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Review of the historical basis of post-mortem meat inspection procedures in Australia

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CONTENTS

THE HISTORICAL BASIS FOR POST-MORTEM MEAT INSPECTION PROCEDURES IN AUSTRALIA

Background

Post-mortem inspection of sheep and cattle in abattoirs is an integral part of quality assurance in the Australian red meat industry. SAFEMEAT and Meat and Livestock Australia have recently commenced a project to comprehensively review meat inspection in Australia's red-meat industry. The aim is to provide a sound scientific basis for increasing the efficiency and effectiveness of post-mortem inspections in abattoirs while maintaining control over the safety of product and its suitability for consumers.

In 2008, the Australian Government commissioned an independent review of Australia's quarantine and biosecurity arrangements, chaired by Mr Roger Beale, AO. Recommendation 79 in the final report *One Biosecurity: a Working Partnership* – the Beale Report (Beale et al., 2008) was that

> "Export certification functions should return to 100 per cent cost recovery as scheduled at the beginning of July 2009".

This recommendation was accepted by the Government and is in the process of being implemented. In the current climate of full cost recovery, it is critical that resources are directed at issues posing the greatest risk to product safety and are not unnecessarily directed at issues having little or no bearing on product safety. An additional consideration is that procedures do not in themselves increase potential hazards present on the carcase.

This paper aims to:

- Explore how the meat inspection system that is currently in place in Australia has evolved.
- Critically examine the basis for the present regulatory and inspection procedures.
- Assess the appropriateness of these for the protection of public health.

Outcomes from this work will help to define which elements of the traditional system should be retained in the future. The overall goal is to move towards a risk-based system of post-mortem meat inspection, one which will meet the requirements of domestic regulators and trading partners and which is consistent with international guidelines, such as those of the CODEX Alimentarius Commission. The respective roles of government and industry in the overall delivery of the meat inspection system will be highlighted.

PART I EVOLUTION OF THE CURRENT SYSTEM OF POST-MORTEM INSPECTION.

Introduction

Post-mortem meat inspection procedures in current use in most developed economies and adopted by the Codex Alimentarius Commission were developed in the late 19th and early 20th centuries. The aim was to detect zoonotic diseases that were of public health significance at the time (Edwards et al., 1997). This inspection is based on organoleptic techniques. This involves the visual and olfactory examination and palpation or incision of parts of the carcase or organs to detect macroscopic abnormalities. This labour- intensive approach is typically applied to all carcases being produced and is only cost-effective when there is a moderate to high risk of the disease. Sensitivity of detecting any pathology can vary depending on the disease, the organ being inspected and the operator.

Two broad significant changes have taken place in the past 50 years that impact on post-mortem inspection, yet these have not been reflected in revised inspection procedures. Firstly, the diseases of concern one hundred years ago - tuberculosis, taeniasis and trichinosis – have, in developed countries in the latter half of the 20th century, been largely eradicated or suppressed to low levels by control programs and substantial advances in scientific knowledge. There has been a consequent improvement in human and animal health and a significant reduction in the likelihood of discovering relevant lesions at meat inspection (Edwards et al., 1997). Secondly, there has been a significant change in animal husbandry with a move from extensive to more intensive production systems with the feeding of supplementary rations and use of agricultural and veterinary chemicals. The close proximity of livestock in these situations affords the opportunity for cross-infection of livestock with microbial pathogens, cross-contamination of feed sources with noxious substances and the presentation of livestock for slaughter which pose a potential public health risk that cannot be identified by traditional organoleptic techniques of inspection (Edwards et al., 1997).

The original objective of post-mortem meat inspection was to identify lesions at slaughter associated with infectious diseases that posed a risk to human and/or animal health and to remove the affected carcases or tissues from the food chain.

Now in the early 21st Century post-mortem meat inspection is undertaken for a variety of reasons that include:

- Protecting public health by attempting to eliminate from the product pathogenic organisms and other harmful substances.
- Removing obvious lesions that make meat unattractive, but not necessarily unsafe for human consumption.
- Ensuring that the product is true to label.
- Maintaining or increasing market access by satisfying the requirements of importing countries.
- Collecting data on the occurrence of animal disease that can be used to enhance the productivity of abattoirs and farms.

The inspection processes now in place to satisfy the above motivations has evolved over many decades. In the following paragraphs the key events affecting the evolution of meat inspection in the Australian meat industry are examined in chronological order. This provides an understanding of the political, social and scientific factors in play at the time when many of today's inspection procedures were first invoked.

Pre-Modern Meat Inspection

From earliest times, humans have been meat-eaters and there have been specific prohibitions on the consumption of certain meats. The prohibitions of the ancient Hebrews and Muslims as recorded in the Bible and Koran respectively are probably the best known and most quoted (Stockman, 1909). While it is tempting to interpret some of these prohibitions in the light of modern knowledge of disease, it is generally accepted that the prohibitions had more to do with pagan and religious rituals established in times when an animal's life was held sacred on account of the kinship between man, beasts and gods. Animals were only slaughtered for a sacrificial meal (Stockman, 1909) (Collins, 1954). The sacrificial nature of the slaughter was progressively relaxed as meat consumption increased, with the exception of certain species of animals which were held as sacred.

In ancient Rome and Athens abattoirs and markets were under the control of meat supervisors who enforced religious and social taboos and forbade the sale of meat from dead or sick animals. In Europe, from 1162 onwards, various laws were enacted controlling the sale of diseased meats. The Augsburg Charter of 1276 mandated the slaughter of cattle, sheep and calves in a public slaughter house combined with the compulsory inspection and declaration of diseased animals – the beginnings of our modern meat inspection system.

By the latter part of the 19th century in England and continental Europe, the role of veterinarians became more recognized and appreciated by physicians, society, and ultimately by politicians who implemented food inspection laws. With the establishment of veterinary schools in the early 19th century came a greater understanding of diseases and the link between eating 'measled' pork and the human tape worm was recognised (Schmid, 1957).

Napoleon established public slaughterhouses in Paris and this spread to the bigger cities in France. Germany was the first country to adopt systematic regulations governing meat inspection in the latter half of the 19th Century (Collins, 1954). In the 1890s, Robert von Ostertag started a rigorous program of meat inspection in Berlin. He was referred to as the 'Father of Veterinary Meat Inspection' in Germany and was instrumental in introducing the meat inspection act of 1900. He is quoted as saying "it is now generally recognised that it is part of the chief functions of veterinary medicine, through the supervision of meat inspection, to protect human health against dangers which may be associated with eating of meat" (Delepine, 1906). He was the author of numerous publications in veterinary science, and is remembered for his influential *Lehrbuch für Fleischbeschauer* (Handbook of Meat Inspection), which was later translated into English.

In the United Kingdom, various Public Health Acts introduced between 1875 and 1897 established the framework for meat inspection in the various jurisdictions. Medical Officers of Health and Inspectors were empowered to inspect meat for sale to ensure it was not diseased or unwholesome.

In the latter half of the 19th century, the US Congress, dominated by special interest groups, steadfastly resisted the passage of federal pure food and drug legislation. However, in the early 1900s, the convergence of industrial and political self-interest with scientific and consumer support, resulted in the passage of the Pure Food and Drug Act and the Federal Meat Inspection Act in 1906 (Barkan, 1985).

A number of traditionally divergent interest groups came together under unique circumstances to facilitate passage of the legislation. There was a realisation by industry that a federal government stamp of approval was required to allow domestic meat to compete favourably with regulated foreign products that were deemed to be superior in quality and safety. At the same time, the link between industrial misconduct in US slaughterhouses and packing sheds and public health risks was elevated to a political imperative by a strong consumer-led movement. Public health horror stories in the popular press were embodied in Upton Sinclair's book, *The Jungle,* an expose of the Chicago meat packing industry. At the same time public health professionals took advantage of this environment to put forward the scientific basis for the federal legislation (Farrand, 1913); (Barkan, 1985); (Ozonoff, 1985).

The (USA) Federal Meat Inspection Act (1906) established a federal meat inspection system that mandated inspection of livestock before slaughter and post-mortem inspection of every carcase; sanitary standards for slaughterhouses and meat processing plants were established and the US Department of Agriculture was charged with the associated monitoring and inspection.

The principle that the competitive market does not necessarily guarantee that the public's health will be optimally served underlies the 1906 legislation and remains in force today (Ozonoff, 1985).

Federation to Conclusion of World War II

The development of veterinary meat inspection in Australia was closely linked to the beginning of the export of frozen beef and mutton to England. Some early shipments were found by English veterinary authorities, to contain blemishes, mainly "nodules" (due to *Onchocerca*) in the beef and "cheesy glands" (caseous lymphadenitis – CLA) in the mutton. From as early as 1929, the findings of "cheesy glands" in mutton consignments of sheep from both Australia and New Zealand at the Port of London were recorded (Ellison, 1929).

These events stimulated more widespread application of traditional meat inspection procedures (both ante-mortem and post-mortem) that had been developed at the end of the 19th century. The procedures for post-mortem inspection were based on organoleptic techniques: observation, palpation and incision with a major focus on the detection and the prevention of two major diseases; tuberculosis and taeniasis. Abnormalities that were found were classified according to their importance for public health, animal health or as blemishes to the carcase.

Guidelines

In 1925, the Commonwealth Department of Trade and Custom's Meat Inspection Service issued a document entitled "*Instructions Regarding Supervision and Inspection of Meat for Export (Appendix IX)*". This document outlined and explained in great detail the important aspects of inspection such as the inspectors' tools (knives and wipes) and examination techniques. It also described which lymph nodes needed to be observed, palpated and/or cut. The document also mentions several of the most prevalent diseases and the associated disposition of carcases and their internal organs e.g. tuberculosis, actinomycosis, tick fever, malignant catarrh, melanosis, cysticercosis, onchocerciasis, hydatidosis, neoplasia, anthrax, blackleg, tetanus, anaemia, fever, jaundice and uraemia.

In Melbourne in 1914 John Johnston, a certified Meat Inspector and fellow of the Royal Institute of Public Health issued "*The Australian Handbook of Meat Inspection*" (Johnston, 1914) which elaborated upon the anatomy, physiology, diseases and pathology of cattle, sheep and pigs. Within the document, Johnson explained post-mortem techniques and outlined regulations concerning the export of meat. As early as 1914, there was a requirement that the brisket be removed ('brisketing') from all beef carcases or forequarters destined for export because of the presence of *Onchocera gibsoni*.

In 1938 the first textbook of meat inspection was printed by a Veterinary Officer in Charge of Inspection at the New South Wales State Abattoir and lecturer in Meat Inspection at the University of Sydney's Veterinary School (Drabble, 1938). Drabble's publication was the most comprehensive text book of meat inspection at the time, with detailed coverage of all aspects of the production and regulation of the meat industry in Australia. This book became the foundation for both the production and the inspection areas of the Australian Export Meat Industry.

Training

Veterinary public health has been an integral part of the veterinary curriculum since the inception of veterinary schools in Australia both in terms of didactic material as well as a requirement for practical training on site in abattoirs. The extent of that practical on site training has waxed and waned over the years, but is now an integral part of all veterinary public health courses in Australia (Dobrenov, 2008); (Cobbold, 2010)

As early as 1896, the Queensland Slaughtering Act created a role for lay meat inspectors who completed a course offered by the Brisbane Technical College (Woolcock & Rogers, 1997). The Board of Public Health in Victoria utilised the 'Australian Meat Inspectors Handbook' (Johnston, 1914) as the basis for training meat inspectors. Prior to 1945, there was no nationally recognized meat inspection qualification, but rather each State Public Health Department conducted training. In more recent times formal courses in meat inspection, with qualifications recognised by the Commonwealth were offered at Gatton Agricultural College in Queensland and Hawkesbury College in NSW. This was a three year course initially and then in 1990 reduced to two years. At present, training in meat inspection is offered through the Mintrac system at Certificate 3 and certificate 4 level through TAFE Colleges

Post-mortem examination of beef

In general, post-mortem inspection prior to World War 2 was based on:

- The observation for abnormalities of the serous membranes (pleura and peritoneum), joints and bones, all cut or exposed surfaces, the internal organs and the lymph nodes.
- The palpation and observation of the internal organs such as the spleen, oesophagus, kidneys, liver and lungs.
- The close examination and slicing of all accessible lymph nodes and the cheeks (both external and internal masseter muscles) into tiny segments to expose multiple cut surfaces for closer examination.

The incidence of tuberculosis (TB) in dairy herds in Victoria in the early 1900s was estimated at 10-15 per cent and over the following 40 years was reduced by about one-third. Cattle were carriers of the disease in every state of the Commonwealth. Incidence was higher in dairy herds than in beef herds and was highest where cattle were run under more confined conditions in the dairying areas of south-east Australia (Seddon, 1953). The primary method of diagnosis and control of TB was by means of clinical examination and skin testing of cattle herds with tuberculin. Post-mortem inspection at abattoirs was a valuable adjunct in identifying infected cattle and herds. Because of the relatively high prevalence of TB, post-mortem inspections had to be thorough. Detailed slicing and examination of lymph nodes by inspectors to look for the presence of minute lesions of TB on the cut surface was critical in the identification of tuberculous cattle.

Apart from TB, there were several other diseases of a parasitic or microbial origin that lent themselves to identification at post-mortem inspection with condemnation of all or part of the carcases and reporting of findings to regulatory authorities. These included the infectious diseases Contagious Bovine Pleuro-Pneumonia, Brucellosis, Actinomycosis and Actinobacillosis; parasites such as hydatid cysts, liver flukes, kidney worms and beef measles and benign and malignant neoplasia. Details of inspection procedures for each of these conditions and their public health significance are in Part III.

Besides post-mortem inspection for pathological conditions, inspectors had to ensure that product was true to description e.g. bull meat was not substituted for cow meat.

Post-mortem inspection of mutton and lamb

The presence of ‘cheesy gland’ lesions in carcases exported to England was an early stimulus for the introduction of post-mortem inspection in mutton and lamb (Ellison, 1929). The same processes and principles were applied to the post-mortem inspection of mutton and lamb that were applied to beef - observation and palpation of the exposed surfaces and the cutting of the lymph nodes that could be affected by a disease process.

As for beef, post-mortem inspection also consisted of palpation and slicing, where necessary, of the visceral organs after removal from the carcase. The outside of the carcase was examined and the thoracic, abdomenal and pelvic cavities (free of viscera) were then examined through observation and palpation.

Caseous lymphadenitis (CLA or ‘cheesy gland’).caused by the bacterium *Corynebacterium pseudotuberculosis* is not of zoonotic importance from a food safety perspective, but humans can become infected through open wounds and therefore it is an occupational hazard for shearers, sheep handlers and abattoir workers. The most significant economic losses caused by CLA occur at the abattoir where it amounts to a serious aesthetic blemish in the quality of affected carcases. There is a need to inspect, trim and, if warranted, condemn affected carcases (Batey, 1986); (Stanford et al.,1998); (Paton, 2005).

Some of the other more common disease conditions found at post-mortem examination in sheep were hydatid cysts, liver fluke, actinobacillosis, degenerative liver disease most often from plant and fungal toxins or metabolic diseases and benign and malignant neoplasia.

Summary

This period represented a continuation of the paradigm established by the end of the 19th century, that is, if inspection removed everything that looked abnormal the goals were achieved. During this period, labour (for inspection) was cheap relative to the value of a carcase, and high levels of expertise were not necessarily needed to detect abnormalities at post-mortem.

In the first half of the 20th century an important role of post-mortem inspection was to reduce disease in carcases – for most of the major inspection issues the ecology and epidemiology of infection in the live animal was not well understood, or, the resources and technical know how for control during primary production simply did not exist. The expanding knowledge of the epidemiology of these diseases brought a refinement of the paradigm so that more pathology was being sought out in a more thorough, standardised and organised manner. Abattoirs had an important role in the early identification of animal diseases and feedback of findings to regulatory authorities for their control. . Consequently, the use of acceptance-rejection inspection applied to all production units was the dominant quality assurance paradigm of this time and beyond.

Post World War II

The meat inspection service was under the jurisdiction of the Commonwealth Government's Minister of Primary Industry. This service had total authority to control livestock, meat production and the processing of meat and meat products until meat, as the final product, was loaded into a vessel for overseas transport. In 1961 the Commonwealth of Australia issued "Export (Meat) Regulations" which covered practically all aspects of meat production. All meat destined for export had to be prepared in a meat plant which was registered for export under the conditions of the Regulations and controlled by Commonwealth employed meat inspectors with a veterinary officer in charge. In practice, every aspect of the meat plant's operations was controlled by its inspection staff, including edible and non-edible offal and by-products. The Regulations also covered the required standard for the export plant, for construction, facilities, equipment, chilling, freezing and storage regimes together with ante and post-mortem inspection procedures.

Post-mortem inspection was maintained to meet the requirements of the importing countries. Throughout World War Two and for several years after the war, the biggest export of beef, mutton and lamb was to the United Kingdom (Thornton, 1957). The Australian inspection and grading system ensured that the United Kingdom Imported Food Regulations, along with amendments which were made from time to time, were fully covered. There were some relatively minor changes in post-mortem techniques, such as the requirement for the stifle joint to be opened to check for the presence of *Onchocerca gibsoni* and the cessation of the requirement for the routine slicing of the supra renal lymph node and cutting into the udder of a cow.

Post-mortem meat inspection was still based on the organoleptic techniques with a major emphasis on the diagnosis of diseases such as tuberculosis (with a noticeable increase in the number of tuberculin positive cases), brucellosis, cysticercosis in beef and CLA and cysticercosis in mutton and lamb. Inspectors in the boning rooms were primarily concentrated on the control and removal of the *Onchocerca gibsoni*, mainly in brisket cuts.

With the advent of the TB control and eradication program, cattle with a positive reaction to the tuberculin test were sent for slaughter (Francis, 1947); (Beveridge, 1983). Many of these did not have overt clinical disease but may have had small TB lesions in some of the lymph nodes not routinely inspected at post-mortem. Additional manpower and time was required for the detailed examination of the other less accessible lymph nodes such as the prescapular and the axillary nodes (Drieux, 1957); (Anon, 1985a).

However, at the beginning of 1960, new and very lucrative markets started to emerge, namely the USA (manufacturing beef and mutton) and Japan (chilled primal cuts of beef). The Japanese veterinary service readily accepted the inspection standards of the Australian veterinary authorities, but the USA did not.

In 1967 when President Lyndon Johnson signed the *Wholesome Meat Act,* meat inspection standards for processors and distributors covered only by state law became more stringent. Almost 40 years of confusion of the respective roles of state and federal authorities in meat inspection came to an end as the US Department of Agriculture (USDA), assumed responsibility for the supervision of meat and meat products in interstate and foreign trade (Rogers, 1968).The regulations that covered imported meat stipulated that these products were to be inspected by a program which was at least equal to the USDA program.

Australia and USDA “Equivalent Program”

A system of regular reviews of inspection practices in Australian plants intending to export to the USA was begun by US authorities. Early on the discrepancies between US requirements and Australian operations were identified and licenses to export to the USA were cancelled for a breach of the acceptable standards. For Australia to maintain the lucrative USA meat market some major changes had to be adopted. These were in areas such as construction materials, facilities, equipment, sanitation, production processes, final product presentation and to lesser extend ante-mortem and post-mortem veterinary inspections: (two knife cuts were required in the masseter muscle in beef and changes to the inspection for presence of CLA in sheep). Every meat plant with a desire to export to the USA had to have a qualified veterinary surgeon in charge of the ante- and post-mortem inspection, sanitation, production hygiene and other related meat production and processing standards (Browne, 1998).

Woodward Royal Commission into the Australian meat industry

In 1981, following the discovery by USDA at port of entry inspection that Australian meat labeled as “beef” was in fact horse meat and/or kangaroo meat, the Commonwealth Government appointed Justice Edward Woodward to head a Royal Commission into the Australian meat industry (Woodward, 1982).

As well as identifying the way in which this meat substitution occurred, the Royal Commission also turned up a number of other instances in which meat inspectors were compromised. For a consideration in the form of free meat, cash payments or false overtime claims, some had been turning a blind eye to undesirable practices. In this way unscrupulous operators in the industry had been extending their profits while putting at risk the whole of the Australian export trade. There was also a misuse of the “Australian Approved” stamps, incorrect content on the labels, lack of “use by” dates, products from local meat plants diverted to export as well as other breaches.

Period after Royal Commission

This investigation, with the above mentioned findings, led to recommendations of the Commission that triggered some of the greatest changes in Commonwealth services to the meat industry of Australia. The Commonwealth Government reformed the whole Department of Primary Industry and Energy and formed a very similar organisation entitled the Australian Quarantine and Inspection Service (AQIS) to oversee the export meat industry.

Export meat inspection became typified by very stringent, all-embracing control by AQIS, the regulatory authority. The security of product and associated labeling came under AQIS control to ensure that the repetition of substitution would never occur again. Inspectors were positioned in several production areas of the plant, where they had not been engaged previously, such as the production of animal food (pet food), condemned area(s), the foetal blood area, small goods, canneries and other processing areas. This conveyed to the world that Australian meat and meat products were safe, clearly labeled and true to the information presented on each labeled product. Every carton of meat and meat product had an approved label and a Commonwealth-approved paper seal to prevent tampering.

The veterinarian, with the help of the meat inspectors, had a new work load – which now included the collection of samples from finished products and the conducting of species tests, to confirm that species named on the label was correct. The amount of office work was also increased for the senior meat inspector and the veterinarian. Duties such as keeping control of the carton paper seals and other metal seals for the locking of chiller /freezer units after production and the sealing of containers and other meat transport vehicles was now included. All these demands and resulting work load were very time consuming and resulted in a significant increase in the number of meat inspectors employed by AQIS and in the overtime worked (Figure 1).

The post-mortem procedures were the same as they were for the previous period. In 1985 AQIS issued a manual entitled 'Australian Export Meat Manual Volume 1' (Anon, 1985a), where in great detail the required standards for the export of meat production and the processing plant were set out in prescriptive detail.

The manual also included sections on the conduct of ante-mortem inspection and the very specific procedures required for post-mortem inspection and disposition for various pathological and patho-physiological conditions and blemishes of the animals, viscera organs and their carcase. The above mentioned sections of this manual still form the basis of ante and post-mortem inspection today.

Recent Times

Implementation of the Commonwealth Government response to the Woodward Royal Commission findings resulted in a highly regulated Australian export meat inspection system with AQIS in full control of the oversight of all aspects of production, security and ancillary activities. With the passage of time and restoration of integrity in the meat export system, it was recognised that some aspects of control could be devolved to industry. This coincided with a move by the Australian government toward full recovery of inspection costs.

Towards Quality Assurance

In 1985, a revised ancillary inspection program (Anon, 1985b) was introduced whereby companies took on the responsibilities for hygienic slaughtering and dressing, checking product, packaging, storage and refrigeration. Companies had to draw up a Code of Practice covering procedures for all aspects of the conduct of hygienic slaughter and dressing and ancillary operations. Quality control was exercised by AQIS through primary health inspection and monitoring of company performance.

1988 saw the beginnings of the introduction of quality assurance in the export meat industry with an increasing focus on AQIS auditing of industry quality systems rather than end-point product inspection alone. In 1989 Production Quality Assurance (PQA) (Anon, 1989a) and Approved Quality Assurance (AQA) (Anon, 1989b) (Anon, 1990) were introduced by AQIS.

At this time the concept of Hazard Analysis and Critical Control Point (HACCP) was introduced by AQIS into the regulatory system. The essence of the HACCP system as it applied to the export meat industry was:

- An assessment of the hazards associated with the slaughter, processing, refrigeration, storage and transport of meat.
- Determination of any critical control points (CCPs) required to control the hazard.
- Establishment of procedures to monitor CCPs.
- Development and implementation of corrective actions to address the CCP failure and prevent its recurrence.

Implicit in the application of HACCP at meat establishments was the realisation that some hazards (microbiological, chemical contaminants) did not lend themselves to traditional organoleptic inspection and quality control and that other tools were required to prevent and control these hazards. The ideological basis of HACCP is very different from the traditional 100 per cent inspection, quality control, quality assurance paradigm in place at the time. Instead of using this opportunity to remodel outdated meat safety systems on HACCP and risk assessment, HACCP was merely added on as an additional layer of quality assurance.

PQA operated at slaughtering plants where AQIS staff were present and able to monitor company performance on a daily basis. It allowed companies to take responsibility for activities previously covered by the Codes of Practice through a fully documented quality assurance program audited by AQIS. Companies took total responsibility for identifying points in the production chain that constituted a potential danger/risk to the hygiene and/or preservation of the final product and had to put in place measures to control and prevent the hazards.

Under AQA some of the AQIS functions that applied to the refrigerated storage, security and transport or packaged meat were devolved to industry provided the company had an AQIS-approved quality assurance program. Routine AQIS inspection was then withdrawn and performance was monitored by AQIS audits. Over the ensuing two years AQA arrangements were expanded to cover export security operations and documentation after completion of post-mortem inspection and application of the 'Australia Inspected' stamp.

1994 saw the initial introduction of Meat Safety Quality Assurance (MSQA) (Anon, 1994). This was further revised in 1998 (Anon, 1998). MSQA incorporated both PQA and AQA systems and provided a more rigorous integrated framework for satisfying meat safety objectives. The essential elements of MSQA were:

- Incorporation of HACCP as the basis for process control (Anon, 1996).
- Establishment of the HACCP team with a coordinator. The team members had to be adequately trained and qualified in HACCP.
- Rigorous application of a Hazard Analysis – biological, chemical and physical hazards had to be identified with the assessment of the significance of each hazard.
- Development and implementation of means to control the identifed hazards.
- Identification of CCPs and their recording in a Hazard Audit Table.
- Establishment of Control Limits for each preventable measure.
- Implementation of monitoring procedures to cover the 'what, when, how, where and by whom'.
- Development of corrective actions for each CCP with an emphasis on the prevention of a recurrence.
- Implementation of a verification process to demonstrate that the HACCP was effectively validated for critical limits.
- Record keeping for all monitoring procedures.
- Organisation of all documentation to cover a quality manual , quality policy and work instruction forms.
- Development by the Company of Good Manufacturing Practice with documentation of Standard Operating Procedures (SOPs) and Work Instructions (WIs) for every working position.
- Development of cleaning procedures and the pest control SOPs with associated verification and corrective actions.
- Establishment, implementation and documentation of training procedures.
- Calibration of all measuring instruments with properly documented records.
- Development of procedures for product identification including product identifed to be 'retained'.

MSQA included a validation program aimed at providing a more objective measure of the application of QA and a transparent pathway for the application of sanctions where deficiencies in delivery were identified. The format of MSQA was consistent with the international ISO 9002 quality standard.

The Export Control (Meat and Meat Product) Orders commenced in July 2005 and incorporated the Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (AS 4696:2002) (Anon, 2002a). The Standard requires that the occupier of an establishment engaged in the preparation of meat and meat products for export has an Approved Arrangement (AA) (Anon, 2004a); (Anon, 2005a). The scope and basis of the AA has as its basis the former MSQA program. AS4696:2002 has now been replaced by AS4696:2007 (Anon, 2007a).

The purpose of the AA is to clearly describe those processes and practices which, when correctly applied by the occupier, will underpin AQIS certification of meat and meat products for export. The AA describes how occupiers will meet legislative requirements, including assuring compliance with:

- Good hygienic practices (GHP) to ensure that food is wholesome.
- The application of HACCP for food safety.
- Product integrity through the application of product identification, segregation, and traceability practices ensuring that product is accurately described and maintains relevant importing country identification.
- Importing country requirements.
- Animal welfare requirements.

International standards recognise that food safety and suitability is based upon a systematic whole of chain approach. This is embodied in the Approved Arrangements for export registered meat establishments.

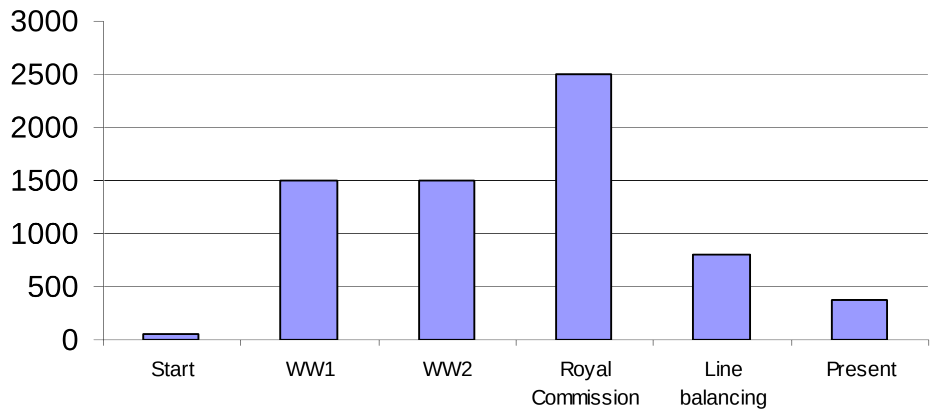
Number and position of the meat inspectors in the export meat plant

Following the Royal Commission, there was a significant increase in the number of meat inspectors employed by AQIS in the various sections of the plant (Figure 1). With the progressive introduction of quality control and quality assurance through PQA, AQA and MSQA, there was significant devolvement of inspectorial duties from AQIS to the company with a concomitant drop in the number of meat inspectors.

The functions of the meat inspectors have become restricted to the slaughter floor. In 1988 the “line balancing system “was implemented. This system researched every function and position on the slaughter floor from the ergonomic, functional and capacity of production (the speed of the slaughtering line) and established the number of meat inspector(s) for every necessary position on the slaughter floor.

The veterinary officer, with or without a senior meat inspector (SMI) undertakes the supervisory roles in the areas of boning and offal rooms , chiller/freezer and load out (it is a European Union requirement that AQIS is present at the time of loading and the sealing of the transport unit destined for European Union markets). This has been the basis of AQIS staffing at export abattoirs until recent times.

Figure 1: Approximate number of Commonwealth Inspectors



Post-mortem inspection

In the 1980s the Inspection Service reviewed post-mortem inspection procedures necessary to protect public and animal health in Australia. This was done taking into account the national and regional occurrences of diseases in Australia and scientific principles relating to the pathogenesis, diagnosis and effectiveness of removal of diseased tissue from the carcase. The primary outcome was to reduce the number of lymph node incisions (Murray, 1986); (McMahon et al., 1987). There has been little change since these publications and these procedures have been incorporated as 'Schedule 2 – Procedures for post-mortem inspection' in the *Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption* (AS 4696:2007) (Anon, 2007a). In summary:

Head

- Observe all exposed surfaces and incise parotid, submaxillary and retropharyngeal lymph nodes.
- Incise internal and external masseter muscles.
- Observe and palpate tongue.

Viscera

- Observe and palpate surfaces of lung and incise bronchial and mediastinal lymph nodes.
- Observe and palpate external surface of heart and incise musculature of heart.
- Observe spleen.
- Observe and palpate liver, its lymph glands and incise large bile ducts transversely.
- Observe oesophagus.
- Observe rumen, reticulum, intestines and mesenteric lymph nodes.
- Observe and palpate enucleated kidneys.

Carcase

- Observe external and internal surfaces
- Observe and palpate superficial inguinal and internal iliac lymph nodes
- Observe cut muscle surfaces exposed during dressing operations.

Minimum post-mortem inspection procedures for sheep and lamb

The only refinements introduced related to the identification and removal of CLA lesions and the recognition that CLA was not a significant food safety concern (Murray, 1986); (McMahon et al., 1987). All incision of lymph nodes was abandoned and replaced by observation and palpation of internal iliac, lumbar, ischiatic and popliteal lymph nodes. The superficial cervical, precrural and superficial inguinal lymph nodes could be either palpated or an equivalent procedure was to excise and discard these nodes without inspection.

Microbiological contamination

Microbial (and especially bacterial) pathogens and contaminants are by far the greatest source of public health risk arising from contamination of meat and meat products (Hathaway & McKenzie, 1991); (Sofos, 2008). Traditional organoleptic meat inspection enables the detection and removal of grossly abnormal and contaminated tissue but cannot detect invisible microbiological contamination. The source of this contamination can be due to poor hygiene and dressing procedure with contamination arising from the hide and ingesta or from pathological lesions or can arise from a contaminated environment – equipment and slaughterers.

In 1997, Australian export abattoirs listed for export to the United States commenced carcase microbiological testing for *E. coli* and *Salmonella.* This was in response to the US HACCP Final Rule, also known as the Mega-Regs.

At the same time the Meat Standards Committee of the Standing Committee on Agriculture and Resource Management (SCARM) mandated the requirement for microbiological testing of product and contact surfaces for validation of HACCP-based quality systems. State regulatory agencies were responsible for implementing this standard (Anon, 1997) at domestic abattoirs.

In order to retain equivalence with the Australian Standard at domestic abattoirs, the Export Meat Industry Advisory Committee endorsed microbiological testing of carcases for *E. coli* and *Salmonella* at all export abattoirs (Anon, 2000) in August 1997. At the same time, voluntary testing for Total Viable Counts (TVCs) was encouraged as an additional aid for establishments to monitor their slaughter and hygiene processes.

All export listed abattoirs were required to participate in the *E. coli* and *Salmonella* monitoring (ESAM) program. The elements of the program were testing of carcase swabs for the presence of *E. coli* (verification of process control) and *Salmonella* (verification of pathogen reduction on product). This program still operates at all export establishments and has had some minor modifications since its inception (Anon, 2003). In 2007, mandatory TVC sampling was introduced for those establishments listed for export to the European Union (Anon, 2007b).

The role of AQIS on plant staff in the ESAM program is to ensure that all components of the ESAM program are operational and are monitored as part of the Approved Arrangement. The program is subject to on-going audit and to verification of sampling protocols and processes through the ‘Check the Checker’ program by AQIS. There is no independent verification testing carried out in the ESAM program by AQIS through independent sample collection by AQIS staff and testing at an independent laboratory.

In 1996, all establishments listed to export raw ground meat food products made from cattle carcases to the United States were required to implement testing protocols for *E. coli* O157:H7 (Anon, 2006); (Anon, 2008); (Anon, 2010a). This requirement is over and above existing requirements for microbiological testing. The role of AQIS in this program is to verify the establishment sampling and testing processes through ‘Check the Checker’ and verification of testing protocols through sample collection by AQIS and testing under AQIS authority at an independent laboratory.

Summary

In Australia, like the rest of the world, meat inspection systems still retain as their basis the traditional 100% organoleptic inspection of observation, palpation and incision of carcases, viscera and lymph nodes that were put in place over 100 years ago and that were developed for diseases that have been largely eradicated or suppressed to low levels by control programs.

In export abattoirs this inspection is undertaken by government inspectors. In more recent times, the system has been augmented by quality assurance programs and the incorporation of HACCP as the basis for process control. Microbiological testing by the meat company has been introduced in the last decade as a verification tool for process control and pathogen reduction in the HACCP program. This has had the effect of passing greater responsibility to the meat companies for processes and practices which are currently embodied in the Approved Arrangement entered into between the Company and the Australian Government. This underpins AQIS certification of meat and meat products for export.

It is probable that these routine government inspection procedures that detect and remove grossly abnormal tissue from the food chain contribute relatively little to the production of a safe product (Hathaway & McKenzie, 1991); (Edwards et al., 1997); (Hinton & Green, 1997); (Uzal et al., 2002) when assessed against the very significant resources allocated to their maintenance.

PART 2 DISCUSSION AND A WAY FORWARD

In the past 20 years, food safety has emerged as a major public health concern with highly publicised outbreaks of foodborne disease and product recalls as a result of contamination with pathogenic bacteria such as *E. coli* O157:H7, *Salmonella* and *Listeria monocytogenes* in which red meat or poultry was implicated as the vehicle (Hathaway & McKenzie, 1991); (Sofos, 2008).

Survey data from the United States Food marketing Institute in 2006 indicated that the top food safety concerns of grocery shoppers were in descending order: bacterial contamination, pesticide residues, product tampering and 'bioterrorism' (Sofos, 2008). Current routine organoleptic post-mortem inspection procedures which detect and remove grossly abnormal tissue from the food chain do little to address these real and perceived public health concerns and risks.

Meat inspection programs throughout the world allocate the bulk of their resources to the maintenance of traditional organoleptic post-mortem procedures, despite the fact that many of the procedures can no longer be scientifically justified. A detailed report on poultry inspection in the United States concluded that the primary focus of routine post-mortem inspection should be shifted to microbiological and chemical residues that are more likely to have a substantial impact on meat-borne human diseases (Hathaway & McKenzie, 1991). The optimum use of post-mortem inspection resources does not require the removal of all hazards, but should remove all major hazards and ensure that any residual hazards are minor in nature and do not pose a risk to consumers (Hathaway & McKenzie, 1991).

The data to inform this allocation of resources is best obtained by a formal risk assessment of the hazards in which the four analytical steps are addressed (Hathaway & Richards, 1993); (Berends et al., 1996); (Anon, 2005b):

- *Hazard identification* – a listing of all the hazards that could be present in the tissues of interest. These include public and animal health hazards and aesthetic defects unacceptable to the consumer.
- *Hazard characterisation* – the determination of the quantitative relationships between administered doses and the observed effect. There are few data regarding the dose-effect relationship of pathogenic organisms and parasites in animals and humans. Infectious agents have an uncertain and often shifting dose-effect relationship because of the multifactorial interaction between agent, host and environment. In the absence of this data, the prevalence or incidence of disease provides a practical approach to the assessment of risk (Berends et al., 1996).

- *Exposure characterisation* – determination of the sources, routes and quantities in which the agent reaches humans.
- *Risk characterisation* – the combination of the three preceding steps with the aim of assessing the probability of adverse effects from the current levels and routes of exposure. When applied to meat inspection, the importance of individual lesions that are missed during the application of a particular procedure must be assessed. In the case of tissues not destined for human consumption, the abnormalities of significance are those that serve an indicator function for other tissues or that have implications for animal health. Where diseases of animal or public health concern do not present grossly detectable abnormalities at post-mortem meat inspection, separate controls are required.

Ideally the risk assessment process should separate the performance characteristics of the various inspection procedures for public and animal health conditions from performance characteristics for aesthetic defects. This can then form the basis for allocation of resources for post-mortem inspection and identify those that need to be undertaken by certifying authorities, those that can be shared between the authorities and the meat company and those of purely aesthetic concern that can be devolved to the meat company.

Where the risk assessment indicates that traditional inspection procedures are inadequate, alternative controls will be required. Australia is a world leader in the application of individual animal identification in cattle that allows traceability from farm to fork through the National Livestock Identification System (NLIS) (Anon, 2010b). The database that underpins the NLIS can be queried at all points along the chain – farmgate, saleyards and abattoirs to verify the identification and life history of a particular animal. This creates great potential for an integrated approach to address animal health and food safety issues in the meat industry.

Already the NLIS database is used to identify cattle that are deemed to be at higher risk of exposure to certain animal diseases or chemical contaminants (e.g. organochlorine residues, *C. bovis* in cattle that have grazed at the Werribee Sewerage farm). When cattle so identified are presented for sale or for slaughter, the risk category is identified on the NLIS database and the required intervention is carried out. This information is also required to be entered on the National Vendor Declaration/Waybill that accompanies the cattle for sale and/or slaughter. It is the responsibility of State Animal Health Authorities to enter the relevant risk category data about cattle or land holdings on the NLIS database. The Australian red meat industry can utilise this powerful tool to even greater effect by expanding the risk categories in the NLIS database to cover diseases or conditions that require specific interventions or inspection procedures at ante- and post-mortem.

The increased sophistication of food production systems, coupled with consumer demands for safe hygienic food, has led to the rapid development and application, for microbiological monitoring and diagnostics, of new technologies in immunology, molecular biology, biochemistry, computer technology and engineering. A whole new generation of test methods and equipment has evolved to meet the requirements for fast, cost-effective, automated and reliable methods (Cox & Fleet, 2003). These include bioluminescence, enzyme-linked immunosorbent assay (ELISA), nucleic acid probes and polymerase chain reaction (PCR).

As these technologies become commercially available they can be included in quality control programs for process control, verification of HACCP plans and end-point testing, as appropriate (Anon, 2005c).

Traditional post-mortem meat inspection that is based on observation, palpation and incision of organs and lymph nodes has the potential to spread bacterial contaminants and pathogens through incision and palpation (Murray, 1986); (Berends et al., 1993); (Edwards et al., 1997). Incision of lymph nodes and bile ducts increases the risk of cross-contamination of *Salmonella* from carrier animals (Samuel et al., 1980); (Moo et al., 1980). While considerable emphasis has been placed by inspection authorities and meat processors in recent times on good hygienic dressing procedures all along the slaughter chain, it is ironic that the very act of government inspection has the potential to cause cross-contamination by food-borne pathogens or by organisms that pose a health risk to meat workers and inspection personnel handling the meat or lesions.

PART 3 CRITICAL EVALUATION OF CURRENT POST-MORTEM PROCEDURES

In this section, those disease and pathological conditions for which specific inspection procedures are applied, or which take up a significant part of an inspectors time are critically examined. A brief synopsis of the disease/condition is provided, followed by a comment on the public health significance, the current situation in Australia and current post-mortem inspection techniques applied for the disease/condition. Potential modifications to the current government inspection regime are canvassed based on the discussion in Part II of this report and the premise that government inspection should be primarily targeted at food safety risks and aesthetic considerations should be the province of the Company.

<table>
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Bovine tuberculosis

Bovine tuberculosis (BTB) results from infection with *Mycobacterium bovis*, a member of the *M. tuberculosis* complex of bacteria. Members of this complex are the primary cause of TB in a number of species. The characteristic lesions after infection are nonvascular, nodular granulomas known as tubercles – these micro-abscesses are up to 3 mm in diameter; the typical dry, yellow pus results from caseation and calcification in their centres (Anon, 2004b)

Diagnosis is by microscopic examination of smears from affected tissues. Small acid-fast bacilli are characteristic of the TB organism. *Mycobacteria* can be isolated on selective culture media and subsequently identified by culture, biochemical tests, DNA probes and PCR techniques (Rothel et al.,1993) (Miller et al., 2002).

M. avium and *M. intracellulare* and other unidentified *Mycobacterium* species can cause granulomas in cattle lymph nodes that are indistinguishable from those caused by *M. bovis* at post mortem examination. They are usually limited in distribution in the body and are not considered infectious between animals (Anon, 2004b).

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<tr><td>

Public health concerns

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TB is a significant zoonosis that can spread to humans through aerosols and raw milk. Although cattle are considered the true host of *M. bovis*, infection can occur in a wide range of domestic animals and wildlife. Human infection with *M. bovis* has been identified in most countries where the facility is available to fully identify Mycobacterial isolates. Usually, the incidence of bovine pulmonary tuberculosis is higher in farm and abattoir workers than in urban residents. The

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	transmission of BTB via milk can be eliminated by effective pasteurisation (Anon, 2002b); (Thoen et al., 2006).
Current disease situation in Australia	Eradication programs in developed countries have significantly reduced the prevalence of the disease. However, BTB is still common in less developed countries where it is a cause of significant economic loss and public health concern (Anon, 2004b). Australia is free from BTB. The last case in cattle was detected in 2000 and in buffalo in 2002. The disease was probably introduced to Australia in the early years of European settlement. BTB control began in the 1870s after the association was made between consumption of milk and human cases of TB. Use of the tuberculin test began in Australia in the 1890s. Over the following decades transmission of TB to humans was significantly decreased as a result of voluntary tuberculin testing and slaughter of infected cattle in the dairying areas (Radunz, 2005). Regulation of BTB commenced in the 1940s with the widespread adoption of pasteurisation and mandatory herd testing of milk suppliers. In the ensuing 30 years, all states and territories implemented formal control and eradication programs. Compensation for loss of infected cattle was used as a means of encouraging farmers to cooperate in the control and eradication of BTB. In 1970, a nationally coordinated tuberculosis eradication program commenced as a component of the brucellosis and tuberculosis eradication campaign (BTEC). The program was based on test and slaughter with abattoir monitoring using standardised national protocols and technical rules. In 1997 Australia officially declared its freedom from bovine tuberculosis to the Office International des Epizooties (OIE) and this brought an end to the official BTEC program (Radunz, 2005). In order to maintain Australia as a TB-free area and support the eradication of BTB, successive programs to replace BTEC have evolved and been implemented: • The Tuberculosis Freedom Assurance Program (TFAP) (Anon, 2005d) was established in 1998 under the auspices of Animal

	Health Australia. The national program combined surveillance, mainly through examination of animals at slaughter and targeted testing of herds for BTB. At the conclusion of TFAP in 2002, a review identified the need for a further period of surveillance. • TFAP 2 (Anon, 2007c) was a four-year program which commenced in 2003 and was essentially a continuation of TFAP. No further cases of BTB were detected during TFAP2. • The Australian Bovine Tuberculosis Surveillance Project (ABTBSP) started in 2007 and will run until 2010 (Anon, 2009). The central activity is meat inspection at export abattoirs by AQIS inspectors with the submission of a targeted number of granulomatous lesions to laboratories for TB and pathological examination. To date, no new TB cases have been detected.
Current specific inspection procedure as per Australian Standard.	• Incise and observe parotid, submaxillary and retropharyngeal lymph nodes. • Incise bronchial and mediastinal lymph nodes. • Observe mesenteric lymph nodes.
Future inspection options for consideration	Bovine TB can now be considered an 'exotic' disease in Australia and routine abattoir surveillance of all bovine carcases for TB may be unnecessary. If this approach were taken then the following may be considered:: • Cease routine incision of the lymph nodes of the head and observe for abnormalities. If abnormalities in shape, size or colour of the lymph nodes are observed, then the affected node must be incised and observed and any granulomatous lesions collected for pathological examination. • Cattle from herds deemed to be a high risk for TB should be identified as such on the NLIS database and inspected as per the current Australian Standard. • No change in the handling of suspect cattle.

Actinobacillosis

Actinobacillosis is caused by the bacterium *Actinobacillus lignieresii*, a normal inhabitant of the oral cavity and rumen of ruminants.

In cattle the disease most commonly causes a granulomatous lesion in the tongue ('wooden tongue') and the lymph nodes of the head, and less commonly the soft tissues around the head and lungs. The disease can also affect sheep, usually as multiple abscesses on the lips and cheeks. Abattoir surveys suggest that subclinical infections are common, manifesting as small actinobacillary granulomas in the draining lymph nodes of the head (Rycroft & Garside, 2000).

The importance of the disease is that the granulomatous lesions in the lymph nodes look very similar to tuberculosis. Definitive differentiation between the two conditions usually requires laboratory examination of specimens.

Public health concerns	Actinobacillus *lignieresii* is rarely associated with human disease but has been isolated from bite wounds inflicted by horses and ruminants (Benaoudia et al., 1994); (Peel et al., 1991).
Current disease situation in Australia	The disease is widespread in Australia wherever cattle and sheep are raised. It usually occurs sporadically on individual farms, though outbreaks with morbidity up to 25% can occur in sheep flocks where pasture conditions predispose to lesions of the lips and cheeks.
Current specific inspection procedure as per Australian Standard.	• Cattle with actinobacillosis are segregated at ante-mortem inspection and slaughtered as 'suspects' at the end of the day to avoid unnecessary contamination of the slaughter floor. • Lymph nodes containing granulomatous lesions are carefully examined to exclude tuberculosis.
Future inspection options for consideration	Actinobacillosis is not a public health issue and consideration should be given to the cessation of routine incision of the lymph nodes of the head and observe for abnormalities. If abnormalities in shape, size or colour of the lymph nodes are observed, then the affected node would need to be incised and observed and any granulomatous lesions collected for pathological examination.

Actinomycosis

Bovine actinomycosis ('lumpy jaw') is a chronic disease of the mandible, maxilla, or other bony tissues of the head caused by *Actinomyces bovis*; seldom are soft tissues involved. The organism is a normal inhabitant of the mouth of cattle and infection occurs through wounds in the buccal mucosa or through dental alveoli when teeth are erupting in young cattle (Radostits et al., 2007).

The characteristic lesion is a hard, immovable bony swelling on the mandible or maxilla as a result of granulomatous fibrosis of the bone. Eventually, the lesions can develop a fistula and discharge honey-like pus containing hard granules on to the skin. The teeth may loosen and eating and breathing can become difficult resulting in progressive loss of condition.

Unlike with actinobacillosis and tuberculosis, the draining lymph nodes of the head are usually not infected, but may show an inflammatory reaction.

Public health concerns	Actinomycosis occurs in humans with a clinical presentation not dissimilar to that of bovine 'lumpy jaw' (Najjar, 2008). However the causative organism is *Actinomyces israelii* and the disease in cattle has no implications for human health.
Current disease situation in Australia	This is a sporadic disease occurring wherever cattle are raised.
Current specific inspection procedure as per Australian Standard.	Cattle with lumpy jaw are segregated at ante-mortem inspection and slaughtered as 'suspects' at the end of the day to avoid unnecessary contamination of the slaughter floor. Since the lesions are usually confined to the head, the head, including the tongue which is usually unaffected, is condemned and the carcase passed fit for human consumption.
Future inspection options for consideration	Consideration could be given to salvaging the tongue, if unaffected, and passing it fit for human consumption instead of condemning the head and all its parts.

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Caseous lymphadenitis (CLA)

Caseous lymphadenitis (CLA) or *Cheesy gland* is a bacterial disease of sheep and goats caused by infection with the bacterium *Corynebacterium pseudotuberculosis*. It results in abscesses in the lymph nodes of the body and internal organs, especially the lungs. The pus in the abscesses is pale green in the early stages and turns cream as the abscess hardens and becomes cheesy or 'caseous'.

Infection of an animal is facilitated by the presence of skin wounds that become exposed to contaminated shearing equipment, shearing boards, dipping fluids and dust in holding pens. It can also spread by direct contact with affected sheep and goats. It was estimated that over 85% of lesions occur in the superficial cervical, precrural and superficial inguinal lymph nodes (Baird & Fontainet, 2007)

The main cost to the sheep industry is through loss of wool production that occurs in affected sheep (Paton et al., 1988); (Stanford et al., 1998). It has been estimated that on average 4-7% of clean fleece weight is lost in the year of first infection In 1991/92 wool losses were estimated at $15 to $20 million in Australia (Paton et al., 1994); (Paton, 2005). Losses also occur through trimming and condemnation of carcases at abattoirs. In 1990/91 the annual losses from condemnation and from trimming the less severely affected carcases was estimated at $1 million and $1 to $3 million respectively. The largest cost to the abattoir was the cost of inspecting for CLA. Estimated at $10 million (Batey, 1986); (Paton, 2005)).

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<tr><td>Public health concerns</td><td>Human infection is rare, causing a lymphadenitis with a long and recurrent course (Peel et al., 1997). Infection is not as a result of ingestion of contaminated meat, but rather is an occupational disease of abattoir workers and shearers with infection occurring through cuts. CLA lesions are excised from carcases for aesthetic rather than public health reasons.</td></tr>
<tr><td>Current disease situation in Australia</td><td>This is the most common bacterial disease of sheep in Australia. An abattoir survey conducted by NSW Agriculture in 1995 showed that 97% of flocks from NSW that were sampled in the survey were infected with CLA. Similar surveys have found a CLA prevalence of 91% in Victorian and 88% in Western Australian abattoirs.</td></tr>
<tr><td>Current specific</td><td>In sheep meat abattoirs, inspection for and removing CLA is the single</td></tr>
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inspection procedure as per Australian Standard.	most time-consuming task of a meat inspector and requires palpation of the internal iliac, lumbar, ischiatic and popliteal lymph nodes. This is usually done by running the hands over the surface of the carcase. If the superficial cervical, precrural and superficial inguinal lymph nodes have not already been excised and discarded, they are palpated.
Future inspection options for consideration	Since running the hands over the carcase increases the chances of accidentally spreading any contamination present on the carcase, an investigation should be undertaken to assess the validity of ceasing palpation of lymph nodes and replacing this with observation only.

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Cysticercus bovis

Livestock can act as the intermediate host for the tapeworms of humans and other animals. When the eggs of the human tapeworm *Taenia saginata* are ingested by cattle, they hatch in the stomach and the larvae penetrate the intestinal wall, pass into the bloodstream and end up in striated musculature where they form cysts (cysticerci). These small oval structures are semi-transparent at first, but later become white and opaque with encapsulation by fibrous tissue, measuring up to 6 mm. Most cysts found at post-mortem inspection are degenerate. All the carcase muscles and the muscles of the jaw, tongue, heart and diaphragm are customary sites for the cysticerci (Dunn, 1978); (Collins & Pope, 1990)

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<tr><td>Public health concerns</td><td>When meat containing these cysts is ingested by humans without proper cooking, the cysts hatch and the tapeworm develops and grows in the intestine (REF: Dunn 1978, Anon 2009).</td></tr>
<tr><td>Current disease situation in Australia</td><td>With improved management of human sewage effluent and limiting access of cattle to grazing effluent treated pasture, the incidence of C. bovis cysts in cattle at post-mortem inspection has decreased significantly over the past 50 years (Collins & Pope, 1990).

A survey undertaken by AQIS at post-mortem inspection in export beef abattoirs over a defined time period in 2008, found no incidence of C. bovis cysts in the cattle examined (Pearse, 2010).</td></tr>
<tr><td>Current specific inspection procedure as per Australian Standard.</td><td>In cattle, incise masseter and heart muscles, the tongue, and diaphragm after removal of serous membranes and observe all exposed surfaces.</td></tr>
<tr><td>Future inspection options for consideration</td><td>If an integrated approach to bovine cysticercosis were taken, where cattle deemed to be at high risk identified on the NLIS database, then routine incision of internal and external masseter muscles could cease and high risk cattle only subjected to more intensive post-mortem examination.</td></tr>
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Cysticercus ovis	
Sheep can act as the intermediate host for the dog tapeworm, *Taenia ovis*. The dog is the definitive host and harbours the adult tapeworm in its intestines. Eggs are shed in the dog's faeces. When sheep graze contaminated pasture, they ingest the eggs which hatch in the stomach. The larvae make their way via the bloodstream from the intestines to the muscles of the sheep where they form cysticerci. Lesions are commonest in the heart and diaphragm, but can occur in all skeletal muscles (Dunn, 1978). Dogs become infected by eating viable tapeworm cysts in sheep and goat carcases. Though the fox can be infected with this tapeworm, it happens rarely in the field (Love, 2008).	
Public health concerns	There are no public health implications arising from ingestion of undercooked meat containing *C. ovis* because humans cannot be infected with this tapeworm or its intermediate stages (Dunn, 1978).
Current disease situation in Australia	Sheep measles occurs throughout Australia where sheep and wild dogs interface.
Current specific inspection procedure as per Australian Standard.	Observation and deep palpation of diaphragm and exposed muscles of the head, neck and brisket.
Future inspection options for consideration	Palpation has the potential to spread contamination. Ovine cysticercosis is not a public health issue and consideration could be given to passing the responsibility to the meat company to address this aesthetic blemish.

Onchocerciasis *Onchocerca spp* are filamentous threadlike worms that cause nodules in cattle, horses, buffalo and camels. The nodules are fibrous capsules that can vary in size from 1 to 3 cm in diameter and are most commonly found in the brisket and stifle (*O. gibsonii*) and ligamentum nuchae (*O. gutterosa*). The nodules contain the adult male and female worms The females lay eggs which develop into microfilaria which make their way to the subcutis where they are taken up by biting midges, the intermediate host. Further development takes place in the midge before they are injected back into cattle and the life cycle is completed (Love & Hutchinson, 2003a).	
Public health concerns	This parasite is not zoonotic and concern over its presence by inspection authorities is purely for aesthetic reasons. If *Onchocerca* nodules are found at port of entry inspection in the United States, authorities regard the nodules as pathological lesions and will refuse entry of the product (Andriessen, 2001a)
Current disease situation in Australia	In Australia, onchocerciasis affects mainly northern cattle where conditions are more favourable for spread by the intermediate host. Infestations can involve large numbers of cattle slaughtered on a particular day, particular if they are from a common source or area (Love & Hutchinson, 2003a)
Current specific inspection procedure as per Australian Standard.	The accidental export of meat containing nodules is prevented by specific inspection and removal procedures undertaken in the boning room by company operatives as party of the Approved Arrangement. Once the brisket is removed in the boning room, it is boned and sliced on a table separate from other meat. The operative slices through the *cutaneous trunci* muscle, exposing the two internal sides of the brisket. The packer observes and palpates the exposed surfaces. Any lesions found are excised and condemned.
Future inspection options for consideration	Procedures currently in place are appropriate.

Liver fluke	
In Australia, the most important species of trematode is the liver fluke, *Fasciola hepatica*. Adult fluke are found in the bile ducts where they lay eggs which pass out in the faeces. After passage through a specific snail intermediate host, metacercaria encyst on vegetation. After ingestion by cattle or sheep, the immature flukes migrate through the liver tissue where they can cause considerable damage to liver function, before ending up in the bile ducts. Fluke can cause impaired liver function, anemia and illthrift (Love & Hutchinson, 2003b)	
Public health concerns	Humans can become infected with liver fluke. However the mechanism of infection is the same as that of cattle and sheep – ingestion of metacercaria off vegetation and not from eating infected liver.
Current disease situation in Australia	This is a relatively common parasite of cattle and sheep, particularly in the winter rainfall and irrigation districts as well as the New England and NSW North Coast districts (Andriessen, 2001b).
Current specific inspection procedure as per Australian Standard.	A transverse incision is made of the main bile duct and the contents observed. The US and EU require additional incisions to be made.
Future inspection options for consideration	In order to decrease the risk of Salmonella contamination at the viscera table, consideration should be given to investigating whether, if routine incision of the bile ducts was replaced with observation and palpation, this would give acceptable outcomes. Where abnormalities are detected, the bile duct could be incised transversely.

Ocular squamous cell carcinoma Bovine ocular squamous cell carcinoma (BOSCC), often referred to as 'cancer eye', is one of the most common neoplasms of cattle. It has been proposed that the cause is due to an interaction between genetic and environmental factors. A relative lack of pigmentation of the cornea, sclera and the skin around the eye (this is heritable) increases the chances of lesion development when the animal is exposed to the carcinogenic effect of the ultraviolet spectrum of sunlight. Papilloma virus can be found in the precursor lesions and papilloma virus DNA in the carcinomas. However, advanced viral techniques have failed to reveal any cause and effect between the virus and the tumour (Rutten et al., 1992).	
Public health concerns	While there has been no direct proof of a viral aetiology for BOSCC, the fact that viral DNA has been found in the tumours will continue to cause the precautionary principle to be adopted and this tumour treated as a potential public health risk.
Current disease situation in Australia	BOSCC is found predominantly in Hereford or Hereford cross cattle, but other breeds can also be affected. With the long distances cattle are transported, BOSCC can be found in cattle at abattoirs throughout Australia. Animal welfare considerations prevent the shipping of cattle with advanced lesions for sale or slaughter.
Current specific inspection procedure as per Australian Standard.	Cattle with visible BOSCC lesions are segregated at ante-mortem inspection and slaughtered as 'suspects' at the end of the day to allow a more detailed inspection of the lymph nodes of the head. The parotid, retropharyngeal and submaxillary lymph nodes are incised and observed for metastatic lesions. If no metastatic lesions are found, only the head is condemned and the carcase passed fit for human consumption. If metastatic lesions are found, this confirms a malignant neoplasm and the carcase and all its parts are condemned as unfit for human consumption. They may be recovered for animal food after heat sterilisation.

Future inspection options for consideration	Consideration should be given to undertaking an investigation of the sensitivity of ceasing routine incision of the head nodes for the detection of metastatic lesions of BOSCC and instead replacing it with close observation of the sclera, cornea, third eyelid and peri-orbital tissue. If any abnormality were detected, then the corresponding parotid node would need to be incised and observed for the presence of metastatic lesions.

Neoplasia

Neoplasia is the pathologic process that results in cells from normal tissues undergoing heritable genetic changes that allow the cells to become unresponsive to normal growth controls and to expand beyond their normal anatomic boundaries to form tumours. Benign tumours do not invade adjacent tissue or spread to new locations in the body. Malignant tumours will invade adjacent tissues and may spread by metastasis to other locations in the body (McGavin & Zachary, 2007a).

The genetic changes to cells that cause cancer can be inherited or they can arise from external factors interacting with the DNA of cells. These external factors can include chemicals, radiation and viruses. To date, viruses that have been conclusively shown to cause tumours in cattle include bovine leucosis and papilloma viruses and in sheep, Maedi-Visna pox and papilloma viruses (McGavin & Zachary, 2007a).

<table>
<tr><td>Public health concerns</td><td>As molecular biology is increasingly applied to cancer research, more cancers are being found to have a viral cause or association with their development. Consequently, public health policy makers and consumers are likely to continue to apply the precautionary principle and disavow meat derived from animals with malignant neoplasia.</td></tr>
<tr><td>Current disease situation in Australia</td><td>A wealth of data is available from abattoir and AQIS records on the number and reasons for condemnation of cattle at ante- and post-mortem. This data has not been systematically collated and analysed. A snapshot of data from a large abattoir in SE Queensland provides the following data (B Dobrenov, 2010):
<table>
<tr><td>Total slaughter</td><td>662,697</td><td></td></tr>
<tr><td>Total condemned at post-mortem</td><td>867</td><td>(0.13%)</td></tr>
<tr><td>Reasons for condemnation:</td><td></td><td></td></tr>
<tr><td>Adrenal and adrenocortical cancer</td><td>449</td><td>(51.8%)</td></tr>
<tr><td>BOSCC with metastasis</td><td>110</td><td>(12.7%)</td></tr>
<tr><td>Multiple abscesses</td><td>70</td><td>(8.0%)</td></tr>
<tr><td>Adenoma (cancer)</td><td>65</td><td>(7.5%)</td></tr>
<tr><td>Cancer of ovaries</td><td>55</td><td>(6.3%)</td></tr>
<tr><td>Fever (pyrexia)</td><td>54</td><td>(6.2%)</td></tr>
</table>
It is noteworthy that 78.3% of cattle condemned at post-mortem were condemned for malignant neoplasia.</td></tr>
</table>

Current specific inspection procedure as per Australian Standard.	Procedures are as described for BOSCC with the following addition: • Observe the external surfaces of the head as well as oral, buccal and nasal cavities. • Observe the external and internal surfaces of the carcase. • Palpate the lungs, heart, kidneys and liver. • Observe the spleen, thymus, pancreas, uterus and bladder. When a malignant neoplasm is identified at post-mortem, the carcase and all its parts are condemned as unfit for human consumption. They may be recovered for animal food after heat sterilisation.
Future inspection options for consideration	Significant numbers of cattle are condemned each year for the presence of malignant neoplasia by the subjective judgment of the inspectorial staff. A better understanding of the types of neoplasia that are the cause of carcase condemnation at post-mortem examination may lead to more objective judgments, particularly with laboratory back-up. Consideration should be given to addressing an omission in the Australian Standard by including in Schedule 2, Table 2, under '*Other tissues and organs*', the need to specifically inspect the adrenal glands and ovaries.

Fever complex

A carcase presented for post-mortem inspection with generalised congestion of the musculature (reddened 'angry' appearance) presents a dilemma to the inspector as to the cause of the condition. If accompanied by enlargement and congestion of lymph nodes and viscera and excess fluid in the body cavities, this could be indicative of an acute inflammatory response as a result of pyrexia (fever) caused by bacteremia, septicaemia, endotoxic shock or toxemia. Such a carcase will generally undergo rigor mortis within 45 minutes post-bleeding and not 'set' properly. Without pathological examination and laboratory follow-up it is not possible for the inspector to make a definitive diagnosis as to the cause of the condition based on the gross appearance of the carcase and viscera (McGavin & Zachary, 2007b).

Where poor slaughter and exsanguination (bleeding out) technique occurs, this can result in the presentation of a congested carcase very similar to that caused by fever. The main points of difference from a fevered carcase are little or no congestion and swelling of lymph nodes and viscera and the lower portions of the carcase (forequarters) are more congested than the hindquarters due to pooling of blood as a result of gravity (Andriessen, 2001c).

Public health concerns	It is important to differentiate a fevered carcase from one that is poorly exsanguinated. The fevered carcase is condemned whereas the poorly bled out carcase can be passed as fit for human consumption in the knowledge that it may have poor keeping and eating qualities and should be graded accordingly.
Current disease situation in Australia	These conditions are seen on a daily basis at beef and sheep meat abattoirs.
Current specific inspection procedure as per Australian Standard.	Observe the external and internal surfaces of the carcase and the viscera. Currently carcases presenting with the above carcase and visceral congestion at post-mortem are condemned with any one of the following terms used: fever, pyrexia, septicaemia, bacteremia, viremia, toxemia or pyaemia.

Future inspection options for consideration	This grab-bag of diagnoses used as reasons for condemnation by AQIS inspectors needs to be scientifically reviewed and thereafter the terminology revised accordingly.

Microbiological contamination

Foodborne illness of animal origin is a significant public health issue worldwide. The most frequent recorded cases of bacterial foodborne disease in the developed world are due to *Campylobacter* and *Salmonella*. A third group of bacteria that has a significant role in foodborne illness of animal origin is pathogenic *Escherichia coli* (*E. coli*). All have food animals as their predominant source (Mead et al., 1999).

In all instances, cross-infection between animals can occur during transport, at saleyards and in the abattoir lairage. Contamination of carcases can occur during slaughter and dressing – during hide removal/dehairing and evisceration bacteria can be transferred to carcase and offal meats. Correct chilling prevents or at least slows down bacterial growth on carcases.

Salmonella species (sp.): (Jay et al., 2003)

- Can persist in environment for many months.
- Multiply at temperatures between 8 and 45°C (optimum 37°C); killed at >70°C and will survive in chilled or frozen meat.
- Are killed by pasteurisation and gamma irradiation.
- Are resistant to drying – survive in dust, dry faeces and in animal feeds.
- Transmission can be direct from animal to animal or human or indirectly via contaminated food or environment.
- S. Typhimurium is the most common serovar isolated from humans. It is one of the most common serovars found in clinically ill animals (but not necessarily the most common when sampling carcases or the faeces of normal, healthy animals).
- Poor food handling contributes to foodborne salmonellosis. This includes: inadequate thawing prior to cooking; inadequate cooking, heating, reheating or pasteurisation; cross-contamination of cooked food or salads with raw foods; storage at temperatures that allow Salmonella to grow (7°C to 45°C) and delay between preparation and consumption.

Pathogenic *E. coli* (Desmarchelier & Fegan, 2003)

- There are many thousands of *E. coli* in nature but only some are known to cause disease in animals and humans. These have been classified into five broad groups based on the toxins they produce, the pathology they induce and the pathogenesis of disease:

- EPEC – enteropathogenic *E. coli*
- EIEC – enteroinvasive *E. coli*
- ETEC – enterotoxigenic *E. coli*
- EHEC – enterohaemorrhagic *E. coli* (also known as STEC – shigatoxin producing or VTEC – verotoxin producing *E. coli*)
- EGEC – enteroaggregative *E. coli*.

- *E. coli* O157:H7 can be readily distinguished from other E. coli strains.
- The principal reservoir is the intestinal tract of ruminants and humans and its faecal origin leads to contamination of surface water sources.
- E. coli O157:H7 can be isolated from the faeces of both healthy and ill cattle; more common in calves, especially when reared intensively.
- The major risk factor for human exposure is direct or indirect exposure to or ingestion of faecal contents from ruminants or humans.
- Foodborne exposure can be either direct or by cross-contamination from undercooked meats, unpasteurised milk, or contaminated fruit and vegetables.
- Control and prevention centres around hygienic practices in abattoirs to minimise carcase contamination. In the home, hygienic practices and storage of foods, appropriate food preparation and cooking procedures and heating mince to 72°C for 2 minutes will destroy EHEC.

<u>*Campylobacter*</u> (Wallace, 2003)

- *C. jejuni* and *C. coli* are the commonest cause of foodborne bacterial enteritis in the developed world.
- They have fastidious growth requirements and do not readily multiply on food at room temperature.
- Cooking and pasteurisation readily destroy *Campylobacter*; they survive chilling and freezing, but viability is diminished.
- The principal reservoir is the intestinal tract of wild and domestic animals and its faecal origin leads to contamination of surface water sources.
- *C. jejuni* is dominant isolate from cattle and sheep, but *C. coli* can also be

	isolated. • Dehydration of cattle, sheep and pig carcasses from forced air chilling greatly reduces *Campylobacter* contamination. • Little data is available on farm carriage rates of *Campylobacter.*
Public health concerns	Many factors can affect the presence and severity of salmonellosis in humans. The very young, immunocompromised or those with underlying disease are at greatest risk. The usual symptoms are enterocolitis of varying severity, but systemic involvement can also occur especially in high risk individuals (Jay et al., 2003). Disease associated with EHEC is due to a number of strains, the most recognisable and common is E. coli serotype O157:H7. The clinical condition in humans ranges from symptomless carriers, diarrhoea, and haemorrhagic colitis to haemolytic uraemic syndrome (Desmarchelier & Fegan, 2003). In humans Campylobacter causes acute enterocolitis, which cannot be easily distinguished from enteric illness caused by other pathogens; they have been shown to cause Guillan-Barre syndrome (Wallace, 2003).
Current disease situation in Australia	In 2002/2003 it was estimated that between 4 and 5 million cases of gastroenteritis occurred in Australia due to foodborne agents (Hall et al., 2002); (OzFoodNet Working Group, 2003). In a 2003 OzFoodNet survey, there were 23,434 notifications of eight bacterial diseases that may have been foodborne. In those outbreaks that were investigated, 5.6% of patients were hospitalised (out of 1,819) and two deaths were reported (OzFoodNet Working Group, 2003). <u>*Salmonella*</u> • Is the 2nd most commonly notified gastrointestinal disease in Australia causing 1-2% of cases of community gastroenteritis. • Is primarily associated with food. • National rate of reported cases is in the region of 36-40 per 100,000 population. • Generally rates increase with decreasing latitude in Australia.

	• Reports of salmonellosis are more frequent in the summer months; • Highest rates occur in young children. • Often can cause outbreaks with multiple cases. *Pathogenic E. coli* • Reported cases - 0.3 per 100,000 population. • *E. coli* O157 (not H7) is the most common serotype. • Most cases in South Australia. • Testing regimes and methods vary between jurisdictions making comparisons difficult. • Most cases are sporadic. *Campylobacter* • Most commonly reported cause of bacterial gastroenteritis in Australia, causing 3% of cases of community gastroenteritis. • National rate of reported cases is in the region of 113 –125 cases per 100,000 population. • Rates are not necessarily higher in northern parts of Australia. • Tendency for increased level of reporting in the fourth quarter of the year. • Highest rates in young children. • Not a common cause of outbreaks – cases are more often than not sporadic.
Current specific inspection procedure as per Australian Standard.	There is no specific inspection procedure for microbiological contamination in the Australian Standard. In general terms, it is covered by the requirement for observation of the carcase and viscera.
Future inspection options for consideration	A holistic approach is required from farm to end product and should include: • Minimal hide contamination when stock leave the property.

	• Transport distance as short as possible. • Clean lairages, water and rest prior to slaughter. • Clean cattle presented for slaughter. • Fastidious attention to pre-operational, operational, personal and post-operational hygiene. • Verification of minimal contamination by routine sampling and testing for pathogens (*Salmonella, E. coli*) and organisms that are indicators of contamination (*Coliforms, E. coli*). • Greater rigour and involvement of inspection authorities in following up and investigating microbiological verification failures.

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