REVIEW ARTICLES

Meat Inspection: An Overview of Present Practices and Future Trends

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Summary

This is a review of meat inspection literature, its history, current concerns and needs for the future. The value and limitations of meat inspection are discussed, along with the possible modifications or changes that are being developed to modernize an increasingly outdated method of safeguarding public health. The potential of on-farm risk assessment of slaughter animals and the practical considerations that need to be overcome are outlined. The needs of the consumer and subsequent challenges to the meat and farming industry are proposed as the driving force behind the changes occurring in veterinary public health. The current risks to consumers, from such microbial pathogens as *Salmonella, Escherichia coli* 0157:H7 and *Campylobacter* infection are highlighted.

Keywords: Meat inspection; risk assessment; on-farm inspection; zoonoses

Introduction

The system of 'traditional' meat inspection procedures, currently used in many countries, was developed in the mid 1880's to detect diseases such as trichinellosis, tuberculosis and taeniasis which were then endemic in Europe (Blackmore, 1986). Around that time Robert von Ostertag (Ostertag, 1899) first recognized the importance of zoonoses for man. He demonstrated that tuberculosis could be contracted from infected meat and that brucella-infected milk caused brucellosis in humans. The obvious pathological changes in tuberculous animals allowed meat inspectors to detect the condition with the use of eye and knife. (M'Fadyean, · 1895; Ostertag, 1899).

In developed countries, classical epizootics such as tuberculosis were largely eradicated during the 19(0s, resulting in major improvements in animal and human health and a dramatic reduction in the likelihood of discovering relevant lesions at meat inspection (Grossklaus, 1987). Modern farm livestock practices are more intensive and earlier slaughter of animals reduces the time available for exposure to microbiological and parasitic agents. Exposure is also reduced in units operating with a biological barriers to wildlife and vermin as is the case with intensive. Unfortunately, raising animals intensively favours the occurrence of sub-clinical infections, including those of zoonotic agents such as *Salmonella*, which are important in meat hygiene. It has been recognized for several decades that reservoirs in livestock of Salmonella and other meat-borne bacterial pathogens result in contamination of carcases during slaughter and dressing procedures, as well as meat inspection. The pathogens are generally found in the gastro-intestinal tract but symptomless carriers may have bacteria confined to the mesenteric lymph nodes. Stress in the

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live animal may lead to faecal shedding with increased risk of contamination of hides and subsequently of carcase meat (Grau, 1986; Grossklaus, 1989). In recent years research has been aimed at reducing the spread of any meat-borne pathogens by minimizing carcase handling., and the number of incisions made during traditional, organoleptic.red meat inspection (Harbers,1991).

The importance of ante mortem inspection in the abattoir has long been recognized in the attempt to avoid the introduction of clinically diseased animals into the slaughterhall. However, the disease and treatment history of slaughter animals, while being reared on the farm, are arguably far more important in determining suitability for slaughter than a brief inspection at the abattoir. This is especially true with regard to 'invisible' meat safety hazards such as chemical residue and certain microbial pathogens, e.g. Escherichia coli O157:H7., Salmonella typhimurium DT104 and Campylobacter jejuni. An important function of meat inspection is to assist in monitoring disease in the national herds and flocks by providing feed-back of information to the producer, the detection and eradication of certain livestock diseases could be greatly added.

Traditonal Meat Inspection

Van Logtestijn (1993) summarized the purposes of meat inspection as: (1) Removal of grossly abnormal products from the meat chain; (2) Prevention of the distribution of infected meat that could give rise to disease in man, and (3) Assisting in the detection and eradication of certain diseases of livestock. Of these, the removal of grossly abnormal products is probably the easiest to accomplish but preventing infected meat from reaching the consumer, thereby ensuring the hygiene of the slaughter process is probably more important.

In the UK, animals intended for slaughter and for human consumption undergo a preliminary ante mortem health inspection at the slaughter-house within 24 hours of arrival (Anon. .. 1995a). This has the purpose of determining whether there are any signs of abnormality such as clinical disease, injury,, fatigue or stress; whether the animals are reluctant to stand, or are in any way different from the others (Anderson, 1987). Visible signs of the administration of pharmacological substances, including injection abscesses and conformational changes suggesting use of hormones or repartitioning agents, may also be detected (Anon., 1995a). Effective ante mortem inspection requires good lairage conditions, such as raised platforms for adequate observation of groups of animal. The effectiveness of ante mortem inspection may be hampered by cramped conditions, large numbers of animals, poor lighting and excessive soiling of hides (Gracey, 1988).

Post morten meat inspection in the UK under the Fresh Meat (Hygiene and inspection) Regulation 1995, which implements Council Directive 64/433/ECC, involves visual examination of the slaughtered animal and the organs belonging to it. This includes a requirement to carry out a detailed examination of certain lymph nodes by multiple incisions. Inspectors may also make such additional inspection as they consider necessary and can detain a carcase and offal for further examination. The legislation provides for local or total seizure, and subsequent disposal of products deemed unfit for human consumption. With septic, generalized or acute conditions, detection at meat inspection is not difficult; however the accuracy of traditional procedures in detecting individual lesions or abnormalities is often less than certain.

The main criticism of traditional meat inspection, the need for palpation and incision of organs and lymph nodes, is not only that it is of doubtful sensitivity but the very nature of the procedures, e.g. incision of lymph nodes, can have a detrimental effect on the safety and quality of meat by posing a risk from the spread of bacterial pathogens (Berends *et. al*. 1993). This is probably most clearly highlighted with Salmonella, localized within the mesenteric lymph as a potential source of contamination following detailed examination by multiple incisions (Archer, 1981; Murray, 1986; Samuel *et. al* 1979; Moo *et. al,* 1980) Hathaway and Mckenzie (1991) claimed that inadvertent contamination with microbes during slaughter and dressing is the most important source of meat-borne public health hazards and that a number of traditional meat inspection procedures were without any scientific basis when applied to the viscera of lambs.

There is an increasing awareness that traditional, labour intensive, organoleptic inspection procedures for macroscopic abnormalities contribute far less to the safety and wholesomeness of the product than general processing hygiene and laboratory surveillance for microbial and chemical contaminants (Hathaway & Pullen, 1990). Sensitivity and specificity in meat inspection are usually inversely related. Madie (1992) found that with high disease frequencies where prevalence rates of more than 80% existed, the predictive value for detecting defect-free carcases dropped dramatically. The test falsely classified the majority of healthy animals as diseased. Similarly low prevalence rates (<10%) significantly decreased the predictive ability of meat inspectors to detect diseased animals (Madie, 1992).

When traditional meat inspection was developed at the end of the last century, tuberculosis and taeniasis (Taenia saginata) were major hazards to human health. The inspection procedures that resulted were largely focused on the detection of these and others conditions. The efficacy of those procedures, however, is now being questioned. For example, in the case of Cysticercus bovis predilection sites, Kvvsgaard *et. al.* (1990) found that five to six incisions were needed in bovine masseter muscle with a thickness of 3cm to reveal all cysticerci, and the current two routine incisions reveal only about 40% of the cysts. Hammerberg et al. (1978) concluded that multiple incisions of the heart, another predilection site for *C. bovis,* would be needed during inspection to increase efficiency in detecting cysticerci. While both these studies found that routine incisions of predilection sites for *C. bovis* had a low sensitivity, a study by McCool (1979) found that only 49% of infected cattle had cysts in tissues considered to be sites of predilection and only 19.8% of all cysts found were located at these sites. Most of the remaining cysts were distributed randomly throughout the musculature. In the study by Hammerberg *et. al,* (1978), involving 18 infected animals five would have been passed by routine inspection procedures. This failure rate of 27.8% compares closely with the level of non-apparent infections reported by Dewhirst *et. al*. (1967) for 27.7% of infected cattle passing routine inspection.

The sensitivity of traditional meat inspection for detecting tuberculosis appears to be far greater than the detection rate for *C. bovis* .cysts. Similarly, a study of condemnation records for cattle in Northern Ireland, found that 57% of diseased animals had tuberculous lesions confined to the bronchial and/or mediastinal lymph nodes, while head lesions (retro-pharyngeal and submaxillary lymph nodes) only occurred as the second most common site in 23% of cases. A further 4.7% of animals had lesions in both head and respiratory tract lymph nodes (Neill *et. al.* 1994). Corner (1994) found that careful examination of as few as six pairs of bovine lymph nodes (mediastinal, medial retropharyngeal, bronchial, parotid, caudal cervical and superficial inguinal), plus the lungs and mesenteric lymph nodes, allowed 95% of cattle with macroscopic tuberculosis lesions to be identified. The lungs were also the most affected organ in a study of tuberculosis condemnations in slaughtered livestock (cattle, sheep and goats) in Northern Nigeria (Alaku & Meruppa, 1993). Towards the end of the last century. Ostertag (1899) had already reported that the lungs and mesenteric lymph nodes were the main sites of tuberculous lesions.

Concern has been expressed that a reduction in the incision of lymph nodes, even the mesenteric lymph nodes, could lead to carcases infected with tuberculosis being missed at meat inspection. In an Australian study comparing old and revised post mortem inspection procedures, there was only one occurrence of a single-site involvement of mesenteric lesions. This represented 0.4% of infected carcases, equivalent to 0.0003% of cattle slaughtered (Murray, 1986). However, despite the above comments, we would emphasize that the examination of tuberculosis reactors submitted for slaughter must include incision of the mesenteric and other lymph nodes

The New Hazards: Bacterial and Virus Pathogens

A number of infection agents associated with foods have been identified. These include *Aeromonas* spp.. *Bacillus cereus, Campylobacter* spp.. *Clostridium perfringens. E. coli* 0157:H7, *Klebsiella pneumoniae, Listeria monocytogenes.* Norwalk virus. Pleisiomonas shigelloides, Serratia *marcescens, Toxoplasma gondii, Vibrio parahaemolyticus, Vibro vulnificus*, and *Yersinia enterocolitica* (Heidelbaugh & Menning, 1993). Of particular importance are salmonellas such as *Salmonella enteriditis* PT4 in poultry and, recently, the multi-drug-resistant *S. typhimurium* DT104 (Wall *et. al.* 1995).

Disease control in the live animal is often very difficult to achieve due to the complex and often poorly understood epidemiology of many of the microbial agents (Mackey & Roberts, 1990). The frequency and extent of carcase contamination by food borne pathogenic bacteria vary between countries, herds and animal species. Such differences in the carriage of Salmonella and other bacteria imply that animal husbandry and animal handling practices probably affect the rate of carriage making the control of such livestock reservoirs possible, at least in principle. It is not unreasonable to assume that animals being presented for slaughter will have pathogens present in the gastrointestinal tract and on their outer coat.

Towards Modern Meat Inspection: Risk Analysis

Meat inspection should be based on the analysis of risk. This involves the identification of risks so that they may be avoided, reduced or otherwise managed (Wilson & Crouch, 1987). The word 'risk' implies uncertainty; so for veterinary public health purposes, the assessment of risk requires qualitative or quantitative estimation of the likelihood of an adverse effect resulting either from exposure to a defined health hazard or from the absence of a beneficial influence. One recognized method of risk analysis for meat production and processing is by use of the Hazard Analysis Critical Control Point (HACCP) system (ICMSF, 1988) which, since 1985, has been recommended by the World Health Organization. To be effective, the HACCP system would require a detailed analysis of the whole process from the farm through to the abattoir. The hazards should be scored according to the magnitude of risk to the consumer and a judgement is then made as to the necessary control points needed to eliminate or minimize the hazards. Once the critical control points (CCP) are in place a monitoring system to ensure that the CCP are working should be maintained. Such a system requires the cooperation and motivation of everyone involved in the chain and independent auditing can help to ensure that problems are not overlooked.

Although the HACCP system is intended as a means of eliminating or minimizing microbial hazards, other hazards such as residues, contaminants and parasitic infestations are all open to the same approach. The evidence that traditional meat inspection, with certain procedures, itself provides a source of major cross-contamination does not alter the fact that the meat inspector acts as a critical control point for macroscopic hazards. Therefore meat inspection, while in need of modification, should still play an important part in meat safety and quality assurance for the consumer. Gracey (1984) wrote that achieving these ideals would involve ante mortem examination, post mortem inspection, and where necessary, laboratory investigations, along with a close link between the abattoir and livestock production. Van Logtestijn (1993) considered the shortcomings of the present system to be a failure to identify pathogens undetected in the live animal, insufficient guarantees of the absence of residues of veterinary drugs, feed additives and other contaminants, and an inability to control the use of feed additives and veterinary drugs by national residue programmes, end-product inspection and meat inspection only. The UK, however, has a national surveillance scheme (NSS) which, during 1995, resulted in 44,000 samples being collected and analysed for a range of some 90 veterinary residues and contaminants. The scheme was complemented by a non-statutory analytical programme (MAVIS, 1996).

To achieve an improvement in meat inspection using this risk analysis approach requires a number of considerations:

Identification of hazards. A list needs to be developed of all conditions of public health, animal health and aesthetic importance that are unacceptable to the consumer and which may cause macroscopic changes in the tissues to be examined (Hathaway *et. al.*. 1988: Hathaway & Richards, 1993).

Hazard characterization. Ranking

of macroscopic abnormalities based on the likely degree of consumer reaction, could be applied to aesthetically objectionable defects. In contrast, diseases that are solely of animal health importance could be ranked according to an economic baseline (Hathaway *et al.* 1988). The optimal use of inspection resources will not eliminate all hazards, but should remove all major ones and ensure that any remaining hazards are minor in nature and exist at a level that does not constitute a risk to the consumer (Hathaway & Richards, 1993).

Exposure characterization. Consumer exposure can be equated with a macroscopic condition that escapes the inspection procedure under investigation. The accuracy of the procedure at a known prevalence of the condition becomes the quantitative statistic (Hathaway *et. al.*. 1988).

Risk assessment model. The logistics of full evaluation of tissues to determine the true prevalence and the interactions between various conditions preclude whole-system comparisons (Hathaway *et. al.*, 1988). It is important to realise that formal risk assessments require a numerical base and the difficulties of defining public health objectives in these terms can result in meaningless comparisons between inspection systems that have not been individually evaluated with respect to sensitivity or specificity, and the hazards or benefits to human health (Hathaway *et. al.*, 1987). In the UK, the Hygiene Assessment System (HAS) has been introduced. This provides a numerical basis for assessing slaughterhouse operation, construction and management (Simmons *et al.*, 1995). The HAS system is only aimed at evaluating hygiene control and does not assess the efficacy of meat inspection in the abattoir.

Visual inspection, without any cutting or palpation of the carcase or organs, has been proposed by several workers as a replacement for traditional meat inspection. Visual inspection would decrease microbial cross-contamination (no handling, cutting and incision) and reduce inspection costs. It would also enable available resources (i.e. meat inspectors) to be released from traditional inspection and be reallocated to hygiene and surveillance, and on the basis of visual inspection, to conduct extended examination of carcases that need more detailed consideration (Harbers, 1991: Mousing *et. al.*, 1997). Harbers et al. (1992) concluded that many abnormalities would be detected just as well visually as by traditional post mortem inspection procedures, but the need to change current post mortem procedures to achieve a decrease in the number of false-negative findings should be carefully considered. Further study is required to determine whether it would be possible to introduce visual inspection into current meat inspection practices.

Cost-effectiveness is an important consideration for meat inspection. Clearly, expensive organoleptic procedures with low detection rates for lesions such as *C. bovis* cysts are likely not to be cost-effective. Hathaway *et al.*, (1987) questioned a number of meat inspection practices which they considered not to be cost-effective:

1) Procedures that put the product at risk from microbiological contamination require detailed evaluation, e.g., the incision of mesenteric lymph nodes, tonsils, the umbilicus and the parenchyma of the liver;
2) A number of organs and parts are

treated as inedible, so should all parts of a carcass be inspected or at least be made available for inspection?

3) The requirements to open the trachea and routinely incise most lymph nodes, are open to challenge;
4) The use of the same inspection procedures for animals of different ages (apart from calves less than 6 weeks of age) cannot be supported; for example, the spectrum and frequency of disease in calves is very different from that in adult cattle. The same is true of lambs and sheep (Hathaway *et. al.,* 1987; Van Logtestijn, 1993).

More recently, a comparative study of visual and traditional post mortem meat inspection procedures was carried out in Denmark in which more than 183 000 pigs were inspected using an electronic data capture system (Kyrval et al., 1995; Mousing *et. al.*, 1995, 1997: Willeberg *et. al.*, 1995). For this purpose Willeberg et al. (1994) developed an approximation procedure to determine differences in non-detection rates for meat inspection procedures without having to determine the true status of the carcase. The traditional meat inspection method has a higher detection frequency for 52 out of 58 lesions (Mousing *et. al.*, 1995). The visual method was better than the traditional method for detecting abnormal odour, abscesses in lungs, contusions, scabies, filled stomach and aspiration of scalding water, although only for the latter two were statistically significant differences observed (Willeberg *et. al.*, 1995). In absolute terms, however, the differences in approximate non-detection rates (ADNDR) were small (only seven lesions had ADNDR values ≤ five per 1000 pigs). Visual inspection recorded significantly less faecal and bile contamination than did the traditional inspection (Mousing *et. al.*, 1995, 1997; Willeberg *et. al.*, 1995). Faecal and bile contamination were the only lesions missed that posed a potential hazard to human health, with visual meat inspection failing to detect four pigs per 1000 carcases, potentially contaminated with salmonellas or Y. enterocolitica (Mousing *et. al.*, 1995, 1997). However, the bacterial cross-contamination that occurs in traditional meat inspection is likely to pose an even greater hazard (Mousing *et. al.*, 1995).

Willeberg et al. (1995) concluded that visual inspection procedures could replace traditional inspection without compromising the detection of most lesions. Similarly, Hathaway *et. al.* (1988), who devised a model for comparing organoleptic post mortem meat inspection procedures using palpation of the spleen of lambs, concluded that the risk assessment model overwhelmingly supported the case for organoleptic inspection being limited to visual examination. However, in an evaluation of post mortem meat inspection procedures for the viscera of lamb in New Zealand, Hathaway and Richards (1993) found that routine incision of the kidneys was a scientifically justified inspection procedure for lambs. Palpation was also found to be a necessary procedure to accompany viewing of the liver (Hathaway & Richards, 1993). With the results of this study, Hathaway and Richards (1993) were tempted to recommend or dismiss an alternative to the traditional system, based on the statistical differences alone. However, such statistical differences could be used to argue either for retention of the old system of meat inspection or implementation of the new· system. Statistical differences alone do not necessarily indicate the superiority of one method over another. This can only be determined by a formal risk assessment (Hathaway & Pullen. 1990).

A similar conclusion was drawn by Westhead (1991) who found that a variety of lesions could be seen on both bovine and porcine kidneys at post mortem examination, thus requiring thorough inspection of these organs. Although the lesions may not represent diseases harmful to the consumer, e.g., congenital cysts, they may render the kidney unacceptable in aesthetic terms so that, while not dangerous to eat, the kidney should be either trimmed· or rejected. The study showed that a number of kidney lesions occur without real lymph node involvement or surface features; therefore, the kidney must be incised and the pelvic mucosa examined (Westhead, 1991). Routine renal lymph node incision and · inspection is not considered necessary, since any pathological condition giving rise to lymph node enlargement will be clearly visible on examination of the outer and cut renal surfaces (Westhead, 1991).

On A Farm Risk Assessment: An Ante Mortem Solution

Meat safety must begin when the animal is conceived. There must be constant monitoring to the point of delivery at the slaughterhouse by the farmer who has contributed to the wholesomeness and quality of the slaughtered product (Hooper, 1992; Snijders *et. al.*, 1989). Every step in animal production must be covered, requiring the prevention of infection and transmission of infectious disease agents, while minimizing the need for therapeutic treatment. Such systems have been successfully applied to pigs and poultry in terms of specific pathogen-free (SPF) herds or flocks, although these are primarily free from diseases of economic importance to producers rather than free from zoonoses (with the exception of the salmonellas). Skovgaard (1987) proposed the production of 'specific human pathogen free' flocks and herds which would be free from organisms such as *C. jejuni, Y. enterocolitica,* and *E. coli.* The feasibility of ensuring that a herd or flock remains free of organisms which are commensal or carried asymptomatically, is questionable. Even in intensive units with well-designed housing the biosecurity of the unit will always depend on the effectiveness, or otherwise, of the microbiological barrier. This does not mean, however, that microbial pathogens and drug residues cannot be minimized in the live animal. Food animal producers and their organizations are responding to the consumers perceived concern over food safety by developing and encouraging verified production control practices and quality assurance programs for their respective commodities. Such total quality assurance in animal agriculture requires that three primary objectives be met food sáfety, consumer acceptability, and scientifically based animal husbandry (Stenholm & Waggoner, 1992).

In a risk assessed meat inspection programme, where the origin and health status of slaughtered livestock are known, high-risk groups of livestock would receive additional attention in the abattoir at increased cost to the producer. Such a system would certainty encourage the producer to improve the health status of their slaughter animals. In addition to studies on the feasibility of on-farm, *ante mortem* inspection, there have been others which have considered improvement in animal health monitoring and the collection of farm data for regional or national databases. The development of monitoring systems is necessary since reliable information on diseases is vital in protecting a nation's agricultural system and its potential for production (Glosser, 1988). Such systems assist the data gathering and handling practices essential for a longitudinally integrated quality assurance programme, and also familiarize the industry with the benefits to be gained from greater knowledge of the herd/flock health status. In the Netherlands, for example, pigs are individually ear-tagged on the breeding or farrowing farms before the age of 12 weeks and, at the end of the period on the finishing farms, each pig is earmarked for a second time. Consequently, each carcase and its herd of origin can be identified at the slaughterhouse (Elbers *et. al.*, 1992). This, and the document accompanying the pigs to the abattoir, enables identification of the rearing pen as well as the farm (Elbers *et. al.*, 1992) and has obvious benefits for on-farm assurance schemes. This approach is in line with the recommendation of the Codex Alimentarius Commission (1991) that the health of animals should be monitored so that information that is relevant at the abattoir to assist in dressing, inspection and judgements can be made available. Obtaining the full benefit of this information requires an effective recording and transfer system, as well as identifying animals with their place of production (Codex Alimentarius Commission, 1991).

The absence of a reliable user and animal welfare friendly method of livestock identification is a major stumbling block to the promotion of a comprehensive data retrieval and feedback service (Gracey, 1988). Progress is being made in the identification of farm livestock with the use of electronic transponders, with many different designs currently being tested. Despite moves towards standardization,, both on a European and worldwide scale there is a vast range of different tags and databases, not all of which are compatible (Fry, 1993; Gabel & Knowles, 1987; Gracey, 1992).With some transponder chips it may be possible to record far more data than just an animal identification number, including, for example, records of drug administered, including date of use and any withdrawal period.

On-Farm Risk Facotrs

Environmental factors

Environmental medicine is concerned with all the factors on the farm that impinge on the animals (Curtis, 1990). Animals kept in a controlled environment can be protected to a large extent from reservoirs and vectors of infectious agents such as wild birds or rodents. However, with extensive animal husbandry systems, there is little or no biosecurity. The water supply may be a source of microorganisms and potable water, preferably from a mains supply, provides the safest source of water for food animal use; ground water or streams are often contaminated so that access to such water by livestock should be prevented. Wells and free-flowing springs may be suitable as long as the water can be satisfactorily monitored for microbial contamination or other pollution.

Farm wastes such as slurry and

farmyard manure should be stored and disposed of according to national and EU guidelines as poor farm waste disposal can lead to contamination of the farm environment and nearby water sources. Animal feed can be either a source of contamination or become contaminated by wild birds, rodents, farm wastes or other pollutants and should be delivered using covered, dedicated wagons or in suitable sealed bags. Silos are best for dry feeds such as cereal grain or pelleted feed, while moist feeds such as brewers grains are better kept in a covered tank rather than in some corner of a yard.

Helminths

Parasites often survive from year to year and from generation to generation (Curtis, 1990), UK and European meat inspection legislation requires the rejection of carcases with generalized infestations but trimming of the localized infection and freezing of the carcases are permitted in certain cases. The monitoring of parasitic infestations and action at meat inspection is a significant cost to the meat industry.

Kvvsgaard *et. al.* (1990) found that a major risk factor in relation to bovine cysticercosis was allowing cattle to drink from streams carrying effluent from sewage treatment plants. Scavenger birds, such as seagulls probably aid dissemination since T. *saginata* eggs can pass through the bird gut and remain viable (Smyth, 1985). In the USA, outbreaks of cysticercosis have occurred in cattle following feeding with a potato by-product contaminated by being transported in trucks previously used to haul material from waste-water settling ponds and vegetable refuse contaminated by human faeces (Bundza *et. al.*1988: Yoder *et. al.*.1994). In Denmark, the most frequent source of infection is sludge from septic tanks illegally applied to pasture or crops, in some cases after having been mixed. with animal slurry (Ilsoe et al.. 1990).

The cestode *Rchinococus granulosus,* with cysts readily recognizable in the lungs and liver of an infected animal, is very much linked with geographical location. The presence of hydatid cysts in sheep or cattle is not only aesthetically unacceptable, but is also an indicator of the presence of a zoonotic parasite in the dog population. Other cestodes, including *Cysticercus tenuicollis (Taenia hydatigena), Cysticerus ovis (Teania ovis)* and *Cysticercus cerebralis (Taenia multiceps)* cause parasitic cysts in carcases and offal.

Animal husbandry practices can lead to unforseen post mortem findings. A study by Jepson and Hinton (1986) showed that the spreading of pig slurry, access to grazing land by hunts and the infrequent use of dog cestocides were factors significantly linked to high lamb liver rejection rateş due to C. tenuicollis. In this study, small sheep farms, particularly those producing non-contract lambs, were most likely to have high rejected rates at slaughter. A complicating factor, often ‿eyond the control of the farm, is that hunting dogs are important diseminators of cestode parasites. These may cover large areas of farmland whilst hunting and the hunting season extends to spring when the young lambs are most susceptible to infection (Edwards *et. al.* 1979). Although the fox is considered to be a potential reservoir of *E. granulosus* it is not normally a definitive host of *T. hydatigena. T. ovis* or *T. multiceps* (Edwards *et. al.*, 1976: Hackett & Walters. 1980).

A parasitic lesion that is easily

recognized during *post mortem* inspection is *Fasciola hepatica* or liver fluke which causes the rejection of approximately 29% of bovine livers in England and Wales (Gracey & Collins. 1992). Liver fluke infestation can assume an acute, subacute or chronic form, and animals infected very heavily with *F. hepatica* may die, while very many more, that are less severely affected, can suffer a substantial reduction in growth rate and production (Goodall *et. al.,* 1993: Gracey & Collins. 1992). German authorities have estimated that *F. hepatica* may reduce beef production by up to 10%, milk production by 16% and sheep production by 25% (Gracey & Collins. 1992). Climatic conditions, greater awareness of the losses caused by liver fluke among farmers, better understanding of the lifecycle of the parasite and greater availability of effective fasciolicides, and the housing of animals, are important factors in the occurrence of fascioliasis in meat animals (Blamire & Goodhand, 1980; Jepson & Hinton, 1986).

Trichinella spiralis is carried by the pig and horse, not by cattle or sheep, with man an obligatory and important anomalous host (Gemmell & Johnston, 1977). Surveillance for trichinosis is part of the EU requirements and currently there is no evidence from this surveillance of trichinosis in the UK pig population.

Animal husbandry factors

The rejection of a small amount of tissue at meat inspection is usually of little' financial consequence to the abattoir. However, the presence of certain conditions, such as pneumonia, may indicate serious economic and animal welfare problems on the farm (Anon., 1990). In lambs, the prevalence of atypical pneumonia increases as the stocking density increases and as the altitude at which the sheep are reared decreases (Simmons & Cutbertson, 1985). Pneumonia and pleurisy in adult cattle may sometimes be a legacy of respiratory disease contracted as intensively reared calves (Blamire & Goodhand, 1980). Catle reared in intensive beef systems are predisposed to enzootic pneumonia due to poor ventilation, while liver abscesses and liver necrosis due to Fusobacterium necrophorum infection may be associated with high concentrate diets (Melrose, 1972).

Dirty hides and fleeces provide a major source for microbial contamination of the carcase. On the farm, wet weather, heavy soil and poor drainage often result in cattle and sheep arriving at the abattoir with muddy feet and abdomens (Magraph & Patterson, 1969). The problem of dirty cattle is mainly related to bedded courts, with or without open yards, where there is a lack of bedding, high stocking density, condensation due to poor ventilation, poor drainage and infrequent removal of slurry (Gracey, 1984). Livestock lorries and the abattoir lairage can make a significant contribution to the level of soiling. The practice of auctioning fatstock at marts further contributes to the problems of transporting clean livestock, which should ideally travel from the farm to the abattoir by the shortest possible route (Magraph & Patterson, 1969).

Jarvis and Cockram (1995) carried out a study to compare the number of bruises found on sheep sold either through two markets or directly from farm to slaughter. While there was no difference in number of bruises, there was a significant difference in where the bruises were found. Apart from the animal welfare implications, bruising affects carcase value; Blamire and Goodhand (1980) noted that during the 1970's there was an increase in partial carcase rejection because of bruising. Although a study by Roger *et. al.* (1992) indicated that bruised meat may be suitable for processing, carcase are still commonly trimmed as a result of bruising.

The kidney can be regarded as an indicator of the fitness of the animal, due to its sensitivity to insult from infection or toxin Monaghan and Hannan (1983), found a difference between cows and younger cattle in the prevalence of kidney changes. With age, the kidneys became more fibrosed, revealing changes in colour and texture. The most common reason for kidney rejection was focal interstitial nephritis (60.1% of rejected kidneys) affecting 173 cattle (mainly cows) out of 4166 clean and cull cattle. Westhead (1991) found that cattle kidneys were rejected because of nephritis, hydronephritis, congenital cysts, infarcts and pyelonephritis, while pig kidneys were also rejected due to fibrosis, pigmentation, petechial haemorrhages and capsular adhesion. Many kidneys had pathological changes such as pyelonephritis or early hydronephrosis, involving dilation of the renal pelvis, but were from carcases in which there were no other signs of abnormality. The prevalence of affected kidneys in clean cattle was 2%; with cull cattle the prevalence was considerably higher at 20% and in pigs the prevalence was 9.7%. Westhead suggested that the main factors affecting kidney changes were age, with an increasing chance of exposure to agents causing kidney lesions as the animal ages, and management factors.

Abscess formation on carcases relates directly to husbandry practice on the farm. The incidence of post-injection abscesses indicates poor hygienic practice by the operator whether administering therapeutic medication or immunization (Pratt. 1992). In pigs, abscessation as a result of tail biting, castration wounds or fighting injuries are common (Norval, 1978; Hill & Jones, 1984). Abscesses pose a problem in terms of contamination should the abscess be ruptured during slaughter, also abscessation can develop into more generalized pyaemia (Norval, 1978) Touvinen *et. al.* (1994) found that abscesses and joint infections were highly correlated with partial carcase rejection and in a study by Knowles *et. al*, (1994), three conditions, abscess, arthritis and pleurisy, accounted for 82% of sheep carcase rejections. Melrose (1972) found that laminitis and foot lesions were major problems with intensive beef systems. Other than in the pig, where the link with pyaemia is recognized, foot lesions rarely affect judgement during *post mortem* meat inspection. Faulty management and the environment were considered to play a role in the aetiology of these conditions.

Tuberculosis-no longer a danger?

Tuberculosis (TB) in cattle and humans is usually caused by *Mycobacterium bovis* and *M. tuberculosis*, respectively, although M. bovis has one of the broadest host ranges of all known pathogens and can produce TB in humans (Grange & Collins, 1987; Grange & Yates, 1994; Morris *et. al.*, 1994). In the EU, cattle tuberculosis is widespread in Italy, Ireland, France, Greece and Spain while, in the Southwest of England, the number of cattle herds newly infected with *M. bovis* almost doubled between 1992 and 1993 (from 121 to 232 herds) and rose again in 1994 to 274 (Anon., 1994; Caffrey, 1994).

There is substantial variation in both incidence and prevalence between geographical regions, and between farms within regions. Some of the variation between herds and regions may be a consequence of the management system used and the opportunity these offer for transmission of infection and development of disease. There may also be specific environmental and management factors in farms and regions which contribute to this variation (Morris *et al* 1994). Barrow and Gallagher (1981) found that badgers in the Southwest of England were acting as a reservoir for *M. bovis*. A close relationship was found between the spatial distribution of tuberculous badgers and cattle herds experiencing breakdowns in the tuberculin test. Currently in the UK a pilot trial is underway to test the efficiency of trapping and testing live badgers, using the Brock test, with a view to developing a new badger control policy (Anon, 1995b).

There has also been limited progress with the Bovine Tuberculosis Eradication Scheme in Ireland and this remains one of the justifications for maintaining post mortem examination of carcases. Even with very high standards of animal husbandry, *M. bovis* (like the salmonellas) can be introduced or re-introduced onto the farm, where wildlife reservoirs harbour or become infected with the disease agent (O'Connor et al., 1993).

As *tuberculosis* and *M. bovis* infections in animals and man become less common in many countries, non-tuberculous mycobacteria, such as *M. avium*, are increasingly involved in mycobacterial illness (Alfredson & Skjerve, 1993). Wild birds my excrete *M. avium* thus exposing swine and, in rare cases, cattle and horses, to infection by eating the dropping of tuberculous free-living birds. Another possible source is contaminated litter or surface waters (Alfredson & Skjerve, 1993; Gunnes *et. al*, 1995). The risk from *M. avium* in animals is not great, due to the localized nature of the lesions but, under certain circumstances, it may be important to humans, particularly those who may be immunocompromised (Alfredson & Skjerve, 1993).

Conclusions

Traditional organoleptic meat inspection has flaws which greatly inhibit its effectiveness in protecting the consumer from meat-borne disease. A change in inspection alone appears promising because of the possibility of reallocation of meat inspection resources to allow more effective enforcement of hygiene regulations both throughout the abattoir and by involving the farm.

Most workers who have recommended visual rather than organoleptic inspection consider that lesions can be detected by either method with equal facility, and apparently believe that public safety will not be compromised. However, considering the much criticised and maligned performance of the traditional meat inspection system, there may be a danger that they are recommending the replacement of one ineffective system with another.

Any alternative approach to meat inspection much seek to improve the detection rates of potential hazards. Merely to reduce the cost and unwelcome side effects of a deficient system can hardly be considered a positive step. Certainly, visual meat inspection will satisfactorily address some conditions but not all. Uncommonly made incisions, such as those of the kidneys should, perhaps, be increased to enable better detection of systemic infections.

The use of on-farm risk assessment to differentiate between animals that are unlikely to have any lesions and those that may, will allow the meat inspector to give more time and effort to the examination of carcases in which conditions are suspected. Animals from herds or flocks of known good health and hygiene status could undergo modified meat inspection of a more visual, less invasive nature. This would only be possible with rigorous on-farm record keeping and reliable animal identification, otherwise any attempt at devising a scheme of on-farm risk assessment and longitudinally integrated quality assurance would be bedeviled by animals of uncertain origin. If a move from conventional inspection of meat is to be successful, there must be a real assessment of the new role of the inspection staff. Central to the change would be the provision of appropriate staff training. This would involve plant management, plant staff and enforcement officers all of whom would need to work as a team. The 1995 Fresh Meat Regulations place an onus on the occupier of licensed premises to arrange or establish, in consultation with the official veterinary surgeon (OVS), a training programme, as considered essentially by the Richmond Committee (1991).

There will continue to be a need for some level of independent assessment of the fitness of meat for human consumption. The requirement for assurance from an independent inspectorate has never been more obvious than with the current concern in the UK over bovine spongiform encephalopathy (BSE). An independent assessment would also ensure the necessary quality of data reported back to the farms, with positive benefits for animal health. It would, of course, also help to remove unfair competition by any unscrupulous members of the industry, who might pose a danger to public confidence in meat. Would the industry, and the consumer, be better served by a change from physical inspection of meat to an overall involvement in and supervision of, the hygienic conversion of live animals to meat? The answer undoubtedly will be yes, but care would be needed to ensure even standards of enforcement based on an adequate assessment of risk. These standards must be in place before any change is made.

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