Chemical Residues in Meat

F.D. Shaw (CSIRO Division of Food Science & Technology)
I.J. Eustace (Australian Meat & Livestock Corporation)

Introduction

Consumer groups in this and other countries are becoming increasingly aware of the occasional presence of trace amounts of agricultural and veterinary chemicals in meat and other foods, and are demanding ‘residue free’ products. Residues in meat and meat products have had a high profile in international trade requirements for many years. There is continuing concern about the potential use of chemical residues as non-tariff trade barriers. Detections of residues present opportunities for importing countries to erect barriers upon technical grounds. Methodology for detection of residues is becoming ever more sensitive and the number of compounds that can be detected in trace quantities is ever increasing so the implications of these possible barriers are greater. As a result much emphasis has been given to monitoring residues in meat by the National Residue Survey (NRS), a multifaceted program to monitor residues in Australia’s agricultural commodities, and by other programs.

Tolerances for residues are defined in terms of maximum residue limits (MRL). The MRL is the maximum concentration of a residue of an agricultural or veterinary chemical which is recognised as acceptable or which is legally permissible in, or on, a food, agricultural commodity or animal feed. For chemicals such as heavy metals which are environmental contaminants, maximum permissible concentrations (MPCs) are established. MRLs and MPCs are usually expressed in mg/kg, and frequently written as parts per million. MRLs are established and given legal status in a particular country from approved use patterns, in that country, of agricultural and veterinary chemicals. Many countries have yet to establish tolerances, particularly for veterinary drugs. Any residue detected may therefore be regarded as a non-compliance.

Testing for Residues – Types of Programs

The National Residue Survey is a national monitoring program that monitors pesticide residues and environmental contaminants in raw food commodities. The survey, which is administered by the Bureau of Resource Sciences, provides an authoritative assessment of the residue status of Australian products, notably meat products. It satisfies the requirements of importing countries for a residue-monitoring program that is managed by the government as one condition for allowing certain products to enter these countries. This is the situation particularly with our meat exports to the European Community, the United States of America and Japan.

Currently about 50,000 samples of meat, dairy products, grains, eggs, honey, fruit and vegetables, and seafoods are analysed each year at a total cost in the vicinity of $6 million. The meat programs alone cost over $4 million. The Commonwealth Government now has a policy of full cost recovery for those government-managed programs of which industries are the main long-term beneficiaries. Legislation enacted in 1992 resulted in imposition of levies to cover the surveys of cattle, sheep, pigs, meat chickens, laying hens, honey, dairy, dried fruits, wheat, certain coarse grains, oilseeds and grain legumes, certain horticultural crops, game meats, horses that are slaughtered for human consumption, and some aquatic animals and related products. The current rate of levy for cattle, for instance, is 18 cents per head; that for sheep is 5 cents; and that for goats is 3 cents.

The NRS is a monitoring program which is based on random sampling to provide unbiased estimates of the prevalence of residues in the population as a whole. Usually the number of samples taken for analysis for a particular residue is set such that if no unacceptable residues are found in those samples, there is a 95%
confidence that the true frequency of unacceptable residues is less than 1%. Testing of produce sampled for the NRS is contracted out to accredited laboratories. Most of the analyses are carried out by the Australian Government Analytical Laboratories (AGAL).

Compliance or surveillance programs are biased to detect residues in suspect stock. Sample selection is based on the knowledge that the particular animal is likely to have been treated shortly prior to slaughter, or to have originated from a property known to be suspect, on the basis of tests on other animals coming from that property. Examples of compliance programs which operate include residue sampling of animals suspected of being diseased or showing some other condition at the time of slaughter, examination of injection-site lesions for residues, and the lot-testing of cattle from properties known to have, or suspected of having, organochlorine residue problems.

Organisations with Responsibility for Chemical Residues Issues

International

International MRLs for pesticides are recommended to a committee of the Codex Alimentarius organisation, the Codex Committee on Pesticide Residues (CCPR), by the FAO/WHO Annual Joint Meeting on Pesticide Residues. CCPR then seeks the adoption of these recommendations by the governments of its member countries. A sister committee, the Codex Committee on Residues of Veterinary Drugs in Food (CCRVDF), was established in 1986 to recommend international MRLs for veterinary drugs in the same way as CCPR does for pesticides. In most countries the development of MRLs for veterinary drugs has lagged behind those for pesticides. Australia is one of the few countries which has made significant progress in the development of MRLs for drugs.

National

AQIS – Within its overall role of providing quarantine and inspection services, the Australian Quarantine and Inspection Service (AQIS) has responsibility for activities with respect to chemical residues. The Food Standards Policy Section undertakes policy reviews and special projects on issues relevant to the maintenance and development of our export markets such as food safety and clean foods. It is the Government’s contact point on international food standards. It liaises with overseas governments and is involved with international organisations such as WHO, FAO, Codex Alimentarius, Organisation Internationale des Epizooties, and General Agreement on Tariffs and Trade. It has played a pivotal role in the management of specific programs including the integrated program for organochlorines, the NARM program for antibacterials and also in education and public relations activities.

SCRAP – One of the important responsibilities of the Standing Committee for Agriculture and Resource Management, comprised of the Commonwealth and State Directors-general for Primary Industries, is animal health. Its Animal Health Committee is responsible for, inter alia, residues issues. The membership of AHC’s Sub-committee for Residues in Animal Products (SCRAP) includes representatives from DPIE, CSIRO, the Australian Agricultural and Veterinary Chemicals Council and State authorities. SREP has the responsibility to consider and make recommendations to AHC on:

a) development and review of surveillance and testing programs for chemicals and contaminants in livestock and livestock products;

b) development and review of integrated action plans to limit the occurrence of these chemicals and contaminants;

c) ability to respond to emergencies arising from detection of residues in livestock products;

d) priorities for research related to residue issues.

Residues of Concern

Cadmium is an environmental contaminant which has been detected in as many as 16% of sheep kidneys (Blackman 1993); however, the NRS showed that the animals affected are generally old ewes, the kidneys from which are rarely used for human consumption. The chemical residues which have created most concern for the Australian export meat industry in recent years have been organochlorines, hormonal growth promotants, ectoparasiticides and antibacterials.

Organochlorines

Australian regulatory authorities, in conjunction with the meat industry, have monitored residues of organochlorines (OCs) in meat since the 1960s. Data from the National Residue Survey (NRS) indicate that, until 1987, the percentage of beef carcasses which exceeded MRLs for organochlorine residues was 0.4%. In May 1987, an additional intensive program of testing beef carcasses was commenced in response to detections in the USA of organochlorine residues in Australian beef. This program was fully funded by the beef industry. The objective of the AQIS-approved Extended Pesticide Residue Testing (EVRT) program was to reduce the national prevalence of carcasses
which exceeded MRLs for organochlorines from 0.4% to 0.2%. During the period of intensive testing until June 1989, over 800,000 cattle from around 137,000 properties were tested (Corrigan & Seneviratna 1990). The testing and associated costs (in excess of $30 million) were met by imposition of a levy on slaughter cattle. The levy continued until 1989.

An integrated action plan was developed to coordinate activities related to the issue. It included the testing program, a ban on the use of DDT, severe restriction on the use of other OCs, recall of existing stocks of OCs, traceback on non-compliant animals to properties, with quarantining of offending properties until they had put appropriate management strategies in place, and the establishment of a national database for residues. The integrated program of education and surveillance testing was very successful in reducing the number of animals sent for slaughter which exceeded the MRLs. By early 1989, the prevalence was around 0.1% according to the NRS and has remained at that level since (Corrigan & Seneviratna 1990; Blackman 1993). The testing component of the program has been discontinued but state authorities will maintain supervision of properties which have had test histories of residue detections exceeding, or near to, MRLs, and which may not be able to be used for livestock production for perhaps many years.

Hormonal Growth Promotants (HGP$s$)

From 1 January 1988, the use of hormonal growth promotants was banned within the European Community, despite indisputable evidence of their ability to improve productivity and a lack of evidence of any harmful effects of their responsible use. As a result of the bans, countries wishing to export meat to the EC from 1989 were required to ensure that animals from which the meat destined for the EC was derived, had never been treated with HGP$s$.

Australia implemented a system of controls that included a verifiable program for monitoring the import and distribution of HGP$s$ in Australia, a declaration by the vendor or his agent to the processor that the stock were eligible for processing for the EC, and monitoring through the NRS. Further refinements were made, but after a visit by EC veterinary inspectors in mid 1991, the EC sought assurances from AQIS that weaknesses in the existing declaration system, relating to a lack of uniformity and the equivocal nature of the wording together with an apparent abuse of the declarations by some vendors, would be rectified.

New measures were introduced from 15 February 1993 to ensure compliance with EC requirements. From that date, anybody wanting to sell cattle as eligible for processing for beef and beef offals for the EC had to produce a vendor declaration stating that the cattle had never been treated with HGP$s$ by the vendor or by the previous owners. This declaration is now required for all transactions including saleyard sales, sales direct to an abattoir, sales on the CALM network, property-to-property sales and stores sales including calf sales. A new declaration is required with every consignment. Cattle sold through a saleyard and intended for immediate or potential processing for the EC market must also be identified by a pink paint mark which has to be applied at the base of the tail before it leaves the property, otherwise they are ineligible for the EC market. In addition, since 15 March 1993, producers who treat any cattle with HGP$s$ are required to identify them by applying a triangular ear-punch mark at the time of implanting the HGP. At the time of purchase of HGP$s$, producers are required to sign a declaration giving details of their tail-tag numbers and agreeing to comply with the requirement for individual identification of treated animals. The system is monitored by state departments of agriculture/primary industries and AQIS.

Authorities hope that changes to the system can be negotiated with the EC which reduce the complexity. These include an annual declaration to replace the current one and identification of individual animals with special tail tags to be supplied to those producers making the annual declaration.

Antibacterials

Antibacterial drugs are used extensively in animals as therapeutic and prophylactic agents. Prompt administration of antibiotics is necessary to return diseased animals to optimum health and to prevent transmission of the diseases to neighbouring animals. This is particularly so in intensive situations such as dairy herds and feedlots. The most commonly used groups of antibiotics are the streptomycins, penicillins, and tetracyclines and sulphonamides (Stephens & Winwood 1988). The latter group is also used prophylactically to enhance feed efficiency and promote growth.

There have been several reports by importing countries of detections of antibiotic residues since the detections in 1986–87 of violative levels of sulphonamide in veal in the USA (Wild 1991). In 1988, Australia was notified of detections of chloramphenicol by US authorities. In November 1990, Japan notified AQIS of detections of unacceptable levels of dihydrostreptomycin and penicillin in lofged beef. In December 1990, the US notified the detection of sulphonamides. In March of 1991, penicillin was detected in Australian beef by Canadian authorities.

These regular detections focussed the attention of the Australian industry and authorities on the issue of antibacterial residues. In 1988, AQIS introduced two
testing programs for antibacterial residues – one for bobby calves and another for individual ‘suspect’ animals.

**Calf Testing Program**

This program for antibacterial residue testing of calves at export abattoirs, which was initiated following sulphonamide detections in veal exported to the US, is a quality-control program where the objective, initially, was to screen out from export all carcasses which were positive to a microbial inhibition test (MIT) screen of urine, thus giving assurance to the processors and regulatory authorities in both Australia and the US that veal product contained no antibacterial residues. The aims now include trying to deter misuse of antibacterial chemicals by identification and traceback to properties where chemicals have been detected, as well as removing from the distribution system carcasses and offals which do not comply with MRLs.

Initially, the program required industry personnel to test 50% of all calves which were slaughtered for export. Following the detections in the 1990-91 period which were referred to above, the rate of testing in export abattoirs was increased to 100%. The testing program together with an extensive information program aimed at raising the awareness of dairy farmers has resulted in a dramatic decline in the prevalence of detections. The positive rate in Victoria in 1989 exceeded 2%; that in 1992 was 0.6%.

**Individual ‘Suspect’ Animal Program**

In this program, veterinary officers at export abattoirs select animals at ante-mortem inspection – usually animals from higher risk categories of stock such as cull cows and bulls – which present with suspicious signs indicating recent treatment with antibacterial substances. Carcasses are tested for the presence of antibacterial residues in urine. Positive urine tests at the abattoir lead to further screening and confirmatory testing on urine and meat samples at approved laboratories after which the suitability of the carcass for human consumption is decided.

**National Antibacterial Residue Minimisation (NARM) Program**

In 1989, following the problems highlighted by the calf-testing program, the Animal Health Committee established a working party to develop a national control program for screening and confirmatory testing for antibacterial residues in meat. This program eventually became NARM.

NARM is a coordinated interaction between State/ Territory and Commonwealth Governments. It involves staff from AQIS, State Departments of Agriculture/Primary Industry and industry personnel who test urine from carcasses at abattoirs using a MIT. After confirmatory testing on meat samples has been completed by approved laboratories and any residues near, or in excess of, MRLs have been quantitated, State authorities undertake trace-back to the property of origin for investigative action.

An important part of the NARM program has been to develop Australia’s confirmatory testing capabilities for antibacterial residues in meat. At the beginning of the program in 1990, laboratories had a limited capability, with most only being able to confirm the presence of sulphonamides. As a result of NARM and additional funding provided by the Meat Research Corporation, most participating laboratories have developed confirmatory capabilities for sulphonamides, tetracyclines and penicillins. Some laboratories are now also able to analyse for aminoglycosides (streptomycins).

In 1990, the NARM program facilitated the collection and testing of 10,000 samples. The number was increased to 20,000 in 1991 and remained at that level until 1993 when funding cuts forced a reduction. Testing is targeted at those classes of stock most likely to produce problems with residues – pigs, calves, cull dairy and beef cows, emergency slaughter animals and feedlot cattle.

**Ectoparasiticides**

Cypermethrin is used in Australia for external tick, buffalo fly, and lice control. It has an MRL of 0.5 mg/kg. In 1991, the USDA testing program for imported meat reported residues of cypermethrin of 0.117 mg/kg in beef form Queensland – well below the Australian MRL but in excess of that in the US (0.05 mg/kg) where cypermethrin is not used for tick control but is applied as a pesticide spray to treat crops destined for human and animal consumption.

In contrast to its MRL for cypermethrin, US has an MRL of 3.0 mg/kg for permethrin, a synthetic pyrethroid used in that country for tick control. This MRL is 60 times the MRL applied to cypermethrin, despite the fact that the toxicities of the two compounds are similar. The identification of this 1991 analysis as a non-compliance resulted in product from the Queensland processor being subjected to a period of intensive testing by US and Japanese authorities and demonstrated the international effects of such detections when the processor/exporter was virtually black-listed by Japanese importers for a considerable period. It also highlighted the need for more rapid progress by Codex in achieving acceptance of international limits.
Emerging issues

As stated earlier, noncompliant residue levels for many chemicals used by some of our trading partners effectively relate to the limits of detection for those chemicals. As techniques used by analytical laboratories of regulators become more sensitive, the effective compliance concentrations decrease. It is vital for the meat industry that Australia maintains adequate monitoring programs and remains at the forefront with respect to analytical capability, otherwise we will be confronted with further crises related to chemical residues. Resource constraints in government departments, CSIRO and the Australian Government Analytical Laboratories threaten to jeopardise our ability to maintain our eminent position.

Many of the chemicals that have been in regular use for some years were approved for specified uses as long as 15-20 years ago when techniques for analysis of residues were relatively insensitive. Observance of withholding periods which were determined from those analyses may no longer reliably guarantee absence of detectable quantities of residues. Recent testing in this country has indicated that some long-acting penicillin and oxytetracycline preparations may result in detectable residue levels at the site of injection for longer periods of time than indicated by the recommended withholding periods (Malmo 1993).

In recent years, the problem of injection-site lesions in cattle entering American feedlots has been identified as a major one. The practice of US cattlemen injecting in the hip frequently results in lesions in top butts that are apparent to consumers. Although the main cause of the lesions was the use of clostridial bacteriocin vaccines, the problem of hard fibrous lesions remains, partly because of antibiotic injections that must be given intramuscularly. This has not been identified as a problem in Australia; it is important that the veterinary profession ensure that injections are administered such that lesions and residues from injections do not impair the quality of meat, particularly of primal cuts.

The current threats to existing analytical capabilities, particularly in regional areas, together with the increasingly stringent requirements of our trading partners, are putting some pressure on meat processors to augment their analytical facilities in order to provide the analytical information demanded. It is worth noting that the Greeley, Colorado facility of the Red Meats Division of ConAgra has a very significant analytical laboratory adjacent to the packing plant which monitors animal feeds for pesticides, herbicides and trace metals. Meat is tested for these chemicals and for antibiotics. Approximately 7,000 samples are analysed per month (Aaronson 1992).

There is one overseas report of collective human food poisoning by residues of clenbuterol a (SYMBOL 98\r
'Symbol'—adrenergic agonist) in veal liver. It is claimed that this is one of the first reports of clinical signs in humans associated with the consumption of food which contains drug residues (Pulce et al. 1991). The clenbuterol was not used legally in this case, however it serves to illustrate the fact that the industry has to be vigilant in order to avoid major damage to its image.

References


