Contaminants of non-biological origin in foods from animals

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Summary
The authors provide an overview of non-biological contaminants in foods from animals. These contaminants comprise chemical and physical hazards which may be introduced during animal production, slaughter and processing or packaging. Emphasis in this paper is placed on those residues which are of most interest to Veterinary Services and for which Veterinary Services have responsibility, namely: residues of veterinary drugs, industrial chemicals, heavy metals and pesticides which may be introduced during animal production. The most contentious residues which occur in meat, milk and eggs are antibacterial drugs, hormonal growth promoters and certain pesticides, heavy metals and industrial chemicals.

While rare incidents of human disease have been attributed to hazardous levels of these contaminants in milk and meat, residues of chemical contaminants in foods of animal origin are, in general, rarely detected at more than trace levels and consequently are not of major public health concern. Nevertheless, non-biological contaminants continue to be very important with respect to international trade and consumer confidence, and efforts to reduce the incidence of occurrence in foods is warranted. Furthermore, continued monitoring and periodic reassessment of risks posed by these contaminants is needed to detect or anticipate new problems so that appropriate action can be taken in the interests of public safety.

Keywords
Animals - Antibiotics - Contamination - Eggs - Food - Hormones - Meat - Milk - Pesticides - Public health - Residues - Veterinary drugs.

Introduction
Historically, the evolution of food safety laws and regulations has been substantively affected by incidents or controversies involving food contamination. These influential events have been of sufficient impact to seize the attention of the public and of policy makers. Some incidents have involved microbiological hazards and general sanitation issues. For example, publication in 1906 of the book by Upton Sinclair entitled The jungle drew public attention to lax hygiene standards in slaughterhouses (39) and led to the enactment of meat inspection laws and regulations designed to reduce the risk of tuberculosis and other microbial hazards (13). In 1993, a large outbreak of foodborne disease occurred in the United States of America (USA). The outbreak, which was attributed to contamination of hamburgers with Escherichia coli O157:H7, caused hundreds of cases of haemorrhagic colitis and haemolytic uremic syndrome, and some of the affected children died (15). Although tragic, the outbreak did act as a catalyst for the major changes which are currently occurring in food safety regulation and practice in the USA (19). The recent epidemic of bovine spongiform encephalopathy in the United Kingdom and the alleged link with disease in humans have fostered tremendous public debate on food safety and a variety of political actions in the United Kingdom, Europe, North America and elsewhere.

Public confidence in the safety of the food supply has also been shaken by incidents involving chemical contaminants. The 1962 publication of the book Silent spring by Rachel Carson drew public attention to the dangers of pesticides in
the environment and in food (12). The association of diethylstilbestrol (DES) with cancer in the daughters of women treated with this hormone raised questions about the safety of using DES as a growth promoter in animals (47). The banning of several artificial sweeteners in the 1970s due to evidence of carcinogenicity demonstrated in laboratory animal experiments raised questions about the safety of food additives and about the role of laboratory animal testing for food safety evaluation. In addition, there have been incidents of illegal use of hormones in animal production, media reports of drug residues in milk, and considerable public debate about bovine somatotropin (BST) use in dairy cattle. Until very recently, the principal food safety issue in the mind of the public was chemical residue contamination and food additives (44), although concerns over microbial contaminants have superseded this in some countries. Notwithstanding the evidence from foodborne disease surveillance programmes showing that microbial contamination of foods is a much greater food safety problem than chemical residues, the recent debate in Europe over removal of the ban on hormonal growth promoters in livestock, and the debate in North America and elsewhere about BST, indicate that these issues are still of prime importance.

Foods from animals (principally meat, fish, milk and eggs) can potentially be contaminated with one or more of the thousands of man-made chemicals which are used in society. Relatively few of these occur with any regularity in foods from animals, and the most contentious residues (in terms of probability of occurrence and impact on human health, trade or consumer confidence) are antibacterial drugs, hormonal growth promoters or production adjuncts, polyhalogenated hydrocarbon pesticides, industrial chemicals and heavy metals. However, the fact that foods from animals may also be contaminated with naturally-occurring toxic substances, including bacterial toxins (e.g., botulinum toxin, staphylococcal enterotoxin), mycotoxins (e.g., aflatoxin and ochratoxin) and algal toxins (e.g., saxitoxin in shellfish), and that even some animal tissues are inherently toxic (e.g., livers of puffer fish), must be recognised (15, 44). Indeed, the suggestion has even been made that a very large number of naturally-occurring substances in foods would be considered potential hazards if subjected to the range of toxicological tests and assays which are applied to man-made compounds (3).

Among the man-made chemicals which occur in foods are a large number of additives used intentionally for production, processing or preservation purposes. A few of these, for example, nitrite, are of concern if toxic metabolites (e.g., nitrosamines) are allowed to form in foods prior to ingestion. Chemical residues (such as iodine, chlorine or bromine) are often contaminants of sanitation procedures, and others which are occasionally migrate from packaging materials. Other non-biological contaminants in foods from animals include fragments of metal, wood and plastic or other material from food processing equipment. Foreign material may also be introduced during animal production; most notably needles broken during injection of drugs or biologicals and subsequently not surgically removed.

This paper provides an overview of non-biological contaminants of foods from animals (except fish). Emphasis is placed on those contaminants which are of the greatest interest to and which are the responsibility of Veterinary Services, namely: veterinary drugs, industrial chemicals, heavy metals and pesticides which may be introduced during animal production.

Risks of chemical residues in foods

Much has been written about the theory, importance and practice of risk analysis (including risk assessment, risk management and risk communication) for food safety (7, 24, 44). Risk assessment principles were first applied explicitly to food safety in the context of chemical residues. The successes achieved in this area have contributed significantly to the international adoption of risk analysis. Risk assessment is a process which has evolved over the last two decades to assist in the characterisation of risks due to low-level exposure to environmental contaminants and other hazards. Used in this context, the term 'risk' connotes both the probability of occurrence and the magnitude (or impact) of the negative health outcome from exposure to the chemical residue in food. The impact may also involve outcomes other than health, such as lost sales or international trade, or loss in public confidence. Hazard identification and hazard characterisation (dose-response assessment in the classical United States National Research Council model of risk assessment (7)) entail description of the negative outcomes (types of disease, e.g., cancer, allergic reaction) which can be attributed to the chemical and the dose (threshold) at which toxic effects begin to be observed. These determinations have been based on evidence from case reports or epidemiological studies in people, when such data are available. More often, the results of animal bioassays have been used to identify both the outcomes and threshold doses or 'no observed adverse effect levels'. Unfortunately, a number of uncertainties arise through the use of these types of data and the most common way of dealing with these uncertainties is by the use of safety factors (often a safety factor of 100 has been used to account for human-animal differences and differences within the susceptibility of the human population). Threshold doses have been used to establish acceptable daily intakes (ADI's) of chemical residues in foods over a lifetime (25, 44). Knowledge of routes of exposure and the estimated consumption quantities of various foods which may contain the contaminants may enable the setting of maximum residue limits (MRLs) in various foods (e.g., milk, muscle or organ tissue). In the case of veterinary drugs, the ADI and MRL estimates can be used to establish milk and meat withholding...
times for animals treated with these compounds, which are intended to ensure that harmful residues do not appear in edible products, provided that the compounds are used in accordance with approved label instructions and good agricultural practice. In the case of carcinogenic substances, ADIs have sometimes been based on doses of chemical thought to pose a human cancer risk in the order of one in a million over a lifetime of exposure, although this is the subject of some debate (44). The World Health Organisation (WHO), through the Joint Food and Agriculture Organisation/WHO Expert Committee on Food Additives, contributes significantly in this area by carrying out some of the elements of risk assessment (especially hazard identification and hazard characterisation components of risk assessment) pertaining to chemical contaminants in foods and for establishing ADI and MRL guidelines which are useful in managing risks (44).

While virtually all substances are toxic at sufficiently high doses in animals (including humans), relatively few of those which occur as residues in foods from animals have been shown in epidemiological studies or case reports to actually be associated with disease in humans. Most of the relatively few incidents of foodborne disease convincingly linked with exposure to chemical contaminants in foods have been acute in nature, involving relatively high concentrations of chemicals. One such example involved high levels of clenbuterol in liver from illegally treated calves (37). Low doses of residues in foods, if these have any negative health effects at all, are likely to produce chronic effects after rather long-term exposure (44). These chronic effects are almost never detected by case reports and may even be beyond the capabilities of extensive epidemiological studies.

• An important aspect of assessing the risk of chemicals to public health is estimating the quantities to which consumers are exposed in foods. Exposure assessment is sometimes achieved by measuring the quantities of residues within people (e.g., measurements of organochlorines in blood or body fat), or by measuring residue levels in foods and then estimating the amounts of the food eaten by people in society (7, 36, 44). The results of monitoring are usually expressed in terms of MRLs, or in some cases, 'tolerance' or 'legal' levels. These levels usually reflect ADIs and residue levels which are achievable using good agricultural practices.

Characterisation of the risk of individual chemical residues in foods is essentially an attempt to assemble the information from hazard assessment and exposure assessment to estimate the type and magnitude of the public health problem posed by that particular chemical, including the concentrations at which the chemical is found, and the frequency with which it occurs in various foods. In many cases, qualitative or semi-quantitative estimates of risk (i.e., the probability and impact of adverse health effects) posed by various chemical residues have been used to rank contaminants in a priority list for risk management action.

The discipline of risk analysis is evolving and maturing in many of its applications, which include environmental chemicals, food microbiology and animal health (7). The available empirical evidence from foodborne disease surveillance programmes suggests that risk assessment and risk management have protected public health in the area of food contaminants. Nevertheless, methodological improvements in risk assessment are foreseeable. For example, few, if any, truly quantitative assessments of the public health risk of veterinary drug residues (or other chemicals) in foods from animals to humans have been conducted. From a risk communication perspective, quantitative estimates of risk which are based on the best available data, which take into account inter-individual variability in exposure and susceptibility and which have been subjected to uncertainty analyses, would be extremely useful. The latter analyses are important to identify knowledge gaps and demonstrate just how conservative these estimates are, given the amount and type of uncertainty present.

Residues of industrial chemicals and environmental pollutants

Industrial chemicals and heavy metals which are not used for agricultural purposes can contaminate animal feeds or the animal environment and thereby gain access to milk, meat or eggs. Some contaminants in this category are fungicides (e.g., pentachlorophenol and hexachlorobenzene) which have been used as wood preservatives and seed grain fungicides, respectively. Wood preservatives, such as pentachlorophenol, may contaminate animals housed in pens made of treated wood or bedded on treated wood shavings. Seed grain fungicides may contaminate animals if treated grains are mistakenly used as animal feeds (48).

Some industrial chemicals have become widespread environmental contaminants and as such can enter the food chain. Polychlorinated biphenyl is an example of a compound which was widely used in industry until, like dichlorodiphenyltrichloroethane (DDT), the tendency of this compound to persist in the environment and bioaccumulate became apparent and both were banned. Although polychlorinated biphenyls are believed to be toxic at high levels, the significance of this chemical at low levels is doubtful other than the ability to bioaccumulate in tissues. Residue concentrations have decreased in monitored foods since these chemicals have been banned in most countries, although trace levels are still apparent in many food commodities, especially fish and, to a lesser extent, milk and dairy products (48). Cadmium, mercury and lead occasionally contaminate meat and milk, particularly when these originate from animals pastured or housed in areas of industrial contamination, or in the case of cadmium, where soils naturally contain significant levels of the element. While the toxicity of lead has been well known for many years, there is growing concern that low levels of lead may be important, especially for children, where low-level exposure may result
in impaired cognitive development. Livers and kidneys from cattle and horses sometimes contain sufficient levels of cadmium to render both organs unsuitable for consumption; lead levels are rarely elevated above MRLs in meats and milk, even in animals which show clinical evidence of lead toxicity. Iodine concentrations in milk have reached levels which cause concern in some countries and have resulted – at least in Canada – in the withdrawal of licensure of iodine-based medicines from feeds of food-producing animals (48).

**Residues from agricultural pesticides**

Although most of the pesticides used in agriculture are herbicides (and residues of these have been reported in fruits and vegetables and occasionally in foods from animals), insecticides and fungicides have been of most concern in meat, milk and eggs (9, 33, 41, 45). Among these, the organochlorine pesticides (such as DDT, heptachlor and hexachlorobenzene or lindane) which are lipid soluble, persistent and therefore prone to bioaccumulation, cause the most concern. Although there is some suggestion that these substances are carcinogens, insufficient human and animal data exist to confirm this. Recently, the presence of organochlorine residues in blood was associated with breast cancer in a large cohort of American women. The role, if any, of these residues in human cancer is under debate (50). Organochlorine pesticides are sometimes found in milk and meat, but in general, the levels detected are below those considered safe. In recent years, these compounds have been withdrawn from use in many countries, and the residue concentrations in foods have been declining steadily (45).

Animals may become contaminated with pesticides when treated with these compounds to rid them of insect pests, or through exposure to contaminated water, buildings or pastures. Contamination of feed may also be important and heptachlor contamination of animal feed has resulted in major episodes of meat and milk contamination. Residues of these compounds in milk are of special concern because milk is consumed in relatively large quantities in vulnerable populations (children) and organochlorines tend to concentrate in the milk fat. Overall, an estimated 40% of pesticides in the human diet are found in meat, milk and eggs, and this exposure has decreased in the past few decades, with the exception of occasional outbreaks, such as the heptachlor contamination of milk (45).

Recently there has been concern that a variety of environmental contaminants, including organochlorines and possibly other pesticides, can behave as 'endocrine disrupters' in animals and perhaps humans (20). The hypothesis states that hormone-like contaminants or metabolites may be causing reproductive disorders. Another related concern is the possibility that different contaminants with oestrogen or other hormone-like activity may interact with one another to produce toxicological effects. Most risk assessments evaluate only one contaminant at a time, but suggestions have been made to evaluate the possibility of interactions of this type in future risk assessments (7). Fortunately, in the case of the so-called oestrogenic endocrine disrupters, there is some recent evidence which suggests that oestrogens derived from waters polluted with human urine, not organochlorines, may have been responsible for the hormonal dysfunction observed in wildlife (27).

**Residues of exogenous hormones**

The use of hormones for growth promotion in meat animals, or for enhancement of milk production in dairy animals remains a very controversial issue. Two items continue to be debated:
- the effects of residues of these chemicals on human health
- the economic, social and political implications of banning the use of these compounds in agriculture.

At present, these compounds are used legally to a varying degree in many countries; the European Union has considered a repeal of the ban on these compounds which was instituted a few years ago as a result of public and political pressure.

Historically, some of the public health concern over these compounds emerged from the observed association of DES treatment of women with reproductive problems and cancer in some female offspring. Secondly, there have been a few (generally unconvincing) reports in the literature which link precocious sexual development in children and possible exposure to foods contaminated with hormonal residues in foods (47).

In the context of food safety, the hormonal substances used in food animals can be usefully considered as belonging to two main groups: those which occur naturally in animals (and therefore also in humans) and those which are synthetic compounds and which do not occur naturally in animals (so-called steroidal and non-steroidal xenobiotics). Among the naturally-occurring compounds are testosterone, progesterone, oestrogen and somatotropin: the fact that BST in particular has been genetically engineered for commercial purposes (recombinant bovine somatotropin [rBST]), with minor structural differences from the natural hormone, should be noted. As a general rule for risk assessment, the presence of residues of the active hormone in foods should be no cause for concern with regard to public safety if the concentrations of the exogenous, naturally-occurring hormone in edible tissues from treated animals do not differ significantly from those in untreated animals. This can be justified although some of these compounds (i.e., the sex steroids) can act as tumour promoters (47).

Residues of BST are generally believed not to be a public health hazard for several reasons, as follows:
- BST is not metabolically active in humans
Although sulfonamides and tetracyclines are administered to allergic consequences, there is little evidence that these occur. People at therapeutic concentrations may have toxic and residues in foods are few and poorly documented. The remaining public health concerns about the use of this compound are based on the increase in insulin-like growth factor which has been observed in the milk of treated animals and the greater frequency of mastitis in treated animals. There has been some debate that an increased incidence of mastitis will lead to increased use of antimicrobials and increased probability of residue contamination of milk (14, 46).

By definition, xenobiotic compounds (including trenbolone acetate, zeranol and melangestrol acetate) do not occur naturally in animal tissues. Safe levels have been established for these compounds in foods through the means of risk assessment described above, with withdrawal times established to prevent the occurrence of harmful residues in foods. Most surveys which have been conducted to monitor the presence of these compounds in foods from animals show that these are rarely present at illegal levels (47).

Residues of antimicrobials

Although antibiotic residues in foods can have a detrimental effect on the processing of cultured products such as cheese, and are important in terms of consumer confidence, the public health significance of residue concentrations of some of these compounds in foods from animals appears to be low, based on substantial scientific assessment (14, 17, 46, 49).

Most of the antibiotic drugs currently used in animal agriculture are relatively non-toxic, even at high concentrations, but there are a few antibiotics which pose a small but significant threat to public health when present in sufficiently high concentrations in foods. Among these is chloramphenicol, which has been associated (in a non-dose related manner) with aplastic anaemia due to bone marrow depression in a small proportion of human patients to whom the drug was administered for therapeutic purposes. Some of the patients who survive the bone marrow depression have developed leukaemia, which creates concerns about possible carcinogenicity. Based on animal bioassay data, nitrofurans and some anti-parasitic drugs, such as dimethidazole, also raise some concern of carcinogenicity (46). Other antibiotics have been associated with allergic reactions of varying severity in people. An estimated four to ten allergic reactions occur per 100,000 courses of penicillin treatment administered directly to people, but actual incidents of allergic reaction to penicillin residues in foods are few and poorly documented (17, 46).

Although sulfonamides and tetracyclines administered to people at therapeutic concentrations may have toxic and allergic consequences, there is little evidence that these occur at the concentrations at which residues are encountered in foods. Based on experimental evidence, however, there is concern that residue concentrations of antibiotics have the potential to encourage the development of antibiotic resistance in the microbial flora of people eating contaminated foods (14).

Control of non-biological contaminants

Managing the risks of contamination with non-biological hazards has been achieved by a variety of methods. These include the enforcement of regulations concerning the availability and use of chemical compounds, as well as residue monitoring, surveillance and sometimes punitive programmes. Additionally, there is a variety of government and industry-sponsored quality assurance and hazard analysis and critical control point (HACCP) programmes in place in some countries.

The monitoring of milk, meat and eggs for antibiotic residues occurs in most countries and the incidence of residues at violative levels is usually rare, and in general the incidence is decreasing (6, 10, 16, 23, 28, 46). When violative levels do occur, illegal residues of these drugs are a consequence of use at the animal production level for treatment of clinical or subclinical infectious disease, for disease prevention or for growth promotion (30, 31, 35, 43). A wide variety of antibiotics and sulfonamides are used in animal agriculture: these include penicillins, tetracyclines, aminoglycosides, sulfonamides and others (26, 29, 32, 35, 40). On account of the temporal proximity of treatment with one or more of these antibiotics to the time of slaughter, certain types of animals, such as cull dairy cows, certain types of veal calves, non-ambulatory or disabled animals and young swine present a higher probability of contamination than other classes of livestock (43). Certain drugs are more likely than others to result in violative residues at slaughter as a result of pharmacokinetic or physical properties. Some of the aminoglycosides, for example, may be found in kidneys for prolonged periods after treatment. Sulfamethazine residues have been a problem in the swine industry, partly because the drug is relatively stable and traces of the drug can be transferred between treated and untreated animals through faeces or feed (43, 46). Another factor which is frequently associated with residues in meat and milk is the practice of 'extra-label' treatment, whereby antibiotics (or other drugs) are administered in a fashion (with respect to dose, frequency of administration, route, animal species or type) which differs from the drug label instructions (22, 29, 30, 40). Withdrawal times are calculated on the basis of the label treatment conditions, thus deviation from these conditions may lengthen the period for which potentially harmful concentrations of drug are present in edible tissues. Even in countries where this practice is legal, considerable caution...
must be exercised to ensure that harmful residues do not appear in edible products.

There are also other types of human error which lead to the presence of residues in foods. People sometimes forget to withhold the milk of cows treated for mastitis, thereby contaminating milk from that farm and often from several other farms after the milk is mixed for transport or processing. There has been evidence that some people simply do not know the proper withholding times for meat or milk which apply to the antibiotic products being used (31, 43).

Although a wide variety of antibiotics may be used on farms, analytical methods used to find residues of these compounds in foods vary considerably in terms of ability to detect such residues. In general, the microbiologically-based screening methods are reasonably useful in detecting the penicillins, but are less effective for some of the other compounds. Fortunately, penicillins are among the most commonly used drugs on farms (29, 35, 40), and technological advances in recent years have enabled detection of a wider range of antibiotic residues in large numbers of food samples (1, 16). Regulatory agencies can use the results of risk assessments to identify residues which will be targeted and to plan surveillance strategies (46).

Of all the chemical residues which occur with some frequency in foods from animals, antibiotic residues are arguably those which can be prevented because these compounds are deliberately used during production (21). Industry recognition of this, coupled with increased awareness of the importance of this type of contamination to consumer confidence and international trade, has led to concerted efforts to reduce residues. Several food-animal producer groups have instituted on-farm quality assurance programmes which are intended to reduce the risk of drug residues in animal products. The pork quality assurance programme and the ten-point dairy quality assurance programmes are notable examples in the USA (4, 42). These programmes are designed to ensure that farmers use antibiotics in a safe and responsible manner which is unlikely to result in residues. These programmes are in many respects analogous to HACCP programmes which are becoming widely used in other sectors of the food industry. However, the extent to which these largely voluntary programmes are adopted by industry and the resulting impact on good agricultural practice as related to veterinary drug use should be assessed. Since human error, lack of knowledge and faulty treatment practices are so often associated with residue violations, formal education programmes for farmers who are legally able to treat their own animals with antibiotics are potentially useful. In Ontario, for example, approximately 1,500 farmers have followed a livestock medicines course in recent years, and this has been shown to increase understanding of the rationale for wise and safe use of antibiotics and other drugs in food animals (2).

Although the move to HACCP has in some respects resulted in less reliance on end-product testing to assure food safety, the monitoring of milk, meat and dairy products by Government officials still has a very important place in validating HACCP programmes and in risk assessment (exposure assessment is largely based on these data), and in some cases in the enforcement of legal limits on residue concentrations (6, 10, 16, 18, 23, 34, 41). Furthermore, the food animal industry is dynamic and continued monitoring for chemical residues is needed to detect the impact which management changes might have on food safety. For example, an increase in clinical cases of infectious disease in a food animal population may be followed by more antibiotic use and greater risk of residues. Introduction of a financial penalty programme which was designed to reduce the herd-level somatic cell count of bulk tank milk in Ontario, Canada, was accompanied by an increase in violative levels of antibiotics in milk because some producers attempted to solve the mastitis problems with antibiotic therapy, which increased the risk of residues (38). When possible, the effects of management changes on food safety should be anticipated and addressed.

Conclusions

Although there have been many concerns in the past several decades regarding the presence of chemical residues in meat, milk and eggs, considerable progress has been achieved in reducing the probability of occurrence of these residues. In general, chemical contaminants in foods from animals are infrequently found at concentrations which could be hazardous to the consumer, and there is a temptation to conclude that these are not very significant from the public health standpoint. Nevertheless, such contaminants remain very significant from the perspective of consumer confidence and international trade (11, 24). As tariffs are removed and goods flow freely between countries, importing countries must be confident that the goods available for purchase are safe, and in addition to this, there is, from time to time, pressure to use chemical residues as non-tariff barriers to importation. Continued vigilance is required to ensure that hazardous residues do not contaminate the international food supply.
Contaminants non biologiques dans les aliments d’origine animale
S.A. McEwen & W.B. McNab

Résumé
Les auteurs décrivent les contaminants non biologiques qui peuvent être présents dans les aliments d’origine animale. La contamination par des agents chimiques ou physiques peut survenir à divers stades de la production, lors de l’abattage, de la transformation ou de l’emballage. Les auteurs mettent l’accent sur les principaux résidus qui sont de la compétence des Services vétérinaires et engagent leur responsabilité, à savoir : les résidus de médicaments vétérinaires, les produits chimiques d’origine industrielle, les métaux lourds et les pesticides auxquels l’animal peut être exposé au cours de l’élevage. Les résidus les plus recherchés dans les viandes, le lait et les œufs sont les médicaments antibactériens, les hormones de croissance et certains pesticides, métaux lourds et produits chimiques industriels.

Les intoxications humaines dues à la présence de ces contaminants dans le lait et la viande sont rares, et les résidus chimiques retrouvés dans les aliments d’origine animale ne le sont qu’à des niveaux négligeables (traces); cette contamination ne représente donc pas un risque majeur pour la santé publique. L’importance des contaminants non biologiques ne doit pas être négligée pour autant, compte tenu des échanges internationaux et de la nécessité de répondre à la demande des consommateurs en la matière ; aussi, les actions menées en vue de réduire la fréquence des contaminants dans les aliments sont-elles pleinement justifiées. De plus, une surveillance régulière et une réévaluation périodique des risques posés par ces contaminants est toujours utile, afin d’identifier ou d’anticiper de nouveaux problèmes et d’y répondre à temps par des mesures appropriées, dans l’intérêt de la santé publique.

Mots-clés

Contaminantes no bióticos en alimentos de origen animal
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Resumen
Los autores pasan revista a los contaminantes no bióticos que pueden estar presentes en los alimentos de origen animal. Esta noción comprende los riesgos químicos y físicos a los que el animal puede estar expuesto durante la cría, el sacrificio, el procesado o el acondicionamiento. Se hace especial hincapié en los residuos de mayor interés para los Servicios Veterinarios y sobre los que estos Servicios poseen competencias, a saber: residuos de medicamentos de uso veterinario, productos químicos industriales, metales pesados y pesticidas que pueden introducirse durante el proceso de producción. Los residuos más problemáticos presentes en la carne, la leche y los huevos son los que derivan de
fármacos antibacterianos, hormonas promotoras del crecimiento y ciertos pesticidas, metales pesados y productos químicos de uso industrial. Aunque en alguna rara ocasión se han atribuido enfermedades humanas a niveles peligrosos de esos contaminantes en la leche y la carne, los residuos de contaminantes químicos en alimentos de origen animal no suelen detectarse en general más que a niveles traza, motivo por el cual no constituyen un problema fundamental de salud pública. Sin embargo, los contaminantes no bióticos siguen revistiendo gran importancia en lo que se refiere al comercio internacional y a la confianza del consumidor, hecho que garantiza la continuidad de los esfuerzos por reducir su presencia en los alimentos. Por otra parte, son necesarios un control permanente y una reevaluación periódica de los riesgos asociados a estos contaminantes para detectar o anticipar la aparición de nuevos problemas y facilitar así la adopción de las medidas de protección alimentaria que se impongan.

**Palabras clave**

**References**


