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SETTING ACCEPTANCE LEVELS OF CONTAMINANTS

A. L. BLACK

Summary

Acceptable levels of chemical contaminants in food are best established through joint consideration of two distinct sets of data: toxicology data on the contaminant which usually establishes a threshold for its toxicity and analytical data on the level of contaminant that occurs in the foodstuff or food. Reconciliation of these two independent data sets, together with the use of an appropriately conservative safety factor, provides a basis for the estimation of a level of contamination acceptable from a food safety perspective. Monitoring of the food supply provides information on the degree of compliance and, indirectly, the appropriateness of the contamination levels so set. Monitoring data can also be used to establish pragmatic levels of contamination in those situations where toxicological data are inadequate.

I. INTRODUCTION

Food contaminants are substances not intended to be present in food. Although often present in only low amounts, particular concerns arise for the presence of many contaminants in food because of their toxicity.

Food contaminants may result from some prior process or some unavoidable source of contamination. In most cases they have no technological function in the food itself. Some arise from food processing, such as residues of extraction, solvents used for extracting fats and oils or decaffeination or coffee. Residues from the use of packaging materials may also occur in food. Xenobiotics such as pesticides or veterinary drugs can contaminate food as can heavy metals such as arsenic, cadmium or lead.

Our Food Law imposes legal limits on the amounts of contaminants occurring in food or raw agricultural produce. Whilst the name of the limit varies with the type of contaminant (Maximum Permitted Concentrations for heavy metals, plastic monomers, PCBs, aflatoxins etc.; Maximum Residue Limits for agricultural and veterinary chemicals or Extraneous Residue Limits for environmental pesticide contaminants), the purpose of the limit is in each case the same.

In the interests of public health, such a limit is set as low as is consistent with proper use of the chemical in agriculture and/or food handling and processing. Such legal limits are intended to provide protection for consumers by determining whether or not a given food item is suitable for sale. The limits are not intended to determine whether or not a given food item is safe to eat. Adherence to the legal limits ensures not only overall food safety but also that the general population is not unnecessarily exposed to food contaminants.

Chairman, Pesticides and Agricultural Chemicals (Standing) Committee, Department of Health, Housing and Community Services, GPO Box 9848, Canberra ACT 2601

II. DIETARY EXPOSURE LIMITS

The process of establishing limits for contaminants in foodstuffs is essentially the same for all chemical contaminants:

1. Estimation of acceptable dietary intake from toxicological data
2. Estimation of level of contaminant in food
3. Reconciliation of anticipated dietary exposure with the acceptable dietary intake.

(a) Acceptable Daily Intake (ADI)

The "Acceptable Daily Intake" is the most common estimate of acceptable dietary exposure. First introduced by the FAO/WHO Joint Expert Committee on Food Additives (JECFA) in 1958, the concept of the ADI has become the keystone in evaluation of the safety of chemical contaminants in food. The ADI is defined as:

"An estimate (by JECFA) of the amount of a food additive, expressed on a bodyweight basis, that can be ingested daily over a lifetime without appreciable health risk" (WHO, 1987).

The ADI is expressed as a range, from 0 to an upper limit, defining the zone of acceptability of the substance. Emphasising that the ADI is an upper limit, encourages lower levels of contamination. It is usually established on the basis of the no-observed-effect level (NOEL) or [sometimes a no-observed-adverse-effect level (NOAEL)] established in toxicological studies in animals. Data from appropriate studies in human volunteers is sometimes utilised. In estimating the ADI, a "safety factor" is applied to the NOEL to provide a conservative margin of safety to the ADI.

The magnitude of the safety factor indicates the "robustness" of the experimental data as well as the hazard potential. Factors such as experimental design, adequacy of experimentation and biological relevance need to be considered. In practice, most NOELs are based upon long-term feeding or multigeneration studies in rodents. If the relevant toxicological endpoint is obtained from human experimentation, the safety factor can be reduced.

The particular value of human data for ADI estimation has been stressed by the FAO/WHO Joint Meeting on Pesticide Residues on several occasions. Relevant human data, whether derived from accidental, occupational or experimental exposure can provide fundamental information to overall toxicological evaluation. It can provide information on human metabolism and excretion of xenobiotics, identify target organs and identify unexpected toxicity and its reversibility. Data from studies from human volunteers can provide a quantitative basis for comparison with human and animal dose-response relationships. In vitro studies with animal and human tissues can provide useful comparative information about mechanisms of toxicity e.g. comparison of inhibition of erythrocyte acetylcholinesterase. Due attention to ethical issues is, of course, necessary in the generation of human data (WHO, 1990).

(b) Other Estimates of Dietary Exposure

Whilst an ADI may be estimated for intentional food additives, subject to established procedures for their safety assessment, there remains the need for estimation of other exposure endpoints, based on public health considerations. These need to be considered in the context in which they are developed and applied.

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In some cases it is not possible to estimate a NOEL for a food contaminant, so that an ADI cannot be set. Often this situation results from unavailability of adequate toxicological data but it may also occur due to particular forms of toxicity. Contaminants which can produce irreversible toxicity, such as carcinogens, teratogens or certain immunotoxicants (e.g. sensitizers) warrant careful consideration. Whilst it is generally agreed that such substances should not be permitted as food additives, it is not always practicable to exclude them as contaminants. For example, arsenic, an established human carcinogen, occurs naturally in seafood. Its presence is tolerated by appropriately conservative limits.

(c) Provisional Tolerable Weekly Intake (PTWI)

The "Provisional Tolerable Weekly Intake" is the estimate introduced by JECFA for substances such as heavy metals which have no technological purpose in food production. The term PTWI is applied to contaminants with cumulative properties. Its value represents permissible human weekly exposure to those contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious food.

The term "provisional" expresses the tentative nature of the evaluation in view of the paucity of reliable data on the consequences of human exposure. "Tolerable" signifies permissibility rather than acceptability (WHO, 1987).

(d) Provisional Maximum Tolerable Daily Intake (PMTDI)

Another JECFA term, the "Provisional Maximum Tolerable Daily Intake" has been established for food contaminants that are not known to accumulate in the body, such as arsenic and tin. Its value represents the permissible human exposure as a result of the natural occurrence of the substances in food and drinking water (WHO, 1987).

The above estimates of acceptable dietary exposure were developed to meet particular circumstances. Their estimation is a fundamental step in setting appropriate regulatory limits for food contaminants. This requires not only due interpretation of scientific data and their biological relevance but also proper appreciation of the technology available to limit such exposures.

III. PESTICIDE RESIDUES

Unlike other food contaminants, pesticide residues in food are to some degree intentional. It is recognised that they can occur in agricultural commodities as a result of their use in agriculture. The overriding philosophy in estimating acceptable limits for their presence in food is that their occurrence should be limited to genuine agricultural need and no more. For this reason, the limits for agricultural pesticides are related to a defined agricultural practice.

(a) Good Agricultural Practice (GAP)

The amount of a residue of an agricultural chemical that occurs in a food commodity is determined by the pattern of use of that chemical. Good Agricultural Practice, defined below, implies that effective pest control can be achieved without yielding more residual contamination than necessary. GAP requires adherence to label directions on matters such as application rates

and withholding periods. Because pests and geographic conditions vary in different regions and between countries, GAPs vary accordingly.

"Good Agricultural Practice in the use of pesticides includes the nationally authorised safe uses of pesticides under conditions necessary for effective and reliable pest control. It encompasses a range of levels of pesticide applications up to the highest authorised use, applied in a manner which leaves a residue which is the smallest amount practicable."

"Authorised safe uses are determined at the national level and include nationally registered or recommended uses, which take into account public and occupational health and environmental safety considerations."

"Actual conditions include any stage in the production, storage, transport, distribution and processing of food commodities and animal feed."(CCPR 1989)

(b) Maximum Residue Limit (MRL)

The Maximum Residue Limit is the maximum residue that should occur when the agricultural chemical is used according to GAP. It is defined as:

"Maximum Residue Limit is the maximum concentration of a pesticide residue (as expressed as mg/kg) legally permitted in or on food commodities and animal feeds. MRLs are based on GAP and foods derived from commodities that comply with the respective MRLs are intended to be toxicological acceptable."

Maximum Residue Limits are estimated from residue data obtained from supervised trials designed to produce reliable data on the residues that would occur under approved agricultural practice. The trials are conducted so as to produce the highest residue (e.g. by application at the maximum registered label rate). In addition, residue data from application at twice the maximum rate is also obtained so that the influence of misuse or overspraying on residues can be assessed.

Residue dissipation is studied by serial analysis of the crop or agricultural commodity. Such data can be utilised to establish withholding periods i.e. the minimum time that should elapse between application of the chemical and harvesting of the crop or marketing of the commodity.

Because of the variety of factors that can influence the occurrence of residues at what are usually very low concentrations, great care must be taken in the design and execution of residue trials. Factors which can influence the residue should be identified and controlled as far as possible. Sampling procedure, sample storage and analysis are particularly important.

In some cases, it is necessary to consider the fate of the residue during food processing in setting MRLs. For example, the distribution of grain protectants during milling of wheat must be determined since it is known that the bran and the germ can contain higher concentrations of the residue than the flour. This segregation of the residue requires the setting of separate levels for these milled products.

Table 1 MRLs for Methoprene

Commodity	MRL (mg/kg)
wheat	2
wheat bran, unprocessed	5
wheat germ	10

Unless separate MRLs are set for a derived commodity, it is generally taken that the MRL for the raw agricultural commodity applies to the "downstream" product. For example, the MRL for flour would be that for wheat.

(c) Extraneous Residue Limit (ERL)

"Extraneous Residue Limit is established when the occurrence of a contaminant does not arise from the approved use of an agricultural chemical (e.g. DDT contamination of fish).

Since the occurrence of such contamination cannot be related to any approved use, ERLs are estimated from analytical monitoring data. ERLs are set as low as practicable. Subsequent monitoring results should be compared with the established limits. These limits should be revised as the level of environmental contamination declines.

(d) Residues at the Limit of Determination

In setting MRLs it is often found that the quantity of the residue actually present is so small as to be not only toxicological insignificant but also analytically unquantifiable without resort to ultrasensitive analytical techniques. The need for a regulatory limit in such situations is met by use of the limit of determination of a contemporary analytical method suitable for enforcement purposes. MRLs set at the limit of determination are, by convention, identified with an asterisk. It should be appreciated that a commodity with an MRL so identified does not necessarily imply it is residue-free, but rather, the occurrence of any residue at or below that level is without regulatory significance.

For example, hexazinone, used on pineapples or sugar cane, could find its way into animal food commodities if pineapple trash and cane were fed to animals. Table 2 indicates that, if hexazinone is used according to GAP, significant residues will not occur in meat, milk or eggs of animals fed with the trash of treated pineapples or grazed on sugar cane.

Table 2 Maximum Residue Limits for Hexazinone

Commodity	MRL (mg/kg)
eggs	*0.05
meat	*0.1
milks	*0.05
milk products	*0.05
pineapple	1
sugar cane	*0.1

(e) Analytical Considerations

The analysis of food contaminants present in the sub-parts per million range is complex and subject to an all-too-often error. As contamination levels fall, the difficulty of estimating the actual concentration rises sharply. This situation has an important bearing upon the setting of a regulatory limit. Interlaboratory studies have shown that there are significant, minimal errors to be expected from conventional analyses at the residue level.

Table 3 Analytical Errors at the Residue Level*

Concentration (mg/kg)	Error %**
0.001	45
0.01	32
0.1	23
1.0	16
10	11
100	8

* JMPR (1988)
** Coefficient of Variation

Table 3 shows that the percentage error in residue analysis is not constant but increases with decreasing concentration. Values below 0.01 mg/kg approach the limit of determination of pesticides in food. Levels of 10 mg/kg and above have greater accuracy and hence improved statistical value. As residue values in the range of 0.01 and 10 mg/kg are those most commonly encountered, such residue data needs to interpreted with due caution.

IV. CONCLUSIONS

The estimation of acceptable levels of food contamination requires concurrent evaluation of relevant toxicological and analytical data together with an appreciation of contemporary food production practice and processing technology. The process is scientifically rigourous and onerous. Monitoring of levels of food contamination is required to ensure overall food safety and to provide feedback on the appropriateness of established levels for food contaminants.

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