The impact of residues on animal food products and human health

L. M. CRAWFORD*

Summary: Six Member Countries of the OIE drew up a report on their experiences in the control of chemical residues in food of animal origin. The author analyses the programmes set up in four developed countries from three different aspects: epidemiology, technology and economy.

Australia, Canada, New Zealand and the United States have operational programmes at their disposal which differ according to the importance of the objectives followed (public health, exportation). The Argentine and Uruguayan authorities put forward a programme which specifically applies to developing countries and stress the difficulties of setting this up.

The author considers that international agencies such as the OIE, WHO, FAO and Codex Alimentarius should play a major role in the coordination of a multilateral cooperative programme in this field.

KEY-WORDS: Animal products - Argentina - Australia - Canada - Drugs - Economics - Epidemiology - Food inspection - Legislation - New Zealand - Pesticides - Residues - Testing procedures - Trade in animals - Uruguay - USA - Veterinary services.

INTRODUCTION

The problem of satisfying the dietary requirements of a growing world population is becoming increasingly acute. Drugs that improve the rate of weight gain, improve feed efficiency, or prevent and treat diseases in food-producing animals are critically needed to meet the challenge of providing adequate amounts of food for that population.

But, the benefit of improved production from the use of animal drugs in food-producing species is not obtained without risk — the risk associated with drug residues that remain in the tissues of treated animals at the time of slaughter.

If animal drugs were not absorbed or were metabolized to harmless products, there would be no concern. Unfortunately, this is not usually the case. It is therefore necessary to collect data on residues and their safety as a basis for establishing safe residue concentrations and withdrawal periods for food animal drugs. And, it is equally important that slaughtered animals be monitored for possible unsafe residues.

In December 1984, while preparing the Conference of the OIE Regional Commission for the Americas, the Director General of the Organisation queried a num-

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ber of Member Countries about their experiences regarding chemical residues in food of animal origin. Specifically, these nations were asked to comment in three general areas:

1. **Epidemiology**: distribution and origin of residues, animal pathology connected with residues.

2. **Technology**: control of the environment, drugs, preparation of food.

3. **Economy**: importance of technological progress for the development of animal production and the health of consumers and animals.

This report will contain the responses of three nations — Australia, New Zealand and Canada — in addition to the United States. Suggested programs and residue control mechanisms for other nations will also be addressed, especially including information provided by Argentina and Uruguay.

**RESIDUE DETECTION AND CONTROL IN THREE NATIONS**

**AUSTRALIA**

1. **Epidemiology**

   (a) **Origin**

   The great majority of residues found in edible tissues of animals have their source at the farm of origin. Most are fairly transient residues derived from recent treatment with pesticides or drugs. Some, however, are derived from inadvertent contamination of soil or buildings with persistent chemicals used in past years. By far the most common cause of residues is the failure to observe the proper withholding period following treatment.

   Occasional residues will be acquired during transport, in saleyards, in holding paddocks at abattoirs, or during processing at the abattoir.

   Care must be taken to avoid confusion by false positives which can arise from post-sampling contamination or from sample switching.

   In addition, laboratories must take care to ensure that their standards are accurate and that their calculations are correct.

   (b) **Distribution**

   Logically, the potential for exposure is greatest and the likelihood of residues highest in those areas where farming is more intensive and where chemicals are used more freely. It can therefore be anticipated that lot-fed animals would be more vulnerable than range-fed animals, that pigs and poultry would be more vulnerable than sheep and cattle, and that dairy cattle would be more vulnerable than beef cattle. In general, it is found that animals from the tropics are more likely to have residues than animals from temperate regions.

   (c) **Animal pathology**

   At ante mortem inspection any animal showing a diseased condition or showing signs of a recent disease condition should be regarded with suspicion. There is every likelihood that such animals have been recently treated. There is a particular need for caution in emergency slaughter. In the normal course of events, there may be
little evidence of recent injections but inspectors should nevertheless be watchful. In the great majority of cases there will be no visual evidence to suggest the presence of residues and laboratory analysis of appropriate samples will be the only means of their recognition.

2. Technology

(a) Control of the environment

The animal environment will be kept free from contamination if farmers use pesticides in strict accordance with directions on registered labels. This includes compliance with any withholding periods for grazing on treated pastures and crops. There is little that can be done to overcome contamination resulting from past use of persistent organochlorine pesticides other than to wait for the passage of a sufficient number of years. Present day evaluation procedures should ensure that contamination of the environment is minimal from this time on.

(b) Control of chemicals

Good regulatory control of pesticides and veterinary drugs is the first line of defense against the occurrence of undesirable residues in agricultural commodities. Control procedures should be designed to ensure that each new product is suitable for its intended purpose and that it will not give rise to unacceptable residues in food or feed if used in accordance with the directions on the registered label.

There should be legislation to make it an offense to sell or offer for sale any unregistered product. In this way it can be arranged that farmers have access only to approved and properly labeled products. Any residues found in food or feed can then be taken as evidence of misuse. It does not take many inspectors to maintain surveillance over products on shelves in retail outlets. Effective policing of use on the farm is a far more difficult matter and for this reason many authorities are not convinced of the value of legislation providing power to control use.

Good regulatory control necessitates sound evaluation of data submitted by chemical manufacturers or sponsors. This evaluation can only be performed by knowledgeable persons with sound judgment. The aim should be to provide the maximum protection for consumers and operators, consistent with keeping producers supplied with the chemical tools they need to remain competitive. At the same time regulatory authorities must bring forward new products as quickly as possible and avoid putting unnecessary obstacles in the path of manufacturers, who, after all, need some encouragement if they are to keep putting new chemicals into the developmental pipeline. The system will undoubtedly grind to a halt if regulatory authorities ask for unreasonable safeguards and safety factors.

(c) Standards for residues

Residues cannot be controlled legally unless legal limits are established. These are called maximum residue limits (MRLs) or tolerances. Food and drug legislation then makes it an offense to sell food in which these limits are exceeded.

It has become accepted procedure that an MRL is set just high enough to cover residues which are difficult to avoid when the particular chemical is used in accordance with good agriculture practice. This approach derives from the philosophy that notwithstanding the apparent harmlessness of a residue, it is prudent to keep human consumption to the absolute minimum. This implies that in nearly all cases the MRL is merely a legal limit. Violations are not likely to be a health hazard unless flagrantly excessive. In any case, the acceptable daily intake (ADI) on which
MRLs are based, is estimated as the quantity which would be without observable effect if ingested every day for the whole of a lifetime. Occasional consumption of food containing levels in excess of the MRL, or even in excess of the ADI, is therefore unlikely to be hazardous.

MRLs are established in Australia by an expert committee working under the aegis of the National Health and Medical Research Council. Regulatory authorities then decide upon a withholding period (WHP) which will ensure that the MRL is not exceeded. This WHP is prominently displayed on the product label.

Ideally, national MRLs are brought into alignment with international MRLs as these are developed by the Codex Alimentarius Commission.

(d) The second line of defense is surveillance over the occurrence of residues in agricultural commodities. This entails submission of samples for laboratory analysis. Samples may be collected at random to provide an overall estimate of the occurrence of residues, or taken selectively from areas where use of the particular chemical is greatest, to provide an estimate of residue occurrence in the worst possible situation. The selective approach is often used in order to make the best possible use of scarce analytical resources. It always seems a little pointless to search for residues in areas where there is little or no likelihood of their occurrence.

Statisticians often criticize analytical programs on the grounds that insufficient numbers of samples are tested. It is noted that 300 consecutive samples must be tested and found compliant in order to be 95% confident that the true violation rate in the population does not exceed 1%. However, resources do not always permit this luxury and it is often necessary to be satisfied with less.

Two systems of residue surveillance are conducted by the Commonwealth Government in Australia. The Department of Primary Industry conducts an extensive survey on agricultural commodities destined for export. The Department of Health conducts a Market Basket Study which provides information on residues in the average Australian diet. Additional residue studies are carried out by State authorities.

(e) *The corrective role*

Wherever possible, violative or near violative residues found in a residue survey should be traced back to the farm of origin where suitable corrective action can be taken to ensure there is no recurrence. Corrective action may vary from advice by extension authorities to quarantine in extreme cases. Quarantine is normally used only in the case of persistent residues. The effectiveness of traceback depends on identification of the sample. In the case of meat, it depends on animal identification and samples are therefore best taken from the killing floor of an abattoir rather than from a retail meat outlet.

(f) *Preparation of food*

Where a residue is removed during normal preparation by peeling or skinning, or if it is destroyed by cooking in a food which is normally cooked, due allowance can be made for this in evaluation of the residue hazard.

(g) Regulatory authorities must watch closely for changes or new trends in agricultural management and practice. Such changes can cause large alterations in the pattern of residues.
3. Economy

*Importance of technological progress*

Farmers must stay abreast of contemporary technology if their product is to be competitive on world markets.

In order that a country's farmers may have access to new products suited to their unique requirements, it is necessary that the country demonstrate a standard of regulatory control which inspires confidence in their overseas trade partners. In the absence of an adequate standard of control, considerable caution must be exercised and the approval and adoption of new technology is delayed.

**CANADA**

1. Epidemiology

The distribution of residues may be ubiquitous within an environment depending on past historical use or may be of local geographic concern depending on specific animal disease patterns or patterns of application of chemical agents.

The main thrust of Agriculture Canada's testing programs is to monitor the domestic herd populations for various agents which may produce residues in the end products. This monitoring is done to determine whether any problems actually exist in the food chain and to predict changes or trends over a given period of time. Imported meat shipments are routinely tested according to pre-established criteria.

The normal monitoring programs are at a 95% confidence level and are capable of detecting a 1% incidence of a given agent within a population. Should a given agent be identified by the monitoring program and considered to be a concern within a population, the monitoring phase moves into a surveillance phase, which consists of more intensive sampling and also traceback mechanisms to determine and control the source of the problem. Mechanisms are also in place to impose constraints on the movement of food animals to slaughter where problems have been identified during surveillance testing.

In general, it is uncommon to see animal pathology per se connected with residues. Normally these can be traced to accidental formulation errors in feed, accidental overdosing, or spillage within a given area which could result in intoxication of individuals or small herds. These types of incidents are certainly the exception rather than the rule and in the vast majority of cases we are dealing with trace levels of various agents which are found in meat products.

It is, however, to be expected that as environmental deterioration continues, the opportunity for finding residues in livestock will increase. As a result, decisions must be made to define tolerable levels of these compounds in animals and meats. In addition, there is an essential need to control and dispose of animals or their by-products which are heavily contaminated with environmentally stable compounds (e.g., PBB incident in Michigan, U.S.A.).

2. Technology

With respect to the general environment, various regulatory controls are in place and are monitored by several federal agencies such as Environment Canada, Health and Welfare Canada and Agriculture Canada. These programs are very
diverse in nature and cover a multitude of areas, e.g. control of electrical transformer fluids vis à vis PCB's, monitoring of dioxins in Great Lakes fish populations, etc.

Drugs may be administered to livestock populations by veterinary prescription, which may be given either parenterally or in the feeds for therapeutic purposes, or by feeds containing approved additives for growth promotant purposes. All such feed additives are registered under the Feed and Fertilizer Act and listed in the Medicating Ingredients Brochure. This brochure specifically states the amounts to be used, the species in which they are to be used and the withdrawal times.

Under the Meat Inspection Act and Regulations, the environment under which meat products are produced is controlled from the time food-producing animals enter the premises of a federally registered establishment until the processed meat products leave that establishment. Such control includes all aspects of the physical environment as well as manufacturing practices, process formulations, the use of additives and non-food chemicals, packaging, use of labels and other ancillary procedures.

All animals receive veterinary supervised ante mortem and post mortem inspection and, in the case of disease, portion or carcass disposition is made according to established guidelines. Day-to-day operating practices, which include the various aspects of the physical structure, are monitored by both professional and lay staff. Supervisory visits are carried out at least once monthly by regional headquarters personnel and reports are forwarded to national headquarters for evaluation. Control charts for canning procedures are available to inspection personnel at all times as are control log books which monitor the use of such substances as nitrite.

Where any animal is suspected of having received any type of chemotherapeutic agent or having been exposed to any type of other agent which would be contrary to legislated standards, the inspection staff have full authority to detail this carcass at any given point for testing purposes. If found positive for any residue which contravenes established tolerances, that carcass is condemned and does not enter the food chain.

3. Economy

Two major factors have acted to increase the perceived risk to human health due to the presence of residues in animals or their meat products. One factor involves the technological advances which permit the detection of residues in increasingly smaller amounts, e.g. at the part per billion and part per trillion level. The second factor involves the activities of both media and consumer groups in bringing information concerning these perceived hazards to the attention of the consuming public. This has amplified the need to systematically define the risk associated with residues at the levels presently detected.

Risk analysis, which involves scientific evidence (or lack thereof), economic concerns and perceived public attitude towards residues must be used to develop standards which are acceptable to both consumers and producers. Demands from trading partners are increasing as well, and in order to maintain a viable export market status, these other needs must also be met. Thus, standards must be compatible with both the national and international arena, and as well as being cost effective and realistic, must also be enforceable by the regulatory bodies involved.
To achieve the greatest benefits from judicious use of chemicals and drugs it is therefore necessary to:

1. Evaluate each compound for effectiveness, need of applications and adverse side effects.
2. Educate the producer in the proper use and application of each compound.
3. Monitor the proper application of each compound.
4. Educate the consumer to distinguish between real hazards and perceived possible side effects.

Great advances being made in biotechnology aimed at decreasing the reliance of livestock producers on drugs for preventive, therapeutic and anabolic purposes may further reduce the potential for residues in animals. Such reduction may be possible through advances in the control of disease through manipulation of the gene pool. Increased disease resistance and improved productivity have been gained in poultry species and with improvement in genetic manipulation, these same gains may be seen in red meat species. Another example is the continuing advance being made in disease prevention and disease detection using monoclonal antibody techniques and gene splicing. Maximum protection of vaccinates is increasing and the removal of vaccines utilizing attenuated or live organisms capable of reversion back to a virulent state will also reduce the likelihood of disease outbreaks resulting from vaccination breaks.

As well, a general trend is seen in the need to collect more data and transfer this data to producers in order to decrease producer losses both from a quality and a pathological point of view. Epidemiological investigations into the relationships between management of livestock and disease have revealed possible mechanisms whereby disease may be prevented or controlled through the alteration of management procedures alone.

NEW ZEALAND

1. Epidemiology

Number of residue violations 1983

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<tr>
<th>Type</th>
<th>O-Cl</th>
<th>O-P</th>
</tr>
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<tbody>
<tr>
<td>Lambs</td>
<td>5 + DDT/570</td>
<td>Nil</td>
</tr>
<tr>
<td>Sheep</td>
<td>2 + DDT/527</td>
<td>Nil</td>
</tr>
<tr>
<td>Calves</td>
<td>Nil/271</td>
<td>Nil/19</td>
</tr>
<tr>
<td>Pigs</td>
<td>1 + DDT/1+dieldrin/392</td>
<td>3 + lindane/</td>
</tr>
<tr>
<td>Deer</td>
<td>1 + DDT/122</td>
<td></td>
</tr>
<tr>
<td>Wild game</td>
<td>8 + /270</td>
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Number of lindane permit holders tested in 1983: 441/nil+.
Number of suspect farms tested in 1983: 38.

Antibiotics

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<tr>
<th>Type</th>
<th>4+ /135</th>
<th>2+ /147</th>
<th>2+ /23</th>
<th>9+ /22</th>
<th>5+ /22</th>
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<tbody>
<tr>
<td>Lambs</td>
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<td>Sheep</td>
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A significant number of positive samples were associated with localized injection lesions.

2. Technology

The New Zealand government is greatly concerned with the quality and acceptability of export products and therefore is very much aware of the need for a strong residue control program. Through regulation, New Zealand has limited the use of drugs and agricultural chemicals to only those vital to their industries, and availability of those is strictly controlled. The intensity of monitoring is certainly adequate to accurately reflect the status of residue contamination in the animals for export trade.

The Meat Division of the Ministry of Agriculture and Fisheries (MAF) is responsible through the Meat Act 1981 and the Meat Regulations 1969 for ensuring by meat inspection and monitoring, that conditions laid down by the Pesticides Board and the Animal Remedies Board are met.

A further function of the Meat Division is to control by regulation the use, handling and storage of chemicals in and around slaughter and processing plants to ensure that illegal residues do not occur.

The Meat Monitoring Section of MAF’s Research Division is responsible for the routine analysis and reporting on samples for examination.

The MAF’s Advisory Services Division field officers are responsible for traceback of the residues of chemicals controlled by the Pesticide Board, while the Animal Health Division of MAF is responsible for traceback of residues of animal remedies controlled by the Animal Remedies Board.

Traceback of slaughter and processing plant residues is carried out by the MAF Meat Division.

The residue testing program described previously therefore can be viewed from three discrete aspects:

— as a “sentinel” program to alert regulatory authorities on a national basis, to emerging problems with chemicals in animal products;

— as a “routine” testing program on a national basis, to ensure that restrictions placed on the users of chemicals are being observed and that regulatory safeguards are adequate;

— as a “suspect” testing program to ensure that stock from properties with above tolerance (or close to tolerance) levels of particular chemicals that have been recognized during “routine” testing, can be removed from the food chain and condemned if necessary.

The success or value of any such program as the above depends on being able to recognize the problem at source, i.e. the ability to trace back a slaughter animal to the property of origin.

Within New Zealand the vast majority of animals submitted for slaughter go direct from the farm of origin to the slaughterhouse. These animals are paid for by the slaughtering establishment after slaughter and thus adequate records of their origin must be maintained to allow payment to the producer.
In the case of the small number of animals passing through a saleyard before slaughter, it has been demonstrated under New Zealand conditions that traceback is possible through trucking company transit records combined with those of the auctioneer conducting the sale.

Every line of animals submitted for slaughter, and that is sampled either in the "routine" surveillance or "suspect" testing program has its property of origin available on the records or is quickly able to be traced back.

Every line of animals tested (either "routine" or "suspect") that shows a level above or close to stated tolerance sets in motion an investigation system to determine the source of contamination.

On the appearance of an "above tolerance" (or near tolerance) level of a particular residue as a result of "routine" or "suspect" testing, the Government laboratory sets in motion a defined chain of events:

(a) The head office Meat Division is phoned with details of the problem, the species, the number of affected animals, the address of the property concerned and the owner. The message is directed to the Assistant Director (Technical Services) or in his absence his nominee.

(b) The phone message is confirmed by written standard format documentation and/or if necessary by telex.

(c) The plant of origin is notified by telex to alert them on the holding of stock from that particular property.

(d) The owner is notified in a standard format by telex/letter that stock from his property will be put on the suspect list. The suspect list is published regularly and copied to Meat Division staff throughout the country. A farmer whose property appears on the suspect list will have his stock submitted for slaughter held at the plant pending test results. Tests from two "lines" of stock must be cleared before the property is deleted from the suspect list.

(e) At the time of the above notification to Meat Division staff and the owner of the animals, the Meat Division formally advises the appropriate investigating body. In the case of agricultural chemicals it will be the Registrar, Agricultural Chemicals, and in the case of animal remedies the Registrar, Animal Remedies. Each can set in motion a review and investigation for the particular situation by direction of MAF field officers. If a sample in violation is detected, field officers of the Ministry are instructed to visit the farm and investigate why this violation occurred. They are empowered to enter and search premises and study records to see whether the pesticide was incorrectly used.

(f) The result of the investigation and the action taken are reported back to the Meat Division and reviewed.

(g) In-plant problems with chemicals are handled internally by the Meat Division between the Assistant Director (Technical Services) and the supervisory staff at the plant involved.

The violation line may be detailed depending on throughput at the freezing works. It would not be normal for this to occur but two subsequent clear tests are required before the farmer is allowed to export. The farmer is put on suspect testing which means that a certain statistical number of the line in question must be sampled and cleared before further export is allowed. Violative carcasses are either des-
troyed or placed on the local market depending on the New Zealand residue tolerance applicable.

GOOD ANIMAL HUSBANDRY PRACTICE AND RESIDUES IN THE UNITED STATES

Proper utilization of drugs and chemicals in food animals provides economic benefits to both consumer and producer while still protecting the public from hazards. In the United States of America it is the responsibility of state and federal authorities to provide this protection. Food animals on the hoof are considered to be food subject to the regulatory provisions of the U.S. Food and Drug Administration (FDA) because the only reason for existence of these animals is to serve as a source of food for the consumer.

The use of drugs to control and treat animal disease and to promote faster, more efficient growth of livestock is a common practice. About 80% of livestock and poultry in the United States receive such animal drugs. However, if animal drugs are misused, the resulting residues in the edible tissues of slaughtered animals threaten the health of humans. FDA and the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA/FSIS) work cooperatively to monitor the use of these animal drugs.

Animal drug manufacturers are required by FDA to show that each new animal drug is safe and effective before it is approved for marketing. Manufacturers also must submit for review by both FDA and FSIS a reliable assay method for detecting drug residues in slaughtered animals. FSIS regularly monitors on a random basis tissue samples of slaughtered animals.

FDA sets tolerances for acceptable levels of residues of a drug in animal tissue after first determining the level at which the drug does not produce any measurable physiological effect in laboratory animals. The Environmental Protection Agency (EPA) also cooperates in the residue monitoring program where pesticide residues are determined to be due apparently to direct applications or environmental contamination. In summary, FSIS assumes primary responsibility for the wholesomeness of the meat supply, EPA has responsibility to assure that pesticides are used according to label directions, and FDA has final authority for enforcement of the laws governing use of animal drugs and acceptability of medicated feeds.

1. Epidemiology

Violative residues in edible tissues, milk and eggs can result from misuse of animal drugs in feed, the presence of pesticides and industrial chemicals, and from natural toxicants such as aflatoxin. Accidental inclusion of pesticides or industrial waste materials in feed formulation, improper storage of feed and pesticides, and application of pesticides to forage or grain crops are among the causes of contamination. Animals also can be exposed when allowed access to rubbish piles with discarded chemicals or pesticides, drinking water contaminated with pesticide run-off or industrial pollution, and when exposed to insecticides either on their bodies or in their housing.

Persistent chemicals of accidental or unanticipated origin caused a number of incidents of violative residues in food animals in recent years. These incidents
ranged in size from situations that involved one producer to those that involved a large number of producers over a large area. Residues of persistent chemicals probably do not pose as large a public health threat, or as large an economic threat to producers, as violative residues of natural toxicants, feed additives, or animal drugs. Nevertheless, the presence of these chemicals is serious because they are insidious. First, the residues are unanticipated by all parties concerned because the compounds do not have a role in normal agricultural production. Second, the chemicals are persistent which means that although they can be detected earlier, because of their nature they will be harder to remove.

In the United States the animal production industry is extensive and the use of drugs to promote growth and prevent disease in confinement rearing is common. Most of the animals raised in this country for slaughter are raised in confinement rather than being allowed to roam on large acreage. This confinement increases the possibility of disease, making it necessary to use drugs subtherapeutically. However, these drugs are subject to withdrawal times prior to slaughter which allow the animal to excrete any residue before marketing. The problem occurs when the withdrawal times are not adequately followed by producers and feedlot operators.

USDA/FSIS routinely takes random samples of meat carcasses at the slaughtering plants to check for detectable residues. Where residues are found USDA notifies the FDA which makes a follow-up investigation at the animal producer level to determine the source of the contamination. Not following label directions and failure to observe the required withdrawal times are the common reasons for the contamination. Other types of contamination, such as those caused by chemicals and pesticides, are more readily detectable at earlier stages.

2. Technology

If producers and feedlot operators follow the label directions and observe proper withdrawal times for animal drugs, the environment should be free of this form of contamination. Producers and feedlot operators should always be alert for the possibility of the accidental introduction of industrial hazards such as PCBs, PBB, TCDD and other halogenated hydrocarbons. The nature of persistent chemicals is such that they are often viewed by the public as a more serious threat than other potential chemical residues. Assuming that producers and feedlot operators have observed the label directions and withdrawal times, meat products are then processed in facilities which are subject to continuous inspection by the USDA. At the retail sales level, the product should be free of contamination and if properly refrigerated and properly prepared should remain free of contamination.

The United States is undertaking these project activities to attain anti-contamination goals:

For illegal residues in animal-derived food FDA will:
— utilize contacts with officials of the national producer groups;
— conduct an epidemiological study of currently available residue reports;
— coordinate voluntary compliance plans and operations with industry and other agencies; and
— develop educational and informational materials for regulated groups.

Key animal food producer groups will be provided with informational material to help them set up quality assurance programs to prevent unintentional or acciden-
tal contamination of animal feedstuffs. In addition, enforcement of all laws designed to prevent illegal distribution of veterinary prescription drugs are being strengthened.

FDA and USDA/FSIS recently warned hog producers that a relatively small number of violators are posing a threat to human health and consumer confidence because of an unacceptable six percent level of sulfamethazine residues in marketed pork. The two agencies mailed a check list to about 114,000 pork producers for posting near feed mixing equipment to help eliminate the problem. The check list is entitled “Avoid Sulfur Violations... It's Good Business”. In addition, FDA has initiated on-site investigations of those persons marketing hogs in which FSIS has found a violative sulfonamide residue in edible tissues to determine the cause of residues. The agency will take regulatory action against those persons found causing sulfur residues in hogs slaughtered for human food.

3. Economy

United States meat production is an enormous business. In 1984, for example, the country slaughtered 87.2 million hogs, 50.6 million beef cattle, 10.3 million calves, 4.5 billion chickens, 163.6 million turkeys, and 20 million ducks. Volume is large and competition is vigorous. For this reason producers must stay abreast of innovations and changing technology. Numerous trade associations as well as the government provide assistance in maintaining high production levels at the least cost and with safety for the consumer.

* * *

CONCLUSIONS

All in all, the reports submitted to the Office International des Epizooties reveal a pattern of genuine national concern on the part of the responding governments, including Argentina and Uruguay, concerning the safety of domestic and exported meats. (Information received from Argentina and Uruguay is presented in the next section.) The programs of these countries can and should serve as models for other countries. The role of FAO, OIE, PAHO, WHO, and the governments of countries with developed programs should be to assist interested countries in the development of sound residue programs with threefold aims — the prevention of residues, the detection of residues, and the enforcement of national laws regarding meat adulteration.

It is also time that international organizations begin to recognize animal drug control as an integral part of animal health programs. Most animal health programs were established before the advent of modern animal drugs and thus do not recognize the importance of the registration of veterinary drugs and the control of residues of those drugs.

It can indeed be argued that animal drug residues represent a greater potential for harm than certain zoonoses.
A MODEL RESIDUE CONTROL PROGRAM*

It is necessary to recognize that control and surveillance in any residue control program — even in countries with advanced technology and resources — are difficult, considering the numbers of factors and systems involved.

The primary technical issues that have to be considered in any such program can be summarized as follows:

1. **Definition of technical assessment of dangerous levels**
   - (a) Variation in lethal levels.
   - (b) Extrapolation of experimental data from laboratory animals to humans.
   - (c) Sublethal actions not easily identified.

2. **Definition of acute toxicology**
   - (a) Selection of animal species for measurement.
   - (b) Selection of models to establish tolerance.
   - (c) Selection of critical tissues and organs for detection.

3. **Definition of chronic toxicology**
   - (a) Interpretation of metabolic pathways.
   - (b) Determination of mutagenic, carcinogenic and teratogenic actions.
   - (c) Extrapolation of pathological lesions from laboratory test animals to humans.
   - (d) Studies on groups, areas or professions that are exposed to contaminated food or are involved in the manipulation of risk substances.

Each substance must be studied in relation to its accumulation in animal tissues and its potential risk when found in human foods. A toxic substance, for example, is absorbed by the animal through the skin, respiratory tract or gastro-intestinal tract. The substance is then metabolized by the liver or through other animal tissues, i.e. by active transport through cell membranes, diffusion and solubility in the organism, diffusion by linkage with proteins, solubility in fats, or through nucleic acid binding. The animal excretes the substance through urine, bile or milk.

The estimation of public health risk — based on residues transmitted through animal food products — can be examined by studying epidemiological and environmental features of the various substances.

**Products applied directly to animals**

<table>
<thead>
<tr>
<th>Product</th>
<th>Tissues for residue detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anabolics</td>
<td>Liver, kidney, muscle</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Milk, meat</td>
</tr>
<tr>
<td>Internal parasiticides</td>
<td>Milk, kidney, liver, fat</td>
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<tr>
<td>External parasiticides</td>
<td>Milk, kidney, liver, fat, skin</td>
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<tr>
<td>General veterinary drugs</td>
<td>Liver, kidney, fat, milk, pharmacodynamic related tissues</td>
</tr>
</tbody>
</table>

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* This program was developed in large part from reports received by the OIE from the governments of Argentina and Uruguay.
Control programs used in monitoring these substances for residues include laboratory tests, field monitoring, timing of use in the animal before food consumption, and the setting and monitoring of tolerance levels.

**Products applied on the animal environment**

Residues of agricultural pesticides, herbicides and fertilizers can be detected in fats, kidneys, liver, muscle and milk from the animals. Control programs used in monitoring these substances for residues are the following: notification and seasonal control of application of the products; determination of degradation of products in the environment; monitoring time interval between use and animal feeding; and the setting and monitoring of tolerance levels.

**Products derived from environmental pollution**

Industrial product derivatives from chemical, mineral and steel manufacturers (Ba, Be, Cd, Cr, Cu, Mn, Ni, Pb, Va, Zn, As) and pollutants from oil distilleries and both stationary and mobile combustion engines can also cause residues which can be detected in skin, mucosas, lungs, bone marrow, liver, kidneys and central nervous system. Control programs include studies on regional contamination profiles; climatological and seasonal studies, by area; and various techniques for prevention and control of contaminants in the environment.

**SAMPLE PROGRAM FOR RESIDUE DETECTION AND CONTROL**

A practical example of a residue program in a developing country is the ongoing operations for surveillance and control in Argentina. That program consists of the following elements:

1. **Objectives**
   
   (a) Surveillance of residues in animal products, examining for causes and origins.
   
   (b) Standardization of norms and procedures for detection.
   
   (c) Study of seasonal incidence and geographic prevalence.
   
   (d) Development of technical basis for legislation.

2. **Responsible agencies**

   (a) National Animal Health Service (SENASA) of the State Secretariat for Agriculture and Animal Husbandry.
   
   (b) Secretariat for National Public Health.
   
   (c) Provincial and Local Public Health Administrations.

3. **Basic operations of the program**

   (a) Process sampling at meat packing plants and in milk and fish industries.
   
   (b) Sampling and surveillance of crops and seeds in pastures and in feed manufacturing plants.
   
   (c) Coordination and control activities in the field and in laboratories by inter- and intra-laboratory tests.
4. General information on techniques used

<table>
<thead>
<tr>
<th>Product</th>
<th>Tissues</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic chlorides, organic phosphorides, general pesticides, PCBs</td>
<td>Peripheral kidney fat, liver</td>
<td>Solvent extraction and gas chromatography</td>
</tr>
<tr>
<td>Heavy metals (As, Pb, Cd, Co, Fe, Ni, Mn, Zn)</td>
<td>Liver, muscle</td>
<td>Incineration and determination by atomic absorption, spectrophotometric analysis</td>
</tr>
<tr>
<td>Mercury</td>
<td>Liver</td>
<td>Chemical reduction and atomic absorption, spectrophotometry</td>
</tr>
<tr>
<td>Hormones and anabolics</td>
<td>Liver, prostate, muscle</td>
<td>RIA and histopathology test</td>
</tr>
<tr>
<td>Antibiotics (penicillin, streptomycin, erythromycin, neomycin, tetracyclines)</td>
<td>Muscle</td>
<td>USDA/FSIS techniques for growth inhibition of standard strains</td>
</tr>
<tr>
<td>Sulfonamides</td>
<td>Muscle</td>
<td>Thin layer chromatographic and densitometer evaluation (USDA/FSIS)</td>
</tr>
</tbody>
</table>

5. Argentina legislation for residue control

Pesticides: Regulations and standards accept the joint program norms of FAO/WHO.

Heavy metals: Regulatory rules establish standards for meat and derivatives, for water standards and for specific products (in particular, mercury of sea origin).

Hormones: Regulatory rules forbid use of estrogenic substances for animal husbandry purposes.

Antibiotics: Regulatory rules establish norms for the use of antibiotics in meat, poultry and fish.

DISCUSSION

The complexity of field surveillance, the high level of analytical techniques requiring extreme accuracy and the problems derived from tolerances and risks all pose serious difficulties for the accomplishment of residue control programs in developing countries. The most difficult issues can be summarized as follows:

1. Lack of enough up-to-date equipment, well-trained personnel, drugs and reagents for modern techniques.
2. Lack of resources for field monitoring and continuous control, surveillance and sampling operations.
3. Occasional lack of updating legislation.

Programs have been developed and expanded in some developing countries to comply with legislation in importing countries. This has caused a re-ordering of
priorities around international trade, even though other problems were more acute from a national health program perspective.

It is vital that a cooperative system by established by which developed and developing countries reach technical agreements on the following issues: (a) notification and epidemiology of any disease case or outbreak in humans or animals, attributed to residue toxicology; (b) information about advances in analytical techniques; and (c) development of effective detection systems for monitoring contaminants and for defining epidemiological characteristics, by area.

International agencies such as the OIE, WHO, FAO and Codex Alimentarius may institute a coordinated system to develop a multilateral cooperative program. In developing countries, control of trace residues in animal products must be included in the program, taking into account resources, ecological features and causes of potential risk.

The developed countries, either on a bilateral basis or through the international agencies, can contribute to world environment control and food safety by accepting a fundamental responsibility for identifying problems and assisting in their control in different areas of the world.

CONCLUSION

New knowledge and technologies in the field of food-animal production and control are constantly being developed. It is our responsibility also to develop communications strategies through which we can share this information with one another.

A beginning has been made. The Codex Alimentarius Commission (CAC)* at its biennial meeting in July 1985, in Geneva, approved the establishment of a Committee on Veterinary Medicine. The CAC selected the United States of America as the host country for the new committee, with Dr. Lester M. Crawford, Director of the Food and Drug Administration Center for Veterinary Medicine as Chairman.

An Expert Consultation, convened in November 1984, had informed CAC that residues of veterinary drugs in foods are of "significant public health and consumer concern and pose problems to international trade".

The Committee on Veterinary Medicine will be charged with a broad scope of issues ranging from establishment of safety criteria and standards for analytical methodology to providing information and training, particularly to developing countries. The U.S. Department of State will sponsor the Committee and the U.S. Department of Agriculture will name the official Delegate.

We face a challenging future. But along with the challenge comes opportunity — the opportunity to develop a worldwide community of scientists, veterinarians, drug manufacturers, and animal producers dedicated to supplying safe and wholesome food to the tables of the world.

* The Codex Alimentarius Commission is a joint food standards program established in 1964 by the World Health Organization and the Food and Agriculture Organization of the United Nations.
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