HOW RESIDUES ARE DETERMINED AND THEIR SIGNIFICANCE

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Summary

The paper describes the methods employed to determine and fix safe residues in foodstuffs; the present and possible future sources of residues in New Zealand and the means by which these are kept to acceptable levels; and the importance of residues in international trade and the approaches being made towards reaching international agreement on use of pesticides.

THE TERM "residue" has taken on a somewhat increasing and sinister quality when used in conjunction with agricultural chemicals and foodstuffs. It refers to the remains of the chemical that persist in or on the food material after treatment with the chemical and until the food reaches the consumers. The menace arises from the thought that the consumers may be exposed to risk through eating the residue of agricultural chemical along with the food.

Awareness of this risk is a comparatively recent development. It arises partly from the greatly increased use of a wider range of agricultural chemicals, some of which are notably toxic, and partly from a greater appreciation of the dangers that may arise to humans from continued ingestion of traces of poison over long periods.

An impression of the rate of increase in use of chemicals may be gained from reports from the United States of America. In that country by 1960 the total annual expenditure on agricultural chemicals was of the order of \$500 million (Ferguson, 1960). Before the discovery of DDT in 1942 there were virtually no synthetic organic agricultural chemicals used, but by 1956, 200 different chemicals were employed in total amount of approximately 250,000 tons annually (Hayes, 1960).

In New Zealand a similar growth is taking place. In 1957, about 0.8% of the total superphosphate manufactured had agricultural chemicals added. This percentage was made up of 7,000 tons of DDT-superphosphate and 400 tons of superphosphate containing weedkillers, mainly 2,4-D. By 1961 these figures had increased to 110,000 tons DDT-superphosphate and 10,500 tons weedkiller-superphosphate or approximately 10% of all superphosphate manufactured and used as topdressing.

The greater appreciation of the possibility of harm resulting from residues is part of a fresh consideration by public health authorities of the dangers of poisoning from prolonged exposure to trace amounts of poisons. The outcome is the "statistical" approach to health and disease problems affecting the community as distinct from the individual. Examples of this approach, to quote only two, are work done to show the influence of cigarette smoking on the incidence of lung cancer, and the consideration being given to possible health hazards from radioactive "fall-out". Any postulated harm from traces of agricultural chemical residues on foods would, like the two cases quoted, be apparent only over a long term and through continued exposure to minute quantities.

The most acceptable view on the residue problem is that no residues should be present on food materials eaten by man. This

view, however, is an academic one and gives way to the understanding that without the use of agricultural chemicals there would be a very considerable drop in the volume of food produced. In very general terms, about one-third of the present food production could be lost if agricultural chemicals were not available.

The problem, then, becomes one of ensuring that residues do not exceed limits that are safe as far as existing knowledge can determine. Various methods are adopted in different countries towards this end. These methods may depend upon exercising control over the agricultural chemicals that may be used and restricting the use to safe compounds; they may achieve control by defining intervals of time that may occur between application of the chemical and harvest; or they may lay down maximum levels of residue that can appear in the product offered for sale.

A decision on the acceptable level of the residue must be made for any method to be applied logically, and this is by no means a simple decision. The first consideration is the toxicology of the chemical in question. Then consideration must be given to the fate of the chemical after application—for example, is it labile and easily destroyed or does the opposite hold, does it remain on the surface to which it is applied or is it absorbed. Finally, the nature of the foodstuff must also be taken into account with due regard to such features as how it is prepared for eating and what proportion it usually occupies in the diet.

Some background knowledge of toxicology may be obtained from published reports of acute toxicity tests on animals or of accidental poisoning in humans. The important information on chronic poisoning effects cannot be got from human experiments but must be derived from planned experiments on laboratory animals. In the U.S.A. this is obtained from trials carried out on at least two species, usually from feeding tests carried out on dogs through two years and for two to three generations in rats. For each species, three groups are employed, with different levels of the chemical in the diet. Any effect on the health of the test animals is determined by survival and growth rate data, and by examination of tissues taken at autopsy, all compared with control animals on similar diets without the chemical added.

The maximum level regarded as safe for humans is 1/100 of the greatest amount that can be fed to the most susceptible test animal without any demonstrable effect. Thus if 100 p.p.m. of the diet was the maximum that could be fed to dogs without effect, then the foodstuff residue could not exceed 1 p.p.m.

But this is not the final answer. The other factors mentioned earlier must be taken into account in deciding whether this figure of 1 p.p.m. may be fixed for the residue. If the chemical tends to accumulate in the body and if it is likely that other residues of similar kind and action may also be encountered, the residue allowable would be fixed at less. Again, if the foodstuff under consideration is likely to form a considerable part of the diet, the amount of residue acceptable is fixed lower. In cases where the food is the main part of the diet, as is milk for young children, the tolerable limit is usually fixed at zero.

Even these do not exhaust the considerations that are applied in fixing residues. In the U.S.A., for example, there are two important additional factors taken into account. The first of these requires that the residue must be in conformity with use of the chemical in "good agricultural practice" as determined by the United States Department of Agriculture. A residue will not be permitted higher than would occur when the use of the chemical follows good agricultural practice, even though this may be less

than that dictated on grounds of public health. This has the result of debarring unsuitable chemicals and unsuitable uses, and clearly expresses the intention that avoidable contamination is not acceptable. Thus the use of mixed isomers of BHC on animals has disadvantages such as persistent tainting of flesh, which are not shared by the purified gamma isomer. The fixing of the lindane residues as nil and of gamma isomer as 7 p.p.m. in beef fat, allows the use of the latter but not of the former for application to animals.

The second additional requirement is that no substance that is carcinogenic may be added to foods. This has already attracted wide attention as in the cranberry incident in the United States of America in which traces of weedkiller amitrole were found present on some lots of cranberries. Amitrole is classed as being carcinogenic since feeding at comparatively high levels to rats produced cystic thyroid adenomata which were considered to be malignant; no trace of amitrole could therefore be permitted in food. When it became known that traces of this chemical had been found in cranberries from one season's harvest there was such a marked public reaction that there was no sale for any cranberries that year, even in those lots which analyses showed were free from residues. A crop valued at about \$10 million was discarded.

Definite residues are fixed in such a manner in North America and it seems likely that residues expressed similarly in figures might well be fixed in European countries that are part of the European Common Market. If New Zealand wishes to trade with such countries its exports must comply with residue standards.

In considering the residue question in relation to exports New Zealand is presented with a restricted range of materials but with a by no means restricted list of problems. Most New Zealand exports are derived from animals and those in which residues could occur are meat and dairy products. Apples and pears are the only other commodities that need be considered. The two main possible sources of contamination of animal products are insecticides applied to pastures and to soil to control pasture parasites like grass grub (*Costelytra* spp.) and treatment used directly on animals against external or internal parasites or for other purposes. Fruit could carry residues from spray programmes.

Some idea of the nature of the problems likely to be met in insecticide usage may be gathered from the following.

In the control of grass grub some 110,000 tons of DDT-superphosphate were used in 1960-61 and it is expected that the use in the next year will be 160,000 tons, or enough to topdress about 1½ million acres. If topdressing with DDT preparations is carried out after the pasture has been grazed hard down, if the operation is performed in dry conditions, and if stock are kept off until regrowth of pasture has sufficiently diluted the small contamination that is inevitable even on hard grazed pasture, then the use of DDT entails no risk of the occurrence of residues in milk or body fat of grazing animals (McDowall *et al.*, 1955). On the other hand, the presence of residues in such materials is inevitable if all the precautions mentioned are not faithfully observed (D. L. Harrison and I. J. Cunningham, unpublished results). Withholding stock for six weeks is suitable for dairy cattle, to comply with a nil tolerance in dairy products, and four weeks for meat animals, for DDT in fat of such animals to fall below the tolerance of 7 p.p.m. provided good grass growth occurs in these periods. If good pasture growth does not occur, the DDT content of the pasture is not adequately diluted and residues could occur. Use of prills and granulated materials, rather than dust, gives less contamination of pasture and shorter withholding periods might eventually be possible.

In the treatment of animals against external parasites it has been found (D. L. Harrison, pers. comm.) that the use of chlorinated hydrocarbons will result in residues in the fat which vary with concentration of active ingredients in the dip, with the body condition of the animals, and with the length of wool. These residues may persist for considerable periods. For example, a plunge dip containing 0.05% dieldrin may leave in sheep detectable residues in the fat for periods of as long as 36 weeks after treatment. On the other hand, organo-phosphate dipping fluids at strengths approved in New Zealand do not cause any residue problem since these compounds are destroyed soon after they enter the animal's body (D. L. Harrison, L. K. Whitten and P. E. Maskill, pers. comm.).

Two methods are available to keep residues within safe limits—legislative control over the use of chemicals, and education of the users.

The Agricultural Chemicals Act provides legislative power to require the safe use of insecticides. Regulations now in force lay down in detail how DDT may be used, and prohibit the use of other insecticides on pasture land except with a permit and under supervision, for special purposes (Anon., 1961a).

Control over the chemicals which may be used on animals and the manner of their use is exercised under the Stock Remedies Act. Recently, as an emergency measure, provision had to be made under the Agriculture (Emergency Powers) Act for immediate prohibition of dangerous chemicals and for supplies of such prohibited chemicals to be taken over from farms and commercial firms (Anon., 1961b).

Such legislative approaches, in either the plant or animal field, are only a part of the effort needed to keep residues in export produce within limits acceptable to overseas customers. The most important requirement is that manufacturers, commercial organizations and farmers understand fully the reasons for restriction in the use of some agricultural chemicals, the dangers to export markets that would arise from improper use, and the alternative agricultural chemicals available. Even one case of deliberate or accidental use of a residue-producing chemical could lead to a serious incident that would prejudice New Zealand's whole trade. A major effort is therefore being made by the Department of Agriculture to inform farmers and commercial interests fully on the residue problem so that their actions will be guided by full knowledge.

In addition to education work there is an urgent need for research on many aspects of the use of presently available and new insecticides. At every turn, a sketchy and inadequate knowledge of the insecticides being used is encountered. It is not known what happens to DDT in the soil, nor is it known with any precision what governs its movement in animal tissues, and its storage in animal fat; how long it will persist there and what can be done to promote its excretion or destruction. Answers to these and to many other questions are needed for DDT and for other related insecticides, and similar questions must be answered for new insecticides as they come along. Moreover, much of the research work that has been done has been carried out overseas where conditions may be different from those in New Zealand, and these important aspects must be confirmed in this environment. Studies must also be made of alternative methods of control that avoid the use of insecticides. For example, control of grass grubs by biological parasites or of other insect pests by interference with breeding by use of the sterile male technique must be investigated. Research work is being carried out to the extent of available facilities, but the cover is most inadequate.

The existing insecticides and the uses to which they are put do not represent the only hazard. New insecticides are being developed and chemicals are being employed in new ways. It is therefore necessary to keep close watch to ensure that undesirable residues will not result from the use of new insecticides, new anthelmintics, antibiotic treatments and even from the use of tranquillizers and other treatments that may be given to stock on the way to slaughter.

The problem of residues is one that has wide international implications. The free movement of foodstuffs between nations and the promotion of safe use of agricultural chemicals would be greatly helped by agreement at an international level on safe limits for residues. There is some encouraging movement in this direction accompanying an increasing interest in pesticides in international organizations.

A World Health Organization Expert Committee on Insecticides first met in 1950 and had as its main interests the effectiveness of various insecticides in fields such as malaria control, and on the hazards to those engaged in the manufacture, packaging and use of insecticides.

The question of pesticide residues was referred to in the 1957 and 1960 reports of the joint FAO/WHO Expert Committee on Milk Hygiene, and the subject of pesticide residues in meat was on the agenda of the September, 1961, meeting of the joint FAO/WHO Expert Committee on Meat Hygiene.

The FAO Council considered the question at its June, 1961, meeting. The diversity of approach, in different countries, on the use of pesticides and on the question of residues, led to the Council referring the subject for further attention to the FAO Conference in November, 1961. The Conference took the important step of requesting the Director-General of FAO to establish a Committee on Pesticides in Agriculture which will assist in planning and organizing a conference between member governments in 1962. This will have as its main purpose the formulation of a plan to cover scientific, legislative and regulatory aspects of the use of pesticides and to arrange for the study of specific problems including pesticide residues, occupational hazards, registration, labelling and marketing of pesticides, and insect resistance to pesticides.

New Zealand strongly supports this international action on the grounds that it will promote safe, efficient and informed use of pesticides and reduce barriers to international trade in foodstuffs.

The recognition of the existence of a problem of residues is promoting research in many countries, notably in the United States of America, towards the finding of new chemicals which have maximal lethal effect on the target insect, minimal toxicity to the host and no residue problem. Progress along the line of no residue has already been made with the organo-phosphates and carbamates and it is certain that progress will continue.

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