Notes on technical progress in veterinary public health

D. GROSSKLAUS, E. WEISE, H. KOLB, P. TEUFEL, J. WEGENER, D. PROTZ, W. MIELDS and W. SCHARMANN *

Summary: Scientific and technical progress in the field of veterinary public health (VPH) over the last one hundred years has contributed to the protection of consumer health and the environment. This report presents examples of the success achieved in the control of epizootics of tuberculosis, brucellosis, rabies and trichinellosis, which are also zoonotic diseases. The discussion also considers hygiene measures in relation to Listeria in food as well as certain challenges resulting from the spread of latent infections among farm animals. The increasing incidence of Salmonella infections among humans is also considered.

Other important VPH tasks include the control of chemical residues of varying origin and of toxic biological substances in foods. Examples are also presented of measures taken and problems which arise in connexion with ensuring that meat is produced under hygienic conditions (meat inspection). The principles involved in efficient controls of establishments and products are outlined. Technical progress in consumer protection is exemplified by the processes of pasteurisation, cooling and freezing, and the limitation of additives. Other important tasks arise in the disposal of animal carcasses and wastes, and in the fields of animal welfare and genetic engineering. Future activities in VPH will depend upon proper education, onward and postgraduate training for veterinarians, and suitable infrastructures for research, examination and surveillance.

KEYWORDS: Animal welfare - Consumer protection - Disposal of animal wastes - Environmental hygiene - Food hygiene - Genetic engineering - Health protection - Meat inspection - Zoonoses control.

INTRODUCTION

The veterinarian today holds an important position within the variety of fields which constitute veterinary public health (VPH). In the industrialised countries, the responsibilities of the veterinarian include epizootics and zoonoses control, hygiene of foods of animal origin (control of infectious agents, biological toxins and chemical residues, monitoring of food establishments and products) and animal welfare. In this way, the veterinarian provides a link with medical experts in the fields of zoonoses control and food hygiene; in addition, there is close cooperation with other professions (farmers, food chemists and biologists). In Europe, this spectrum of activity has been defined in numerous documents of European Community (EC) legislation. In the

* Bundesgesundheitsamt (Federal Health Office), Robert von Ostertag-Institute (Institute for Veterinary Medicine), Thielallee 88-92, D-1000 Berlin 33, Federal Republic of Germany.
World Health Organisation (WHO) terminology, these activities are encompassed by the term “veterinary public health”, expressing the fact that important contributions are made by veterinary medicine to the protection of consumer health and the environment.

This role was not randomly assigned. Rather, great efforts and achievements were required from veterinarians before they became involved in tasks concerning human as well as animal health. The utilisation of the professional training and knowledge of veterinarians still varies among governments. In the EC, veterinarians are responsible for the entire field of food control including foods of vegetable origin. This development was preceded by the adaptation of veterinary school curricula and the establishment of comprehensive programmes for postgraduate studies and advanced training. In all cases, however, there should be further efforts to encourage the interest of students in VPH, by providing training beyond what is taught in the basic courses, and also to ensure an adequate number of young veterinarians with sufficient qualifications and maintain the social and professional prestige of veterinary medicine.

In the nineteenth century, scientific and technical knowledge in the field now known as veterinary public health underwent revolutionary change, when the associations between human tuberculosis and the consumption of beef infected with tuberculosis bacteria were discovered. L. Pasteur was the first (in 1870) to suspect microbes to be the agents of disease, and K. Gerlach (in 1875) described bovine “pearl disease” (later referred to as tuberculosis of the serosa) and suggested that it might be transmissible to humans. When the agent of tuberculosis was discovered by R. Koch in 1882, a causal relationship was assumed to exist for the first time. Ten years later, in 1892, having confirmed that tuberculosis could be transmitted to man by infected beef (16), R. von Ostertag was appointed to the first academic chair established anywhere in the world to cover the fields of meat inspection and milk hygiene at the University of Berlin. Under his authorship, the first Meat Inspection Act in the world was drawn up in 1900, following the promulgation of the first Epizootics Act in 1880. These two legal fields subsequently formed the pillars of VPH.

Recent world-wide developments in this field are the activities of the Codex Alimentarius Committees on “Food Hygiene”, “Meat Hygiene”, “Processed Meat and Poultry Products” and “Fish and Fishery Products”.

CONTROL OF ZOONOTIC DISEASES

TERMINOLOGY

In 1950, the WHO adopted the term “zoonosis” to designate what was formerly called “zooanthropozoonosis” (i.e. a disease transmissible from animals to humans) and “anthropozoonosis” (i.e. a disease transmissible from humans to animals). A distinction is made between zoonoses which may result from contact with an infected animal or its excretions (e.g. rabies) and those which tend to develop as a consequence of the consumption of infected foods (food-borne infections). For example, trichinellosis is a food-borne infection; brucellosis (Bang’s disease) may be food-borne or produced by contact with an infected animal. Tuberculosis too may be food-borne, though in developed countries infection is now more commonly via aerosols (5, 14, 24, 26).
BOVINE TUBERCULOSIS

Although tuberculosis is a disease which may affect all farm animals, this discussion is limited to bovine tuberculosis, first detected (as “pearl disease”) by Gerlach in 1875.

Advance remarks

The extended controversy about the association between the disease affecting the lungs and that which affects the serous membranes (pearl disease) did not come to an end until 1882 when the agent of tuberculosis was demonstrated for the first time by Koch. As early as 1890, the introduction by Koch of tuberculin as a diagnostic agent provided a suitable methodological basis for veterinarians. Following an international congress on tuberculosis in London in 1901, the Royal Commission and the German Health Office in Berlin began intensive investigations into the problem of differentiating the agent of tuberculosis. Thus it became evident, even before the end of World War I, that Mycobacterium bovis, the agent of bovine tuberculosis, was also capable of causing tuberculosis in humans, and that the high number of infections among children was to be attributed to the presence of the agent in cow’s milk. This provided a firm basis for the international control of bovine tuberculosis.

Experience has shown that these sources of infection can be removed by an eradication of bovine tuberculosis. Moreover, calculations have revealed that the average value per head of tuberculous cattle is reduced by one-quarter to one-third as compared to that of healthy animals.

The cost and duration of campaigns to control bovine tuberculosis vary considerably depending on the initial number of cases and the method used (12). However, there are still many parts of the world where this objective has not yet been achieved for financial and organisational reasons.

Methods of control

In Prussia, from 1899 until 1939, the method of control developed by von Oster tag was applied. It consisted in the elimination of cattle affected by open (clinically recognisable) tuberculosis at the earliest time possible. Better results were achieved through measures based on allergic skin tests.

A second method calls for the eradication (e.g. by the stamping-out method practised in the United States of America) of all animals reported as infected. Such radical elimination will result in the most rapid success. However, as a rule, it can be applied only where the number of cases is low, or where losses for farmers are offset by government subsidies.

A third method (Bang’s method) involves strict segregation of infected animals from non-reactors, segregation and tuberculosis-free raising of calves and a gradual elimination of reactors.

In most countries of the world where bovine tuberculosis has been eradicated, the principles of Bang’s method have been applied.

Prevention

Monitoring and protection of tuberculosis-free stock are based on intracutaneous tuberculin testing at intervals of up to three years as well as slaughterhouse control.
The importance of ante-mortem and post-mortem examination of meat animals is shown by data published in the international literature from 1962 to 1981 (Table I). Between 1975 and 1980, almost 80% of fresh infections in tuberculosis-free farms were detected by way of slaughtering and subsequent investigations, while only about 10% of cases were detected by regular tuberculinisation monitoring, according to Salfelder (19).

### Table I

**Isolation of mycobacteria from lesions found during meat inspection, 1962-1981 (figures from literature)**

<table>
<thead>
<tr>
<th>Animal species</th>
<th>Total</th>
<th><em>M. tuberculosis</em></th>
<th><em>M. bovis</em></th>
<th><em>M. avium</em> and other mycobacteria</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>3,242</td>
<td>11</td>
<td>1,316</td>
<td>1,915</td>
<td>Federal Republic of Germany</td>
<td>1961-1970</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>261</td>
<td>432</td>
<td>France</td>
<td>1971-1981</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>77</td>
<td>1,254</td>
<td>United States</td>
<td>1973-1977</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>194</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>784</td>
<td>213</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-total</td>
<td>10,373</td>
<td>97</td>
<td>263</td>
<td>10,013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>100%</td>
<td>0.9%</td>
<td>2.5%</td>
<td>96.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *M. tuberculosis* and *M. bovis* not differentiated

### Protective measures

In part, supra-national regulations have been promulgated, which harmonise and increase the efficiency of protection and control measures. Evidence of this is given by a number of EC Directives.

### Disinfection

Disinfection is applied primarily upon termination of eradication measures, to render animal quarters free from infectious organisms after the elimination of reactors. Of the various chemical agents available, only those products should be used which have been successfully tested for their tuberculocidal effect. Under prevailing conditions in animal areas, physical methods of decontamination such as air filtration and ultra-violet irradiation are insufficient, as are the use of hot water or steam injectors. These methods have a good cleansing effect but no tuberculocidal efficiency.
There has been considerable progress in the control of the zoonotic diseases known under this name since contagious abortion of cattle (Bang's disease) was discovered by F. Bang in 1896.

Overview

According to WHO data, the number of cases of human brucellosis world-wide is approximately 500,000 (23). However, owing to the varied symptomatology of the disease, many cases escape diagnosis. In acute cases of the disease, most patients will be initially diagnosed as suffering from "influenza", "typhoid" or an "unknown infection associated with fever". It is estimated that in France, only about 10% of persons falling ill from brucellosis are treated at all; the remainder of those affected either voice "subjective" complaints or their infections take an almost or completely symptomless course (9). It has been stated that only between 20-33% of the clinically apparent cases of brucellosis are diagnosed as such and reported to health authorities (reporting rate 2-3.3%). In the United States of America (USA), the National Brucellosis Technical Commission rated brucellosis in 1977 as under-diagnosed and under-reported, with an estimated reporting rate of 10% (for California) (32).

The epidemiology of human brucellosis is closely associated with the spread of brucellosis among animals. Bovine brucellosis (caused by Brucella abortus) is a worldwide disease. Generally, biotype 1 is predominant. Other biovars may, however, be predominant in certain areas, e.g. biotype 2 in Japan and biotype 3 in parts of Europe and Africa (15). Bovine brucellosis is considered as largely eradicated at present in some areas.

The reservoir of Brucella melitensis is formed by the small ruminants (sheep and goats); it is present in most parts of the world.

Brucella suis biotype 1 is found in all parts of the world where swine brucellosis occurs. Biovar 3 has been isolated from swine only in the southern states of the USA and in South-East Asia. Biotype 2 is found in many European countries. There are epizootiological associations between brucellosis caused by this biotype in swine and in the European hare; wild boar also seems to be involved (8). B. suis biotype 4 is present in reindeer in North America and the north of the former Soviet Union.

Although cattle form the most important reservoir for B. abortus, sheep and goats for B. melitensis and swine for B. suis, these three Brucella spp. may, in principle, also give rise to disease in other hosts.

Transmission to humans

Brucella-infected animals may harbour the agent in all organs and tissues. The most frequently colonised organs are the placenta and the mammary glands. The agent is excreted through the placenta and milk. There are two principal routes of infection from the animal reservoir to man:

- contact with infected animals and their products such as lochial secretion, placenta and milk (contact infection);
- consumption of foods (in particular, milk) from infected animals (food-borne infection).
In the epidemiology of brucellosis, humans form a dead end for the chain of infection. Infection from man to animals has never been reported.

While in the state of Minnesota (USA), in 1947, 25% of brucellosis cases had to be attributed to the consumption of contaminated milk or milk products (13), recent figures show that now only 9% of cases in the USA are of food-borne origin. Between one-half and two-thirds of these cases were caused by foreign milk products (particularly by fresh goat cheese from Mexico) (32). This decrease in the relative incidence of food-borne infections in the USA can be attributed to successful measures for eradicating bovine brucellosis, and the pasteurisation of milk which is a common practice today (3). A similar decrease in food-borne brucellosis has been observed in many European countries.

Milk from species other than cattle, sheep and goats may also be a source of food-borne Brucella infections. Water buffalo, dromedaries and bactrian camels, reindeer, horses (11), llamas, yaks, bison and saiga species (27) may shed the agent with their milk.

**Diagnosis and control**

There is hardly any other zoonotic disease for which the methods of examination and the diagnostic agents to be used have been so well standardised at an international level. (Reference is made in this respect to pertinent publications of the United Nations Food and Agriculture Organisation [FAO], WHO and the Office International des Epizooties [OIE] and to EC directives.) The examination of bulk samples (milk from tankers) to confirm the Brucella-negative status of a herd has meanwhile become a routine procedure in a number of countries.

None of the steps of brucellosis control can be achieved without the simultaneous development of the veterinary infrastructure. The permanent identification of individual animals and herds, the control of commerce in animals inclusive of transportation, appropriate diagnostic facilities, a detailed system to report on diagnoses and measures taken (slaughter, sale, vaccination) and legal regulations on epizootics must be seen as integral parts of a structure which is imperative for the eradication of this zoonotic disease. The presence of highly-qualified laboratories and competent scientific staff in a country do not suffice for this purpose, though it is one of the major prerequisites for control programmes based on mass vaccination.

**TRICHINELLOSIS**

Despite its discovery in 1835 by J. Paget, *Trichinella spiralis* was not recognised as a serious health problem until 1860, when F.A. Zenker, R. Virchow and R. Leuckart made discoveries clearly demonstrating the life-cycle, transmission and pathogenicity of the parasite. As a result of these discoveries, obligatory inspection of pork for the presence of trichinae was introduced in Prussia in 1877. Most Western European countries had adopted trichinae inspection by the end of the nineteenth century. Except for a brief period from 1891 to 1906, trichinae inspection has not been performed in the USA. Inspection of pork throughout most of the twentieth century has been carried out by visual examination of swine tissues using the compression method and low-power microscopy or a projection trichinoscope.
Inspection of pork has resulted in a dramatic decline in the incidence of infection in pigs and humans in countries where inspection is mandated. For example, in Germany, infection rates in pigs declined from 0.05% in 1878 to 0.005% in 1907, 0.001% in 1926, and to near zero in recent years. Other factors have also contributed to a decline in swine trichinellosis, as is evident in countries such as the USA where inspection is not required. These factors include improved management, confinement rearing, rodent control and, most importantly, regulations prohibiting the feeding of uncooked refuse to hogs. These factors have combined to reduce transmission in the domestic pig cycle of the disease.

Alternative methods to the laborious and expensive practice of trichinoscopy have been developed over the years. In 1978, artificial digestion of pooled samples from 50 to 100 pigs was permitted and has since become the method of choice throughout the EC. These procedures have not only enhanced the sensitivity and reliability of testing, but have also considerably reduced the time required and the costs of inspection. Under Commission Directives 77/96/EEC and 84/319/EEC, a total of five methods are allowed for the inspection of pork for trichinae by digestion methods.

Despite improvements in inspection methods, the sensitivity of testing for trichinae by direct methods such as artificial digestion is limited to the amount of tissue examined. In testing a one gram sample, as allowed by the EC, a theoretical limit of one larva per gram of tissue is established; the actual lower limit of sensitivity has been demonstrated to be closer to three larvae per gram of infected tissue. Thus, an opportunity exists for a low level of infection to persist in the swine population, which is not detected by existing methods.

Future improvements in trichinae inspection will be based on new technology. A Directive of the Council of the European Communities, dated 27 April 1989, approved the use of an automated digestion method using the commercially available "Trichomatic 35". Using this device, inspection of a pool of thirty-five one-gram samples can be accomplished in twelve minutes. Highly sensitive serological methods, such as the enzyme-linked immunosorbent assay (ELISA) test, are currently in use in the Netherlands and the USA. It is likely that serology will be used more widely in the future, given the improved test results thus obtained, the lower cost and the ability to be integrated with testing systems for other food contaminants.

Despite major advances in eliminating the risk of trichinellosis from the pork supply, human cases continue to occur. Various factors contribute to ongoing transmission, including a low-level persistence in swine and a higher incidence in wildlife (the sylvatic cycle). Efforts to educate consumers concerning the hazards of eating raw or undercooked meat are important, particularly in certain ethnic groups. In addition, consumers need to be informed concerning the hazards of trichinellosis in game meats, particularly bear, which is an increasingly important source of infection.

RABIES

Rabies occurs on all continents, except Australia and Antarctica. In different geographical areas, different main hosts are responsible for its maintenance and spread (1, 21). The species of the order Carnivora recognised as main hosts of rabies in different parts of the world are the red fox (Vulpes vulpes) in subarctic and northeastern North America, in temperate zones of Asia and in Eastern and Central Europe;
the arctic fox (*Alopex lagopus*) in arctic regions of America and Asia; striped skunks (*Mephitis mephitis*) in the American Midwest and California; raccoons (*Procyon lotor*) in eastern North America; different species of mongoose in Southern Africa, the Caribbean and possibly also Southern Asia; and jackals (*Canis aureus* and *C. mesomelas*) in Africa and parts of Asia. All of these animals are able to support initial epidemics of high case density and thereafter an oscillating prevalence over many years. They are all small to medium-size omnivores, scavenging and preying on rodents, other small vertebrates and invertebrates. Several other carnivore species besides those mentioned above may also function as main hosts of rabies. Grey foxes (*Urocyon cinereoargenteus*) in some North American areas, and introduced raccoon dogs (*Nyctereutes procyonides*) in Eastern and subarctic Europe are sometimes suspected of supporting independent epidemics. The role of other common carnivores in Africa, Asia and Latin America is not, as yet, well understood. Populations of a number of bat species in the Americas, Northern Europe and perhaps Asia and Africa also maintain independent epidemics. The rabies strains circulating in bats are transmitted to terrestrial mammals (including humans) only rarely, with the exception of bovine paralytic rabies transmitted at high frequency by vampire bats in Latin America.

Monoclonal antibodies produced by cloned hybridoma cells distinguish clearly between strains with different passage histories, isolates of different geographic origin and rabies viruses circulating in different host populations (18). Within an area of predominantly fox, skunk or raccoon rabies there is very little viral variation. An occasional rabid skunk or raccoon in a fox rabies area yields virus with fox rabies characteristics, and vice versa. During an epidemic in the main host, rabies cases in nearly all other species of mammal occur with different frequencies. But these are more sporadic, spatially and temporally isolated. Short chains of intraspecific transmission are rare in species other than the main hosts, e.g. in badgers (*Meles meles*) in Central Europe.

Dogs are the main hosts over large areas of Africa, Asia and Latin America. There they make up 95% or more of all diagnosed rabies cases. About 35,000 persons die from dog-transmitted rabies every year. The number of persons receiving post-exposure treatment — mostly after dog bites — is estimated at about 3.5 million per year. Almost all human rabies deaths and the vast majority of treated bite exposures occur in developing countries. Despite the easy access to dog populations, not much is known about the epizootiology. Dog rabies appears to be highly enzootic with only moderate fluctuations in prevalence.

Canine rabies disappeared from Central and Northern Europe around the turn of the century, and later from most European areas bordering the Mediterranean. The reasons for this disappearance are unknown. During the same period, epizootic fox rabies emerged and spread from subarctic North America southward (20) and from Eastern Europe southwestward (2), while at the same time in the USA, canine rabies disappeared and rabies in terrestrial wildlife (foxes, skunks, raccoons) and bats became apparent.

The ultimate purpose of rabies control is the protection of man from infection and from economic losses. The incidence of rabies in man can be controlled by prophylactic vaccination and post-exposure treatment, by reducing the risk of human exposure and, conclusively, by disease elimination. The easiest way to reduce the incidence of contamination is by prophylactic immunisation of domestic animals,
which are the most common source of human exposure. The live attenuated vaccines which were quite successful for domestic animal immunisation in past decades are now being replaced by potent inactivated tissue culture vaccines. A far more ambitious task is the elimination of rabies in its main host. Mass vaccination campaigns of dogs as early as 1920 in Japan, and later in other parts of the world, eliminated canine rabies in several areas (1, 6, 24). In the 1980s, dog rabies control programmes were very successful in Latin American cities, but unfortunately not in other areas with canine rabies.

Wildlife rabies control effectuated by decimating host populations has been attempted in nearly all host species. But their resilience to such measures and their reproductive potential in connection with high carrying capacities of rural and urban habitats often render control efforts unavailing. Accordingly, only a few documented instances exist where population control measures actually have inhibited the spread of an epidemic into a new area (e.g. Denmark). In an endemic situation, decimation, in combination with rabies as an important mortality factor, often succeeds in reducing host population densities locally below a threshold level at which disease transmission can occur. However, during the absence of rabies, these populations recover rapidly and reinvasion of the disease is the consequence. More promising is the mass vaccination of the main hosts. But immunising free-living wild animals is not a simple task. The wild mammal must be lured into vaccinating itself. This method has to be simple and efficient, so that it becomes technically and economically possible to establish the herd immunity required to eliminate rabies. The goal of wildlife rabies control should be the local elimination of disease, or the control of its spread to uninfected areas. The desired herd immunity can be established in a population only when the following requirements are met:

- the vaccine is safe and potent for field application
- the vaccine delivery system ensures the mass immunisation of the target species.

The control of wildlife rabies by immunisation became an attainable target in the early 1970s when it was found that attenuated rabies vaccine immunised foxes orally. This discovery indicated the possibility of administering an oral rabies vaccine to wild carnivores by bait. It was found that the Street-Alabama-Dufferin (SAD) strain and its derivatives fulfilled the majority of the requirements to immunise foxes in areas with fox rabies, although SAD does not immunise other main hosts by the oral route. The first field trial in foxes was carried out in Switzerland in 1978, followed by additional campaigns. These rapidly freed the major part of Switzerland from rabies and, more recently, large areas of other European countries and Canada (22). Genetically-engineered recombinant vaccines have lately been prepared with great potential for wildlife rabies control. A vaccinia-rabies glycoprotein recombinant is used successfully in Belgium and in parts of France and the first limited field trials are being carried out in raccoon rabies areas of the eastern USA.

**HIDDEN AND FOOD-BORNE DISEASES**

A most important problem consists in the spread of certain infectious agents due to latent infection, i.e. among animals and animal stocks which, during their lifetime, appear healthy on gross inspection and show no signs of infection. The consequence of such latent infection is that (taking the ubiquitous *Salmonella* bacteria as an
example) feeds, excrement, soil, ground water — and thus the environment — become contaminated with agents of infection. This can result in the contamination of foods of animal origin. Whereas health-conscious consumers seek out a wholesome diet, avoiding excess intake of fat, salt and sweets, the spread of infectious agents (and the presence of chemical residues) causes hidden defects in food which cannot be recognised by the consumer. As consumers cannot protect themselves against such risks, protection should be afforded by governments.

At present, special importance is attributed to zoonoses in the field of meat hygiene. Animals become carriers of these agents without necessarily suffering from clinical disease. This situation and, particularly in this case, the ubiquitous distribution of certain pathogenic intestinal bacteria such as *Salmonella* and *Campylobacter* have contributed to the world-wide increase in the incidence of food-borne diseases (Fig. 1). In Europe the German Federal Health Office has been commissioned by the WHO to develop a surveillance programme for the region. This programme will provide for the collection and regular publication of information on reported outbreaks of food infections and intoxications, as well as the issuing of recommendations on how the sources of infection identified by the participating governments could be eliminated in the future. The involvement of individual types of food in the epidemiological situation varies. There can be no doubt that many foods of animal origin must be incriminated; their share among reported infections exceeds 60% (Fig. 2).

![Fig. 1](image)

**Fig. 1**

**Infectious enteritis**

**Notified cases**

(former Federal Republic of Germany including West Berlin, 1980-1990)

*Source: Robert von Ostertag-Institute; FAO/WHO Centre Berlin*
FIG. 2
Presumed sources of infection
(1,064 first isolations of *Salmonella*)
(former Federal Republic of Germany including West Berlin)
Given this situation, the question arises as to why the control measures taken so far do not seem to ensure adequate health protection of the consumer. It would be impossible to mention all the factors which could be held responsible. Instead the efficiency of the official examination of meat animals and meat should serve as an example. This system has made an excellent contribution to safeguarding the consumer. Such examination is based on specific pathologic-anatomical tissue changes in the carcass which can be easily diagnosed by "eye and knife" in the course of meat inspection.

Since 1960, the total number of food production animals has not increased in the industrialised countries, but there has been an increase in the number of animals in each herd or flock. The development of large-scale livestock farming, together with the use of modern husbandry and feeding technology, has resulted in the spread of latent infections among meat-producing animals. The influence of slaughter and processing technology may, in addition, contribute to further spread of infectious agents and result in the contamination of previously uninfected foods. Traditional meat inspection is unable to cope with these modified hygiene risks, as is becoming evident in changes in the performance of ante-mortem and post-mortem examinations.

Isolation of *Salmonella* in commercial minced meat is now frequent: out of 500 retail samples of minced pork tested in 100 German establishments, 226 were contaminated with *Salmonella* (30). The presence of *Campylobacter* in water and animals and of *Toxoplasma* in animal carcasses is also frequently reported (17): in Germany, thermophilic *Campylobacter* were isolated in 0-53% of samples from river water as well as from clinically healthy animals and humans (10-43% in cattle, 14-91% in poultry, 66-88% in pigs, 13-49% in dogs, 0-53% in cats and 0-1.6% in humans).

The importance of such infections for the human population underlines the necessity of urgent improvements in consumer health protection through a system of examination adapted to the present (Table II).

### Table II

*Important zoonoses in meat hygiene in Europe (literature data)*

<table>
<thead>
<tr>
<th>Zoonosis</th>
<th>Occurrence in animals</th>
<th>Ease of diagnosis at meat inspection</th>
<th>Public health relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonellosis</td>
<td>++ +</td>
<td>(+)</td>
<td>++ +</td>
</tr>
<tr>
<td>Toxoplasmosis</td>
<td>+</td>
<td>-</td>
<td>++ +</td>
</tr>
<tr>
<td>Cysticercosis</td>
<td>+</td>
<td>+</td>
<td>++ +</td>
</tr>
<tr>
<td>Trichinellosis</td>
<td>(+)</td>
<td>+</td>
<td>++ +</td>
</tr>
<tr>
<td>Q fever</td>
<td>+</td>
<td>-</td>
<td>++ +</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Listeriosis</td>
<td>( + )</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Sarcosporidiosis</td>
<td>++ +</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>-</td>
<td>+ ++</td>
<td>++ +</td>
</tr>
<tr>
<td>Brucellosis</td>
<td>-</td>
<td>+</td>
<td>++ +</td>
</tr>
<tr>
<td>Certain viral infections</td>
<td>?</td>
<td>-</td>
<td>?</td>
</tr>
</tbody>
</table>

+ + high                  (+) very low
++ medium                 + extremely low
++ low                    ? no sound data available
Thus, EC authorities have set out a number of "pointers" which are principally intended to prevent a worsening of the present hygiene situation, and to make collective progress. Firstly, scientific research is needed to improve the potential of ante-mortem and post-mortem diagnosis. Slaughter technology should also be improved to eliminate the most important sources of contamination. The objective is to improve the examination of meat animals and meat, and ensure for the future the three objectives of meat examination:

- health protection of the consumer
- epizootics control
- the conservation of valuable animal protein (i.e. assets for the national economy).

In recent years, successful efforts have been made to improve the hygienic conditions for the scalding of pig carcasses and the cooling down of slaughtered poultry. Owing to an essential improvement in the bacteriological technique, the detection of *Salmonella* has become more reliable. At the same time, this technique has been standardised for its uniform application throughout the EC. Methods for the detection of cysticercosis and trichinellosis have also improved, and efforts have been concentrated on the creation of possible ante-mortem diagnoses.

To interrupt the chains of infection and to reduce the wide distribution of certain infectious agents, farmers and veterinarians have been called upon to make efforts to ensure the absence of agents of infection in the course of raising and keeping farm animals, in particular meat animals. Such efforts have led to considerable progress in the Netherlands and Denmark, illustrating that the necessary scientific and technological conditions exist. Monitoring programmes are needed to record the distribution and nature of agents of zoonotic diseases among animal stock, along with systematic epidemiological studies to gain more knowledge of the true reservoirs of the agents of infection which affect the animal and then pass into food of animal origin.

**LISTERIAS AND FOOD HYGIENE**

Cases of disease caused by *Listeria monocytogenes* have been reported for more than fifty years. Particularly in the 1960s and the early 1970s, demonstrations of the presence of listerias in animals, feeds and raw milk, and of their shedding by a high proportion of healthy persons, raised the question as to whether contaminated food could be causally associated with human *Listeria* infections. At that time, the question could not be conclusively answered.

In 1987, cases of listeriosis following upon the ingestion of some European cheeses were reported. These outbreaks again drew attention to the possibility that contaminated food (in particular, milk products) was involved in the apparent increase in cases of listeriosis. A vast survey was therefore undertaken in the food industry and control measures were implemented, leading to a significant diminution in the percentage of products contaminated by *L. monocytogenes*.

Meanwhile, a clear relationship between contaminated foods and disease was found to exist in outbreaks of listeriosis and in individual cases as well. Accordingly, human listeriosis, with the exception of contact infections from the handling of infected animals, is considered essentially a food-borne disease.
The infectious dose of *L. monocytogenes* for humans is still unknown. However, in view of the broad distribution of listerias in the animate and inanimate environment and the low incidence of infections, the assumption seems to be justified that a serious health risk exists only at high bacterial counts and for particularly susceptible population groups. It was therefore necessary to develop a catalogue of graduated measures for implementation.

During production, storage and sale, manufacturers must generally ensure by controls of their own that, even under unfavourable conditions, the relevant criteria will be satisfied in the final product.

The methodology of the examination of foods for the presence of *L. monocytogenes* has been developed in analogy to the corresponding International Dairy Federation standard.

A great deal of research is still needed to elucidate the pathogenicity of various strains of *L. monocytogenes*, the epidemiology of the disease in animals, the relation between the infection in animals and humans and other problems.

**CHEMICAL RESIDUES IN FOODS**

**Causes of the contamination of foods of animal origin**

The contamination of foods of animal origin with chemical residues is another field where consumer protection is needed.

Knowledge in this field has made considerable progress in the last twenty years. First of all, it has become apparent that there is a great variety of reasons for which chemical residues may be present in animals and result in a contamination of foods. Chemical residues may also belong to quite different chemical substance groups. Finally, there are different routes of contamination which may even support one another. In practice, contamination may result from either deliberate legal or illegal use of chemical substances or from substances present in the environment. Examples of the first type can be seen in the use of veterinary medicines and pesticides; examples of the second, in the use of prohibited substances such as hormonal growth promoters; examples of the third, in the presence of heavy metals or chlorinated hydrocarbons from a contaminated environment. Naturally, substances belonging to the first and second groups are easier to monitor (Fig. 3) (6).

**Toxicological evaluation**

Numerous methods have been developed to study the toxicity of chemical substances. The performance of such studies is guided by national and supra-national (European Community, Organisation for Economic Co-operation and Development) recommendations, testing guidelines and legal regulations for the different uses of pharmacologically active substances.

**Toxic substances in fish**

Contrary to the majority of meat provided by animals, fish and seafood usually originate from an environment unshaped and hardly touched by man. Nevertheless, harmful substances may be present in such food due to environmental factors or formation by micro-organisms.
Histamine

The biogenic amine, histamine, may form as a result of an excessive non-specific bacterial count in the product concerned, or due to the availability of a sufficient amount of original decarboxylase in the product. Metabolic products such as histamine which are referred to as "pressor amines" are not infrequently found in fish products (tuna, mackerel, sardines). For a consumer whose aminooxidase activity does not suffice for detoxication, exposure to certain amounts of these metabolic products may result in shock, acute circulatory disorders and other conditions. Prevention is difficult because fish products with a relatively high histamine level (up to 1,000 mg/kg) may appear under sensory testing as completely safe, although intoxications are known to occur in man at such concentrations. Histamine concentrations above 1,000 mg/kg food are considered a health hazard and products thus affected are not marketable.

Algal toxins

In certain geographical areas and in seasons of high algal growth, harvested mussels may produce acute poisoning of the central nervous system (mytilotoxism) in consumers. This phenomenon is commonly referred to as "paralytic shellfish poisoning" (PSP). Another clinical picture is characteristic of "diarrhoeic shellfish poisoning" (DSP), described for the first time in 1978. The poison producing PSP is synthesised by a dinoflagellate, Gonyaulax, and accumulates in mussels. It has proved to be more or less heat-stable. Meanwhile, eighteen naturally-occurring PSP toxins including saxitoxin have been isolated. In recent years, the DSP toxins have been isolated and their chemical structure elucidated.
Shellfish and shellfish products must not be marketed as foods if fat-soluble algal toxins (DSP) can be demonstrated or if they contain more than 400 mg water-soluble toxin (PSP) per kg of shellfish meat.

Residue analysis

The efficiency of analytical operations is of great importance for food hygiene control. In anticipation of the single market within the EC, more and more methods of analysis have been standardised, and the ideal is that everywhere within the EC territory, the same residue can be detected by the same methodology, the same procedure and with the same sensitivity. However, this goal is still a long way off. As the sensitivity of detection has increased, it is understandable that residues of chemical substances are increasingly detected in foods. Often, the general public has misunderstood the true meaning of such figures, so that any detection of residues is considered as a health hazard. It is relevant in this context to recall Paracelsus' statement that "only the dose" makes a substance a poison. There is no doubt that governments should improve education of the public to contain unnecessary fears, perhaps by giving wider publicity to the concepts of the Acceptable Daily Intake (ADI) and the Maximum Residue Limit (MRL). The ADI (in mg/kg body weight) is the amount of a chemical which can be consumed every day of an individual's entire life in the practical certainty that no harm will result. The MRL (in mg/kg or mg/litre) is the maximum concentration of residue permitted in or on food and considered to be without any toxicological hazard for human health.

For the most varying substances, specific methods of detection have been improved, from simple screening tests to sophisticated and expensive large-scale analytical equipment. Needs can sometimes be satisfied by simple methods, as has been proved by the biological test for inhibitory substances. After its introduction, a drastic reduction was noted in the illegal use of antibiotics for the fattening of animals because users feared the detection of such substances in spot-checks. An elimination of the presence of such microbiologically active substances in foods also serves the purpose of reducing the development of resistance phenomena in bacteria on both the chromosomal and the extrachromosomal (plasmid) level.

METHODS TO GUARANTEE HYGIENE IN FOODS OF ANIMAL ORIGIN

Official examination of meat animals and meat (4, 16)

Soon after Pasteur and Koch made their pioneering discoveries in the late nineteenth century concerning the nature of infectious diseases and their agents, the role played by farm animals and the foods derived from them (meat, eggs, fish) in the transmission of infectious diseases to humans was clearly identified. As a veterinarian and member of parliament, von Ostertag successfully advocated the passing of the first Meat Inspection Act in Germany at the turn of the century.

These tasks were officially conferred upon veterinarians who had the necessary expertise through their professional training. They also were empowered to decide on the acceptance of animals for slaughter (permission, ban, or permission with certain restrictions) and to evaluate the fitness of meat for consumption. These regulations,
which essentially still apply today, served as a model for many governments when passing their own rules for inspection.

The mode of examination has been modified repeatedly over the years. Initially, the primary objective was the detection of infectious diseases (intensive clinical and/or pathological examination, bacteriological examination of meat, detection of trichinae), whereas today attention focuses on the establishment of evidence of illegal methods of fattening, the detection of residues of medicines and environmental chemicals (residue analysis), and the damage caused by storage and transportation (lung manifestations, abscesses, bone fractures, mastitis).

Moreover, in view of the improved mechanisation and acceleration of the slaughtering process, it has become increasingly difficult to reserve adequate scope for what remains indispensable examination on the processing line.

World-wide efforts will thus be needed to maintain ante-mortem and post-mortem inspection while at the same time ensuring hygiene among animal stocks, i.e. at the primary production stage. This requirement was pointed out some forty years ago by one of the major figures of veterinary food hygiene, M. Lerche. The way in which examinations at the farm of origin and post-mortem inspection might be linked is shown in Figure 4.

**Hygiene: regulations, standards and technologies (4, 28, 30, 31)**

In many parts of the world, but primarily in the industrialised countries, so-called "hygienic packaging" has been developed within the last twenty years, with the aim
of guaranteeing hygienic standards in food. Such packaging is intended both to safeguard the integrity of food in terms of consumer health and to help promote uniform conditions of competition in view of the increasing liberalisation of trade. A typical example of this liberalisation is the EC common market which, from 1993 on, will cover a single economic zone. A package of rules on hygiene (EC Directives) has been made available to cover food trade in the region. This legal field is given additional support by harmonisation and standardisation measures (e.g. in methods of examination) including standardisation work in the field of technology and hygiene (activities of the European Committee for Standardisation [Comité Européen de Normalisation; CEN], etc.).

In the course of the last one hundred years, a great deal of technology has been developed in the service of hygiene (concerning slaughter, treatment, processing and preservation), contributing to improved consumer safety especially with regard to foods of animal origin which are endangered by agents of infection, spoilage and chemicals. More than any other field of hygiene, consumer health protection has derived world-wide benefit from the activities of VPH.

Methods of heating, cooling and freezing; irradiation

Since the basic findings by N. Appert in 1809, the use of heat treatment for the preservation of foods has undergone a tremendous development. Pasteurisation of milk (short-term heating from 71°C to 74°C), which kills the agents of tuberculosis and brucellosis, has made an excellent contribution to the control of these diseases. Ultra-high temperature (UHT) treatment (~ 132°C for 2-3 seconds only) completes the potential for producing milk which is hygienically acceptable for drinking and other uses while maintaining its biological value.

Pasteurisation of liquid egg at 63°C has resulted in an essential reduction of Salmonella infections in man. In many countries, there are legal regulations similar to those on milk which stipulate minimum requirements for plants and equipment, and permissible microbial counts. Modern canning technology is based on the decimal reduction period expressed as the so-called D value and the lethality unit F (i.e. Fahrenheit). The F value refers to the reference temperature of 121.1°C/1 min. Depending on the temperature/time ratio, a distinction is made between semi, three-quarters, full and tropicalised preserves. Modern methods of heat treatment have contributed to the reduction of botulism, the prevention of “bulging” cans and resulting economic losses.

The development of efficient cooling chains – beginning at slaughter, continued during transport and ending with the finished product (storage at temperatures between 0°C and + 7°C) – has resulted, above all in the industrialised countries, in extended storage life for foods of animal origin and the reduced incidence of food intoxications due to spoilage. Finally, technological progress in deep-freezing (~ 12°C to ~ 40°C) has contributed to a considerable extension of storage life. Without deep-freezing, world-wide trade in certain foods (e.g. poultry, fish and crustaceans) would be impossible. It should also be noted that the process of deep-freezing stops the growth of micro-organisms, and larvae such as Anisakis simplex are killed.

Under certain conditions, irradiation of foods (final products) is considered non-hazardous to health, and has been recommended by the World Health Organisation (in 1981). Such conditions would correspond to a dose of ionising radiation (electron, beta or gamma irradiation) of up to 10 K Gy (25, 29).
**Addition of nitrate and nitrite; smoking**

Certain specific dietary habits – such as those prevailing in some (particularly Eastern) European countries – have resulted, over the centuries, in meat technology which, in addition to fulfilling a sensory purpose (forming the red colour and typical flavour), also entails hygienic (botulism) and toxicological aspects (acute intoxication in the event of overdosage when used as pure nitrite, or due to the formation of carcinogenic N-nitroso compounds). These aspects have resulted in legal regulations concerning a safe dosage of the so-called nitrite pickling salt, which contains 0.4-0.5% nitrite and presents no risk to human health. The permissible intensity of smoking to preserve meat products is guided by the resultant level of the carcinogenic indicator substance 3,4-benzopyrene, which must not be present in concentrations above 1 mg/kg (1 ppb). This limit can be respected thanks to modern smoking technologies. Veterinary food hygienists and food technologists have played an essential role in research to elucidate the complex relationships between progress in food-processing and hygiene safety. Such work also belongs within the terms of reference of VPH.

**Control of food establishments and products**

To avoid the contamination of originally uncontaminated foods, it will be necessary to introduce, continue or extend self-regulated controls in food establishments as part of the proper application of good manufacturing practice. Considering the world-wide liberalisation of the food trade and the associated competition, a great deal of responsibility rests with the food hygienist employed by a governmental body or acting as a private advisor. If only for economic reasons, it would seem sensible for governmental and private control bodies to join forces to improve consumer health protection. It should be the principal objective of such joint efforts to identify, by a specific internal process control, those phases in processing which are critical with regard to hygiene, and to eliminate sources of contamination. The resulting network of controls should cover the entire route from primary production to the final product which is ready for consumption. Such controls might be based, for example, on the recommendations for Good Manufacturing Practice (GMP), Good Hygiene Practice (GHP), the Code of Practice (CP) of the FAO/WHO Codex Alimentarius Commission and the Hazard Analysis Critical Control Point (HACCP) concept developed by the International Commission on Microbiological Specifications for Foods (ICMSF) in 1988 (10) to ensure microbiological safety and quality. Methods of detection based on molecular biology (e.g. the DNA hybridisation technique or the analysis of the plasmid pattern of Gram-negative organisms), which are still being developed, will determine new diagnostic techniques in the 1990s. Self-regulated controls by establishments have been of special importance in dealing with the problem of *Listeria* infections. These have been designed above all to detect contamination with high bacterial counts.

**DISPOSAL OF CARCASSES AND OFFAL**

The safe disposal and productive utilisation of animal wastes can make a major contribution to environmental hygiene. The volume of waste material, 80% of which consists of by-products from slaughter in the industrialised countries, is passed on not only to rendering plants but also to special industries which process it, e.g. into feeds.
The technological processes employed must be designed in such a way as to ensure adequate sterilisation, i.e. the elimination of agents of infection. German legislation on the disposal of animal carcasses requires heating to 133°C for 20 min. Worldwide harmonisation of the requirements for heating will be necessary to prevent the spread of agents of infection among animal stocks. Strict separation between clean and unclean areas must be ensured in establishments processing animal carcasses.

ANIMAL WELFARE

In recent years, social concern for the interests of animals has increased considerably. On account of their unique professional knowledge, veterinarians have a specific responsibility to use their abilities in the interests of animal welfare. There is no longer any doubt that animals can experience not only physical pain but also fear, loneliness, boredom and other forms of psychological distress. Thus, any utilisation of animals by humans is justifiable on ethical grounds only if the animals are treated with the greatest care possible and if all unnecessary suffering is avoided. Today, almost all nations have passed legislation on animal welfare to fulfil these obligations. However, legislation will be ineffective unless competent and devoted experts apply such provisions in day-to-day practice. Society expects veterinarians to be highly active in such tasks. For example, intensive efforts are needed to modify the mass keeping of animals in accordance with the requirements of the species involved.

In recent years, special centres have been established to deal with animal welfare issues in the USA and a number of European countries, e.g. the Centre for Collection and Evaluation of Alternatives to Animal Experiments at the Robert von Ostertag-Institute of the German Federal Health Office (Berlin).

GENETIC ENGINEERING AND VETERINARY PUBLIC HEALTH

Genetic engineering presents veterinary medicine with unprecedented opportunities to improve the health status of farm animals (e.g. by the manufacture of highly specific and in part multiple vaccines, or the production of transgenic animals resistant to certain diseases). A valuable contribution is also being made by genetic engineering technology in the field of animal nutrition. In the long term, this technology will also be of importance for the manufacture of conventional and completely new foods.

Early in the relatively short history of genetic engineering it was recognised that, despite its great potential, this technology also involves risks for humans, animals and the environment. In individual countries, attempts are being made to control these risks through a variety of regulations. In the Federal Republic of Germany, a Genetic Engineering Act has been in force since July 1990. Under this Act, the application of genetic engineering has been made subject to preventive controls in a number of fields, as follows:

- Approval of genetic engineering work and installations for research and industrial purposes. Such approval is granted by Länder (regional) authorities upon recommendation by the Central Committee on Biological Safety (ZKBS)
- Approval of the release of genetically modified micro- and macro-organisms. Such approval is granted by the Federal Health Office upon recommendation by ZKBS, with participation of the public.

- Authorisation of the marketing of corresponding products by the Federal Health Office upon recommendation by ZKBS.

Many of the problems raised for veterinary medicine are still unresolved, e.g. the evaluation of transgenic farm animals. The situation may call for the development of specific conditions for slaughter, transport and marketing. This has also resulted in open questions regarding the approval of substances which are "identical to nature". In some cases, it will have to be clarified whether, in terms of current legislation on foods, such substances are to be considered as substitutes or natural substances.

ACKNOWLEDGEMENTS

The authors are grateful for the expert advise of Dr H.R. Gamble, Dr J. Haagsma, Dr K. Bögel, Dr C. Lahellec, Dr A.P. MacMillan and Dr A. Wandeler in the preparation of this manuscript.

* * *


Résumé: Les progrès scientifiques et techniques accomplis dans le domaine de la santé publique vétérinaire (SPV) depuis un siècle ont contribué à protéger la santé du consommateur et l'environnement. Ce rapport présente des exemples de succès enregistrés dans la lutte contre les épizooties de tuberculose, brucellose, rage et trichinellose, qui sont des maladies transmissibles à l'Homme. Les auteurs discutent des mesures d'hygiène destinées à empêcher la présence de Listeria dans les aliments et de certains défis découlant de l'extension des infections latentes parmi les animaux d'élevage. Ils traitent aussi de l'incidence croissante des salmonelloses chez l'homme.

Parmi les autres tâches essentielles en matière de SPV, il faut citer la lutte contre la présence des différents résidus chimiques et des substances biologiques toxiques dans les aliments. Les auteurs présentent des exemples de mesures destinées à faire respecter les conditions d'hygiène lors de la préparation de la viande et citent certains des problèmes qui se posent (inspection des viandes). Ils rappellent les principes d'un contrôle efficace des établissements et des produits. Pasteurisation, refroidissement, congélation et limitation des additifs sont présentés comme autant d'exemples de progrès techniques favorisant la protection du consommateur. La destruction des carcasses et des déchets d'origine animale, le bien-être animal et le génie génétique constituent d'autres préoccupations importantes dans ce secteur. Les actions futures dépendront de la nature de l'enseignement, de la formation et des cycles post-universitaires destinés aux vétérinaires ainsi que de l'adéquation des infrastructures de recherche, de diagnostic et de surveillance.

Resumen: Los adelantos científicos y técnicos de estos últimos cien años en materia de salud pública veterinaria (SPV) han contribuido a la protección de la salud del consumidor y a la del medio ambiente. El presente informe da ejemplos del éxito obtenido en el control de epizootias como la tuberculosis, la brucelosis, la rabia y la triquinelosis, que son también zoonosis. Trata de las medidas de higiene en relación con la listeriosis en los alimentos, así como de los problemas creados por la propagación de infecciones latentes entre los animales de cría. Se examina también el aumento de la incidencia de las salmonelosis humanas.

Otra de las misiones importantes de la SPV es el control de los residuos químicos de distintas fuentes y de las sustancias biológicas tóxicas en los alimentos. Los autores presentan ejemplos de medidas adoptadas al respecto y de problemas relacionados con la garantía de producción de la carne en condiciones higiénicas (inspección de la carne). Señalan los principios en que se basa el control eficaz de los establecimientos y los productos. Destacan, entre los adelantos técnicos que han contribuido a la protección del consumidor, los procesos de pasteurización, refrigeración y congelación, así como la limitación de los aditivos. Recalan la importancia de la eliminación de los cadáveres y desechos animales, y de todos los aspectos relacionados con el bienestar de los animales y la ingeniería genética. Las actividades futuras en materia de SPV dependerán de una educación adecuada, una formación continua y postuniversitaria impartida a los veterinarios, y de la existencia de infraestructuras convenientes para la investigación, los exámenes y la vigilancia.

PALABRAS CLAVE: Bienestar animal - Control de zoonosis - Eliminación de desechos animales - Higiene alimentaria - Higiene medioambiental - Ingeniería genética - Inspección de la carne - Protección del consumidor - Protección sanitaria.

REFERENCES


