Risk analysis and meat hygiene

S.C. HATHAWAY *

Summary: Meat hygiene consists of three major activities: post-mortem inspection; monitoring and surveillance for chemical hazards; and maintenance of good hygienic practice throughout all stages between slaughter and consumption of meat. Risk analysis is an applied science of increasing importance to these activities in the following areas: facilitating the distribution of pre-harvest, harvest and post-harvest inspection resources, proportional to the likelihood of public health and animal health hazards; establishing internationally-harmonised standards and specifications which are consistent and science-based; and improving the safety and wholesomeness of meat and meat products in local and international trade.

Risk analysis, in one form or another, is well developed with respect to establishing standards and specifications for chemical hazards; methods for risk analysis of post-mortem meat inspection programmes are beginning to emerge. However, risk analysis of microbiological hazards in meat and meat products presents particular difficulties. All areas of application currently suffer from a lack of international agreement on risk assessment and risk management methodology.


INTRODUCTION

Food-borne disease is generally recognised as a major human health problem and an important cause of decreased economic productivity in both developed and less developed countries. Despite this, very little information is available on the true level of exposure of specific populations to potential hazards, particularly in the case of bacterial diseases transmitted by consumption of meat and meat products. Attempts to quantify human health risks consequent to exposure to food-borne hazards largely rely on extrapolation, to the population at large, of information gained from individual disease outbreak investigations.

In the case of meat hygiene, the qualitative recognition that unseen microbiological and chemical contamination, rather than grossly-apparent abnormalities, are now the most important sources of hazards to human health has led to increasing demands for a more systematic regulatory approach to combat these hazards. In particular, traditional meat hygiene programmes which focus the large majority of resources on routine ante- and post-mortem inspection are now recognised as inadequate (8, 12, 15, 19, 20, 52, 68, 78).

* MAF Regulatory Authority, Ministry of Agriculture and Fisheries, P.O. Box 646, Gisborne, New Zealand.
A wider recognition of the high level of complexity of food safety issues and increasing demands from consumers for maximum protection are other factors which are forcing regulatory authorities to adopt a more systematic and scientific approach to meat hygiene. Commensurate with these changes, protection of food from contamination, spoilage and adulteration is no longer primarily a domestic issue; regulatory authorities must also respond to increasing demands for the facilitation of international trade.

Food safety goals

The food safety goals now being adopted by regulatory authorities profess to incorporate the philosophy that resources should be allocated towards identifying and controlling the hazards of greatest public health importance and that, in doing so, there should be cost-effective allocation of resources (8, 21, 23, 54, 55, 68, 80, 81). In reality, there has been little scientific progress to aid this philosophy. Despite the resource-intensive nature of meat hygiene programmes, assessment of the overall benefit of such programmes is still limited by the lack of systematic data with regard to the various elements of meat hygiene as they relate to public health, and by the inherent difficulty in relating findings which are made during inspection to end-points in terms of public health.

In the medium term, regulatory authorities need to develop science-based decision-making criteria which justify the chosen allocation of resources and underpin the overall functioning of meat hygiene programmes. In particular, normative (value-laden) decisions which have been made in the absence of good scientific knowledge need to be reassessed, and coherent strategies need to be developed for the control of hazards in the pre-harvest area of production.

Although widely applied in the assessment of engineering and nuclear risk, formal risk analysis is relatively new to the field of food safety. Risk analysis of meat hygiene programmes is the primary focus of this paper; however, the discussion has general application to other raw foods. Risk analysis will be used to re-shape existing meat inspection programmes, as well as being a vehicle to address technical issues which affect international trade in meat and meat products. In the field of animal health, risk analysis is more likely to focus on the latter area of activity – assessing (and managing) risks associated with the international movement of animals and animal products.

Risk analysis

Risk analysis is based on an amalgam of scientific and technical information, and social and political policy decisions. Thus, it is an applied, rather than a theoretical science (48). The elements of risk analysis are: risk assessment, risk management and risk communication.

Risk assessment is the primary scientific process, and is regarded as the estimation of the likelihood (probability) and severity (magnitude) of harm or damage resulting from exposure to hazardous agents or situations. In an ideal situation, the risk assessment process would be restricted to the “value-neutral” (non-normative) assessment of purely objective scientific data generated by alternative courses of action.

Scientific value judgements and policy choices are inevitably involved at some decision points in the risk assessment process. Thus, in assembling risk assessment data, scientific experts should be guided by clear policy directives when any value judgements affecting the outcome of the assessment are made (33, 37, 64). Determining this "risk
assessment policy" is an interactive process. The following are examples of decision points where policy guidelines are necessary:

- range of hazards included in the primary hazard identification
- judging the scientific adequacy of the available data
- treatment of uncertainty
- deciding on the statistical basis for the standard of proof.

The treatment of uncertainty is a risk assessment policy issue with particularly important implications: should the “worst case”, the “best case” or the mean of the range of uncertainty be chosen?

Health risk assessment is a specific application which has been used almost exclusively to investigate chemical and radionuclear hazards. In this sense, risk is the likelihood of an adverse outcome when a person (or persons) is exposed to a particular concentration or dose for a specific period of time (i.e. risk is a function of exposure and absorbed dose) (70). Health risk assessments are typically divided into four activities: hazard identification, hazard characterisation (including dose/response assessment), exposure characterisation and risk characterisation (6, 11).

Risk management is concerned with the development and selection of policy options for the purpose of decision-making, and the implementation of the regulatory programme which is developed from the risk assessment. The options considered may be quantified solely in economic terms, and risk management decisions may be made according to some risk-balancing standard, e.g. the analysis producing the highest cost/benefit ratio. However, risk management decisions must often be made in the face of significant scientific uncertainty, and it may not be possible to reduce the values considered to monetary values alone. Relevant social criteria concerned with issues of "equity and ethics" include: standards of health, technological feasibility, social concerns and politics (44, 79).

The likely distribution of risks and benefits is another key issue in risk management decisions. For example, economic benefits from more cost-effective production methods for a food commodity will predominantly accrue to the producers, whereas any increase in public health risks which might possibly result from the changes would be borne by the consumer. This also raises the question of who should provide the burden of proof of public health safety when a change in production methods is proposed: should it be the producer of possible risks or the bearer of these risks?

Risk managers must make a choice regarding what constitutes an “acceptable” level of risk. The simplest technique is a cost/benefit approach in situations where all risk management options can be reduced to economic terms and quantified in such terms. Risk analyses involving human values will require the use of another methodology, such as threshold risk, comparative risk, “zero risk” or “as-low-as-reasonably-achievable” (ALARA) risk standards. The last of these techniques is useful in many public health situations, and typically adopts the means of reducing an identified risk which most effectively uses the available resources. In doing so, ALARA adopts “zero risk” as an ideal, while balancing the ideal against “reasonable” cost limits on the resources required for the obtained level of safety (37).

Three general models of risk analysis can be recognised (6, 11, 37, 70): the “one-stage” model, the “two-stage” model and the interactive model. The
"one-stage" model attempts to reduce risk analysis to a purely technical exercise, integrating all aspects of risk assessment and risk management into one decision-making matrix based on a cost/benefit standard.

The "two-stage" model demands clear functional separation of risk assessment and risk management, and has emerged as a common regulatory principle in the United States of America (USA) (6, 11, 76). The risk assessment stage is a purely scientific and technical exercise which attempts to deliver fully quantified assessments of risk to risk managers. The risk management stage is concerned with deciding on an acceptable level of risk which is explicitly recognised as a value judgement.

The interactive model also identifies risk assessment and risk management as separate functions, while recognising that the interactive normative decisions which determine risk assessment policy must operate in tandem, rather than sequentially (37). The same value choices underpinning the risk management process should also underpin the risk assessment policy decisions taken during the assessment.

Recognition of risk communication is a vital part of the risk analysis process. The results of risk assessment and risk management need to be effectively communicated both within and between regulatory authorities and to the public. The formulation of regulatory policy should include representative consultations with public "stakeholders", and the basis for risk management decisions should be effectively disseminated in a "transparent" format to all interested parties.

Public health and animal health risk analyses share common principles (31, 50); however, the way in which an animal health risk analysis proceeds may be quite different. Quantitative information on the prevalence of a disease agent in the host population and the probability of transmission is much more likely to be included in the risk analysis in cases of specific diseases of animal health importance than with (often unspecified) diseases of human health importance. Furthermore, risk management decisions in animal health import risk analysis are likely to depend on the reliability of information gathered in another country on an ongoing basis; such decisions are also likely to focus on the means of reducing risks associated with imported animals or animal products, as well as being limited to estimating the probability of the hazard occurring (rather than including an estimation of the severity of such an outcome).

In discussing risk analysis, it should be recognised that, while uniform principles of risk assessment and risk management can be pursued, uniform conventions (such as levels of statistical significance) are not necessarily advisable in deciding the level of proof which is acceptable for policy purposes (33). As an example, it may be appropriate to rely on "most likely" estimates of risk when evaluating the risk of using a chemical which is essential to a beneficial societal activity (e.g. use of radionuclides in medicine), whereas a "worst case" estimate may be appropriate when evaluating a non-essential chemical (70).

Why risk analysis in meat hygiene?

Meat hygiene programmes are primarily instituted to ensure that meat and meat products are "safe and wholesome". In the case of raw meat, this is only a qualitative measure of freedom from hazards to human (and animal) health (51). Post-mortem meat inspection cannot guarantee freedom from all grossly-detectable abnormalities, and sampling programmes have limited ability to detect randomly-occurring violative levels of chemical residues and contaminants. More importantly, some degree of inadvertent microbiological contamination is inevitable in the slaughterhouse environment.
Risk analysis provides a specific tool to assess the risks and benefits associated with a particular meat hygiene system. In this respect:

- "Risk assessment" is now a regulatory principle in a number of countries and reference is increasingly being made to this principle in food safety legislation. Risk assessment and risk management in public policy decision-making are probably most advanced in the USA, where Federal regulations require that risk research defines and considers the effects of risk, identifies target populations, and provides some form of cost/benefit analysis (11, 16). Some statutes include consideration of cost/benefit balancing (e.g. with regard to pesticides), whereas others specifically exclude this (e.g. disposal of hazardous wastes). Where appropriate, a formal consideration of risks to occupationally-exposed groups, the public and the environment is being included in new European Economic Community (EEC) directives. Directive 89/391/EEC (1 January 1993) provides a general framework for risk and safety issues.

- Food law usually documents the general requirements for food safety; regulations provide the detail required for specific applications. However, the pace of change in food technology and scientific knowledge is now rapidly outstripping the rate of amendment of legislation, and regulations must be flexible enough to accommodate these rapid changes. Application of the principles of risk assessment and risk management provides the opportunity for flexible, but science-based, rule-making within a legislative framework.

- International agencies, in particular the Codex Alimentarius Commission (CAC), are playing an increasing role in developing standards and guidelines for food safety, leading to harmonisation of the requirements governing world trade (26). The report of the 38th Session of the Codex Executive Committee (29) stated that all relevant Codex committees should be required to describe the basis of the risk assessment methods used in arriving at recommendations, guidelines or standards.

- With the intent that national measures be based on international standards and guidelines wherever possible, the draft Decision on Sanitary and Phytosanitary (SPS) Measures of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) talks states that "contracting parties shall ensure that their SPS measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organisations" (24). Evaluation of the "equivalence" of particular inspection programmes used by different trading partners will increasingly depend on risk analysis.

- The Hazard Analysis Critical Control Point (HACCP) approach to food safety is gathering momentum worldwide (20, 23, 41). The principles of risk assessment and risk management are primary elements in the design of HACCP systems and in the utilisation – for regulatory purposes – of the data generated by these systems.

- The public perception of food safety is often very different from that which is scientifically appropriate or even feasible. Well-structured research based on risk assessment principles, coupled with effective risk communication, is needed to change this perception.

- Veterinary animal health authorities and the Office International des Epizooties (OIE) are actively developing import risk analysis in the field of animal health (31, 62). Guidelines for import risk assessment include a consideration of adverse events of both animal and public health importance; however, it is noteworthy that the OIE guidelines
limit risk management to “the identification, documentation and implementation of the measures that can be applied to reduce the risks and their consequences”. In addition to the need for consistent application of risk analysis methodology in the domain of both veterinary public health and animal health, the cost-effective allocation of regulatory resources in the pre-harvest area of food production will increasingly demand an integrated risk analysis approach.

**POST-MORTEM MEAT INSPECTION**

Despite the fact that most meat hygiene resources are devoted to routine post-mortem meat inspection activities, there has been very little emphasis on gaining scientific evidence to link this function with measurable outcomes in terms of human health. Additionally, there has been little progress in tailoring inspection procedures to the spectrum and prevalence of the diseases and/or defects present in a particular class of slaughtered livestock from a specific geographical region (8, 49, 52, 55, 80). A risk assessment model can be used to address these problems and facilitate the proportional allocation of resources according to the level of risk (53, 57). In doing so, the performance and equivalence of different meat inspection systems can also be judged.

**Risk assessment**

In broad terms, the major “hazards” detectable at post-mortem meat inspection are identified during observation of tissues. Following removal of the most important hazards, incremental benefits decrease as the level of inspection intensity increases. The optimum usage of post-mortem inspection occurs when the incremental gain in benefits (in the broadest sense) equals the incremental increase in costs (74). Thus, the optimal use of inspection resources does not eliminate all hazards, but removes all important hazards and ensures that any residual hazards are minor in nature and exist at a prevalence which constitutes a “negligible” risk to the consumer (57).

A number of studies have been conducted in recent years to evaluate particular post-mortem inspection programmes (40, 49, 52, 67, 68, 69, 80, 84). Each study has used different methodology and very few have assessed the true performance attributes of the procedures under investigation, even in those cases where the presence of a disease may constitute a specific zoonotic risk. In the absence of rigorous risk assessment methodology, such studies leave regulatory authorities exposed to legitimate challenge if the outcomes have been used as the basis for risk management decisions on the allocation of inspection resources. As an example, the National Research Council in the USA reviewed changes to traditional inspection procedures for poultry and swine between 1979 and 1983, and concluded that the changes were unlikely to diminish protection of public health (8). However, it also concluded that there was “no clear evidence that the traditional inspection procedures were based on objectives and criteria that relate to public health. In the absence of a systematic accumulation of data on which to base a complete technical analysis, no overall assessment of risks and benefits could be made.”

A well-designed risk assessment model can provide a quantitative basis for comparative evaluations, thus delivering scientifically-appropriate information for risk management decisions. The four analytical steps of the general health risk assessment model (6, 11) can be suitably modified, as outlined below.
Hazard identification

All hazards which could be present in the tissues of interest and could be detected by organoleptic inspection procedures need to be identified. "Hazards" in meat hygiene include public health hazards, animal health hazards and aesthetic defects which are unacceptable to the consumer.

Hazard characterisation

Dose/response relationships developed from laboratory animal trials to assess chemical hazards are inappropriate for the characterisation of gross abnormalities detectable at post-mortem meat inspection. Therefore, consideration is given to all conditions which may be present in the final product and can be detected by post-mortem inspection procedures.

Exposure characterisation

Exposure of the human population to "hazards" in meat which should have been detected by the procedures under investigation is very dependent on the particular processes and conditions applied to the meat prior to human consumption. Nevertheless, the "worst case" exposure characterisation must assume that the consumer will be exposed to all hazards which organoleptic meat inspection is capable of detecting but which escape the inspection procedures in place. Thus, the establishment of the performance attributes of individual procedures (sensitivity, specificity and non-detection rate) allow a quantitative characterisation of exposure. The non-detection rate can be defined as the proportion of abnormal tissues among those classed as normal by the individual procedure, and is equivalent to 1 minus the negative predictive value of the test (57).

Risk characterisation

A consideration of the difference between non-detection rates for all identified hazards with each procedure, together with a scientific assessment of the consequences of each difference, provides the basis for the risk characterisation. The investigator must consider the importance of all individual "hazards" which escape detection during the application of particular procedures on a case-by-case basis. However, in the case of tissues not destined for human consumption, the only hazards of significance are those which serve as an indicator for other tissues or which may have implications for animal health.

The design of field trials incorporating the above elements has been described previously (52, 57). As a working example, the application of a risk assessment model to evaluate all post-mortem inspection procedures for the viscera of lambs slaughtered in New Zealand utilised field trials conducted in 37 export slaughterhouses and involved more than 963,000 comparative evaluations (52). This has resulted in a new national code of meat inspection for these tissues. The quantitative methodology used in the risk assessment model provides the basis for determinations of equivalence between the New Zealand code of ovine meat inspection and similar codes in other countries.

Risk assessment policy decisions

The risk assessment model quantifies the precise non-detection rates which accompany the various post-mortem inspection procedures for a specific class of livestock, and provides the basis for the establishment of an acceptable defect level based on a scientific assessment of the likely public health, animal health and aesthetic
risks. Adequacy of design can be assessed by reference to established scientific principles. The only likely sources of contention in the risk assessment model should be the risk assessment policy decisions inherent in the model.

Selection of sampling parameters involves risk assessment policy decisions which are primarily scientific value judgements. Samples must be representative of the population to which the conclusions are to relate and must include enough samples to enable definite conclusions to be reached with regard to the consequences of any change in inspection procedures (57). The level of residual risk which is not addressed by the model also depends on sample size. For example, a fixed sample size (S) has a 95% chance of including any abnormality which occurs at a prevalence of approximately 1 in S/3 (47). Therefore, a sample size of 30,000 has the capability of limiting the chance of non-detection of an unidentified hazard to less than 1:10,000 with 95% confidence, and this would represent a practical compromise between the desire to detect all abnormalities which could possibly occur at very low prevalences and the practicality of conducting large-scale field trials.

Other risk assessment policy decisions include the statistical choice for comparison of the outcomes of different inspection procedures. Some studies have used tests of statistical significance to decide on equivalent performance; however, although superficially attractive, such tests provide only limited information on the comparative performance of the procedures (57). The most rigorous approach upon which to base risk management decisions is to consider the “worst cases” included in the confidence intervals for the non-detection rates for each procedure.

Risk management

Decision-making criteria for establishing an acceptable level of risk for post-mortem meat inspection programmes may be complex. With the realisation that even high-intensity routine inspection procedures are neither 100% sensitive nor specific (52, 67, 69, 74), risk management decisions should focus on the comparative performance of the different procedures under test. It is neither technically feasible nor cost-effective for current meat inspection systems to eradicate all potential hazards from fresh meat produced for human consumption. Thus, a “zero risk” approach to risk management is inappropriate. A framework for risk management decisions on the comparative performance (and equivalence) of different post-mortem meat inspection programmes should include:

- demonstration that any potential increase in public health risks on a case-by-case basis is “effectively zero”, using an ALARA standard
- application of an ALARA standard for any differences in aesthetic and other risks
- identification of “scenario trees” and, where appropriate, the likely modification of exposure to identified hazards
- judgement by expert arbitration as a procedural standard
- integration with risk assessments for other components of the meat hygiene programme
- consistent and credible risk analysis policy which is communicated to all interested parties.

The detection of any abnormalities which are potentially of severe human health, animal health or aesthetic importance is an obvious prerequisite of any inspection
regime; however, the application of high-intensity procedures to detect all abnormalities of trivial importance is not defensible if resources are to be allocated according to areas of greatest risk. ALARA does not demand the exact quantification of risks and benefits in terms of a single denominator, and would be sensitive to the uncertainties implicit in veterinary public health risk analyses. As such, ALARA is a reasonable compromise between the often unachievable demands of “zero risk” and the practical and social/political difficulties of a quantitative cost/benefit approach (37).

An important issue in risk management is the consideration of scenario trees for meat and meat products. The scenario tree begins with an initial event and charts the functions which can affect the outcome of this event. Construction of a scenario tree describes the risk model, and the likelihood of each of the risk scenarios can be calculated (and aggregated into an overall quantification of risk) by several statistical methods. The use of probability density formats is becoming increasingly acceptable (61) and, in this case, quantification of each scenario parameter depends on expressing each numerical value as a probability curve against all possible values. Computer software programmes (such as @Risk [Palisade Corporation, New York, USA]) can use more elemental probability distributions (e.g. triangular distributions based on minimum, most likely and maximum estimates) to perform iterative calculations for risk assessment.

Constructing scenario trees for risk analysis of raw meat and meat products is not a simple task and should be undertaken on a case-by-case basis. Some process interventions remove public health hazards (e.g. freezing of meat to specified temperatures to kill parasitic cysts [60]), whereas microbiological hazards may be amplified by product abuse prior to consumption. In contrast, some aesthetic hazards may be rendered unrecognisable by further processing interventions. Difficulties in determining true levels of human exposure to microbiological hazards which may be associated with grossly-detectable abnormalities (including amplification by cross-contamination), as well as the likely magnitude of the effects of such exposure (see below), are compounded by the wide variation and unpredictability of events between processing and consumption for different meat products. In the absence of adequate dose/response data and given the wide variability of outcomes in different individuals if transmission of an infectious agent occurs, risk management will usually be limited to decisions based solely on the probability of the hazard(s) occurring under different operating systems.

It is likely that post-mortem meat inspection activities which detect and remove grossly-abnormal tissue contribute relatively little to safety in modern meat production systems (8, 15, 53, 54, 56). Unfortunately, there is no risk assessment model to assess the relative importance of these activities compared with those of process control systems which attempt to minimise inadvertent microbiological contamination during slaughter, dressing and further processing. In the absence of any systematic data on the public health impact of current post-mortem inspection procedures for poultry in the USA, a major study by the National Research Council concluded that the primary focus on organoleptic inspection should be shifted to quality assurance systems for microbiological and chemical surveillance (15). In a New Zealand context, an extensive bacteriological survey of grossly-detectable abnormalities in lamb viscera revealed very few bacteria of public health importance; a subsequent literature review indicated that almost all potential meat-borne zoonoses would occur as a result of unseen contamination with enteric pathogens, many of which have high asymptomatic carriage rates (54).
International activities

The need for systematic risk analysis of post-mortem meat inspection programmes is now widely recognised on the international level. Although this need is acknowledged in principle, there have been few international initiatives to translate this principle into generally-agreed risk analysis methodology. The widely-recognised need to accept the equivalence of different national programmes (where these are warranted) and to harmonise international requirements for trade depends on such methodology. National initiatives have led to some changes in domestic programmes, but there is concern that inadequate methodology may lead to criticism of such changes in the future (8, 15, 56).

The recent re-drafting of the codes of practice on all aspects of meat hygiene by the Codex Committee on Meat Hygiene (27) incorporates general principles for a risk analysis approach; however, it is beyond the purview of this committee to initiate a working group to develop specific methodology. Nevertheless, the CAC has asked that all relevant Codex Committees describe the basis of any risk assessment methods used (29). International agreement on risk analysis methodology is also implicit in the SPS Decision of the Uruguay Round of GATT (24).

Risk analysis of any post-mortem meat inspection programme would necessarily entail public recognition that some level of exposure to grossly-detectable abnormalities is unavoidable. In the past, regulatory authorities have avoided challenging the “zero defect” concept held by the consumer, largely because the authorities themselves have had very little scientific data with which to quantify empirical knowledge of risk. If regulatory authorities are genuinely to engage in a scientific and risk-based allocation of inspection resources, they will need to develop particular skills in communicating to the public the residual risks inherent in all components of any meat hygiene programme.

CHEMICAL HAZARDS

Routine monitoring and surveillance for chemicals, contaminants and residues in meat and meat products (“chemical substances”) constitutes a major element of meat hygiene programmes. During processing, food additives will have been deliberately added at levels up to those allowed by food standards, whereas other chemical substances may have entered the food chain at any stage of production or processing.

Unlike the situation with on-line post-mortem inspection, risk analysis in one form or another is relatively well established in the development of standards and guidelines for chemical substances in meat and meat products. This is largely consequential to the application of “risk analysis” in the general area of chemical contamination of foods and the importance of meat as a dietary component in average daily food intake calculations. However, in some specialised applications in meat hygiene (e.g. residues of veterinary drugs) formal risk analysis is a relatively recent development.

Risk analysis of chemical hazards has primarily been used to establish maximum permitted limits in target tissues or meat products. In the international arena, the CAC and the Food and Agriculture Organisation of the United Nations (FAO) and World Health Organisation (WHO) expert groups (the FAO/WHO Joint Expert Committee on Food Additives [JECFA] and the Joint Meeting of the FAO Panel of Experts
By comparison, the sampling plans for monitoring chemical substances in meat and meat products are rarely evaluated on a risk analysis basis. In the absence of 100% monitoring (cf. post-mortem meat inspection), the statistical adequacy of sampling plans is an essential component of a systematic risk-based approach. As a parallel activity, risk analysis of the scientific validity of regulatory responses when violative levels for specific substances are detected (domestically or at port-of-entry inspection) has rarely been conducted.

Risk assessment

Prior to toxicological evaluation, data are required on the chemical structure, stability, presence of impurities, and breakdown products of the compound to be assessed. These data facilitate identification of the chemical to be used in animal toxicity tests, and the type of studies to be performed.

In general terms, the safety assessment of chemical substances in meat and meat products should contain the elements of the four analytical steps described for all health risk assessments (6). Differing methodologies have been developed in different countries, but the safety assessment of all chemical substances is largely based on the results of high-dose toxicological studies in laboratory animals, and conjectures about what might occur at lower doses (14, 63, 71, 76). Detailed descriptions of the methodologies used are widely available and the dose/response part of the risk assessment is based on the scaling up of animal data to humans. Relevant biological data include biochemical tests, acute and chronic toxicity studies, special studies (e.g. testing possible neurotoxic, reproductive or mutagenic effects) and observations in humans. Metabolic studies may be used to complement the extrapolation of laboratory animal findings to humans.

The "no-observed-effect-level" (NOEL), determined from laboratory animal studies, approximates a threshold level below which an adverse health effect will not ordinarily occur (14, 16, 17). (This assumes that a threshold dose actually exists and that no toxic effect will occur below this.) In most evaluations, the NOEL determined in the most sensitive species is divided by a safety factor in order to compensate for uncertainties in the scientific process. However, a shortcoming of this step is the inability to take the shape or gradient of the dose/response curve into account.

The "safe" dose is established as an acceptable daily intake (ADI) for a food and is expressed in relation to body weight. This dietary intake is not expected to result in any adverse health effects over the lifetime of an individual in the general population. In the case of contaminants which are inadvertently present in food, "provisional tolerable daily (or weekly) intakes" are calculated; these figures denote permissibility rather than acceptability.

The total intake of a chemical determines exposure. For most safety evaluations of chemicals occurring in food, diet will constitute virtually the entire avenue of exposure. If a chemical is highly toxic but exposure is very low, the risk will be successfully ameliorated. In contrast, long-term dietary exposure to large amounts of a chemical of low toxicity may represent a significant level of risk. Information from
national dietary intake studies (22) is used to evaluate whether a proposed maximum level for a chemical substance in a particular food is toxicologically supportable in terms of the cumulative intake in all foods.

Safety evaluations carried out in this manner cannot be regarded as a quantitative measure of risk. Although the approach contains some of the elements used in a formal health risk assessment, the ADI end-point is derived by imposing a specific margin of safety. The use of safety factors has the advantage of preventing problems which may be associated with determining an acceptable level of risk against which a quantitative risk assessment would have to be compared.

Evaluations of residues of veterinary drugs present a specific departure from the general methodology of safety evaluations of chemical hazards in food. Fixed assumptions are made about dietary intake and these are used to characterise the ADI (14). The number of tissues in which veterinary drug residues are found is limited, and intakes in the upper range limits for edible tissues (e.g. 300 g of muscle) are chosen. Maximum residue levels (MRLs) are calculated by using the ADI and the selected intake factors. Use of a drug according to good veterinary practice yields MRLs which are compared with the potential MRLs derived from the ADI.

True quantitative risk assessment has a specific application in the safety evaluation of chemical substances which have carcinogenic potential. Quantitative risk assessment begins with identification of those chemicals which may pose a human cancer or developmental hazard, and involves characterising the nature and strength of the evidence of causation (2, 70). Most methods use a "weight-of-evidence" approach and the classification will be of primary importance if this dictates the nature of the quantitative risk assessment to be performed (e.g. chemicals placed in Group A and B by the Environmental Protection Agency [EPA] in the USA are always assessed using "upper-limit" estimates of risk and "worst case" default options [4]; chemicals placed in Group C are assessed on a case-by-case quantitative risk assessment basis).

Quantitative risk assessment utilises a mathematical extrapolation to fit the observed data (usually derived at high-dose levels) to the expected dose/response curve at low-dose levels (3, 28, 30, 70). The available models evaluate the slope of the dose/response curve but are unable to take account of the biological factors which may modify the response at low levels and which may thereby have an influence on the calculation of excess lifetime cancer risks for humans. Quantitative risk assessment has also been used in the USA to develop cancer potency estimates (Q*) (16); however, this application is now controversial (70). The outcome of quantitative risk assessment for carcinogenic chemicals is to estimate a "virtually safe dose" which correlates with an excess over background risk which is acceptable to society (e.g. 1 x 10^-6 cases of cancer per lifetime of daily exposure to the calculated amount of the chemical in foods).

While quantitative risk assessment methodology offers considerable potential for improving risk assessments, the current inability to construct a reliable model of the underlying biological mechanisms of carcinogenicity suggests limited usefulness. In this respect, recent availability of human epidemiological data indicates that, in some cases, the quantitative risk assessment dose/response model may grossly overestimate the actual cancer risk (70). It has been suggested that, in certain circumstances, application of the NOEL safety factor approach would be a more rational means of evaluating non-genotoxic carcinogens (38).

Newer quantitative approaches include physiologically-based pharmacokinetic models and biologically-based cancer models which raise the prospect of more accurate scaling-up of laboratory animal data to estimate human risk (70).
Risk assessment policy decisions

There are many risk assessment policy decisions embodied in both the safety factor and the quantitative risk assessment approach to safety evaluations of chemical substances in food; some examples are given below. Scientific value judgements are implicit in the evaluation of non-uniform data sets and the determination of toxicological end-points on a case-by-case basis. Technical concerns may also intrude at certain decision steps.

The application of safety factors to the NOEL represents a specific mechanism to address uncertainty and create conservative margins of safety proportional to the development of a “no risk” level of exposure. The respective values of the safety factors used are arbitrary and have no measured biological significance; however, the value of the safety factor chosen in a particular evaluation has a marked effect on the ADI which is set. Nevertheless, the appropriateness of these safety factors is somewhat borne out by empirical experience.

In carrying out an exposure assessment in the safety evaluation for residues of veterinary drugs, the predicted dietary intake used is an “upper-limit” value; this is an additional safety factor which affects the final MRL. The use of an upper-limit estimate of withdrawal time in the animal also incorporates a safety factor; mean exposure levels are much lower. The choice of these statistical parameters represents a particular risk assessment convention and contributes to characterising exposure as a “worst case” scenario.

Comparison of potential MRLs with MRLs established through the use of a given veterinary drug in field trials forms the basis for recommended MRLs. If concentrations of residues lower than the potential MRLs are found in field trials, the recommended MRLs are reduced accordingly. This is a risk assessment policy option which is unique to the evaluation of veterinary drug residues. In the case of pesticide residues, the MRLs are usually established as the levels resulting from use of the pesticide in accordance with “good agricultural practice”.

Risk management

There are many situations where social benefits and economic need, as well as human safety, are taken into account when elaborating maximum permitted levels for chemical substances in food. The above discussion also clearly illustrates that it can be difficult to separate risk assessment and risk management, and that the basis for risk management decisions varies between and within countries. In the USA, cost/benefit analysis is required in risk analyses for pesticides, whereas this is prohibited in risk analyses for standards for drinking water and occupational health. In Europe, risk analysis is the foundation of most health and safety standards; however, the EEC Drinking Water Directive (80/778/EEC) sets virtually zero limits for individual pesticide residues (0.01 ppb). These limits bear no relationship to a potential toxicological risk to consumers, and risk management therefore essentially constituted a political decision.

Risk management of contaminants and natural toxicants often embodies consideration of the nutritional value of the food concerned, as well as the toxicity of the chemical substance and the extent to which this can be controlled. In setting an acceptable level in food, there may be explicit consideration of the consequences of this level on the quantity and price of the food supply.
The ability to set irreducible levels for chemical substances, based on feasibility rather than safe numerical limits (14), is a risk management option (51). For contaminants, the irreducible level usually represents the concentration of a substance which cannot be eliminated from a food without discarding the food altogether. Such is the case for mycotoxins, where the data do not allow “safe” numerical limits to be set (46). However, it is difficult to achieve the consensus needed to develop international guidelines when maximum permitted levels are set in this manner.

The availability of analytical methods can be an important risk management component in the setting of MRLs. If no practical analytical method is available to measure veterinary drug residues under the conditions of use, the recommended MRLs are raised so that compliance with them can be checked.

Quantitative risk assessment models for carcinogens in food generate a numerical estimate of risk to be used in decision-making. Legal decisions regarding acceptable levels of risk inevitably require accommodation between law and science (34). In recent court decisions in the USA, the legal interpretation of “safe” does not mean risk-free, and “acceptable risk” involves a judgemental determination based on three factors: the statutory basis, the scientific data and the “risks that are acceptable in the world in which we live” (34).

In Europe, there is increasing use of “unacceptable”, “tolerable” and “acceptable” levels of risk in regulatory decisions (1). “Unacceptable” represents exposure which is not acceptable on any reasonable basis, whereas “tolerable” represents exposures which are not welcome but can be reasonably tolerated. “Acceptable” means that exposures can be accepted without further improvement (i.e. when protection has been optimised). The view of the Royal Society is that the annual fatal cancer risks from a single source represented by these terms are greater than $3 \times 10^{-5}$, between $3$ and $1 \times 10^{-5}$, and $1 \times 10^{-5}$ per year from a single source, respectively (42).

In the Netherlands, the unacceptable level has been set at $1 \times 10^{-6}$ (1). Within the “tolerable” range, which is considered conditionally acceptable, the question remains regarding the extent to which hazards should be reduced in the light of social and economic factors. For pesticides evaluated in the USA, the judgement is made against a negligible risk standard of less than $1 \times 10^{-6}$ additional cases of cancer over a seventy-year lifetime (16). If dietary risks fall between $1 \times 10^{-4}$ and $1 \times 10^{-6}$, further studies are undertaken and there may be explicit consideration of benefits.

If a risk assessment is properly conducted, not only will exposures at or below the MRL provide the level of safety desired, but exposures at levels higher than the MRL will also provide some measure of safety (16).

Monitoring and surveillance

Establishment of maximum permitted limits for chemical substances in food constitutes only one aspect of a comprehensive risk analysis approach. Inclusion of monitoring and surveillance as an element of risk analysis provides a “risk profile” of potentially hazardous substances and a means of focusing limited analytical resources where they will have most benefit. In the case of international trade, “risk profiles” can only be fully utilised for risk analysis purposes if there is a complete and systematic exchange of information, coupled with continual updating of epidemiological data (25). In the USA, the Pesticide Monitoring Improvements Act of 1988 (18) mandates the Food and Drug Administration to establish pesticide usage and other data in countries of origin of imported foods, thus adding to the information gained by analytical testing at the port of entry.
The performance of sampling plans and analytical methods as they pertain to risk analysis of chemical substances in food is beyond the scope of this discussion. In general terms, sampling plans identify trends but are unlikely to be sufficient for prevention and are unable to cope with rapid change. Thus, short-term ad hoc programmes may be needed to identify the presence of newly-identified hazards or to establish whether small numbers of violative samples represent a significant risk. Sampling plans need to be linked to systematic traceback systems and to the establishment of quality assurance programmes at the point of entry of a hazard into the food chain. The rapid success obtained in achieving a marked reduction in sulpha drug residues in veal in New Zealand provides a good example (13).

Accept/reject criteria

Following the detection of a violative level in an inspected “lot”, the regulatory authority must decide on the appropriate action to take. The range of possible options includes: outright rejection, intensified sampling of the same lot, intensified sampling of further lots or consignments of the same commodity, and recourse to monitoring data to gain more complete information on the extent of the problem (32). Decision-making criteria should be based on systematic risk analysis, particularly in the case of chemical hazards in fresh meat and meat products, e.g. the heterogeneous origin of “lots” should engender a different approach to the regulatory response for a single violative test than would be the case for more homogeneous commodities.

Because of widely varying levels of dietary intakes of particular foods, it is probable that some individuals in the population will exceed the ADI for a chemical substance to some extent and for some limited length of time. Quantitative data on the health risk of these incursions are generally not available, but the significance of any minor incursion above the ADI can be put into context by an understanding of the scientific basis on which the standard was established, i.e. by reference back to the animal test data and the NOEL which gave rise to the ADI for the particular substance. In this respect, the “worst case” scenario for exposure which has been the recent historical basis for risk assessments for chemical substances is under challenge (70, 82). Researchers developing new risk assessment methods are already showing that, in several cases, the severity of human health hazards has been overestimated (70). A systematic risk analysis approach to decision-making in the event of detection of very low numbers of violative levels of chemical substances would include consideration of the precision of the NOEL (primarily for acute toxic effects), the gradient of the dose/response curve, the likelihood of acute toxicity, the likely extent of individual exposure consequential to the violative level, and the outcome of any subsequent, intensified sampling plan over a specific period of time.

Risk analysis is necessary because the imposition of specific accept/reject criteria can have major economic (and political) importance, especially in international trading situations. An important question is: “What effect will the regulatory decision have on reduction of the risk?” A risk management option in cases of violative levels of hazardous chemicals which are the consequence of illegal use or bad agricultural practice should include a punitive response, even though a low level of violation would be unlikely to have any effect on human health.

International activities

Risk analysis of chemical substances in meat and meat products is inevitably tied to similar analysis of chemicals in all foodstuffs, and a major responsibility of the CAC
is to elaborate MRLs for chemical substances in all foods. Expert groups (primarily JECFA and JMPR) consider scientific data and make recommendations on food standards to the relevant Codex committees on a case-by-case basis. The committees consider a range of “equity and ethics” issues, as well as the recommendations from the expert groups, when elaborating draft Codex standards. The consensus modality governing decision-making at a committee level contains no formal elements of risk assessment or risk management.

A number of general recommendations on the future risk analysis activities of JECFA and JMPR were developed at the 1991 FAO/WHO Food Conference (26); these included the need to harmonise the methodology used by different countries, the establishment of internationally-agreed principles for the risk assessment of substances which have been shown to be carcinogenic in animal studies, and ensuring the transparency of the decision-making process. The Secretariat of the Joint FAO/WHO Food Standards Programme has followed up this initiative with the commissioning of a report on the use of risk analysis by JECFA, JMPR and the relevant Codex committees (51).

Other wide-ranging initiatives are taking place under the auspices of the WHO, including those which form part of the International Programme on Chemical Safety (IPCS) and the Inter-governmental Mechanism for Chemical Risk Assessment and Management which resulted from the United Nations Conference on the Environment and Development held in Rio de Janeiro in 1992 (58). The IPCS has recently begun a study on “Guiding principles and methodology for quantitative risk assessment in setting exposure limits”, with the goal of harmonising risk analyses at the national and international level. Work is also being undertaken by the Organisation for Economic Co-operation and Development to harmonise risk assessment methodology for pesticides (59).

In the USA, the EPA has sponsored a Federal inter-agency working group to improve scientific methods of risk assessment in order to harmonise approaches, reduce uncertainty and develop an inventory of existing databases and information needs (30).

International harmonisation of MRLs is a stated objective of the CAC; this depends on reducing national differences where those differences are not justified, and on mutual recognition of comparable standards employed by different countries. In addition to the above international initiatives, work on risk analysis of accept/reject criteria for violative levels of chemical substances detected in meat and meat products at port-of-entry testing is required, and this is the purview of the newly-formed Codex Committee on Import Inspection and Certification (32). Systematic exchange of information on monitoring and surveillance programmes in the country of origin will constitute an important element in this risk analysis activity.

**MICROBIOLOGICAL HAZARDS**

Despite recognition of the problem, the question of allocation of regulatory resources commensurate with the importance of microbiological contamination of meat and meat products is only just beginning to be addressed (8, 25, 43, 45). Control of this source of hazards has generally depended on a traditional approach, which includes the following elements: ensuring that raw materials are as free as possible of specific
hazards; keeping microbiological contamination to the lowest practicable level during slaughter, dressing and processing; and preventing any subsequent growth of microbiological agents during further processing or consumer activities. HACCP programmes are specifically designed to enhance achievement of these objectives and the CAC is encouraging the use of such programmes as a means to ensure food safety and better utilisation of inspection resources, and to provide a more timely response to problems (26). However, there has been only limited uptake of HACCP in meat production systems (56), largely as a consequence of the specific adaptation required.

Quantitative evaluation of the microbiological safety of foods has primarily been dependent on the establishment of microbiological criteria (as standards, guidelines or specifications). There is considerable debate over the application of microbiological criteria in classifying food as microbiologically acceptable or unacceptable, and many standards and guidelines have proved to be impractical (5, 7, 9, 39).

The principles for the establishment and application of microbiological criteria for foods include the following (5, 7, 9):

- listing of hazardous micro-organisms
- qualitative characterisation of likely exposure
- evaluation of available methods for detection and quantification
- design of sampling plans.

Any criteria which are elaborated must be effective and practical, and a cost/benefit analysis should be a basic component in the development of a mandatory standard. It is evident that the application of these principles requires elements of a “risk analysis” approach in some form or another. Additionally, a direct and statistically-based link is required between the adequacy of sampling plans and the severity of any microbiological criteria imposed (9); such linkages are not currently employed with respect to MRLs for chemical substances in food. Decision criteria applied to a lot should be “administratively and economically feasible” and should take into account the heterogeneity of distribution of micro-organisms (9).

To date, it has proved impractical to elaborate microbiological criteria which adequately define the safety and wholesomeness of raw meat (7, 9). The WHO has stated that the “establishment of microbiological criteria for raw foods in general cannot serve the purpose of protecting the health of the consumer when the main source of the pathogenic micro-organisms is the raw food itself, and when processing does not include steps which will eliminate or substantially reduce the numbers of these micro-organisms” (39). This is clearly the case for raw meat and meat products. The National Research Council in the USA has similarly reviewed data on the occurrence, potential for causing infection, and pathogenicity for humans of bacterial species known to be present on chicken, and has reached a parallel conclusion (15). The research committee stated that “minimising microbial contaminants on chicken is a worthwhile objective, but it is premature to establish formal microbiological criteria for classifying raw products of poultry as microbiologically acceptable or unacceptable”, and concluded that the data required to justify such formal regulatory standards do not currently exist.

At this time, genetically-engineered micro-organisms are not regarded as fundamentally different from those which have been isolated from nature (and introduced into new environments) or produced by breeding and selection (10); thus, genetically-engineered micro-organisms have not engendered a specific risk assessment approach.
Risk analysis

The problems associated with formal analysis of the risk of food-borne microbiological disease are very different from those associated with the risk analysis of food-borne chemical hazards. Micro-organisms multiply and die, and the biological interactions which occur are complex. In the case of meat, the characteristics of contamination during slaughter and dressing dictate the character of the initial microflora, but this can be markedly modified by subsequent events. Additionally, there are marked differences in the virulence and pathogenicity for humans of animal and environmental strains, and the interaction of host and microbiological pathogen is very variable. Thus, it is apparent in microbiological systems that a prediction of exposure should not lead to an automatic assumption of risk (9, 73, 77).

If an uncritical assumption is made that a human health hazard exists because of the presence of particular contaminating microflora, it would be tempting to try and characterise this risk by assessing the level of exposure. One approach would be to construct a numerical dose/response curve for each potential pathogen which may be present in the final product and attempt to characterise risk in these terms. However, experience in ecological risk assessment would suggest that, irrespective of the difficulty in gaining the quantitative data, developing this additive organism-by-organism approach would be very difficult (72, 77, 83). In the case of meat, the biological interactions in the microflora which occur after the product leaves the slaughterhouse or packing house cannot be quantified with any certainty and, as stated above, prediction of exposure should not automatically lead to an assumption of a human health risk.

Despite these problems, microbiological hazards in food can be subjected to a formal risk analysis process with data being generated principally through clinical and epidemiological studies in humans, and surveillance. The best probability estimates would come from a “perfect” epidemiological study on the human population of interest at the range of doses or exposures of interest (65). Unfortunately, such studies rarely exist. Estimates of risk derived from epidemiological studies are therefore often expressed in terms of relative risk or attributable risk.

Development of quantitative microbiological risk assessments is in the early stages but will probably increase in the future; this may lead to the establishment of more meaningful microbiological criteria in terms of human health risks. Despite the complex challenges of microbiological risk analysis, a quantitative risk assessment model has been developed for water-borne disease in the USA (73). This work was based on a number of dose/response relationships derived from human experiments with a range of micro-organisms. A number of assumptions were made, including homogeneous distribution in water, average daily water intake and an “acceptable” level of risk. Such work was only possible because of the low pathogenicity of the micro-organisms involved and is unlikely to be repeated for other microbiological risks. Thus, future microbiological risk assessments are likely to have a more qualitative base.

The choice of a human health end-point for microbiological hazards is very different from the choice of an end-point when chemical hazards are involved; this choice would be an important risk assessment policy decision in a quantitative microbiological risk assessment. Possible outcomes of microbiological contamination are true exposure, infection, disease and death. Positive diagnostic tests in epidemiological investigations are often indicative of infection rather than disease, and undifferentiated risk management decisions based on an outcome with no consequence for health would be wasteful of resources which could be better used elsewhere (44, 77).
A consideration of the OIE guidelines for import risk analysis (31) provides an interesting comparison with attempts at risk assessments for microbiological hazards in foods. A limited number of well-documented animal diseases make up the OIE Lists A and B, and adequate data on the prevalence of a specific disease in the exporting country (country factor) is usually available. Similarly, an adequate estimate of the probability of the specific disease agent being present at the time of import (country factor x animal import unit/animal product) can usually be determined. Estimation of the probability of exposure to animals or humans in the importing country and the likelihood of transmission is achieved by constructing scenario trees; this results in an unrestricted risk estimate.

Currently, risk assessments for microbiological hazards in fresh meat and fresh meat products are very unlikely to be able to draw on quantitative data equivalent to those described above for specific pathogens of animal health importance. The absence of detailed knowledge of the prevalence and specific zoonotic potential of the wide range of bacterial species which are commonly found as inadvertent contaminants on fresh meat, coupled with very limited dose/response data for those pathogenic strains known to be transmitted to humans by ingestion, makes microbiological risk assessment for public health hazards a difficult proposition. In addition, a microbiological risk assessment for meat at a particular time of importation/distribution is only meaningful if the subsequent measures which are taken maintain the same microbiological quality.

International activities

Current risk analysis of microbiological hazards is primarily inhibited by lack of information and the absence of a detailed conceptual framework. However, these problems are not intractable, and national initiatives are underway to address these issues in the general area of food safety. Several countries have recently embarked on studies to gather microbiological baseline data on dressed carcasses as a first step in providing quantitative input to a “risk analysis” approach to meat hygiene (43, 85). Both pathogens and indicator organisms are being investigated, but these research initiatives are not expected to provide enough comprehensive data to allow development of microbiological risk assessment models in the short term. Nevertheless, it is important that the long-term goals of this research in different countries are strategically aligned. Microbiological research for food safety is both resource-intensive and time-consuming, and information-sharing in the initial stages would be of marked benefit. The development of a substantial conceptual framework is a prerequisite for successful microbiological risk analysis.

The development of HACCP systems for meat and meat products needs to be closely aligned with the development of risk analysis methodology for microbiological hazards. A number of HACCP initiatives for raw meat appear to be based on a systematic application of traditional parameters of hygienic practice, rather than on a microbiological database which validates the design of the HACCP plan. In addition, very little quantitative information is available on the effectiveness of HACCP in reducing food-borne illness in the human population. It is assumed that operating procedures and process interventions which reduce overall microbial loads on carcasses will reduce public health risks. However, this assumption has been criticised by those who point to a general lack of correlation between total microbial counts and specific pathogens. Counter to this criticism, it should be realised that current knowledge of micro-organisms capable of causing human disease is far from complete. As an example, only about half of the human cases of presumed infectious diarrhoea are
of known aetiology (77), and thus it seems reasonable to assume that a higher level of general microbial contamination of gastrointestinal origin on fresh meat will result in a higher level of human exposure to potential pathogens.

In the case of slaughter and dressing, initial research in New Zealand suggests that traditional organoleptic parameters may not be related to microbial loads on carcasses, and the monitoring of specific critical control points (CCPs) in these terms could be fallacious (36). If the additive marginal risks imposed by microbiological contamination at different CCPs are to be ranked and evaluated – together with an evaluation of the cost-effectiveness of reducing these risks – detailed microbiological data are required. The statistical limitations of organoleptic monitoring programmes to control processing in raw meat production systems also have an impact on the scientific validity of the HACCP plan.

CONCLUSIONS

As science advances and the ability of regulators to detect risks improves, the opportunities for influencing risks have proliferated. A desirable goal for society is therefore to develop systematic rules for decision-making across the entire spectrum of risks (86). Within the spectrum of risk associated with food-borne hazards, regulatory authorities need to meet this challenge with quantitative, unambiguous risk assessments which have a transparent and readily-understandable methodology.

International co-operation in food safety and the harmonisation of food regulations worldwide are essential in the present environment; this demands resources which are only now becoming available. However, there is an enormous diversity in possible food-related hazards and it is therefore unlikely that a single risk analysis approach can be developed to suit all situations (44, 75).

In emerging as a “regulatory science”, risk analysis offers a new opportunity to facilitate the achievement of modern meat hygiene goals. International objectives in the future regulation of veterinary public health risks should include the following:

- Alignment of national regulatory agendas
- Systematic exchange of information in order to establish conceptual frameworks for risk analysis
- Development of internationally-accepted risk assessment methodology, and the opportunity for peer review
- Development of international policy on standards of acceptable risk
- Mutual recognition of comparable standards and specifications employed by national agencies, and reduction in the differences where risk analysis shows that these differences are unjustified
- Development of risk analysis-based principles to govern regulatory responses to violative levels of chemical substances detected in foods at port-of-entry inspection
- Design and implementation of HACCP systems which are correlated with new developments in the field of microbiological risk assessment.

* *

* *
Résumé : L’hygiène des viandes a trois composantes principales : l’inspection post-mortem, le contrôle et la surveillance des risques chimiques et le respect des règles d’hygiène à tous les stades, de l’abattage à la consommation. L’analyse des risques est une science de plus en plus souvent appliquée à ces activités car elle permet de faciliter la répartition des moyens nécessaires à l’inspection, avant, pendant et après l’abattage, selon la probabilité des risques pour la santé publique et la santé animale ; d’établir des normes et spécifications internationales cohérentes et scientifiques ; et d’améliorer la salubrité et l’hygiène des viandes et des produits à base de viande dans le cadre des échanges nationaux et internationaux.

L’analyse des risques, sous toutes ses formes, a d’ores et déjà fait ses preuves pour l’élaboration de normes et spécifications applicables aux risques chimiques, tandis que les méthodes d’analyse des risques appliquées aux programmes d’inspection des viandes post-mortem, commencent à voir le jour. Cependant, des problèmes subsistent dans l’analyse des risques microbiologiques présentés par les viandes et les produits à base de viande. Tous les domaines d’application souffrent actuellement de l’absence d’un accord international sur les méthodes d’évaluation des risques et de gestion des risques.


El análisis de riesgos aplicado a la higiene de la carne. - S.C. Hathaway.

Resumen: La higiene de la carne incluye tres componentes principales: la inspección postmortem, el monitoraje y la vigilancia de los riesgos químicos y el respeto de las reglas de higiene en todas las etapas de la producción, desde el sacrificio (faena) hasta el consumo. El análisis de riesgos es una ciencia aplicada cuya importancia en la actualidad respecto de estas actividades es cada vez mayor: contribuye, en efecto, a facilitar la distribución de los medios necesarios para la inspección, antes, durante y después del sacrificio, según la probabilidad de riesgos para la salud pública y la sanidad animal, permite establecer normas y especificaciones internacionales coherentes y con fundamento científico y ayuda a mejorar la inocuidad y salubridad de la carne y productos cárnicos en el marco de los intercambios nacionales e internacionales.

El análisis de riesgos, en todas sus formas, ha mostrado ya su utilidad para la elaboración de normas y especificaciones con respecto a los riesgos químicos, y empiezan a darse ahora aplicaciones de métodos de análisis de riesgos a los programas de inspección de carne postmortem. Subsisten todavía problemas, en cambio, en el análisis de los riesgos microbiológicos en la carne y productos cárnicos. Todos los ámbitos de aplicación de estos métodos se ven afectados actualmente por la falta de un acuerdo internacional acerca de los métodos de evaluación de riesgos y de gestión de riesgos.

REFERENCES


