Public health hazards of meat from small ruminants: the perspective of Australia

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Summary
The production of meat from sheep and goats in Australia occurs almost entirely at pasture in zones known as the semi-arid pastoral zone, the wheat-sheep zone (where sheep and crops form an agricultural rotation system) and the high rainfall zone. Each zone has particular factors which affect the human health hazards associated with sheep and goat meat and the opportunities for prevention.

The authors provide an overview of small ruminant production in Australia and a synopsis of the diseases encountered, including the factors which influence epidemiology. Animal health arrangements for underwriting food safety at the pre-harvest and post-harvest stages of production in Australia are also outlined.

Specific public health hazards related to sheep and goat meat, together with measures for prevention, are considered under the headings of zoonoses, enteropathogens and chemical residues.

Keywords

Introduction
Some essential conditions apply to the husbandry of sheep and goats world-wide. However, the circumstances for husbandry in any country, or region of that country, result from an individual blend of physical, biological and economic factors. These factors can have either a direct or indirect impact on the safety, for human consumption, of products derived from these animals. With this in mind, the authors present an outlook on the potential for microbial and other contamination of meat from small ruminants, and methods for addressing public health hazards at the pre-harvest, harvest and post-harvest stages of production, as viewed from Australia.

Overview of small ruminant production in Australia
The cluster of epidemiological factors which determine the pattern of sheep and goat disease in Australia and the opportunity for microbiological and chemical contamination of products from these animals arise from the environment, history and prevailing husbandry practices.

Environmental aspects
Sheep and goats entered Australia with the first European settlers in the late eighteenth century, into an environment which had never experienced grazing ungulates and which contained a biota of plants, parasites and pathogens which had co-evolved with marsupial herbivores, such as kangaroos. Accordingly, many diseases of sheep and goats do not exist in Australia and those which are present were introduced. At first, the long sea voyage to Australia would have worked as an effective de facto quarantine measure against infectious animal diseases. In addition, small and dispersed populations of existing sheep and goats would have acted as a second line of defence and made the establishment of any agents of infectious disease which survived the sea voyage more difficult.

Non-infectious diseases of sheep and goats, including many of the plant poisonings, result from plants introduced into the country either accidentally or for their agronomic value. At the moment, the large sheep population in Australia is
sustained on pastures improved through introduced legumes such as white clover and lucerne, and grasses such as ryegrass and phalaris. Large inputs of phosphatic fertiliser have been required to overcome the constraints of the Australian environment. Australia is an ancient land mass where the predominant soils missed the rejuvenating influence of recent glaciations and are weathered, shallow and relatively infertile. The epidemiological consequence is that the diseases constraining sheep and goat production in Australia are generally nutritional rather than infectious.

The absence of the zoonotic diseases recorded elsewhere is a significant epidemiological factor in the public health hazard profile associated with the production of safe sheep and goat meat in Australia. Examples are infection due to Brucella melitensis, louping ill, European tick-borne encephalitis and classical rabies. This relative freedom from infectious disease of public health importance occurs as a matter of history and explains why Australia has a strong concern for animal and plant quarantine. However, while Australia is an island-continent, biological isolation is not absolute. There is a long-term trend for the two-way diffusion of species between the Australasian and Oriental biogeographical regions which are demarcated by various imaginary lines such as the Wallace line (6).

Australia has an indigenous fauna of placental mammals, such as rodents and bats, which have a more recent phylogenetic history than marsupials, and which harbour a distinct set of co-evolved pathogens. Among these are zoonotic agents which have not included sheep or goats in their natural host range. For example, recent studies point to flying foxes as maintenance hosts for the bat paramyxovirus (synonym: equine morbillivirus) (21) and the Australian bat lyssavirus (5). Zoonotic agents found in Australian rodents include the lymphocytic choriomeningitis virus (19), encephalomyocarditis virus and the rickettsias associated with murine and scrub typhus (20).

**Current sheep and goat husbandry in Australia**

The total sheep population in Australia oscillates in response to climate and the market for fine merino wool. Recent experience shows that periods of low rainfall occur in a given region each seven to ten years. Figures from the Australian Bureau of Statistics show a peak of 175 million sheep in 1990. In 1995, there were 120.7 million sheep on 45,900 farms. Wool, rather than meat production, is the major consideration and the clear trend is for more merinos. The most recent demographic analysis shows that the Australian flock consists of approximately 90% merinos, 7% cross-breeds and 3% other breeds (17).

Sheep are located throughout most of Australia except for the wetter tropical and sub-tropical areas of Northern Australia (Fig. 1). Production takes place in several broad climatic zones. The pastoral zone consists of arid and semi-arid areas in Queensland, New South Wales, South Australia and Western Australia where average annual rainfall ranges from 150-650 mm and droughts are a regular and frequent occurrence. The wheat-sheep zone has an average annual rainfall of 250-650 mm and sheep husbandry occurs in rotation with cropping. The high rainfall zone has an annual rainfall of 500-1000 mm and is further subdivided into summer, winter and intermediate rainfall areas. The summer rainfall area occurs on the tablelands in northern New South Wales and southern Queensland. The winter rainfall zone makes up most the remainder, except for the intermediate

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**Fig. 1**

The distribution of sheep in Australia (one dot = 20,000 sheep)
zone in the central tablelands of New South Wales. Meat-sheep production occurs in the wetter areas of the wheat-sheep and high rainfall zones.

Sheep production in Australia occurs almost entirely at pasture. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. Exceptions are specialised production of ultraline merino wool in enclosed sheds, milk production and the pastoral. 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Johne's disease was first observed in Australian sheep in 1981 (8). The disease shares some pathological features with Crohn's disease in humans. However, research has not shown a substantial causal relationship, and on currently available evidence a linkage cannot be substantiated. Johne's disease has a low and patchy prevalence and is being managed by programmes for eradication and accreditation of disease freedom.

Non-infectious disease

In Australia and elsewhere, intensive husbandry is accompanied by non-infectious disease arising from hazards in the natural environment. Poisonous plants and poisoning from mycotoxins, toxins from blue-green algae and inorganic chemicals such as copper, molybdenum and selenium cause sporadic disease and are a background consideration in sheep and goat production (18). Metabolic disorders such as hypocalcaemia, grass tetany and pregnancy toxaemia can be troublesome on individual farms but are only a minor nuisance at the regional and national level. The balance of non-infectious disease occurs intermittently and comprises neoplasms, dietetic disorders, urinary calculi and enzootic pustitis in rams and wethers (1).

Arrangements for managing public health risks from small ruminants and their products

The Australian Quarantine and Inspection Service (AQIS) has a major role in the protection of public health at the harvest and post-harvest stages of meat production. AQIS provides meat inspection to an export industry which supplies sheep and goat meat to markets in more than 100 countries. Inspection services are delivered to registered export abattoirs, independent boning rooms, meat processing establishments and cold stores. AQIS also issues veterinary health certification for edible and inedible animal products (including hides, skins and wool) as required by importing country authorities. A further role for AQIS is the pre-embarkation health and welfare inspection of sheep transported from Australia for slaughter elsewhere in the world.

Risk from specific zoonotic diseases

The occupational zoonoses associated with sheep and goats in Australia are contagious ecthyma, dermatophilus infection, anthrax, Q fever, salmonellosis, melioidosis, caseous lymphadenitis, Chlamydia trachomatis (ovine), and erysipeloid. In addition, sheep are intermediate hosts of the hydatid tapeworm and harbour the liver fluke, Fasciola hepatica, and the intestinal nematode, Trichostrongylus trichostongylus, which are known to infect people on rare occasions. Contagious ecthyma, dermatophilosis, Chlamydia trachomatis (ovine) and erysipeloid are not regarded as hazards associated with products from sheep or goats.

Notifications of the major zoonotic diseases found in people in Australia from 1991 to 1995 are shown in Table I. Some of these organisms can be found in fresh sheep and goat meat. However, the relative contribution of this potential zoonotic source is unknown. Brucellosis is overwhelmingly related to Brucella suis infection in hunters of wild pigs (16). Infections with Leptospira spp. in sheep and goats are rare in Australia, where cattle and pigs account for most of the occupational leptospirosis observed (20). Protection against leptospirosis is given by meat safety controls. Q fever is an occupational hazard for meat workers, but is not a foodborne disease and can be prevented by vaccination. Hydatidosis is managed by meat inspection in abattoirs and control of Echinococcus granulosus in dogs is ensured by the use of effective anthelmintics such as praziquantel.

Table I

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<td>Brucellosis</td>
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<td>29</td>
<td>20</td>
<td>34</td>
<td>29</td>
<td>140</td>
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<tr>
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<td>38</td>
<td>32</td>
<td>56</td>
<td>42</td>
<td>212</td>
</tr>
<tr>
<td>Leptospirosis</td>
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<td>159</td>
<td>178</td>
<td>123</td>
<td>143</td>
<td>772</td>
</tr>
<tr>
<td>Listeriosis</td>
<td>44</td>
<td>60</td>
<td>53</td>
<td>34</td>
<td>59</td>
<td>250</td>
</tr>
<tr>
<td>Ornithosis</td>
<td>136</td>
<td>94</td>
<td>98</td>
<td>95</td>
<td>180</td>
<td>593</td>
</tr>
<tr>
<td>Q fever</td>
<td>505</td>
<td>543</td>
<td>889</td>
<td>867</td>
<td>465</td>
<td>3,159</td>
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Except for salmonella and other organisms classified as enteropathogens, the zoonoses not listed in Table I can be considered rare. Anthrax is confined to known 'anthrax belts' in Australia (for example in the central west and south-west of New South Wales) where Bacillus anthracis persists in soil and produces sporadic disease. Anthrax heads the list for differential diagnosis in all instances of sudden death or febrile disease in 'anthrax belts'. The disease is controlled by vaccination but can occur sporadically in unvaccinated animals. Animals may not be sent for slaughter within 42 days of vaccination. Ante- and post-mortem inspection for animals showing fever or carcasses at abattoirs prevents anthrax from entering the food chain.
Enteropathogens

The assessment of risk from enteropathogens

No outbreak of food poisoning in Australia has been specifically associated with sheep or goat meat. Nevertheless, the pathogenic bacteria which may be associated with sheep and goat meat cannot be excluded as meatborne zoonoses. These include *Clostridium botulinum*, *Cl. perfringens*, *Escherichia coli* (the enterohaemorrhagic variants in particular), *Listeria monocytogenes*, *Salmonella* spp. and *Staphylococcus aureus*.

Foodborne salmonellosis is a major concern world-wide. The rate of notification of salmonellosis to the National Salmonella Surveillance Scheme of Australia (located at the University of Melbourne) has increased, particularly since the late 1980s. *S. Typhimurium* remains the most important serovar: widespread outbreaks caused by *S. Enteritidis* have not been observed. There are significant differences in the serovars isolated from food animals and people in Australia (9). *S. Bovismorbificans* seems to be the dominant serovar isolated from sheep (62% of isolates) followed by *S. Typhimurium* (26% of isolates).

A comprehensive survey was conducted in 1995 to quantify the microbiological quality of beef and sheep meat in Australia (3). The results for sheep meat summarised in Table II come from 25 meatworks and 470 carcasses. Only 12% of sheep carcasses and 14% of boneless sheep meat samples demonstrated bacterial counts in the undesirable range of greater than 100,000 per cm$^2$. *Salmonella* and *Campylobacter jejuni* were found in 5.7% and 1.3% of sheep carcasses, respectively. *E. coli* type 1 is an indicator of processing contamination and was not isolated from 25% of bone-in and 50% of bone-out carcasses, respectively. Enterohaemorrhagic *E. coli* O157:H7 was found on only one occasion, that is in 0.24% of carcasses.

The management of risk from enteropathogens

Process controls based on hazard analysis critical control points (HACCP) have been gradually introduced into meat processing establishments in Australia to complement the usual meat inspection and to minimise microbiological contamination in meat. The strategic plan of the Meat Industry Council of Australia to the year 2001 envisages an integrated package of quality systems operating at each stage of the meat production chain commencing on-farm and continuing to the consumption of the product. The aim is a ‘paddock to plate’ quality assurance system. Quality assurance systems already in place and relevant to sheep and goat meat production include ‘Sheepcare’ (an accreditation scheme driven by producers), and best practice standards for livestock transporters and sale yard operators are also being used.

A decision by State and Federal Ministers for Agriculture obliged all meat processing establishments in Australia to have quality systems which address HACCP principles in place by the end of 1996. HACCP-based systems in meat processing plants in Australia are supported by daily counts on carcasses of indicator organisms which reflect the quality of hygiene, e.g. *E. coli* type 1, which is an indicator of faecal contamination. Adverse trends in bacterial numbers or detection rates prompt the correction of elements in the production system rather than the acceptance or rejection of product.

Chemical residues

The strategy employed in Australia for controlling chemical residues in meat is composed of three parts. First is the strict registration and regulation of chemicals used in agriculture through the National Registration Authority. Second is education and the implementation of integrated control programmes for pests and parasites which reduce the need for chemical use. Third is the monitoring of residues in products such as meat from sheep and goats.
The National Residue Survey (NRS) was set up in the early 1960s to monitor the presence of agricultural and veterinary chemicals in meat (10). A summary of the 1995 results for sheep and goat meat is shown in Table III.

Sampling by the NRS is stratified to reflect different classes of stock, the location of abattoirs and seasonal variation in activity. Results may occasionally show residue trends which require further investigation. In this case, a discrete, flexible programme is implemented to target a particular species and chemical, for example organochlorine residues in cattle. No targeted testing programmes have operated for sheep or goats, but these could be implemented rapidly if required.

Conclusion

The present survey of public health hazards of meat from small ruminants in Australia indicates that few hazard points occur at the farm level. Procedures are in place to control chemical residues. Major zoonoses such as Q fever are occupational rather than foodborne. A recent survey shows adequate control of enteropathogens at the processing stage of the meat production chain and provides a benchmark for continuing improvements in hygiene.
Riesgos en materia de salud pública asociados a la carne de pequeños rumiantes: la perspectiva de Australia

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Resumen
En Australia, la producción de carne de cabra y cordero se da casi exclusivamente a campo, en pastoreo, en tres zonas bien delimitadas: la zona de pastoreo semiárido, la zona triguero-cabrera (donde el pastoreo de cabras y los cultivos forman un sistema de rotación) y la zona de alta pluviosidad. Cada una de estas zonas reviste características especiales que influyen sobre los riesgos que entraña para la salud humana la carne de cabra y cordero, así como sobre las posibilidades de prevención.

Los autores ofrecen una panorámica general de la producción de pequeños rumiantes en Australia, así como un resumen de las enfermedades observadas y de los factores que influyen en su epidemiología. También exponen las disposiciones en materia de sanidad animal que garantizan la protección alimentaria en Australia, disposiciones que afectan a las fases del proceso productivo tanto previas como posteriores al sacrificio. Por último evocan los riesgos de salud pública ligados específicamente a la carne de cabra y cordero y las medidas oportunas para su prevención, considerando separadamente las zoonosis, los enteropatógenos y los residuos químicos.

Palabras clave
Australia - Cabras - Higiene de la carne - Ovejas - Protección alimentaria - Residuos químicos - Salud pública - Zoonosis.

References


