



The Environment and Food Quality

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Preface

Australia: State of the Environment 1996 (the first ever independent and comprehensive assessment of the state of Australia's environment) was presented to the Commonwealth Environment Minister in 1996. This landmark report, which draws upon the expertise of a broad section of the Australian scientific and technical community, was prepared by seven expert reference groups working under the broad direction of an independent State of the Environment Advisory Council. While preparing the report, the former Department of the Environment, Sports and Territories, on behalf of the reference groups, commissioned a number of specialist technical papers. These have been refereed and are now being published as the State of the Environment Technical Paper Series. Reflecting the theme chapters of the report, the papers relate to human settlements, biodiversity, the atmosphere, land resources, inland waters, estuaries and the sea, and natural and cultural heritage. The topics covered range from air and water quality to sea grasses and historic shipwrecks.

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Abstract

Just as agricultural production inevitably has an impact on the environment, the quality of food produced inevitably reflects its production environment and process. This paper reports on the quality of food produced in Australia as it is affected by measures of environmental quality, specifically the content of pesticide residues and heavy metals under the *Food standards code*. Australian food is of a high standard, its quality protected by a regulatory framework backed up by monitoring systems. Monitoring of residues and heavy metals in food prepared to a table-ready state is undertaken by the Australia New Zealand Food Authority in its Market Basket Survey. Monitoring of export commodities is contracted to the National Residue Survey by agricultural industries. Additional targeted monitoring programs are carried out by the States to identify any breaches of good agricultural practice and to test specific commodities as required by importing countries. However, current monitoring for chemical residues and heavy metals focuses upon the food commodity/product rather than the environment. At present there are only a few programs monitoring chemicals in the Australian environment and there is a lack of baseline data against which to measure trends. Greater consideration is being given to the environmental impact of production processes. In future, this impact on the environment is likely to become as important as the quality of the end product.

1 Introduction

Food quality has many attributes. They can include nutritional value, taste, smell, texture, appearance, freshness, microbial contamination, and the presence of toxic substances. This paper focuses on those issues of food quality that result from activities occurring in the production of food. Quality has now come to refer not only to 'product quality' but also to the 'quality of production'. The latter concept takes into account the effect on the environment and society of the methods used to produce crops and livestock (EIF 1995). Consumers worldwide are becoming increasingly demanding about the quality of the food they purchase, increasing the market demands for good quality products.

Food is rarely harvested from an undisturbed environment in Australia and, by its nature, food production has an impact on the environment. Some activities specifically aimed at improving food quality may affect the environment. Examples include lotfeeding of beef cattle for meat quality; herd and pasture management to increase milk production; nitrogen fertilisers applied to wheat to increase protein content; control of pests and diseases to

reduce their effect on the quality and safety of fruit, vegetables and grains; and refrigeration to maintain freshness. Other measures, applied to increase production of food, may also have unintended impacts on food quality. Two dominant issues with respect to the environment and food quality are:

- residues of agricultural and veterinary chemicals
- contamination by heavy metals such as cadmium, lead and mercury.

Other issues of concern include the production of food containing genes from other species, genetic modifications to improve quality and whether such foods will be labelled for consumer identification.

A major proportion (94 per cent by value) of food sold in Australia is produced locally. Only 6 per cent is imported, mostly spirits, processed seafoods and fish, vegetables (frozen, dried and canned), cheeses, cocoa, coffee and margarine. By contrast large quantities of food are exported, predominantly meat, cereal grains and sugar in addition to significant amounts of seafood, condensed and powdered milk, cheeses and malt. Competition on both domestic and export markets helps to ensure that high quality food is produced in Australia.

2 Sources of contamination

2.1 Agricultural and veterinary chemicals

Contemporary agriculture depends heavily on inputs of agricultural and veterinary chemicals to enhance productivity in a number of ways, including minimising losses caused by insects, weeds, rodents, birds and microorganisms. Agricultural and veterinary chemicals registered for use in Australia include pesticides that kill insects, weeds, plant and animal pathogens and parasites of livestock, such as worms, lice and ticks. As well, a range of veterinary chemicals, growth promotants, sanitisers and disinfectants are used in livestock production while others with cosmetic effects are used in horticulture to enhance colouring and to alter fruit shape. Chemicals are also used to attract insects to aid in the pollination of crops.

Problems of contamination by agricultural and veterinary chemicals arise from both deliberate administration or use and from chance contamination by residues of these in the environment. The list of registered agricultural and veterinary chemicals is very large. Their impact on the environment varies widely, depending upon frequency, method and volume of use. In addition, characteristics such as toxicity to non-target organisms, persistence, mobility and ability to bio-accumulate up the food chain are important factors determining environmental impact.

It is not only the active ingredient of a pesticide but also other components of final formulations such as carriers, adjuvants and surfactants that may have undesirable environmental impacts. An example is polyoxyethylene amine, a surfactant present in some glyphosate formulations which was recently found to pose risks unacceptable to the safety of frogs and other aquatic fauna (NRA 1996). The National Registration Authority for Agricultural and Veterinary Chemicals (NRA) has responded by amending label recommendations and including a warning statement precluding unauthorised use of glyphosate-based products on or adjacent to waterways. The issue raises a general question about the evaluation of the environmental impact of surfactants and other additives.

The rate and frequency of application of pesticides can vary enormously between growers, depending on their perception of risk (Penrose et al. 1994). The cost

of agricultural and veterinary chemicals generally represents a small, although not insignificant, part of the overall cost of production and pesticides may therefore commonly be used as 'insurance' (e.g. Stirling 1994). While such use may not constitute misuse, it must be considered overuse. Overuse of chemicals, whether in amounts or at times when it is unnecessary for the adequate control of pests or diseases (e.g. calendar spraying), adds to the burden of residues in food and the environment. Chemical overuse also increases the selection pressure on pests and pathogens leading to the emergence of organisms able to resist pesticides and antimicrobial agents and results in the loss to agriculture of some valuable tools.

Contamination through misuse, that is use in ways contrary to the registered label, also occurs. Inability to read or understand chemical labels can result in the application of chemicals at inappropriate rates or on crops for which the products are not registered. Pilot projects have made progress in improving the safety of chemical use patterns in communities from non-English-speaking backgrounds and led to interest in the development of a 'best practice' model of training and a national network of trainers.

2.2 Environmental chemicals—Heavy metals

Many metals naturally present in the earth's crust are essential components of biological systems, but the toxic heavy metals and metalloids of dietary significance (including arsenic, tin, cadmium, mercury and lead) are not needed for biological processes and tend to be toxic to living organisms even at low concentrations (Dingle 1992). Heavy metals are not biodegradable and result in long-term contamination of soil. Heavy metals in agricultural commodities come from a number of sources. Low but measurable amounts of heavy metals occur in agricultural commodities because of uptake by plants from trace amounts in the soil. In some cases these trace amounts are supplemented by impurities in fertilisers and the previous use of pesticides containing these metals. Sewage sludge and other wastes also contain heavy metals and can add to the burden in soils if applied at high rates. Naturally occurring concentrations of geological origin are increased through anthropogenic redistribution of heavy metals, for example through industrial processes that result in elevated levels in soils and

marine sediments. Marine environments can have naturally high levels of heavy metals so that fish, crustaceans and molluscs in Australia, as elsewhere, contain levels which may at times exceed legal concentrations.

Cadmium is the element of most concern because its transfer from soils to the edible portions of agricultural food crops is significantly greater than for other heavy metals (McLaughlin et al. 1996). Cadmium has captured the attention of authorities in Australia because of the presence of relatively high levels in superphosphate manufactured from rock phosphate obtained from Nauru, Christmas and Ocean Islands, the primary sources of phosphate in Australian fertilisers until recently. These oceanic sedimentary, guano-based rock phosphate deposits can contain cadmium concentrations ranging from 42–99 mg/kg (McLaughlin 1996), generally higher than phosphate-bearing rocks found in other countries.

Phosphatic fertilisers are an essential input into most agricultural systems in Australia, where the soils are naturally low in phosphorus. In combination with subterranean clover, the use of these fertilisers over vast areas has led to improved production and better quality pastures compared to those that existed before and have resulted in large increases in yields of meat, grain and wool. In the acid and highly weathered soils characteristic of so much of our agricultural land, cadmium in phosphatic fertilisers is readily available for uptake by plants.

3 Limiting chemical and heavy metal content in foods

3.1 Regulating standards

3.1.1 Agricultural and veterinary chemicals

All agricultural and veterinary chemicals registered for use in Australia are assessed to ensure that these meet appropriate standards for quality, safety and efficacy and have no adverse impact on the environment or trade when used appropriately. This is the responsibility of the National Registration Authority for Agricultural and Veterinary Chemicals (NRA) which was established in 1993 to consolidate activities previously carried by State governments. The NRA receives specialist toxicological advice

from the Chemicals and Non-prescription Drugs Branch of the Department of Health and Family Services, from the Risk Assessment Section of Environment Australia and from Worksafe Australia. Among other things, the NRA has responsibility for recommending Maximum Residue Limits (MRLs) for chemicals in food commodities to the Australia New Zealand Food Authority (ANZFA). MRLs are based on residue levels expected if label recommendations are followed and are designed to reflect good agricultural practice. After public consultation, these MRLs are adopted into the *Food standards code*, which is itself automatically adopted by reference into all State and Territory food laws.

Calculations of acceptable daily intakes (ADIs) are also undertaken by health authorities and used as the basis for establishing the safe level of human lifetime exposure (ANZFA 1996a). The ADI is measured in milligrams per kilogram body weight and is the amount of chemical to which an individual can be exposed, through food, air, water or any other means, with no ill effect. An MRL is the maximum residue of a chemical allowed in food available for sale, and is measured in milligrams per kilogram of food. Total intakes from dietary and non-dietary sources are considered safe if they are below the ADI. Consumers concerned about chemical residues lobby governments and industry to seek ways to produce food commodities with ever lower residues and to find alternative means of controlling animal and plant pests. Governments around the world are responding to increased public concern about chemicals in foods and the environment. In Australia ANZFA has recently published a framework for the assessment and management of food-related health risks, outlining the general principles that underlie the decision-making processes for the protection of public health and safety (ANZFA 1996a).

The NRA is now implementing an Existing Chemicals Review Program to evaluate chemicals registered many years ago to ensure that these meet contemporary standards. Five chemicals have been selected for reassessment in the first cycle: atrazine, endosulfan, mevinphos, parathion and parathion methyl.

Since 1990 the Australian Consumers' Association has worked together with the pome fruit, rice and banana industries to encourage the minimisation of pesticide use in Australian agriculture, initially

through the collaboration of signatories to the Pesticides Charter (ACA 1995).

3.1.2 Environmental contaminants—Heavy metals

Governments seek to minimise dietary intake of heavy metals to avoid adverse impacts on health by setting limits to the amounts allowed in food, these amounts are designated Maximum Permitted Concentrations (MPCs). Standards are set taking account both of the concentrations of heavy metals that occur in foods and the contributions that different foods make to the average diet. The initial standards for cadmium in Australia were set by the National Health and Medical Research Council in 1980, when limited data were available on actual levels of cadmium in various commodities and dietary modelling was poorly developed. It became evident in some cases that the standards set did not reflect the current levels found in some food commodities. ANZFA recently initiated a major review of MPCs for

cadmium and proposed new standards based on extensive data on levels of cadmium found in various food commodities and a risk assessment process that incorporates improved dietary modelling procedures (ANZFA 1996b). Table 1 shows the current and the proposed MPCs for cadmium.

The risk assessment process indicated that, for some food commodities, the cadmium MPC could be increased without being likely to cause any adverse health effects. Thus, the limit for crustaceans (prawns and lobsters) has been increased to reflect levels found in some species from natural concentrations in the marine environment. Survey data indicate an age-related increase in cadmium concentrations in animal offals such as liver and kidneys and the MPCs remain unchanged while further dietary modelling is undertaken. Staples such as potatoes may contribute as much as 25 per cent of the dietary cadmium intake (ANZFA 1996b) and while no adverse health outcomes are anticipated, the margin of safety may be small for consumers who regularly consume large quantities.

Table 1: Proposed changes to maximum permitted concentrations of cadmium in food commodities—Standard A12 of the Food Code.

Food	Current MPC mg/kg	Proposed MPC mg/kg
Cocoa/cocoa liquid	0.5/0.35	**
Crustaceans	0.2	2.0
Fish (marine and freshwater)	0.2	0.05
Green leafy vegetables	0.05	0.05
Kidney (mammalian)	2.5	2.5
Liver (mammalian)	1.25	1.25
Meat muscle (mammalian)	0.2	0.05
Molluscs	2.0	1.0
Peanuts	0.05	0.1
Rice	0.05	0.02
Root and tuber vegetables	0.05	0.1
Wheat	0.05	0.1

Note: ** ANZFA is currently seeking further data upon which to base an MPC for cocoa

Source: (ANZFA 1996b)

Concern about cadmium is such that authorities have taken additional steps to limit dietary intake including:

- reducing the level of cadmium allowed in phosphatic fertilisers
- eliminating the feeding of phosphate supplements containing high levels of cadmium to cattle
- banning the sale of offal from aged sheep and cattle (there is an age-related increase in cadmium concentrations in animal offal such as liver and kidney)
- regulating the disposal of industrial wastes into urban sewerage systems to minimise contamination of agricultural lands by cadmium
- monitoring cadmium levels in fertilisers, soils and commodities by Commonwealth and State agencies.

3.1.3 Imported foods

Responding to industry and consumer concerns about the safety of imported foods, the Commonwealth introduced the *Imported Food Control Act 1992*. The Act requires that imported foods meet domestic standards laid down in the Australian and New Zealand *Food standards code*, including standards for residues of agricultural and veterinary chemicals and for environmental contaminants such as heavy metals. The Imported Food Inspection Program is managed jointly by the Australia New Zealand Food Authority (ANZFA) and the Australian Quarantine and Inspection Service (AQIS).

3.1.4 Organic produce

Some people have a strong preference for food produced without the use of synthetic pesticides and fertilisers. While production of organic produce in Australia is small, it is projected to grow. Concern about unscrupulous people seeking to capitalise on the premium prices commanded by organic produce led to the formation of the Organic Produce Advisory Committee (OPAC) and the adoption by the Committee of the National Standard for Organic and Biodynamic Produce for exported produce. This was the first nationally-agreed standard for organic produce outside the European Union. The Committee is answerable to the Minister for Primary Industries and Energy. Individual organic organisations enforcing the OPAC standards, such as the Biological Farmers of Australia (BFA), the Biodynamic Farming

and Gardening Association of Australia (BDFGAA) and the National Association of Sustainable Agriculture Australia (NASAA), are audited regularly by AQIS.

Organic foods have to comply with Australian standards such as the MRLs and MPCs set for all foodstuffs. In addition, organic producers must comply with industry production standards for organic produce. These differ from current standards for other foodstuffs in that production procedures are an intrinsic part of the identification, labelling and claims for such products. Among other things these standards aim to protect consumers against deception and fraud in the market place. They outline the principles of production at the farm level and list the substances approved by the organic industry for soil fertilisation and for the control of pests and diseases in plants and animals.

3.1.5 Genetically modified organisms

Genetic engineers are incorporating new sources of resistance to pests and pathogens and other traits into plants, animals and micro-organisms. In Australia several transgenic crops are nearing, or have reached, commercial reality, including glufosinate-tolerant lupins and transgenic cotton. The latter contains genes coding for the expression of a bacterial insecticide (BT) produced by *Bacillus thuringiensis*. Its adoption is expected to reduce pesticide use in the cotton industry. The safety of foods derived from genetically modified organisms (GMOs) is an issue for ANZFA. Where the composition of foods derived from these organisms is substantially equivalent to foods derived from conventionally cross-bred varieties, the food will be cleared for sale and consumption. Transgenic foods that contain substances that are not substantially equivalent to conventional foods will require more extensive evaluation before they can be permitted to be sold.

The release of GMOs into the environment is currently assessed by the Genetic Manipulation Advisory Committee (GMAC). GMAC is a non-statutory expert body which assesses the biosafety risk factors of transgenic organisms and advises the Minister for Science and Technology on regulating genetic engineering technology. Major environmental risks of transgenic herbicide-resistant crops are the potential for herbicide resistance genes to escape into weedy relatives (Mikkelsen et al. 1996) and excessive use of herbicides to control weeds

growing in a tolerant crop, leading to over-exposure of the environment to chemicals, and possibly to the emergence of resistance (Holland & McDowall 1995). Arguments are also put forward that the use of herbicide-resistant crops will result in reduced pesticide use and the use of more environmentally friendly products, although the adoption of this technology would seem to consolidate the dependence of cropping systems on herbicide inputs.

The transboundary movement of both transgenic crops and the commodities produced from these are being discussed in the international arena. International negotiations have commenced on a Protocol for Biosafety under the Biodiversity Convention relating to the procedures and regulations for the safe handling, use and transfer (including transboundary transfer, i.e. trade) of any living organism produced using biological techniques such as recombinant DNA technology.

The growing 'consumer-right-to-know' movement has particular resonance in the unfolding debate about labelling requirements for products derived from GMOs. International consumer organisations are demanding compulsory labelling for all products of genetic engineering (GRAIN 1996). The US Food and Drug Administration thought it inappropriate to label plants 'that have been modified in a way which does not significantly change their composition'. This specifically excludes from labelling any plants that have been genetically engineered for 'agronomic purposes', such as those developed with resistance to herbicides or environmental stress (GRAIN 1996).

The European Union has been struggling to agree on a common position on legislation for 'novel foods' (a term used in Europe to describe foods produced using novel techniques, including the use of GMOs, and in Australia to refer to food made using new or unusual raw materials). Austria, Germany and Denmark support the amendments passed by the European Parliament in March 1996 which call for comprehensive labelling requirements, while France, Italy, Ireland and the United Kingdom support the original common position that would restrict labelling to products that are 'significantly' different from conventional ones (AGROW 1996).

The Commission of the European Communities recently prepared guidelines, taking the position that labelling will be required except where it would be neither meaningful nor enforceable. The issue of

GMO labelling remains a source of tension between the United States and the European Union. On 3rd December 1997 the European Commission recommended that manufacturers must place a label indicating a commodity 'may contain' GMOs if it is unclear whether a processed product or ingredient contains genetically modified products. Manufacturers have the option of labelling products to indicate they do not contain GMO products (LABELS 1997).

It is possible that some countries may prohibit the use of genetically engineered crops and commodities produced from these. Other countries may seek advantage through the imposition of domestic labelling requirements. There are real threats and advantages as well as risks to domestic sales posed by labelling requirements of food importing countries for foods derived from GMOs or produced using processes involving recombinant DNA technology.

3.2 Research and development

There is a growing international trend to reduce chemical use. This stems from concern about the sustainability of agricultural systems that depend on large inputs of synthetic chemicals, both pesticides and fertilisers. Issues of particular concern include:

- the unknown long-term consequences of pesticides in the environment
- problems of resistance of pests to pesticides
- the impact of fertilisers on surface and groundwater quality
- the increasing demands of importing countries relating to pesticide residues in food and the need for exporters to maintain access to markets.

Recognising that Australia is not immune to the risks posed by the dependence of agricultural industries on pesticides, agricultural scientists have responded to the challenge and have been actively seeking ways to reduce dependence on and use of pesticides. Particular attention is being given to developing integrated pest management systems and alternative control strategies (e.g. Norton & Brough 1995). A commitment to reduce pesticide use in the apple and pear industry led to the successful development of supervised pest and disease management programs (Bower et al. 1993). Research is also being carried out to identify agronomic practices to minimise heavy metal accumulation in soils and the uptake of these by crops (McLaughlin et al. 1996).

3.3 Education and training

Training producers in the responsible use of agricultural and veterinary chemicals is a key element in the production of high quality food. It is a major platform underlying the Commonwealth Government's promotion and support for expanding exports of Australian primary products. The opportunities to improve chemical use patterns have also been recognised by producers and processors, by the farm chemicals industry, by educators and by industry peak bodies, all of whom have responded with initiatives to promote the production of high quality food that is free from unacceptable residues of agricultural and veterinary chemicals.

Initiatives include the Agsafe accreditation scheme which trains all chemical resellers in the safe, effective and legal use of chemicals and the National Farmcare course (previously known as the Farm Chemical Users' Training Program) conducted through technical and further education institutions under the supervision of individual State committees. In South Australia, Farmcare has undertaken successful pilot programs targeting safe chemical use by primary producers from non-English-speaking backgrounds (Georg 1993, 1996).

4 Monitoring for chemical residues in foods

4.1 The National Residue Survey

The National Residue Survey (NRS) monitors chemical residues in Australian raw food commodities. Monitoring programs include both domestic and export market segments. NRS monitors agricultural and veterinary chemicals used in the production of meat, grains, honey, fruit, vegetables, nuts and seafood. For example, in the most extensive NRS exercise, the beef monitoring program, 91 chemicals are tested in a program in six categories. This involves 8600 individual samples testing 138 000 monitoring units. Since December 1996, it has been compulsory for meat from all species slaughtered for export or domestic purposes in Australia to be tested by NRS, under the *Australian standard for the hygienic production of meat for human consumption* (SCARM 1997).

Heavy metals and organochlorines such as DDT that may be present in the environment as a result of past use by industry are also surveyed as environmental

contaminants within these programs. NRS surveys provide a snapshot of the national status of agricultural commodities. Data produced are increasingly used by industries to validate their quality assurance (QA) programs, to provide important underpinning for Australia's export programs and are also used to support Australian positions taken in international discussions with the Organisation for Economic Cooperation and Development (OECD) and the European Union.

4.2 The Australian Market Basket Survey

The primary focus of the Australian Market Basket Survey is to estimate the dietary intakes of a range of pesticides and contaminants. Diets consisting of over 70 foods are constructed, based on the most commonly eaten foods in Australia, as shown by the *National dietary surveys of adults and schoolchildren* (Department of Community Services and Health 1983 & 1985). The foods are prepared to a table-ready state and are individually screened for organophosphates, organochlorines, pyrethroids, dithiocarbamates, antimony, arsenic, cadmium, copper, lead, mercury, selenium and zinc. Other toxicologically active contaminants such as aflatoxins, herbicide residues, tin and aluminium have been analysed in selected foods. This is a small survey in terms of numbers of samples, but useful because measurements are made on table-ready food.

4.3 State surveys

While the Commonwealth is now responsible for the registration of agricultural and veterinary chemicals, the States retain responsibility for controlling both agricultural/veterinary chemical use and misuse leading to residues above the limits established by ANZFA and adopted into State food laws. In order to assure consumers of the safety of foods and to regulate misuse of agricultural and veterinary chemicals, most States have established small targeted monitoring programs for pesticide residues in some commodities. Some selectively survey for heavy metals as well. These surveys are largely done to identify issues of misuse rather than to provide sufficient data to show residue status of the commodities tested. In Tasmania and the Northern Territory there is no routine monitoring for either pesticides or heavy metals. Analysis of commodities for export clearance is undertaken as required by importing countries.

4.4 Other surveys

In addition to the monitoring programs described above, industry and government authorities engage in other surveys of food commodities for agricultural and veterinary chemicals and heavy metals for a variety of reasons. One example is the National Antibacterial Residue Minimisation (NARM) program, run by the NRS. It targets animal carcasses at risk of exceeding standards for antibacterial residues. The results are used to increase awareness among producers of the risk to trade from the presence of excessive levels of antibacterials in meat. Contraventions invite counselling of the producer responsible, prosecution or in some cases, quarantining of stock.

5 State of food quality in Australia

Taken in aggregate, the results of Commonwealth, State and industry-sponsored programs monitoring agricultural and veterinary chemical residues in food commodities provide evidence that misuse of agricultural and veterinary chemicals is low, with most analyses returning either no detectable residues or residues well below established legal limits. A large survey conducted by the New South Wales

Department of Agriculture in collaboration with the Sydney Market Authority (Edge 1993) is illustrative. The survey examined fruit and vegetables for up to 24 pesticides. In all, over 25 000 individual analyses returned a result of 25 or 0.1 per cent of analyses that contravened the MRL (Table 2). This corresponded to a contravention rate of 1.7 per cent for the 1509 pieces of fruit and vegetables taken for testing.

Most samples did not yield any evidence of detectable pesticide residues and no sample contained more than one residue above the MRL. While the fact that 25 samples returned a residue above the MRL is a concern, ten of the twenty five breaches were organochlorine residues in vegetables and were almost certainly attributable to traces of the pesticides BHC and dieldrin in soil from applications made some years earlier. Thus the contravention rate was 0.99 per cent for chemicals applied to the sampled commodities. The survey data reported by Edge have been incorporated into the results of an extended (six year) survey of residues in fruit and vegetables purchased from the Flemington Markets (Plowman 1996). Overall, the results are consistent with those reported by Edge, with 1.6 per cent of all samples returning a chemical contravention, 18 of which were residues of organochlorines no longer used.

Table 2: Flemington Markets residue survey

Crop	Number of samples exceeding MRL	Pesticide residue	Residue mg/kg	MRL mg/kg
Carrot	1	Chlorpyrifos	0.02	0.01
Chinese cabbage	2	Endosulfan	2.27–3.10	2.00
Lettuce	5	Endosulfan	2.05–7.18	2.00
Lettuce	2	Fenvalerate	0.17–0.48	0.00
Lettuce (hydroponic)	1	Fenvalerate	0.3	0.00
Lettuce (hydroponic)	1	Furalaxyl	0.13	0.00
Onion	1	BHC	0.13	0.00
Onion	1	Endosulfan	0.25	0.20
Pear	1	Chlorpyrifos	0.26	0.20
Silver beet	1	Permethrin	0.15	0.00
Zucchini	9	Dieldrin	0.01–0.12	0.00

Note: Survey shows the number of samples with a residue exceeding Maximum Residue Limit (MRL).

Source: (Edge 1993)

The results of the 1992/93 Clean Agriculture Produce Monitoring Program (Victorian Department of Agriculture 1993) also show only a small percentage of contraventions. The program targeted a selection of agricultural and veterinary chemicals in 303 samples of fruit and 145 samples of vegetables; 98 per cent of the samples were within established limits for residues of all chemicals. Eight of the 448 samples contained a level of the insecticide chlorpyrifos above the MRL and one contained a level of a dithiocarbamate fungicide above the MRL. The 1992 Australian Market Basket Survey (National Food Authority 1992) found that dietary intake of agricultural and veterinary chemicals and heavy metals was within the safe limits set down by the World Health Organisation.

Results contained in the 1993/94 report of the National Residue Survey (Bureau of Resource Sciences 1997) are similarly encouraging, with the majority of samples containing no residues, and the majority of those with residues had levels below the MRL. While the number of commodities surveyed by the NRS varies between programs, it is the largest

monitoring program for chemical residues and heavy metals in livestock and grain commodities and provides a useful time series for monitoring residues of some chemical groupings. The coverage of horticultural commodities declined in 1993, when the NRS moved onto a full cost recovery basis, and the program is still not comprehensive for horticulture. Some of the trends emerging from the surveys are reported here. Results for the 1995 and 1996 surveys have now been published and are available on the web at <<http://www.nrs.brs.gov.au>>.

The incidence of organophosphate residues detected in Australian grain samples has fallen steadily from over 90 per cent of samples taken in the National Residue Survey in 1986 to less than 20 per cent in 1995 (see Figure 1). Organophosphates were once the main grain protectants used in the Australian grain industry and the declining residue trend is largely the result of reduced reliance on chemical grain protectants for insect control in favour of fumigation and improved hygiene practices in grain handling. Residues above MRL are rarely found in samples (Figure 1).

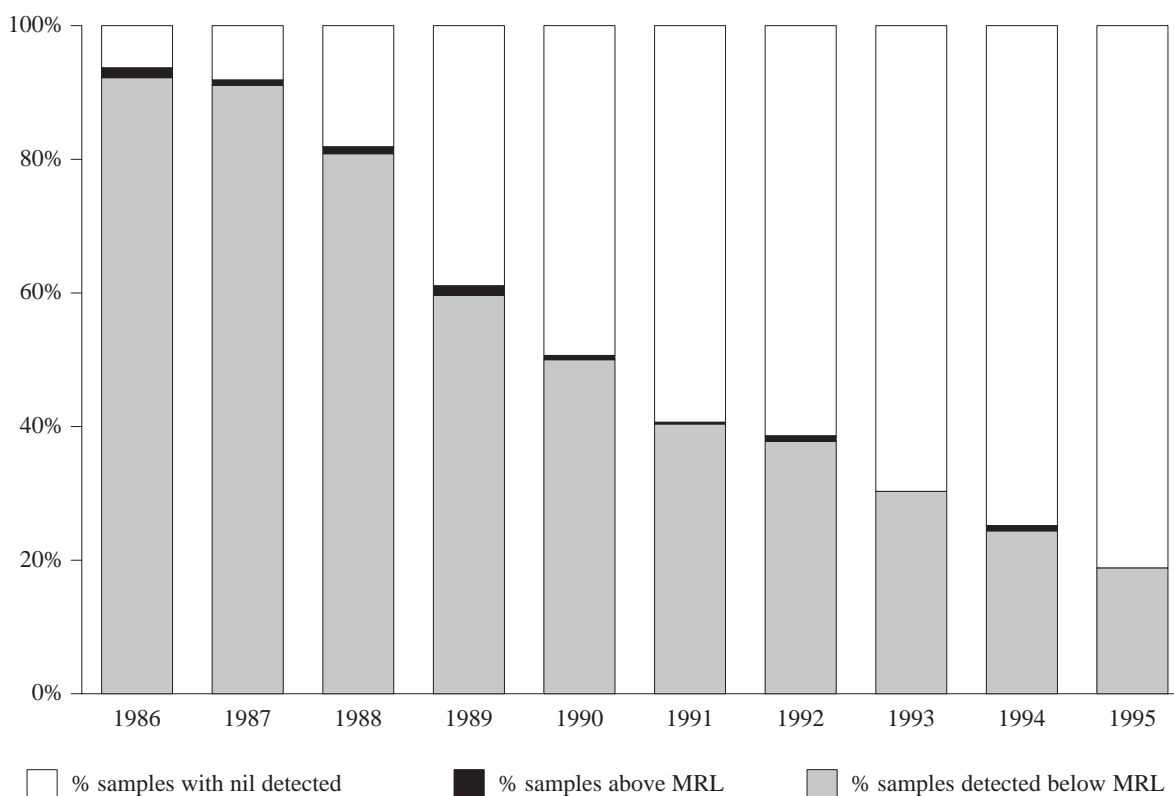


Figure 1: Percentage of grain samples with detectable organophosphate residues from 1986 to 1995

Note: MRL is the recommended Maximum Residue Level for chemicals in food commodities

Source: National Residue Survey

Over the period examined (1984–94), there was a general downward trend in the percentage of beef and sheep fat samples with organochlorine residues (Figure 2). When reviewing the NRS results for beef, it is important to consider the source of compounds detected as these may not arise directly from current agricultural usage. Although organochlorines have not been used for controlling pests of livestock in Australia since the early 1970s, these highly persistent chemicals are still present in pasture soil and some can be ingested by grazing cattle. In contrast to environmentally persistent compounds, residues of agricultural chemicals in current use are far less common. The level of compliance with the MRLs for agricultural chemicals was greater than 99.9 per cent (Figure 3). The results overall show that beef contains very few agricultural and veterinary chemical residues, indicating that good agricultural practice is followed by the cattle industry.

The percentage of beef fat samples containing synthetic pyrethroids used to control ectoparasites (mainly for tick and buffalo fly control), showed an upward trend and then dropped sharply in 1994 following revised reporting (Figure 4). The most commonly detected synthetic pyrethroid was flumethrin, with an MRL set in meat of 0.05 mg/kg but no limit has been set for beef fat, which is the actual tissue tested by NRS when screening for fat-soluble chemicals. In 1994 Australian regulatory authorities set an action level of 0.25 mg/kg for flumethrin in beef fat for managing targeted testing programs, as the meat MRL cannot reasonably be applied to fat. Other synthetic pyrethroids detected, all below MRL and over 90 per cent of them less than one fifth of MRL, were cypermethrin, deltamethrin, permethrin, cyhalothrin, fenvalerate and cyfluthrin. Overall the number of samples exceeding the MRL was low.

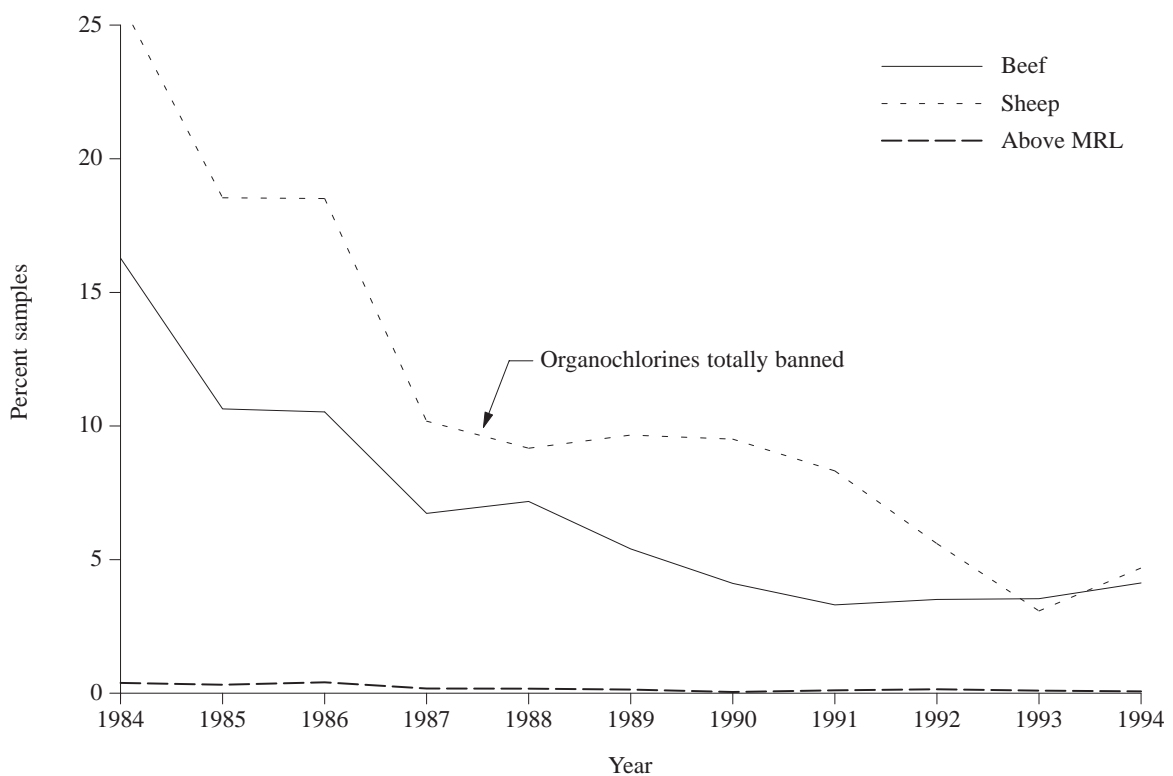


Figure 2: Percentage of beef and sheep fat samples with detectable organochlorine residues from 1984 to 1994

Note: MRL is the recommended Maximum Residue Limit for chemicals in food commodities

Source: National Residue Survey

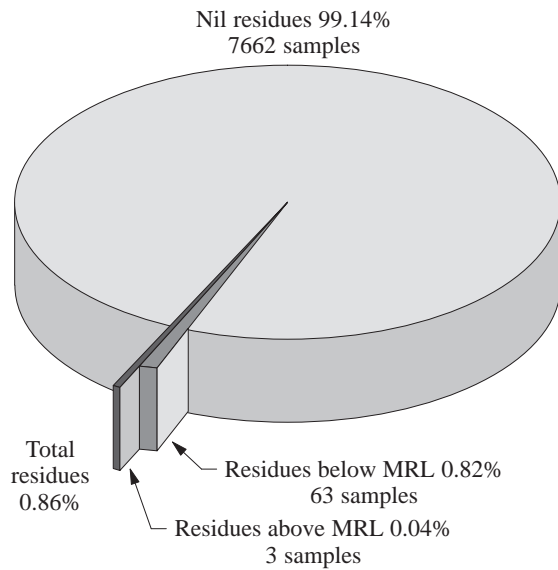


Figure 3: Percentage and numbers of beef samples with detectable agricultural chemical residues in 1994

Note: MRL is the recommended Maximum Residue Limit for chemicals in food commodities.

Source: National Residue Survey

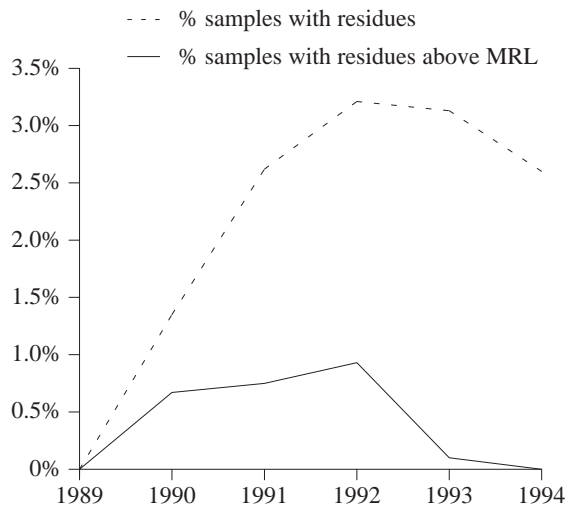


Figure 4: Percentage of synthetic pyrethroids in beef fat samples from 1989 to 1994

Note: MRL is the recommended Maximum Residue Limit for chemicals in food commodities

Source: National Residue Survey

Heavy metals, almost exclusively cadmium, regularly exceed the maximum permitted concentrations in offal and potatoes. The NRS reports that 8 per cent of meat samples (liver) in 1991 and 1992 exceeded the established MPC for heavy metals. Metals can be directly acquired by cattle from the environment and levels found in beef offal are not usually directly related to agricultural practices, apart from the use of superphosphates containing cadmium. In 1992/1993 the Victorian Clean Agriculture Produce Monitoring Program (Victorian Department of Agriculture 1993) tested a total of 543 samples of fresh fruit, vegetables and grain for heavy metals. More than 10 per cent of these samples had cadmium exceeding the MPC, but none had lead or mercury exceeding 50 per cent of the MPC. Cadmium violations were detected in carrots, potatoes, silverbeet and safflower.

Levels of trace elements and chemical residues in Australian seafood are generally well below maximum recommended levels (NRS unpublished data). Orange roughy, *Hoplostethicus atlanticus*, is a deep-sea fish and a voracious long-lived predator at the top of the food chain, thus it is a good indicator species for marine contamination. Of 300 orange roughy samples analysed for copper, mercury, cadmium, lead, selenium and zinc, all complied with Australian standards with the exception of some samples showing increased selenium levels. Selenium is an essential nutrient but can be toxic at high doses and human illnesses, related to both insufficient and excessive intakes of selenium, have been described (WHO 1987). An Australia-wide survey of 300 samples of abalone, *Haliotis rubra* and *H. laevigata*, were found to be 100 per cent free of pesticide, with no pesticide detections. However, some organochlorines accumulate in fatty tissue and may concentrate in predatory fish higher up the food chain. NRS sampling (unpublished data) of sea mullet, *Mugil cephalus*, shows that dieldrin, chlordane and heptachlor are the organochlorines most often present at levels above the MRL, reflecting the bottom filter-feeding habits of these fish and their proximity to areas of high human population. Nevertheless, the figures show 95–98 per cent compliance with the MRL, a level which should improve with time as most organochlorines are no longer available for use in Australia.

6 Conclusion

Food produced in Australia is of a high quality and a strong regulatory framework exists to ensure that food reaching domestic and international markets is safe. The monitoring of food for chemical residues, although somewhat limited for some commodity groups, provides evidence that their presence in food does not pose a health hazard to the Australian consumer. In the past this system has worked well to secure access to international markets. However, the international community is moving into a phase in which certification of minimal impact on the environment from agricultural production may become as important as evidence of low residue status or other quality attributes. This trend will result in increasing linkages being made between trade and the environment.

This paper focussed on those aspects of food quality that in some way reflect the status of the resource base underpinning its agricultural production system. However, results gathered from the monitoring for chemical residues in end products, either in their raw form or processed into a table-ready state, do not adequately reflect the environmental impact of agricultural production. There is potential for environmental contamination to occur throughout the entire production cycle of crops and livestock. For example, chemicals that have been sprayed on a crop may not be present at the time of harvest and thus leave no residues in food commodities, but this does not mean that chemicals have not escaped into air, soil or water bodies or affected non-target organisms at some stage of production. At present there are only a limited number of programs monitoring chemicals in the Australian environment and a lack of baseline data against which to measure trends. Developing a comprehensive picture of the fate of chemicals and

heavy metals in the environment will require additional gathering of data.

Abbreviations

ACA	Australian Consumer Association
ADI	Acceptable daily intake
ANZFA	Australia New Zealand Food Authority
AQIS	Australian Quarantine Inspection Service
BDFGAA	Biodynamic Farming and Gardening Association of Australia
BFA	Biological Farmers of Australia
BRS	Bureau of Resource Sciences
EIF	European Initiative for Integrated Farming
GMAC	Genetic Manipulation Advisory Committee
GMO	Genetically Modified Organism
GRAIN	Genetic Resources Action International
MPC	Maximum permitted concentration
MRL	Maximum residue limit
NARM	National Antibacterial Residue Minimisation Program
NASAA	National Association of Sustainable Agriculture Australia
NFA	National Food Authority
NRA	National Registration Authority for Agricultural and Veterinary Chemicals
NRS	National Residue Survey
OECD	Organisation for Economic Co-operation and Development
OPAC	Organic Produce Advisory Committee
WHO	World Health Organisation

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