combinations examined.

A worked example for dithiocarbamates on apples demonstrates how information from supervised trials, processing studies and residue incidence are combined.

Eighteen recommendations are provided for estimating the level of pesticide residues likely to be present in food as consumed.

A worked example for dithiocarbamates on apples demonstrates how information from supervised trials, processing studies and residue incidence are combined.

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RECOMMENDATIONS

The IUPAC Commission on Agrochemicals and the Environment makes the following recommendations.

General. The focus of the paper is on estimating the level of residues likely to be in food as consumed

1. *Dietary intake estimations should make the best use of all available data. This is preferred to a tiered approach because it is more economical to evaluate all information at the time of the review than to revisit it later. Also, a tiered approach may give the impression of "manipulating the estimates until a desired result is achieved".*

2. *Data from supervised residue trials should be used as the starting point for evaluating residues in food for consumption. Previous approaches have used the MRL as the starting point, but the MRL is a maximum residue estimated from supervised residue trials while these actual trials data provide basic detail for an improved estimation of probable residue levels.*

Residue definition and portion of commodity

3. *The residue definition for dietary intake purposes should include metabolites and degradates of toxicological concern. The dietary intake residue definition will not necessarily agree with the residue definition used for MRL enforcement.*

4. *The edible portion of commodity or the portion processed for consumption is relevant for dietary intake estimates, while the portion of commodity for MRL enforcement is usually the commodity of trade but with some prescribed sample preparation procedures.*

Data available prior to registration for assessment of chronic intake

5. *Estimate the median residues in the edible portion from supervised trials, taking one residue value per trial. That residue value will be the highest value in each trial where the pesticide use and timing have been within existing or proposed Good Agricultural Practices.*

6. *Estimate the median residue for dietary intake purposes to be at the LOQ when the median residue in the supervised trials is less than the LOQ except when evidence suggests residues are essentially zero.*

7. *Estimate the mean processing factors (or median processing factors when residues below the LOQ in the processed food predominate) for residues in processing studies.*

8. *Apply the derived processing factors to the median residues from the supervised trials.*

9. *Processing (reduction or concentration) factors do not apply where toxic degradation products are generated during processing. Assess the conversion yields according to the processing conditions.*

Data available prior to registration for assessment of acute intake

10. *Estimate, from supervised trials, the maximum residue in food as consumed likely to result where the pesticide use and timing have been within existing or proposed Good Agricultural Practices.*
11. *For commodities with an inedible portion, eg. bananas, estimate the maximum residue likely in the edible portion only.*
12. *For pesticides where acute intake concerns merit closer attention and where residues occur in commodities consumed as meal-sized individual pieces of fruit and vegetables, supervised trials residue data will be needed on individual pieces as well as on composite representative samples.*
13. *For commodities consumed as individual pieces of fruit or vegetables estimate the maximum residue level on samples equivalent to meal sized portions rather than on large composite representative samples.*
14. *For commodities that are always cleaned or processed in some way before consumption, estimate the maximum residue in food prepared for consumption from raw agricultural commodity which theoretically contains residues equivalent to the maximum residue resulting from use and timing within existing or proposed Good Agricultural Practices.*

Data available after registration: total diet and residue monitoring studies

15. *Use market basket or total diet studies to provide the best estimates for chronic dietary intake of pesticide residues. The results of such studies should generally displace other estimates.*
16. *Use the results of monitoring studies to provide information on incidence of pesticide residue occurrence in raw agricultural commodities which, for many pesticide uses, may be taken as an estimate of % crop treated..*
17. *Use the results of monitoring studies to assist pesticide priority setting when market basket or total diet studies are planned.*
18. *Reports of monitoring studies should include a set of supporting information and the data should be reported in a standard format which will allow data combination from different studies and comparisons from one year to another.*

CONTENTS

1. INTRODUCTION

A vital issue for national and international acceptance of maximum residue limits (MRLs) for pesticides in food commodities is prediction of dietary residue intake and risk assessment.

TMDI calculations are being used to question the suitability of proposed MRLs. However, TMDIs vastly over-estimate chronic intake of pesticide residues.

> *The TMDI is a prediction of the maximum daily intake of a pesticide residue, based on the assumptions of MRL levels of residues in food and average daily food consumption per person. The TMDI is expressed in milligrams of residue per person.*[1]

Theoretical maximum daily intake (TMDI)[1]

The TMDI is an estimate of dietary intake calculated using the MRL and the average daily per capita consumption of each food commodity for which an MRL has been established. The TMDI is calculated by multiplying the MRL by the average food consumption for each commodity and then summing the products:

$$\text{TMDI} = \sum F_i \times M_i$$

where

F_i = the average food consumption for the relevant commodity, as derived from the hypothetical diet in kg of food per person per day; and

M_i = the MRL for the relevant commodity in mg of pesticide per kg of food.

The use of the MRL as a starting point for intake estimation has the potential to distort the MRL estimation process. An MRL is estimated from supervised trial data and is the maximum residue which should result when the pesticide is used according to Good Agricultural Practices. There is a temptation to rationalise data by disregarding some residue values because they are "outliers" so that a lower MRL can be established. The lower MRL then produces a lower calculated TMDI.

The MRL should not be used for purposes other than as a standard for the maximum residue which relates to approved uses. It should not be used as an indicator of typical, likely or average residues to be found in food.

Bates and Gorbach[2] reviewed the estimation of consumer exposure to pesticide residues in the diet and the assessment of risks. They described options of increasing complexity and recommended that dietary intake of residues should be calculated by a 'best estimate' rather than TMDI approach, using knowledge of pesticide use patterns, residue data from supervised trials and food consumption patterns. These 'best estimate' values were lower than the Codex ADIs by factors of greater than 100 for all but a few of 120 pesticides.

Ladomery[3] similarly showed that TMDIs grossly overestimate exposure and proposed that, where needed, intake estimates should be adjusted for residue occurrence in food and residue disappearance using factors derived from US-FDA monitoring and total diet study data sets (Frawley and Duggan, 1978)[4].

Tomerlin and Engler[5] showed that the anticipated residues in food commodities may differ from the tolerance (equivalent to the MRL) for numerous reasons. They suggested that an average residue level based on field data could be developed in estimating the anticipated residues from field trial data. Also, they discussed the use of processing data, cooking data, anticipated residues from usage data and monitoring data. The distinction was drawn between actual exposure to any pesticide and the estimation of that exposure. The assumptions, data and calculations produce an estimate of exposure; changes in the assumptions, data and calculations do not change the actual exposure.

Winter[6] has carried out an in-depth review of the process of dietary risk assessment based on three elements - estimation of residue levels, estimation of food consumption patterns and characterisation of risk. He showed that residue intakes based on TMDIs lead to grossly over-estimated risks and he recommended that average residue levels from trials, pesticide use patterns, monitoring results and post-harvest effects all need to be considered in deriving more accurate estimates of residue levels in food.

The factors and errors in estimating pesticide residue dietary intake were considered in detail by the Committee on Pesticides in the Diets of Infants and Children[7] A substantial volume of residue surveillance data was available from the US FDA (Food and Drug Administration of the USA). This could be used to indicate percentage of commodity with detectable residues and to calculate a distribution of probabilities that a given residue would be present. Similarly, a detailed analysis was made of food consumption patterns, particularly those of children and infants, so the probability of an individual having a given diet could be decided. Many of the residue data were generated for compliance purposes, with the sampling biased to find potential violations, with a consequent shift in the residue distributions to higher levels.

A Joint FAO/WHO Consultation[8] was convened in 1995 to provide recommendations for revising the WHO guidelines for predicting dietary intake of pesticide residues. An early draft of this paper was available to the Consultation as background information. The Consultation recommended the use of median rather than maximum residues from supervised trials for chronic intake estimation. Estimates of acute intake would rely on maximum residues from supervised trials and large portion sizes. Separate residue definitions may be needed for some pesticides for dietary intake and enforcement purposes.

Market basket or total diet studies can provide the best estimate of pesticide residues in diets. The results of properly conducted market basket and total diet studies, where available, should generally displace other dietary intake estimates, but they do not cover all pesticides. Dietary intake estimates based on supervised trials data, processing studies and food commodity residue monitoring should be supplementary to the estimates from market basket and total diet studies. Of course, for a chemical at its initial registration there will be no market basket or total diet studies, but for a chemical at re-registration or under periodic review the results of these studies provide data on actual dietary intake.

The Global Environment Monitoring System (GEMS, sponsored by UNEP, FAO and WHO) compiles food contamination monitoring data from different countries for world-wide presentation, synthesis and evaluation. Pesticide residues are included in the GEMS program[9].

This paper will focus on improving estimates for residue levels likely to be present in food as consumed. Available information from supervised trials, residue monitoring, metabolism and processing will be used to improve intake estimates. The complexities of deciding which diets to use in intake estimation will not be discussed.

The paper will include a set of recommendations on the general approach, residue definition, use of supervised residue trial data and use of residue monitoring data.

1.1 General approach

In the absence of suitable total diet or market-basket survey data, for example in the evaluation of a new pesticide, estimates for dietary intake must be based on residue data from supervised field trials and processing studies. For older compounds, where data from random monitoring exist, improved estimates of frequency of use can be made to refine the estimates.

Two types of risks from intake of a particular pesticide are considered: acute risk, which requires an estimate of the highest probable residues in food consumed at one serving and chronic risk, which considers the overall average exposure to residues in a diet over an extended period.

The distribution of residue data in supervised trials will be examined. The starting point for estimation of acute dietary intake will be the MRL or maximum residue in the edible portion of a commodity. The starting point for chronic dietary intake estimation will be the supervised trials median residue (STMR).

Studies on processing and food preparation will be used, in conjunction with the STMR, to estimate a supervised trials median residue (processed) (STMR-P) for some foods.

Food commodity residue monitoring data will be examined for some commonly used and monitored pesticides with the intention of estimating the incidence of residues, or percentage of crop treated to estimate chronic dietary intake of pesticide residues.

The STMR for food commodities, the STMR-P and the percentage of crop treated will then be available for use with dietary information to estimate pesticide residue dietary intake.

2. SUPERVISED RESIDUE TRIALS

A basic pre-requisite for official approval or registration of pesticide uses is the availability of reliable data on pesticide residues in food, feed and the environment. Maximum residue limits (MRLs) are established from supervised trials residue data with the objective of specifying a residue limit which should not be exceeded in practice when the approved application conditions are followed.

Copious data have been produced in supervised residue trials; the data provide the support for setting national MRLs. FAO[10] has published guidelines for pesticide residue trials. The Joint FAO/WHO Meeting on Pesticide Residues (JMPR) evaluates such data and makes recommendations to the Codex Committee on Pesticide Residues (CCPR) for establishment of international MRLs. The extensive data sets from supervised trials represent a resource for establishing most likely as well as maximum residue levels on food commodities resulting from treated crops and animals.

The most likely and maximum residues in food prepared for consumption are needed for estimating chronic intake and acute intake of residues respectively. This section will discuss the distribution of residue data and the methodology available for deriving residue values to be used in intake estimations.

2.1 Supervised residue trials - distribution of data

The median or mean residues for each set of trials more closely represent the typical residues likely to occur if the directions for maximum application and the specified pre-harvest interval (PHI) were followed. The median or mean are better starting points for dietary intake estimation than the maximum residue from the supervised trials or the MRL because median or mean represent the likely residue to occur if the pesticide is used according to the maximum label conditions.

Evaluation of supervised trials data for intake estimation will then be different in some respects from data evaluation for MRL estimation.

When a set of supervised trials for a pesticide on a particular crop truly represents the range of weather conditions, application equipment and techniques, seasons, crop varieties and cultural practices likely to be encountered commercially, then a considerable spread in the resulting residues is expected.

Some information is available on the range of residues occurring in a set of trials carried out with identical application rate, number of applications and pre-harvest interval, but at different sites with various crop varieties, operators, equipment and cultural practices. Trial data were compiled from the summaries published in JMPR Residue Evaluations. Data sets were chosen where there were 8 or more trials with identical application rate, number of applications and PHI. Trial data from aerial application were not included in the set even if the directions for application and the PHI were identical to those for ground application trials.

In Table 1 the data spread is summarised, with one set of trials to a line, according to the minimum, mean, median and maximum residue. Data in Table 1 were selected from trials covering 22 crops and 10 pesticides according to these criteria: one data point from each trial; data obtained only at the stated conditions; if data from replicate plots were available, the highest of the replicates was taken.

The relation between the medians and means in Table 1 was examined by observing the spread of "median ÷ mean" (Fig. 1). The range of "median ÷ mean" was 0.19-1.27. The distribution of values was a little asymmetrical with a tail towards the lower values. The modal value for "median ÷ mean" was in the 0.91-1.00 range, with the median value at 0.82 and the mean value at 0.80.

Cases where the median was less than half of the mean were examined in more detail. These residue distributions tended to have many values at the lower levels or were bimodal.

Residue distributions commonly show positive skewness, ie. the tail of the distribution is towards the higher values and the modal value is towards the lower end of the distribution. In a positively skewed distribution the mean value exceeds the median. In the 102 supervised trial residue data distributions the mean exceeded the median in 79 cases, while the median exceeded the mean in 14 cases.

Choice of mean or median in the estimation of dietary intake would give very similar results, but median is preferred because it avoids part of the calculation problem when some residue data are less than the LOQ[11] (limit of quantitation), and it is less influenced by the values at the extreme ends of the residue range. The median should generally be closer to the modal value (most commonly occurring value) for simple population distributions.

0.19
0.25 0.25 0.25 0.29 <.29
0.32 0.33 0.36
<.40 0.41 0.48
0.54 0.57 0.58 0.59
0.60 0.63 0.63 0.63 0.64 0.66 0.67 0.67 0.68 0.68 0.69 0.69
0.70 0.71 0.71 0.71 0.72 0.73 0.73 0.74 0.75 0.75 0.76 0.77 0.77 0.77 0.78 0.78 0.79 0.79 0.79
0.80 0.81 0.81 0.81 0.83 0.83 0.83 0.84 0.86 0.86 0.88 0.88 0.89
0.90 0.91 0.91 0.92 0.92 0.93 0.93 0.93 0.93 0.94 0.94 0.95 0.95 0.95 0.95 0.96 0.96 0.96 0.97
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.01 1.02 1.04 1.05 1.05 1.07 1.09 1.10
1.13 1.15 1.16 1.17 1.18
1.27

Fig. 1. Rank-order histogram of values for "median ÷ mean" from Table 1. The median value for "median ÷ mean" is underlined. (Histogram ranges are: 0.10-0.19; 0.20-0.29; 0.30-0.39; 0.40-0.49; 0.50-0.59; 0.60-0.69; 0.70-0.79; 0.80-0.89; 0.90-0.99; 1.00-1.09; 1.10-1.19; 1.20-1.29).

The relation between medians and maxima in Table 1 is summarised in Fig. 2. "Median ÷ maximum" ranged from 0.03 to 0.92, with the majority of values spread broadly from 0.1 to 0.7. The median value for "median ÷ maximum" was 0.32.

0.03 0.03 0.04 0.04 0.05 <.05 0.06 <.08 0.09
0.11 0.12 0.13 0.13 0.13 0.14 0.15 0.17 0.17 0.18 0.19 0.19
0.20 0.20 0.20 0.20 0.21 0.21 0.22 0.22 <.22 0.23 0.23 0.24 0.25 0.25 0.25 <.25 0.26 0.26 0.26 0.27 0.27 0.28 0.28 0.28 0.28 0.28 0.28 0.28
0.30 0.32 0.32 0.33 0.33 0.33 0.33 0.34 0.34 0.35 0.35 0.37 0.39 0.39
0.42 0.43 0.43 0.44 0.44 0.45 0.47
0.50 0.50 0.50 0.50 0.50 0.52 0.53 0.55 0.55 0.56 0.56 0.56 0.56 0.58 0.59
0.60 0.61 0.61 0.62 0.64 0.64 0.65 0.66 0.67 0.68 0.69
0.70 0.72 0.72 0.78 0.78
0.92

Fig. 2. Rank-order histogram of values for "median ÷ maximum" from Table 1. The median value for "median ÷ maximum" is underlined. (Histogram ranges are: 0-0.09; 0.10-0.19; 0.20-0.29; 0.30-0.39; 0.40-0.49; 0.50-0.59; 0.60-0.69; 0.70-0.79; 0.80-0.89; 0.90-0.99).

Maximum residues (maximum residue in each trial) obtained from a set of trials with identical application conditions and PHI often cover a wide range of values. The distribution of "lowest maximum ÷ highest maximum" is summarised in Fig. 3 (the lowest maximum, recorded in Table 1 as "min", is the maximum from the trial with the lowest maximum residue). The significance of this observation is that precise control of application conditions and PHI does not generally produce a narrow range of residue levels.

<.008 0.009 <.0098
0.01 <.01 <.01 <.01 <.01 <.01 <.02 <.02 <.02 0.02 <.02 <.02 <.03 <.03 0.03 <.04 <.04 0.04 0.04
0.05 <.05 0.06 0.06 0.06 0.06 <.06 0.06 0.06 0.06 0.07 <.07 0.07 <.07 <.08 0.08 0.08 <.08 <.08 <.08 <.09 0.09
0.10 0.10 0.10 0.11 <.11 0.11 <.12 0.13 0.13 <.13 0.14 0.14 0.14 <.14 0.14 <.14 0.14
0.15 0.16 0.16 0.17 0.17 0.17 0.17 <.17 <.17 0.18 0.19 0.19
0.20 0.20 0.20 <.20 <.21 <.21 0.21 0.22 0.22 <.22 0.23 0.24 0.24
0.25 0.25 <.25 0.25 <.25 0.26 0.27 0.27 0.27 0.28
0.33 0.33 0.34
<.36
0.40
<.56

Fig. 3. Rank-order histogram of values for "lowest maximum ÷ highest maximum" from Table 1. The median value for "lowest maximum ÷ highest maximum" is underlined. (Histogram ranges are: 0-0.009; 0.01-0.04; 0.05-0.09; 0.10-0.14; 0.15-0.19; 0.20-0.24; 0.25-0.29; 0.30-0.34; 0.35-0.39; 0.40-0.44; 0.45-0.49; 0.50-0.54; 0.55-0.59).

The conclusion of this analysis of a wide range of trial data is that the most likely (median) residue on a raw commodity resulting from use of a pesticide under maximum officially approved conditions represents a good starting point for estimating dietary intake. This value can be established directly from the supervised trials data when the data are being evaluated for MRL purposes.

2.2 Estimation of a supervised trials median residue (STMR)

In estimating the median residue for a particular pesticide from supervised trial data on a particular crop, a number of factors need consideration, some of which require a different emphasis from when the data are being used only for setting an MRL.

- Differences may occur between use patterns in the trials and use patterns approved as GAP (Good Agricultural Practice)[11].
- Some data may be below the LOQ.
- The enforcement residue definition may not be suitable for dietary intake purposes.

These factors are now considered in more detail and then two examples of residue data evaluation are developed to illustrate the recommended approach.

2.2.1 Use pattern

When MRLs are to be established the aim is to estimate the maximum residue likely to occur when use is according to GAP. Residues from some treatments involving fewer than recommended applications, lower rates or longer PHIs than maximum GAP, while taken into account, generally do not influence the maximum. However, the resulting median for dietary intake purposes will be affected by which residue data are included in the data set.

It is often difficult to compare use patterns from different countries, because only rarely do the application rates, number of applications and pre-harvest intervals correspond. For the purposes of median residue evaluation, trial data should be included if they correspond to the maximum registered use in the trial country or in a country with comparable climatic and cultural conditions.

Judgement will also be needed on which data to include when the trial conditions deviate from approved (label) instructions. The same question arises for MRL estimation. The JMPR (1994)[12] commented on acceptable variations in application rate, number of applications and pre-harvest interval. For example, the application rate in a trial would normally be considered consistent with the label rate when it exceeded the label rate by 20-30%, which includes likely variation in commercial practice.

Because the highest maximum residue from a set of trials is commonly 5-10 times as high as the lowest (Fig. 3), it is highly likely that residues from a trial at 50% of maximum label rate will exceed residues from some trials at the label rate. An example is provided by sets of trials for abamectin on pears (JMPR 1992)[13]. Abamectin was applied 4 times at 0.028 kg ai/ha and harvested 14 days after the final application in one set of 11 trials in USA. In a companion set the application rate was 0.056 kg ai/ha but the other conditions were the same. The resulting residues are shown in a rank order histogram in Fig. 4. It is clear that there is considerable overlap of the two data sets.

It will be necessary to state explicitly which data are included in the STMR estimation. Generally, application rates within -30% to +30% of the label rate should be included in the evaluation but the acceptable range will very much depend on the particular case.

⊧ <.005 0.005
⊧ 0.006 0.007 0.007 0.007 0.008 0.008 0.010 0.010
⊧ 0.012 0.013 0.014 0.017 0.019 0.020
⊧ 0.024 0.024 0.026 0.029 0.036
⊧ 0.090

Fig. 4. Rank order histogram for residue data from 11 trials on pears where abamectin was applied 4 times at 0.028 kg ai/ha and harvested 14 days after the final application, and data from a companion set of 11 trials where the only difference was the application rate (0.056 kg ai/ha). Data from the 0.056 kg ai/ha treatment are underlined. (Histogram ranges are: 0-0.005; >0.005-0.010; >0.010-0.020; >0.020-0.050; >0.05-0.1)

The inclusion of trial data according to the number of applications and the pre-harvest intervals will depend on the persistence of the residue and the growth habit of the crop. Trials data should be included in the estimates where the harvest intervals theoretically correspond to ±30% change in residue concentration around the level at the PHI. The theoretical ±30% change should be calculated from residue decay or dissipation curves. The rate of decline can also be used to estimate when the number of applications will have negligible effect (<10%) on the final residue level.

TABLE 1. Pesticide residue data on food commodities from supervised trials carried out under identical directions for application and harvest (rate, number, PHI) with one data point from each trial. The data point was the highest from the replicates, or the single data point as available, at the stated trials conditions (application rate, number of applications and PHI). The trial conditions for each set of trials were not necessarily within approved label conditions.

Commodity, country	Pesticide	Application			No. of trials	Residues, mg/kg (calculations based on one value per trial)						Ref JMPR 1992[14]
		kg ai/ha	no.	PHI, days		min	mean†	median	max	median ÷ mean	median ÷ max	JMPR 1993[15] JMPR 1994[16]
Apple, USA	captan	4.5	6-8	0	8	1.4	3.7	4.3	5.5	*1.17*	*0.78*	JMPR 1994
Apple, USA	fenpropathrin	0.45	8	14	15	0.14	2.3	2.4	4.3	*1.04*	*0.56*	JMPR 1993
Apple, Germany	mancozeb	2.3-2.4	10-12	0	9	2.1	3.9	3.0	8.7	*0.77*	*0.34*	JMPR 1993
Apple, Germany	mancozeb	2.3-2.4	10-12	14	9	1.3	2.5	2.3	4.0	*0.92*	*0.58*	JMPR 1993
Apple, Germany	mancozeb	2.3-2.4	10-12	21	8	0.68	2.3	2.2	4.0	*0.96*	*0.55*	JMPR 1993
Apple, Germany	mancozeb	2.3-2.4	10-12	28	8	0.59	2.3	2.5	4.1	*1.09*	*0.61*	JMPR 1993
Pear, USA	abamectin	0.028	4	0	10	0.013	0.029	0.029	0.048	*1.00*	*0.69*	JMPR 1992
Pear, USA	abamectin	0.028	4	1	11	0.008	0.020	0.018	0.046	*0.92*	*0.39*	JMPR 1992
Pear, USA	abamectin	0.028	4	3	11	0.007	0.015	0.010	0.037	*0.68*	*0.27*	JMPR 1992
Pear, USA	abamectin	0.028	4	7	10	<0.005	0.012	0.0105	0.024	*0.88*	*0.44*	JMPR 1992
Pear, USA	abamectin	0.028	4	14	11	<0.005	0.0100-0.0105	0.008	0.024	*0.80*	*0.33*	JMPR 1992
Pear, USA	abamectin	0.056	4	0	11	0.030	0.057	0.057	0.089	*1.00*	*0.64*	JMPR 1992
Pear, USA	abamectin	0.056	4	1	11	0.014	0.040	0.033	0.10	*0.83*	*0.33*	JMPR 1992
Pear, USA	abamectin	0.056	4	3	11	0.011	0.031	0.023	0.088	*0.75*	*0.26*	JMPR 1992

Commodity, country	Pesticide	Application			No. of trials	Residues, mg/kg (calculations based on one value per trial)						Ref JMPR 1992[14]
		kg ai/ha	no.	PHI, days		min	mean†	median	max	median ÷ mean	median ÷ max	JMPR 1993[15] JMPR 1994[16]
Pear, USA	abamectin	0.056	4	7	11	0.010	0.030	0.019	0.098	*0.64*	*0.19*	JMPR 1992
Pear, USA	abamectin	0.056	4	14	11	0.007	0.026	0.020	0.090	*0.78*	*0.22*	JMPR 1992
Pear, USA	fenpropathrin	0.45	6	14	13	0.58	1.5	1.6	2.9	*1.07*	*0.55*	JMPR 1993
Cherries, USA	azinphos-methyl	0.56	2	7	8	0.16	0.38	0.355	0.71	*0.93*	*0.50*	JMPR 1993
Cherries, USA	azinphos-methyl	0.56	2	14	8	0.090	0.38	0.255	0.90	*0.67*	*0.28*	JMPR 1993
Cherries, USA	diazinon	3.3	4	10	28	<0.01	0.18	0.105	0.73	*0.58*	*0.14*	JMPR 1993
Cherries, USA	diazinon	3.3	4	20	24	<0.01	0.045-0.050	0.015	0.28	*0.33*	*0.05*	JMPR 1993
Peach, USA	captan	4.5	6-8	0	9	2.0	8.2	7.8	14	*0.95*	*0.56*	JMPR 1994
Peach, USA	diazinon	3.3	4	9-10	12	<0.01	0.45	0.57	0.81	*1.27*	*0.70*	JMPR 1993
Peach, USA	diazinon	3.3	4	19-20	12	<0.01	0.028-0.030	0.03	0.07	*1.00*	*0.43*	JMPR 1993
Plums and prunes, Germany	bromopropylate	0.56	3	0	10	0.82	2.2	1.85	3.9	*0.84*	*0.47*	JMPR 1993
Plums and prunes, Germany	bromopropylate	0.56	3	7	10	0.62	1.4	1.3	2.2	*0.93*	*0.59*	JMPR 1993
Plums and prunes, Germany	bromopropylate	0.56	3	14	10	0.52	1.4	1.35	2.0	*0.96*	*0.68*	JMPR 1993
Plums and prunes, Germany	bromopropylate	0.56	3	21	10	0.27	1.0	1.05	1.6	*1.05*	*0.66*	JMPR 1993
Plums and prunes, Germany	bromopropylate	0.56	3	28	10	0.30	0.96	0.90	1.6	*0.94*	*0.56*	JMPR 1993
Plums, USA	diazinon	3.3	4	10	20	<0.01	0.21	0.10	0.78	*0.48*	*0.13*	JMPR 1993
Plums, USA	diazinon	3.3	4	20	20	<0.01	0.081-0.085	0.015	0.53	*0.19*	*0.03*	JMPR 1993
Black currants, UK	mancozeb	2.3	5-8	0	8	2.9	9.3	9.0	17	*0.97*	*0.53*	JMPR 1993
Blackberries, USA	diazinon	1.1	5	14	15	<0.01	0.034	0.01	0.080	*0.29*	*0.13*	JMPR 1993
Blackberries, USA	diazinon	2.2	1	7	16	0.01	0.043	0.035	0.090	*0.81*	*0.39*	JMPR 1993
Grapes, Germany	captan	2.3	8	0	8	1.5	3.9	2.9	6.7	*0.74*	*0.43*	JMPR 1994
Grapes, Germany	captan	2.3	8	10	8	1.1	2.6	2.85	4.4	*1.10*	*0.65*	JMPR 1994
Grapes, Germany	captan	2.3	8	20-21	8	0.65	1.9	2.2	2.4	*1.16*	*0.92*	JMPR 1994
Grapes, Germany	captan	2.3	8	26-29	8	0.54	1.9	2.15	3.0	*1.13*	*0.72*	JMPR 1994
Grapes, Germany	captan	2.3	8	33-35	8	0.42	1.7	1.6	3.1	*0.94*	*0.52*	JMPR 1994
Grapes, USA	diazinon	1.12	5	7	18	<0.01	0.38	0.155	2.6	*0.41*	*0.06*	JMPR 1993
Grapes, USA	diazinon	1.12	5	14	18	<0.01	0.30	0.075	1.9	*0.25*	*0.04*	JMPR 1993
Grapes, USA	fenpropathrin	0.22	4	21	16	0.37	1.4	1.05	5.6	*0.75*	*0.19*	JMPR 1993
Raspberries, USA	diazinon	1.1	5	7	8	0.06	0.11	0.115	0.18	*1.05*	*0.64*	JMPR 1993

Commodity, country	Pesticide	Application			No. of trials	Residues, mg/kg (calculations based on one value per trial)						Ref JMPR 1992[14]
		kg ai/ha	no.	PHI, days		min	mean†	median	max	median ÷ mean	median ÷ max	JMPR 1993[15] JMPR 1994[16]
Raspberries, USA	diazinon	1.1	5	14	20	<0.01	0.021-0.022	0.02	0.04	*0.95*	*0.50*	JMPR 1993
Raspberries, USA	diazinon	2.2	1	0	8	0.76	2.1	2.15	3.2	*1.02*	*0.67*	JMPR 1993
Strawberry, USA	abamectin	0.022	4	0	12	0.009	0.021	0.020	0.036	*0.95*	*0.56*	JMPR 1992
Strawberry, USA	abamectin	0.022	4	2	10	<0.005	0.005-0.008	0.007	0.014	*1.00*	*0.50*	JMPR 1992
Strawberry, USA	abamectin	0.022	4	3	12	<0.005	0.005-0.007	0.007	0.009	*1.00*	*0.78*	JMPR 1992
Strawberry, USA	diazinon	1.12	3	3	36	<0.01	0.094-0.095	0.09	0.44	*0.95*	*0.20*	JMPR 1993
Strawberry, USA	diazinon	1.12	3	5	32	<0.01	0.051-0.052	0.06	0.12	*1.15*	*0.50*	JMPR 1993
Strawberry, USA	diazinon	1.12	13	7	32	<0.01	0.039-0.040	0.04	0.12	*1.00*	*0.33*	JMPR 1993
Onion bulb, USA	maneb	2.7	10	0	10	0.28	0.85	0.86	1.8	*1.01*	*0.72*	JMPR 1993
Cabbages head, USA	diazinon	0.55	5	7	20	<0.01	0.48	0.155	1.3	*0.32*	*0.12*	JMPR 1993
Cabbages head, USA	diazinon	0.55	5	13-14	20	0.01	0.14	0.035	1.1	*0.25*	*0.03*	JMPR 1993
Cabbages head, USA	diazinon	0.55	5	20-21	20	<0.01	0.034-0.040	<0.01	0.20	*<0.29*	*<0.05*	JMPR 1993
Cantaloupe, USA	diazinon	0.83	5	7	11	0.01	0.058	0.05	0.18	*0.86*	*0.28*	JMPR 1993
Cantaloupe, USA	diazinon	4.4	1	3	8	0.03	0.13	0.095	0.30	*0.73*	*0.32*	JMPR 1993
Cucumber, USA	diazinon	0.84	5	7	10	<0.01	0.061-0.063	0.015	0.40	*0.25*	*0.04*	JMPR 1993
Cucumber, USA	diazinon	4.48	1	3	8	0.03	0.099	0.07	0.20	*0.71*	*0.35*	JMPR 1993
Cucumber, USA	fenbutatin oxide	2.2	3	1	9	0.30	0.62	0.50	1.1	*0.81*	*0.45*	JMPR 1993
Cucumber, USA	fenbutatin oxide	2.2	2	1	9	0.20	0.52	0.50	1.0	*0.96*	*0.50*	JMPR 1993
Cucumber, USA	fenbutatin oxide	2.2	3	2	9	0.20	0.39	0.30	1.0	*0.77*	*0.30*	JMPR 1993
Cucumber, USA	fenbutatin oxide	2.2	2	2	9	<0.05	0.35-0.36	0.20	0.87	*0.57*	*0.23*	JMPR 1993
Summer squash, USA	diazinon	0.83	5	7	10	<0.01	0.014-0.018	0.01	0.05	*0.71*	*0.20*	JMPR 1993
Summer squash, USA	diazinon	4.4	1	3	10	0.01	0.064	0.04	0.18	*0.63*	*0.22*	JMPR 1993
Peppers, USA	diazinon	0.56	5	3	8	0.02	0.055	0.055	0.09	*1.00*	*0.61*	JMPR 1993
Peppers, USA	diazinon	4.48	1	1	8	<0.01	0.065-0.068	0.08	0.13	*1.18*	*0.62*	JMPR 1993
Tomato, USA	abamectin	0.022	10	0	19	<0.005	0.007-0.009	0.005	0.030	*0.72*	*0.17*	JMPR 1992
Tomato, USA	abamectin	0.045	10	0	14	0.006	0.024	0.020	0.095	*0.83*	*0.21*	JMPR 1992
Tomato, USA	diazinon	0.84	5	3	34	0.01	0.084	0.075	0.22	*0.89*	*0.34*	JMPR 1993

Commodity, country	Pesticide	Application			No. of trials	Residues, mg/kg (calculations based on one value per trial)						Ref JMPR 1992[14]
		kg ai/ha	no.	PHI, days		min	mean†	median	max	median ÷ mean	median ÷ max	JMPR 1993[15] JMPR 1994[16]
Tomato, USA	diazinon	4.48	1	1	35	0.02	0.14	0.13	0.48	*0.93*	*0.27*	JMPR 1993
Tomato (indoor), Germany	fenpropathrin	0.08	3	0	8	<0.01	0.20	0.145	0.73	*0.73*	*0.20*	JMPR 1993
Tomato (indoor), Germany	fenpropathrin	0.08	3	1	8	<0.01	0.21	0.195	0.56	*0.93*	*0.35*	JMPR 1993
Tomato (indoor), Germany	fenpropathrin	0.08	3	3	8	<0.01	0.20	0.165	0.58	*0.83*	*0.28*	JMPR 1993
Tomato (indoor), Germany	fenpropathrin	0.08	3	5	8	0.01	0.22	0.13	0.47	*0.59*	*0.28*	JMPR 1993
Tomato (indoor), Germany	fenpropathrin	0.08	3	7	8	0.03	0.125	0.075	0.27	*0.60*	*0.28*	JMPR 1993
Lettuce, USA	abamectin	0.022	8	0	12	0.006	0.036	0.028	0.11	*0.78*	*0.25*	JMPR 1992
Lettuce head, USA	diazinon	0.56	5	14	22	<0.01	0.037-0.040	0.02	0.15	*0.54*	*0.13*	JMPR 1993
Lettuce leaf, USA	diazinon	0.56	5	14	20	0.01	0.068	0.055	0.15	*0.81*	*0.37*	JMPR 1993
Lettuce leaf, USA	diazinon	0.56	5	21	20	<0.01	0.025-0.031	<0.01	0.12	*<0.40*	*<0.08*	JMPR 1993
Lettuce head, USA	diazinon	4.48	1	7	18	<0.01	0.14	0.11	0.44	*0.79*	*0.25*	JMPR 1993
Lettuce leaf, USA	diazinon	4.48	1	7	16	0.04	0.12	0.105	0.25	*0.88*	*0.42*	JMPR 1993
Spinach, USA	diazinon	0.56	5	14	8	<0.01	0.098-0.101	0.035	0.37	*0.36*	*0.09*	JMPR 1993
Spinach, USA	diazinon	0.56	5	21	8	<0.01	0.019-0.023	0.015	0.06	*0.79*	*0.25*	JMPR 1993
Common beans, USA	diazinon	0.83	3	13-14	16	<0.01	0.009-0.016	<0.01	0.04	*1.00*	*<0.25*	JMPR 1993
Common beans, USA	diazinon	4.4	1	6-7	13	<0.01	0.030	0.02	0.11	*0.67*	*0.18*	JMPR 1993
Peas, USA	diazinon	0.83	5	14	8	0.02	0.033	0.03	0.05	*0.91*	*0.60*	JMPR 1993
Peas, USA	diazinon	0.83	3	14	12	<0.01	0.013-0.018	<0.01	0.09	*0.77*	*0.11*	JMPR 1993
Peas, USA	diazinon	4.4	1	7	16	<0.01	0.050-0.051	0.035	0.15	*0.69*	*0.23*	JMPR 1993
Celery, USA	abamectin	0.022	10	0	20	0.072	0.25	0.16	0.76	*0.63*	*0.21*	JMPR 1992
Celery, USA	abamectin	0.022	10	1	12	0.026	0.075	0.051	0.20	*0.68*	*0.26*	JMPR 1992
Celery, USA	abamectin	0.022	10	3	14	0.006	0.026	0.018	0.075	*0.69*	*0.24*	JMPR 1992
Celery, USA	abamectin	0.022	10	5	18	<0.005	0.019	0.017	0.039	*0.91*	*0.44*	JMPR 1992
Celery, USA	abamectin	0.022	10	7	18	<0.005	0.013-0.014	0.010	0.036	*0.76*	*0.28*	JMPR 1992
Celery, USA	abamectin	0.022	10	14	10	<0.005	0.005-0.008	<0.005	0.023	*1.00*	*<0.22*	JMPR 1992
Celery, USA	abamectin	0.045	10	0	20	0.18	0.50	0.43	1.3	*0.86*	*0.33*	JMPR 1992

Commodity, country	Pesticide	Application			No. of trials	Residues, mg/kg (calculations based on one value per trial)						Ref JMPR 1992[14]
		kg ai/ha	no.	PHI, days		min	mean†	median	max	median ÷ mean	median ÷ max	JMPR 1993[15] JMPR 1994[16]
Celery, USA	abamectin	0.045	10	1	12	0.051	0.17	0.12	0.47	*0.71*	*0.26*	JMPR 1992
Celery, USA	abamectin	0.045	10	3	14	0.014	0.061	0.040	0.24	*0.66*	*0.17*	JMPR 1992
Celery, USA	abamectin	0.045	10	5	18	0.011	0.064	0.040	0.20	*0.63*	*0.20*	JMPR 1992
Celery, USA	abamectin	0.045	10	7	18	0.009	0.047	0.042	0.15	*0.90*	*0.28*	JMPR 1992
Celery, USA	abamectin	0.045	10	14	10	<0.005	0.017-0.018	0.0135	0.042	*0.79*	*0.32*	JMPR 1992
Wheat, USA	parathion-methyl	1.4	6	13-14	9	<0.05	1.1	0.78	5.1	*0.70*	*0.15*	JMPR 1994

† Residue values less than the limit of quantitation (LOQ) were included in the calculation of the mean as a range, ie. a residue value of <0.005 mg/kg was included as a range 0-0.005 mg/kg. The resultant mean would then fall over a range. If that range included the median value the "median ÷ mean" was set at 1.00. If the median fell outside the range the "median ÷ mean" was calculated with the end of the range closest to the median.

2.2.2 Supervised trials - analytical data below the limit of quantitation

When the median residue is less than the limit of quantitation (<LOQ) the median residue for dietary intake purposes should be estimated to be at the LOQ except when evidence from the trials at the specified conditions and supporting evidence suggests a zero residue situation. Supporting evidence includes residue data from related trials at shorter PHIs, exaggerated application rates or greater numbers of applications, expectations from metabolism studies and data from related commodities.

If the median residue is less than the LOQ, but residues are detectable in some trials within the specified application and harvest conditions the median residue for dietary intake purposes should be established at the LOQ.

If all the residues in the set of trials at the specified conditions are undetectable, but residues are detectable in exaggerated, but related conditions of application rate, number of applications and PHI, then the median residue for dietary intake purposes should be established at the LOQ.

If all the residues in the set of trials at the specified conditions and at exaggerated, but related, conditions (if available) are undetectable, then the median residue for dietary intake purposes should be estimated to be zero. Support may also be obtained from metabolism studies, eg. a foliar applied non-absorbed pesticide is not expected as a residue in root crops.

2.2.3 Residue definition

The residue definition established for MRL enforcement purposes may not necessarily be the ideal definition for dietary intake assessment. For dietary intake purposes it is desirable to monitor any metabolites which have similar toxicity properties to the parent. For enforcement purposes (testing of food consignments for compliance with MRLs) it is not desirable to include the metabolites if they are present as only a minor part of the residue, or if present in a relatively constant ratio to the parent. Monitoring for additional compounds only adds to the cost of analysis and standards for metabolites are not always readily available.

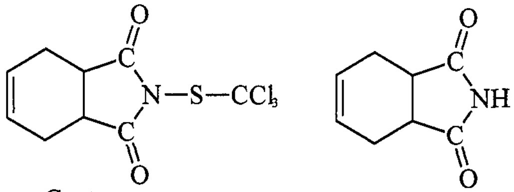
Metabolites or analytes common to other pesticides are generally avoided in residue definitions if the pesticides are to have separate sets of MRLs because anomalies in enforcement work will occur. This is a situation where the requirements for the enforcement definition and the dietary intake definition are different. Dietary intake assessments are interested in levels of certain metabolites irrespective of their source.

The Codex residue definition for parathion is parathion only. The definition is suitable for enforcement purposes because the metabolite paraoxon is usually a minor part of the residue especially when the residue is reasonably fresh and at the higher levels. For aged residues under some conditions paraoxon levels may be of the same order as the parathion levels.

A metabolite such as paraoxon should be taken into account in the estimation of the STMR for parathion and in the residue level for acute intake. Furthermore, if a situation occurred in a set of supervised trials where parathion was not detectable, but occasional paraoxon residues were detectable, the supervised trials median residue would not be set at zero, but would be based on the paraoxon data.

2.2.4 Examples of data evaluation for MRL and STMR - captan and parathion-methyl.
Captan and parathion-methyl were evaluated by the 1994 JMPR[17] and maximum residue levels were estimated. The supervised trial data have now been re-examined to see how the estimated STMRs (supervised trials median residues) compare with the MRLs. The data and conclusions are summarised in Table 2.

The captan trials provide examples where the residues were generally much higher than the limit of quantitation. For each trial included in the assessment (trial conditions sufficiently close to GAP to be relevant) one residue data point was recorded. The highest residue from replicate plots within a trial was taken to represent the trial.

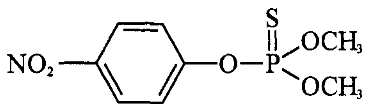


Captan THPI

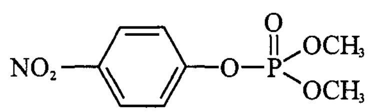
Captan MRLs are based on a residue definition of captan only. Captan breaks down under some storage conditions to form THPI (1,2,3,6-tetrahydrophthalimide) and when a sample contains captan and THPI residues it is possible that some captan was converted to THPI during sample storage. The residues for STMR estimation are captan + THPI expressed as captan.

For captan the pear STMR was highest with respect to the MRL at 75% of the MRL while the lowest was grapes at 15% of the MRL. Most captan STMRs were 20-50% of the respective MRLs.

The residue definition for parathion-methyl for enforcement purposes is parathion-methyl only, but for dietary intake purposes the combined residue of parathion-methyl + paraoxon-methyl is used.



Parathion-methyl



Paraoxon-methyl

Parathion-methyl residues for some commodities were undetectable and MRLs were estimated to be at or about the limit of quantitation. In other cases the supervised trials median residue was below the limit of quantitation even though residues were detected in some trials and the MRLs were proposed at higher levels. Supporting evidence from the GAP trials and other related trials was used to decide if the STMR should be at the limit of quantitation or should be a zero residue.

For parathion-methyl, apart from the MRLs set at the LOQ, celery and artichoke STMRs were highest in comparison to the respective MRLs at 62-5% of the MRLs while the lowest was turnip greens at 2.5% of the MRL. There was often a big difference between the STMR and the MRL, particularly in cases where most trials produced low or undetectable residues with a few trials giving residues orders of magnitudes higher. Some uses and commodities are prone to produce a wide range of residues from the same use pattern. In this situation the MRL represents the occasional residue occurring from the approved use, and is somewhat remote from the expected residue.

TABLE 2. Summary of captan and parathion-methyl supervised trial residue data (from JMPR 1994)[17] evaluated for MRL and supervised trials median residue (STMR). For each trial with rates and timing according to label recommendations one residue data point is recorded. Median residues from the set of trials are underlined.

PESTICIDE crop	**Countries**	**No. of trials**	**Residues mg/kg**	**Estimated MRL**	**Estimated STMR**
CAPTAN [A]					
Apple	Brazil Canada Japan UK	28	0.66 0.98 1.0 1.0 1.6 1.6 1.8 2.2 2.3 2.6 2.9 2.9 3.0 <u>3.4</u> <u>3.6</u> 3.9 4.1 4.3 4.4 4.4 4.5 4.5 4.6 4.6 4.7 5.1 7.8 14	10	3.5
Pear	UK USA [B]	6	1.5 4.8 <u>7.4</u> <u>7.6</u> 9.5 12	10	7.5
Cherries	Japan USA	9	0.58 1.3 7.6 10 <u>11</u> 14 15 16 20	20	11
Peach	Spain USA	13	2.0 2.8 3.5 4.3 4.4 6.0 <u>6.0</u> 7.4 8.1 9.8 11 13 14	15	6.0
Nectarine	Spain USA	5	0.40 0.77 <u>1.5</u> 2.2 4.1	5	1.5
Plums	USA	3	0.45 0.60 5.6 (nectarine data to supplement plum data)	5	1.5

PESTICIDE crop	Countries	No. of trials	Residues mg/kg	Estimated MRL	Estimated STMR
Grapes	Argentina Chile France Germany Japan	39	0.42 0.46 0.98 1.1 1.2 1.3 1.5 1.5 1.6 1.6 1.7 1.8 1.9 2.2 2.3 2.7 2.9 3.0 3.1 3.1 3.1 3.2 3.3 4.0 4.1 5.2 6.0 6.3 6.5 6.5 7.0 7.1 7.5 7.8 9.5 10 12 15 21	20	3.1
Blueberries	USA	9	2.0 3.3 4.8 5.6 8.4 8.5 8.7 15 18	20	8.4
Strawberry	Canada Chile Hungary USA	11	0.93 3.0 3.0 4.6 4.8 4.9 5.1 5.7 6.5 8.3 15	15	4.9
Tomato	Brazil Canada Greece Israel Mexico	15	0.12 0.15 0.30 0.30 0.31 0.34 0.39 0.61 0.73 0.93 1.0 1.3 1.7 2.8 2.8	2	0.61
PARATHION-METHYL [C]					
Cabbages, Head	USA	16	<0.05 (16) [D]	0.2	0.05
Broccoli	USA	12	<0.05 (10) 0.05 0.24	0.2	0.05
Lettuce, Head	USA	6	<0.05 (6) [E]	0.05*	0.05
Lettuce, Leaf	USA	8	<0.05 (5) 0.11 0.23 1.6	0.5	0.05
Mustard greens	USA	14	<0.05 (10) 0.06 0.09 0.10 0.60	0.5	0.05
Turnip greens	USA	7	<0.05 (6) 1.8	2	0.05
Spinach	USA	14	<0.05 (8) 0.05 0.06 0.06 0.07 0.09 0.40	0.5	0.05
Common bean	USA			0.05*	0
+		13	<0.05 (13) [F]		
Lima bean	USA			0.05*	0
Beans (dry)	USA	6	<0.05 (6)	0.05*	0
Peas (dry)	USA	8	<0.05 <0.05 <0.05 0.06 0.06 0.07 0.16 0.18	0.2	0.06
Garden pea	USA	8	<0.05 (5) 0.08 0.21 0.68	1	0.05
Carrots	USA	6	0.22 0.26 0.38 0.49 0.67 0.79	1	0.44
Potato	USA	10	<0.05 (10) [G]	0.05*	0
Sugar beet	USA	10	<0.05 (10) [H]	0.05*	0
Turnip, Garden	USA	7	<0.05 (7) [I]	0.05*	0.05
Artichoke, Globe	USA	4	1.1 1.2 1.3 1.6	2	1.25
Celery	USA	8	0.87 1.8 2.2 2.5 4.0 4.4 4.4 4.7	5	3.25
Rice	USA	6	0.28 0.42 0.44 0.67 2.1 2.5	3	0.555
Wheat	USA	12	<0.05 (3) 0.15 0.22 0.33 0.35 0.78 0.93 1.1 1.6 5.6	5	0.34
Hops, dry	USA	7	<0.04 0.41 0.49 0.58 0.60 0.66 1.3	1	0.58

* at or about the limit of quantitation

[A] The residue data for STMR estimation include tetrahydrophthalimide (THPI) expressed as captan because under some sample storage conditions captan may be converted to THPI.

[B] The two US trials were post-harvest treatments.

[C] Parathion-methyl residue data for supervised trials median residue estimation include paraoxon-methyl where detected.

[D] Residues on cabbages with wrapper leaves removed were chosen for dietary intake estimation. Paraoxon-methyl was detected in some samples demonstrating that, even though median residues were less than the LOQ, the residues should not be regarded as totally absent.

[E] Parathion-methyl residues were detected in some trials which did not represent commodity in commercial trade, but did demonstrate residues could be present and the median should not be considered as zero residues.

[F] Snap beans and lima beans were considered together. No residues of parathion-methyl or paraoxon-methyl were detected in the trials, which is good evidence of a nil residue situation.

[G] Two trials had exaggerated application rates.

[H] Two trials had exaggerated application rates.

[I] In a modified use pattern in another 7 trials with the final application rate reduced and a briefer pre-harvest interval residues were mostly not detected, but parathion-methyl was present in one trial, suggesting that residues may sometimes occur.

2.3 Residue levels to be considered in the assessment of potential acute effects

Dietary intake for acute effects is best related to residue levels in a single serving of a food, or at least the average residue level in servings of the food over a day or so. The maximum residue occurring in the edible portion is the preferred starting point for intake estimates for potential acute effects. The incidence of residues, or percentage of crop treated, should not be taken into account as a factor in the assessment of residue levels and potential acute effects. The incidence of residues is a relevant factor in assessing long term average dietary intake.

For commodities which are consumed whole with little or no preparation the MRL will generally represent the maximum possible residues in the edible portion. If residue levels are heterogeneously distributed between individual pieces of fruit or vegetables and the average residue level is at the MRL then residues on some pieces will exceed the MRL. Adjustments to the MRL will be needed in those cases where the residue definition for enforcement purposes does not agree with the residue definition for dietary intake purposes.

A recent report from the UK[18] has provided data on the variation of organophosphorus insecticide residue levels in individual carrots and compared the levels with analyses on samples composited in accordance with Codex recommendations of sampling for enforcement[19]. Mean residues in the carrots were generally similar to the residues in the composites, but levels in individual carrots varied by large factors - up to 25 times the composite level, or up to 4-5 times the composite level when the composite level was above ½MRL. This is an active area of research because the data base on the variation of residues between individual pieces of fruit or vegetables is limited and improved information is needed for estimation of acute intake.

For commodities with an inedible portion, eg. bananas, the maximum residue in the edible portion is the best starting point. Most modern supervised trials provide residue data separately for peel and pulp for fruits such as bananas and citrus.

For commodities which are always cleaned, milled or processed in some way before consumption, eg. wheat and cotton seed, the maximum residue in food prepared for consumption from raw agricultural commodity with residues at the MRL is a suitable starting point. Supervised processing studies are usually available on such commodities.

3. FOOD PREPARATION AND PROCESSING

Changes in residue levels that often occur post-harvest, particularly through food preparation and processing, should also be taken into account when estimating residue levels on food as consumed.

Residue levels in prepared food are often much reduced when the raw commodity is subject to trimming, washing, cooking, milling and refining. Holland *et al*[20] have recently reviewed the effects of storage and processing on pesticide residues and have recommended study protocols for conducting processing studies.

Processing studies have been reported for a variety of commodities where pesticides leave measurable residues. Information on the fate of residues during food preparation steps such as washing, peeling and trimming of fruit and vegetables is also available for some pesticides.

Table 3 gives a list of raw agricultural commodities and food items where information on the fate of residues during processing is often available.

To make use of the information for dietary intake purposes it is necessary to know the dietary consumption of individual food items rather than the total consumption of the raw agricultural commodity.

For example, residue depletion may be quite different amongst the various processed potato products. For dietary intake estimation it is then necessary to know the percentage of potato consumption to be assigned to each potato product.

Similarly, the percentage of apples consumed as processed products such as juice or apple sauce rather than as the raw commodity should be taken into account and the residue intake estimated accordingly. The Committee on Pesticides in the Diets of Infants and Children[7] noted that in the USA apple-based foods constitute a substantial portion of foods consumed by infants and young children, and that virtually all the foods consumed by infants are processed. Information on the fate of pesticide residues during apple processing is needed for realistic dietary intake estimates.

TABLE 3. List of raw agricultural commodities and food commodities involved in processing studies on the fate of residues.

Raw agricultural commodity	**Food commodity**
FRUIT	
Apple	thick juice, clear juice, apple puree, apple pomace, apple sauce, apple jelly, sliced canned apple
Banana	pulp
Citrus	pulp, peel, juice
Grapes	thick juice, clear juice, wine, grape pomace, dried raisins
Olives	olive oil

Raw agricultural commodity	**Food commodity**
Pineapples	juice
Plums, prunes	dried prunes
VEGETABLES	
Cabbages	trimmed cabbages (wrapper leaves removed)
Celery	celery trimmed (foliage removed)
Lettuce	lettuce trimmed (wrapper leaves removed)
Potato	peeled and washed potatoes, boiled potatoes, baked potatoes, French fries, granules, chips, flakes
Snap beans	canned beans
Sweet corn	canned corn
Tomato	juice, tomato pomace, tomato puree, tomato paste
CEREALS	
Barley	beer, barley bran, barley flour
Maize	crude oil, refined oil, grits, flour, meal
Oats	flour, bran, rolled oats
Rice	brown rice, polished rice
Wheat	flour, bran, germ, semolina, wholemeal, white bread, wholemeal bread, steamed bread, flat bread, yellow alkaline noodles, white salted noodles
OILSEEDS	
Cotton seed	crude oil, refined oil
Peanut	oil
Rape seed	crude oil, refined oil
Sunflower seed	crude oil, refined oil
OTHER	
Tea	transfer to water in tea making

3.1 Evaluation of food preparation and processing studies

Food preparation and processing studies provide the basic information on the dissipation or increased levels of residues in passing from the raw agricultural commodity to a processed commodity (eg. flour) or a food ready for consumption (eg. trimmed celery, peeled banana). Supervised residue trials on citrus and tropical fruit commonly provide residue data on the edible portion as well as on the commodity of trade.

The purpose of the evaluation is to decide the level of residue likely to occur in a food produced from raw agricultural commodity with residues at the STMR (supervised trials median residue).

The complications of data distributions and variability and residues below the limit of quantitation are similar to those in supervised residue trials and should be treated similarly. Generally the mean processing factor will best represent the most likely residue behaviour for a set of processing trials, but median is preferred when residues below the LOQ in the processed food predominate. Additional complications are clear identification of processed food commodities, eg. juice could be unclarified or clarified juice, where residue levels can be quite different.

Some processed commodities are prepared from only a specialised segment of the raw commodity market. For example, raisins are produced from seedless grapes in a climate which allows sun drying. Residues in those grapes, rather than residues in all grapes, should be taken into account in the estimation of likely residues in raisins.

Some pesticides are destroyed by food preparation processes such as heating and boiling. The knowledge that residues of such pesticides are not expected to occur in canned food and juices, etc, subjected to heating, can be used in the interpretation of processing trial data and extrapolation to other commodities.

3.2 Examples of processing data evaluation - captan and parathion-methyl

The captan and parathion-methyl evaluations from the 1994 JMPR[17] have been further examined to interpret the processing data in terms of likely residues in food as consumed if the food was prepared from raw agricultural commodity treated according to the registered use patterns.

Captan residues in biological material are destroyed by heat. Whenever there was a heating or boiling step in the process captan residues disappeared. For example captan residues had disappeared from canned fruit or boiled juices, and the STMR-P can be set at zero in these instances.

The processing factor is the residue level in the processed product divided by the residue level in the raw agricultural commodity.

The summary in Table 4 provides examples of how the processing factors (from processing trials) are combined with the supervised trials median residues to produce the supervised trials median residues for prepared and processed food (STMR-P).

It must be recognized that the wide range of processing factors obtained in the various processing trials summarised in Table 4 is not atypical. Much of the range arises from differences in the actual processes and therefore it is important that processing trials reflect the conditions of typical commercial processes.

TABLE 4. Summary of captan and parathion-methyl processing data (from JMPR 1994)[17] evaluated for supervised trials median residues (prepared and processed) (STMR-P).

Raw agricultural commodity	STMR, mg/kg	Processing factor	Mean processing factor	Food commodity	STMR-mg/kg
CAPTAN					
Apple	3.5	0.36 0.48 0.52 0.62 0.67 1.26 1.53	0.78	apple juice, unclarified (from unpeeled apples, no heating)	2.7
		NDR[A]	0	apple juice, unclarified, canned	0
		NDR	0	apple juice, clarified	0

Raw agricultural commodity	STMR, mg/kg	Processing factor	Mean processing factor	Food commodity	STMR-mg/kg
		0.13 0.17 0.40 0.47 0.67 0.89 1.07 2.65 2.85 3.09 4.09	1.50	apple pomace (wet)	5.2
		0.23 0.31 0.33 0.83 0.91 1.08 1.33 1.33 1.61 1.89 2.12 2.22 2.50 3.65	1.45	apple pomace (dry)	5.1
		NDR	0	apple slices, canned	0
		NDR	0	apple jelly	0
		0.78 1.11 1.27 2.00	1.29	dried apple	4.5
Grapes	3.1	0.68	0.68	washed table grapes	2.1
		0.22 0.83 0.91 1.00	0.74	grape juice	2.3
		NDR	0	grape juice, boiled	0
		NDR	0	grape jelly	0
Grapes for raisins	0.10	1.00 1.12 1.20 1.33 2.64	1.46	raisins	0.1
Plums	1.5	0.23	0.23	dry prunes	0.3
Tomato	0.61	NDR	0	tomato juice	0
		NDR	0	tomato puree	0
		NDR	0	tomato ketchup	0
PARATHION-METHYL					
Rice	0.555	0.185 0.175	0.180	Brown rice	0.1
		0.037 0.051	0.044	Polished rice	0.0
Wheat	0.34	1.94 2.4	2.17	Bran	0.7
		0.33 0.29	0.31	Flour	0.1

A NDR: no detectable residues in processed commodity. Captan residues are degraded when heated in the presence of biological material.

4. PERCENTAGE OF CROP TREATED.

The STMR measures of residue levels in crops will generally over-estimate the levels in diets because, among other reasons, all crops of a particular type will not be treated with a particular pesticide. Residue monitoring data have been examined to provide a measure of percentage of crop treated.

4.1 Methodology

Seventeen commonly used and monitored pesticides or pesticide groups were chosen.

Acephate	Deltamethrin	Fenvalerate
Benomyl/carbendazim	Dicofol	Malathion
Carbaryl	Dimethoate	Parathion
Chlorothalonil	Dithiocarbamates	Permethrin
Chlorpyrifos	Endosulfan	Vinclozolin
Cypermethrin	Fenitrothion	

Residue monitoring data were assembled from reports of random sampling (surveillance) of raw agricultural commodities. The number of samples analysed and the number of samples found to contain residues (at or above the limit of quantitation or reporting) were recorded in tables.

Because the data were to be used to indicate degree of usage on the crop, the following criteria were adopted:

- ❑ Include only those pesticide/commodity combinations which are covered by Codex MRLs or proposed Codex MRLs.
- ❑ Include only those pesticide/commodity combinations where the Codex MRLs or proposed Codex MRLs exceed the limit of quantitation or reporting by a factor of 10 or more.

The purpose of the first point is to allow combination of monitoring data from disparate sources and recorded in a variety of formats.

The purpose of the second point is to gain reasonable correspondence between use and detection of residues. If MRLs are set at or close to the limit of quantitation there will be occasions when the pesticide is used but no residues are detectable. If the MRL is somewhat higher than the limit of quantitation, then detection of uses relating to that MRL should be more reasonably assured.

There will still be uses of the pesticide which are not detectable by residue analysis, eg. when the pesticide is used only at an early stage of crop growth. For the purposes of dietary residue intake estimates, these instances can be included with the instances where the pesticide was not used.

Residue data from various sources were combined in tables. When the number of samples for a pesticide/commodity combination exceeded 100, the summarised data were entered into Table 5.

4.2 Incidence of residue detection

The data from Table 5 are further summarised in Tables 6 and 7, distributing the cases according to commodity group and pesticide respectively. The majority of cases show less than 1% incidence of pesticide residues (median value 0.5%). Grain protectant uses on cereals show the highest incidence of residues. Pyrethroids generally have a low incidence of detection.

The incidence of residue detection exceeds 10% in 25 cases. In the 25 cases endosulfan appears 6 times (6 vegetables), dithiocarbamates 4 times (2 fruits and 2 vegetables), carbaryl 3 times (3 cereal grains), chlorpyrifos 3 times (1 fruit and 2 vegetables) and permethrin 3 times (3 vegetables). It is not surprising to find such widely used pesticides appearing at the head of this list.

TABLE 5. Summary of residue monitoring data sorted in order of incidence of residue detection. Monitoring data were available from Australia[21 22 23 24 25 26 27], Brazil[28 29], Denmark[30 31], New Zealand[32], Sweden[33], USA[15 34 35].

Pesticide	Codex MRL (or proposed MRL) and commodity	Grp†	Number of samples tested	Number of samples with residues	% samples with residues
Carbaryl	10 Sorghum	GC	156	151	**96.8**
Fenitrothion	10 Cereal grains	GC	12759	9511	**74.5**
Chlorothalonil	10 Celery	VS	375	246	**65.6**
Vinclozolin	10 Strawberry	FB	509	245	**48.1**
Vinclozolin	10 Kiwifruit	FI	126	55	**43.7**
Carbaryl	5 Oats	GC	130	44	**33.9**
Endosulfan	1 Lettuce, Leaf	VL	483	157	**32.5**
Dithiocarbamates	5 Tomato	VO	866	241	**27.8**
Chlorpyrifos	0.5 Tomato	VO	3613	1006	**27.8**
Chlorpyrifos	0.5 Peppers	VO	1428	395	**27.7**
Endosulfan	0.5 Melons	VC	925	249	**26.9**
Endosulfan	2 Spinach	VL	183	40	**21.9**
Chlorpyrifos	2 Kiwifruit	FI	127	26	**20.5**
Dithiocarbamates	5 Pome fruits	FP	1135	226	**19.9**
Endosulfan	0.5 Cucumber	VC	1659	329	**19.8**
Permethrin	2 Lettuce, Head	VL	2451	449	**18.3**
Dithiocarbamates	5 Grapes	FB	285	51	**17.9**
Carbaryl	5 Barley	GC	188	33	**17.6**
Endosulfan	1 Lettuce, Head	VL	2169	365	**16.8**
Permethrin	2 Celery	VS	422	65	**15.4**
Dicofol	5 Citrus fruits	FC	1022	148	**14.5**
Permethrin	2 Spinach	VL	183	23	**12.6**
Dithiocarbamates	2 Cucumber	VC	613	73	**11.9**
Endosulfan	0.5 Common bean	VP	574	67	**11.7**
Dimethoate	0.5 Peas	VP	837	96	**11.5**
Permethrin	1 Tomato	VO	3241	288	**8.9**
Endosulfan	2 Vegetables except ...	V	4715	416	**8.8**
Acephate	5 Lettuce, Head	VL	2167	182	**8.4**
Dithiocarbamates	10 Lettuce, Head	VL	774	64	**8.3**
Endosulfan	2 Celery	VS	434	34	**7.8**
Dimethoate	2 Beans	VP	560	43	**7.7**
Dimethoate	2 Lettuce, Leaf	VL	483	36	**7.5**
Dimethoate	2 Lettuce, Head	VL	2335	174	**7.5**
Chlorothalonil	5 Melons	VC	875	63	**7.2**
Benomyl/carbendazim	5 Pome fruits	FP	1226	84	**6.9**
Chlorothalonil	5 Tomato	VO	3716	233	**6.3**
Dicofol	5 Peach	FS	115	7	**6.1**
Dimethoate	1 Peppers	VO	2472	125	**5.1**
Malathion	0.5 Peas	VP	837	40	**4.8**
Parathion	0.5 Lemon	FC	112	5	**4.5**
Carbaryl	5 Peppers	VO	1048	45	**4.3**
Malathion	8 Cereal grains	GC	5561	224	**4.0**
Benomyl/carbendazim	10 Citrus fruits	FC	204	8	**3.9**
Benomyl/carbendazim	5 Berries and other small fruits	FB	541	21	**3.9**
Chlorpyrifos	1 Apple	FP	933	35	**3.8**
Permethrin	1 Peppers	VO	1157	40	**3.5**
Dithiocarbamates	2 Oranges, Sweet, Sour	FC	115	4	**3.5**
Permethrin	2 Kiwifruit	FI	127	4	**3.2**
Parathion	1 Peach	FS	381	12	**3.2**
Acephate	5 Broccoli	VB	382	12	**3.1**
Endosulfan	2 Fruits except ...	F	2060	61	**3.0**
Malathion	6 Peach	FS	391	11	**2.8**
Dimethoate	1 Spinach	VS	176	5	**2.8**
Dicofol	5 Pome fruits	FP	1292	36	**2.8**
Parathion	0.5 Oranges, Sweet, Sour	FC	408	11	**2.7**
Carbaryl	7 Strawberry	FB	375	10	**2.7**

Pesticide	Codex MRL (or proposed MRL) and commodity	Grp†	Number of samples tested	Number of samples with residues	% samples with residues
Endosulfan	0.5 Garden peas	VP	837	21	**2.5**
Dimethoate	2 Cucumber	VC	1668	41	**2.5**
Dimethoate	1 Grapes	FB	1725	43	**2.5**
Malathion	4 Citrus fruits	FC	779	19	**2.4**
Chlorothalonil	10 Lettuce, Head	VL	2072	49	**2.4**
Dithiocarbamates	1 Peppers	VO	344	8	**2.3**
Dithiocarbamates	0.2 Potato	VR	316	7	**2.2**
Carbaryl	5 Apple	FP	681	15	**2.2**
Endosulfan	1 Cabbages, Head	VB	285	6	**2.1**
Endosulfan	0.5 Tomato	VO	3508	75	**2.1**
Dimethoate	2 Citrus fruits	FC	1017	21	**2.1**
Fenitrothion	2 Citrus fruits	FC	911	18	**2.0**
Dimethoate	2 Brussels sprouts	VB	153	3	**2.0**
Vinclozolin	3 Tomato	VO	3353	63	**1.9**
Carbaryl	5 Grapes	FB	1347	26	**1.9**
Chlorothalonil	5 Common bean	VP	563	10	**1.8**
Carbaryl	7 Citrus fruits	FC	786	14	**1.8**
Malathion	1 Strawberry	FB	540	8	**1.5**
Chlorpyrifos	1 Chinese cabbage	VL	135	2	**1.5**
Carbaryl	5 Common beans	VP	528	8	**1.5**
Dimethoate	2 Cabbages, Head	VB	419	5	**1.2**
Dimethoate	1 Tomato	VO	3941	49	**1.2**
Chlorothalonil	5 Winter squash	VC	1497	18	**1.2**
Chlorothalonil	10 Peppers	VO	2323	27	**1.2**
Vinclozolin	1 Pome fruits	FP	726	8	**1.1**
Permethrin	5 Cabbages, Head	VB	179	2	**1.1**
Parathion	0.5 Mandarin	FC	189	2	**1.1**
Chlorothalonil	5 Broccoli	VB	375	4	**1.1**
Permethrin	1 Strawberry	FB	497	5	**1.0**
Endosulfan	1 Pome fruits	FP	1403	14	**1.0**
Chlorothalonil	5 Cucumber	VC	1566	16	**1.0**
Vinclozolin	3 Peppers, Sweet	VO	1418	13	**0.9**
Vinclozolin	5 Lettuce, Head	VL	2479	21	**0.9**
Vinclozolin	5 Raspberries, Red, Black	FB	115	1	**0.9**
Malathion	0.5 Peppers	VO	1298	12	**0.9**
Malathion	1 Celery	VS	436	4	**0.9**
Dimethoate	2 Peach	FS	482	4	**0.8**
Dicofol	5 Grapes	FB	1568	12	**0.8**
Permethrin	1 Brussels sprouts	VB	144	1	**0.7**
Fenvalerate	1 Tomato	VO	3144	21	**0.7**
Endosulfan	0.5 Cauliflower	VB	290	2	**0.7**
Dicofol	1 Peppers	VO	1418	10	**0.7**
Vinclozolin	5 Grapes	FB	1553	9	**0.6**
Dimethoate	1 Apple	FP	1098	6	**0.6**
Chlorothalonil	1 Carrot	VR	333	2	**0.6**
Carbaryl	2 Carrot	VR	167	1	**0.6**
Acephate	5 Brussels sprouts	VB	159	1	**0.6**
Permethrin	0.5 Citrus fruits	FC	602	3	**0.5**
Malathion	0.5 Egg plant	VO	423	2	**0.5**
Endosulfan	0.5 Broccoli	VB	383	2	**0.5**
Dimethoate	1 Strawberry	FB	649	3	**0.5**
Dimethoate	2 Cauliflower	VB	385	2	**0.5**
Chlorothalonil	1 Peach	FS	184	1	**0.5**
Carbaryl	5 Tomato	VO	3116	14	**0.5**
Acephate	5 Tomato	VO	3768	17	**0.5**
Malathion	3 Tomato	VO	3421	13	**0.4**
Chlorpyrifos	0.5 Carrot	VR	284	1	**0.4**
Vinclozolin	1 Cucumber	VC	1357	4	**0.3**
Malathion	2 Apple	FP	616	2	**0.3**
Malathion	8 Cabbages, Head	VB	343	1	**0.3**
Malathion	8 Lettuce, Head	VL	2630	8	**0.3**
Fenvalerate	2 Broccoli	VB	315	1	**0.3**
Fenvalerate	2 Celery	VS	362	1	**0.3**

Pesticide	Codex MRL (or proposed MRL) and commodity	Grp†	Number of samples tested	with residues	% samples with residues
Fenitrothion	0.5 Grapes	FB	367	1	**0.3**
Dicofol	1 Tomato	VO	3606	10	**0.3**
Chlorpyrifos	1 Grapes	FB	1568	5	**0.3**
Permethrin	1 Common bean	VP	547	1	**0.2**
Malathion	2 Common bean	VP	550	1	**0.2**
Fenvalerate	2 Pome fruits	FP	593	1	**0.2**
Fenitrothion	0.5 Apple	FP	608	1	**0.2**
Endosulfan	1 Grapes	FB	1543	3	**0.2**
Cypermethrin	2 Citrus fruits	FC	602	1	**0.2**
Carbaryl	10 Leafy vegetables	VL	2233	5	**0.2**
Acephate	5 Citrus fruits	FC	1014	2	**0.2**
Permethrin	2 Grapes	FB	1409	2	**0.1**
Fenvalerate	1 Berries and other small fruits	FB	2124	2	**0.1**
Fenvalerate	2 Lettuce, Head	VL	2357	2	**0.1**
Fenitrothion	0.5 Tomato	VO	3508	2	**0.1**
Cypermethrin	0.5 Tomato	VO	3241	3	**0.1**
Cypermethrin	0.5 Berries and other small fruits	FB	2126	3	**0.1**
Chlorothalonil	0.5 Grapes	FB	1485	2	**0.1**
Carbaryl	5 Peas	VP	817	1	**0.1**
Carbaryl	3 Melons	VC	843	1	**0.1**
Vinclozolin	1 Gherkin	VC	118	0	**0.0**
Vinclozolin	1 Melons	VC	865	0	**0.0**
Vinclozolin	0.1 Potato	VR	205	0	**0.0**
Vinclozolin	2 Common bean	VP	547	0	**0.0**
Vinclozolin	1 Cauliflower	VB	286	0	**0.0**
Vinclozolin	1 Cabbages, Head	VB	179	0	**0.0**
Permethrin	1 Raspberries	FB	115	0	**0.0**
Permethrin	2 Pome fruits	FP	634	0	**0.0**
Permethrin	2 Stone fruits	FS	187	0	**0.0**
Permethrin	1 Egg plant	VO	415	0	**0.0**
Permethrin	0.5 Winter squash	VC	1575	0	**0.0**
Permethrin	2 Broccoli	VB	375	0	**0.0**
Permethrin	0.5 Cauliflower	VB	286	0	**0.0**
Permethrin	0.5 Gherkin	VC	118	0	**0.0**
Permethrin	0.5 Cucumber	VC	1381	0	**0.0**
Malathion	8 Grapes	FB	1581	0	**0.0**
Malathion	0.5 Pear	FP	168	0	**0.0**
Malathion	8 Raspberries, Red, Black	FB	115	0	**0.0**
Malathion	5 Broccoli	VB	390	0	**0.0**
Malathion	0.5 Cauliflower	VB	317	0	**0.0**
Malathion	0.5 Root and tuber vegetables	VR	870	0	**0.0**
Fenvalerate	0.5 Winter squash	VC	1575	0	**0.0**
Fenvalerate	2 Kiwifruit	FI	127	0	**0.0**
Fenvalerate	0.5 Watermelon	VC	462	0	**0.0**
Fenvalerate	2 Citrus fruits	FC	533	0	**0.0**
Fenvalerate	3 Cabbages, Head	VB	164	0	**0.0**
Fenvalerate	2 Brussels sprouts	VB	144	0	**0.0**
Fenvalerate	2 Cauliflower	VB	286	0	**0.0**
Fenvalerate	0.5 Peppers	VO	1157	0	**0.0**
Fenvalerate	1 Beans, except ...	VP	521	0	**0.0**
Fenitrothion	1 Peach	FS	369	0	**0.0**
Fenitrothion	0.5 Peas	VP	406	0	**0.0**
Fenitrothion	0.5 Lettuce, Head	VL	2608	0	**0.0**
Fenitrothion	0.5 Strawberry	FB	487	0	**0.0**
Fenitrothion	0.5 Cabbages, Head	VB	300	0	**0.0**
Fenitrothion	0.5 Pear	FP	168	0	**0.0**
Endosulfan	0.2 Carrot	VR	132	0	**0.0**
Endosulfan	0.5 Oranges, Sweet, Sour	FC	233	0	**0.0**
Endosulfan	0.2 Potato	VR	274	0	**0.0**
Dimethoate	1 Celery	VS	411	0	**0.0**
Dimethoate	2 Broccoli	VB	390	0	**0.0**

Pesticide	Codex MRL (or proposed MRL) and commodity	Grp†	Number of samples tested	with residues	% samples with residues
Dimethoate	1 Pear	FP	344	0	**0.0**
Dimethoate	1 Carrot	VR	605	0	**0.0**
Dicofol	0.5 Cucumber	VC	1315	0	**0.0**
Dicofol	2 Common bean	VP	537	0	**0.0**
Deltamethrin	0.1 Pome fruits	FP	122	0	**0.0**
Deltamethrin	0.5 Leafy vegetables	VL	2595	0	**0.0**
Cypermethrin	2 Spinach	VL	176	0	**0.0**
Cypermethrin	0.5 Peppers	VO	1157	0	**0.0**
Cypermethrin	2 Lettuce, Head	VL	2446	0	**0.0**
Cypermethrin	2 Peach	FS	103	0	**0.0**
Cypermethrin	1 Brassica vegetables	VB	1022	0	**0.0**
Cypermethrin	2 Pome fruits	FP	633	0	**0.0**
Cypermethrin	0.5 Common bean	VP	547	0	**0.0**
Chlorpyrifos	0.5 Pear	FP	161	0	**0.0**
Chlorothalonil	5 Cabbages	VB	255	0	**0.0**
Chlorothalonil	1 Cauliflower	VB	348	0	**0.0**
Chlorothalonil	5 Brussels sprouts	VB	144	0	**0.0**
Chlorothalonil	5 Citrus	FC	842	0	**0.0**
Carbaryl	5 Cabbages, Head	VB	179	0	**0.0**
Carbaryl	10 Kiwifruit	FI	127	0	**0.0**
Carbaryl	5 Egg plant	VO	415	0	**0.0**
Carbaryl	2 Radish	VR	184	0	**0.0**
Carbaryl	3 Winter squash	VC	1552	0	**0.0**
Carbaryl	3 Cucumber	VC	1270	0	**0.0**
Benomyl/carbendazim	3 Potato	VR	244	0	**0.0**
Benomyl/carbendazim	5 Lettuce, head	VL	132	0	**0.0**
Acephate	5 Cauliflower	VB	139	0	**0.0**
Acephate	5 Cabbages, Head	VB	273	0	**0.0**

† Codes for commodity groups.

F	Fruits	V	Vegetables
FB	Berries and other small fruits	VB	Brassica vegetables, head cabbages
FC	Citrus fruits	VC	Fruiting vegetables, cucurbits
FI	Assorted tropical and sub-tropical fruits - inedible peel	VL	Leafy vegetables (including Brassica leafy vegetables)
FP	Pome fruits	VO	Fruiting vegetables, other than cucurbits
FS	Stone fruits	VP	Legume vegetables
GC	Cereal grains	VR	Root and tuber vegetables
		VS	Stalk and stem vegetables

TABLE 6. Cases from Table 5 distributed according to commodity group.

	Number of cases classified according to percentage of samples with detectable residues.					
	0%	**0-1%**	**1-5%**	**5-20%**	**20-100%**	**TOTAL**
F			1			1
FB Berry	4	11	6	1	1	23
FC Citrus	3	3	9	1		16
FI Tropical	2		1		2	5
FP Pome	7	5	4	2		18
FS Stone	3	2	2	1		8

	Number of cases classified according to percentage of samples with detectable residues.					
	0%	**0-1%**	**1-5%**	**5-20%**	**20-100%**	**TOTAL**
Fruits TOTAL	19	21	23	5	3	71
V				1		1
VB Brassica	18	7	6			31
VC Cucurbit	10	2	3	3	1	19
VL Leafy	5	4	2	7	2	20
VO Fruiting	4	11	7	3	3	28
VP Legume	5	3	4	3		15
VR Root	7	3	1			11
VS Stalk	1	2	1	2	1	7
Veg TOTAL	50	32	24	19	7	132
GC Cereal			1	1	3	5
Cereal TOTAL	0	0	1	1	3	5
TOTAL	69	53	48	25	13	208

TABLE 7. Cases from Table 5 distributed according to pesticide.

	Number of cases classified according to percentage of samples with detectable residues.					
	0%	**0-1%**	**1-5%**	**5-20%**	**20-100%**	**TOTAL**
Carbaryl	6	5	6	1	2	20
CARBAMATE	6	5	6	1	2	20
Benomyl/ carbendazim	2		2	1		5
Chlorothalonil	4	3	6	2	1	16
Dithiocarbamates			3	4	1	8
Vinclozolin	6	5	2		2	15
FUNGICIDES	12	8	13	7	4	44
Acephate	2	3	1	1		7
Chlorpyrifos	1	2	2		3	8
Dimethoate	4	4	7	5		20
Fenitrothion	6	3	1		1	11

	Number of cases classified according to percentage of samples with detectable residues.					
	0%	0-1%	1-5%	5-20%	20-100%	TOTAL
Malathion	6	8	5			19
Parathion			4			4
ORGANOPHOSPHORUS	19	20	20	6	4	69
Cypermethrin	7	3				10
Deltamethrin	2					2
Fenvalerate	9	6				15
Permethrin	9	4	4	4		21
PYRETHROIDS	27	13	4	4	0	48
Dicofol	2	3	1	2		8
Endosulfan	3	4	4	5	3	19
ORGANOCHLORINE	5	7	5	7	3	27
TOTAL	69	53	48	25	13	208

4.3 Reporting of monitoring data

Information for residue monitoring is valuable, particularly for re-evaluation of older compounds. The data can provide an indication of the incidence of residues in commodities and the percentage of the crop treated.

It is often difficult to decipher monitoring data because vital information is lacking or summarised in such a way as to be obscured. Sometimes reports do not include the null results, ie. the results for pesticides which were determined by the analytical methods employed but which were not detected above the validated limit of quantitation in the monitoring program.

The following information should be included in residue monitoring reports:

- ❑ country
- ❑ pesticide (and residue definition)
- ❑ year
- ❑ commodity (Codex commodity description if possible)
- ❑ Codex or national MRL
- ❑ limit of quantitation or limit of reporting
- ❑ domestic, import or export
- ❑ number of samples analysed
- ❑ residues, or summarised residue data
- ❑ analytical methods (or literature references)
- ❑ validation data

- ❑ basis for residue expression if other than whole commodity fresh weight
- ❑ random monitoring and targeted sampling kept separate
- ❑ protocol for sampling a lot or consignment (or reference to Codex protocol)

Residue monitoring data are often too voluminous to be able to report individual data. It is possible to summarise data for each pesticide in a simple and standard format, such as the following table, which will allow comparison with other data or combination with data from other reports.

Country: .... Residue definition: ....

Year	Commodity	Codex or national MRL mg/kg	Limit of reporting mg/kg	Number of samples analysed	Number of residues detected	Number of residues >MRL	Number of samples in residue range (mg/kg)										
							≤0.005	>0.005 ≤0.01	>0.01 ≤0.02	>0.02 ≤0.05	>0.05 ≤0.1	>0.1 ≤0.2	>0.2 ≤0.5	>0.5 ≤1	>1 ≤2	>2 ≤5	>5 ≤10

5. EXAMPLE OF DATA EVALUATION - DITHIOCARBAMATES ON APPLES

5.1 Supervised trials

Supervised trials with mancozeb[36] and metiram[37] on apples were reviewed by the JMPR in 1993 and 1995 and detailed residue summaries are included in those monographs.

Those apple trials were selected where the experimental conditions were close to the registered conditions of use (application rate or spray concentration, number of applications and pre-harvest interval, PHI) in the country of the trials or of a neighbouring country with similar climate and cultural practices. One data point was recorded from each selected trial. Residue data for both mancozeb and metiram are recorded as dithiocarbamate residues and expressed as mg CS_2 per kg.

TABLE 8. Dithiocarbamate residues on apples from supervised field residue trials with mancozeb[36] and metiram[37].

	Country, number of trials	**Apples Dithiocarbamate residues (as CS_2), mg/kg**
Mancozeb	Austria, 1	1.4
Mancozeb	Hungary, 1	0.71
Mancozeb	Brazil, 1	1.5
Mancozeb	Japan, 1	0.29
Mancozeb	Germany, 8	0.34, 0.59, 0.63, 0.92, 1.2, 2.6, 3.0, 4.1
Mancozeb	Italy, 10	0.40, 0.64, 0.76, 0.79, 0.82, 0.88, 1.1, 1.3,

	Country, number of trials	Apples Dithiocarbamate residues (as CS_2), mg/kg
		1.5, 1.7
Mancozeb	UK, 2	0.35, 1.5
Metiram	Germany, 32	0.06, 0.07, 0.10, 0.10, 0.12, 0.16, 0.21, 0.24, 0.25, 0.26, 0.29, 0.32, 0.37, 0.37, 0.40, 0.42, 0.43, 0.45, 0.48, 0.57, 0.60, 0.63, 0.67, 0.79, 0.83, 0.89, 0.93, 1.3, 1.4, 1.5, 1.9, 2.0
Metiram	Australia, 2	1.0, 2.1
Metiram	Hungary, 1	0.45
Metiram	Italy, 4	0.15, 0.34, 0.67, 2.6

When the mancozeb and metiram residues (as CS_2) from the 24 and 39 valid trials respectively are assembled in rank order histograms it can be seen that the median values of 0.90 and 0.45 mg/kg lie close to the modal or most likely values. The conclusion is that where mancozeb or metiram are used on apples according to the registered use patterns reflected in the above supervised trials, including harvest at the recommended PHIs, the most likely resulting dithiocarbamate residue is in the vicinity of 0.90 mg/kg for mancozeb and 0.45 mg/kg for metiram.

MANCOZEB

0.29 0.34 0.35 0.40
0.59 0.63 0.64 0.71 0.76 0.79 0.82 0.88 0.92
1.1 1.2 1.3 1.4 1.5 1.5 1.7
2.6 3.0 4.1

METIRAM

0.06 0.07 0.10 0.10
0.12 0.15 0.16
0.21 0.24 0.25 0.26 0.29 0.32 0.34 0.37 0.37 0.40 0.42 0.43 0.45 0.45 0.48
0.57 0.60 0.63 0.67 0.67 0.79 0.83 0.89 0.93 1.0
1.3 1.4 1.5 1.9 2.0
2.1 2.6

5.2 Processing studies

The fate of mancozeb[36] residues during the processing of apples was reviewed by the 1993 JMPR and the processing factors (residue level in processed commodity ÷ residue level in raw commodity) are summarised in Table 9. In some trials apple juice was described as "clarified" or "unclarified", but all are included in the evaluation.

Studies on the fate of metiram[37] residues on apples during the production of apple juice were reviewed by the 1995 JMPR. Each of 42 field trials with apples had been sampled on a number of occasions resulting in 129 cases where dithiocarbamates were detected in apples which were processed. The processing factors for metiram in apple juice are listed in Table 9.

TABLE 9. Processing factors for dithiocarbamate residues during the processing of apples treated in the field with mancozeb[36] and metiram[37]. Numbers in parentheses are number of processing trials.

Raw agricultural commodity	**Processing factor**	**Food commodity**
Mancozeb, apples	0.094 0.14 0.30	apple juice
Mancozeb, apples	0.12 0.29	apple juice unclarified
Mancozeb, apples	<0.026 <0.04	apple juice clarified
Metiram, apples	<0.01 (3) 0.01 <0.02 (10) <0.03 (11) 0.03 (5) <0.04 (5) 0.04 (2) <0.05 (4) 0.05 <0.06 (8) <0.07 (3) 0.07 (2) <0.08 (6) <0.09 (5) 0.09 (2) <0.10 (6) 0.10 <0.11 (9) 0.11 <0.13 (6) <0.14 (5) <0.15 (3) <0.17 (7) <0.18 (4) <0.20 (8) 0.20 <0.25 (2) <0.33 (3) <0.40 (2) <0.67 <1.00 1.75	apple juice

The processing factors for mancozeb, apples → apple juice, in rank order (median underlined, mean 0.14) are: <0.026, <0.04, 0.094, 0.12, 0.14, 0.29 and 0.30. The median processing factor for metiram, apples → apple juice, is 0.09. For metiram the median is used to estimate the likely processing factor because many of the trials produced no detectable residues in the apple juice thus resulting in a processing factor prefixed by a "less than" sign. (The production of ethylene thiourea or ETU during processing is a separate issue and is not dealt with in this exercise. Intake estimates for ETU should be made separately).

5.3 Residue level for chronic intake estimation

Mancozeb on apples, STMR	0.90 mg/kg (as CS_2)
Processing factor, apples → apple juice:	0.14
Mancozeb, STMR-P, apple juice	0.90 × 0.14 = 0.126 mg/kg (as CS_2)
Metiram on apples, STMR	0.45 mg/kg (as CS_2)
Processing factor, apples → apple juice:	0.09
Metiram, STMR-P, apple juice	0.45 × 0.09 = 0.0405 mg/kg (as CS_2)

The residues need molecular weight adjustment because they are expressed in terms of CS_2 and the ADIs are in terms of parent compounds. Mancozeb = CS_2 × 1.78. Metiram = CS_2 × 2.09.

In Table 5 dithiocarbamate residues are recorded as being detected in 226 of 1135 pome fruit monitoring samples, which is an incidence of 19.9% residue detection. In the absence of contrary information this can be used as an indicator of percentage of crop treated.

Pesticide	Commodity	Residue, mg/kg		
		STMR or STMR-P (as CS_2)	STMR or STMR-P (as parent)	Residue (as parent) adjusted for % crop treated (×0.199)
Mancozeb	apples	0.90	1.60	0.32
Mancozeb	apple juice	0.126	0.224	0.045
Metiram	apples	0.45	0.94	0.19
Metiram	apple juice	0.0405	0.085	0.017

For the purposes of chronic dietary intake estimates these residue level estimates should be combined with apple and apple juice consumption data for various populations. The chronic dietary intake estimates for other food commodities where the pesticide has MRLs should be similarly derived and then added for comparison with the ADI.

Intake estimates for each dithiocarbamate for comparison with the individual ADIs can be made separately by the methodology because the STMRs are based on the supervised trials for individual compounds.

5.4 Residue levels for acute intake estimation

The maximum residues in apples in the supervised trials within the registered use patterns were 4.1 mg/kg (as CS_2) for mancozeb and 2.6 mg/kg (as CS_2) for metiram. These values are derived from composite samples. In the absence of residue data on individual apples assumption of a residue level at the MRL is a reasonable starting point. The recommended Codex MRL for dithiocarbamates on pome fruit is 5 mg/kg, equivalent to 8.9 mg/kg as mancozeb or 10.5 mg/kg as metiram.

These levels should be combined with dietary consumption data for apples as meal sized portions to provide estimates of acute intake.

The estimates of acute intake should then be compared with acute reference doses for mancozeb and metiram derived from their toxicology.

6. CONCLUSIONS

We can estimate more realistic pesticide residue levels in diets by better use of existing data.

In particular, we can obtain a median value from a set of supervised trials which represents the likely residue in a food if the pesticide is used at the maximum registered conditions. We can combine this value with processing factors to obtain likely levels in processed and prepared food commodities. These levels are good starting points in estimation of chronic intake.

We can use monitoring data in some cases to estimate percentage of crop treated.

We can use the maximum residues likely to occur in the edible portion for estimation of acute intake. We can usually obtain these values directly from supervised trials, but in some cases we will need additional residue data on individual pieces of fruit and vegetables.

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